CROCODILES

Proceedings of the
16th Working Meeting of the Crocodile specialist Group
of the Species Survival Commission of
IUCN – The World Conservation Union
convened at
Gainesville, Florida, 7 – 10 October 2002

(Unedited and Unreviewed)

IUCN – The World Conservation Union
Rue Mauverney 28, CH-1196, Gland, Switzerland

2002

Cover: American alligator, *Alligator mississippiensis* - photograph by C. C. Lockwood©. Courtesy of <www.cclockwood.htm>www.cclockwood.com.

Literature citations should read as follows:
For individual articles:

[Author] 2002. [article title]. pp. [numbers]. *In*: Crocodiles. Proceedings of the 16th Working Meeting of the Crocodile Specialist Group, IUCN – The World Conservation Union, Gland, Switzerland and Cambridge UK.

For the volume:

Crocodile Specialist Group. 2002. Crocodiles. Proceedings of the 16th Working Meeting of the Crocodile Specialist Group, IUCN – The World Conservation Union, Gland, Switzerland and Cambridge UK: xx + 416 p.

ISBN: 2-8317-0550-9

Published by: IUCN/SSC Crocodile Specialist Group

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THE CROCODILE SPECIALIST GROUP

The Crocodile Specialist Group (CSG) is a worldwide network of biologist, wildlife managers, government officials, independent researchers, non-governmental organization representatives, farmers, traders, tanners, manufacturers and private companies actively involved in the conservation of crocodilians (Crocodiles, Alligators, Caiman and Gharials). The Group operates under the auspices of the Species Survival Commission of IUCN. The CSG provides a network of experts to assess conservation priorities, develop plans for research and conservation conduct surveys, estimate populations, provide technical information and training, and to draft conservation programs and policy. CSG also assists monitoring international trade and identifying products. The Group is headed by the chairman, Professor Harry Messel, and maintains offices in Gainesville, FL, USA. Working meetings of the CSG are held every two years.

FOREWORD

Once again CSG members from all over the world have come together in a spirit of friendship and cooperation to share their expertise, knowledge and vision for the global conservation of crocodilians. Our vision and policies for this important effort continue to evolve and adapt to changing circumstances. This meeting presented results of an initiative begun at the 14th Working Meeting in Singapore 1998 to look more closely at the economic imperatives driving crocodilian trade and the linkages- or lack of linkages- to conservation. By recruiting new expertise from resource economists, and with the cooperation of the commercial sector of our membership, we have gained new insights into how these factors affect each other, and new ideas on how we can more effectively channel economic benefits and incentives toward conservation of crocodilians and their habitats. Many papers in these Proceedings reflect this developing view.

At the same time, we remain deeply concerned about continuing endangered status, and in some cases, continuing declines, of a small group of species for which commercial incentives are either inappropriate or not working. The good news is that for many of these species, including Chinese alligator, Siamese crocodile, Philippine crocodile and Tomistoma, there are new and active national programs addressing their needs. We continue to be deeply grateful for the efforts of our partners in China, the Philippines, and among international NGO's like Wildlife Conservation Society and Fauna and Flora International, who are spearheading these efforts. As always, it is by the individual efforts of CSG members operating in their day to day work, that crocodilians are saved. The CSG continues to promote and enhance these efforts by mobilizing international concern to support members' activities. The activities of dedicated task forces on Siamese crocodiles, Philippine crocodiles and a new task force on Tomistoma, provide a focus for these efforts. By meeting together every two years, we affirm the importance of our work, refresh our energy for the task and renew valuable professional and personal connections. My thanks again to the organizers, sponsors and the participants at this working meeting.

Harry Messel, Chairman, CSG

SUMMARY OF THE MEETING

Between 7 and 10 October 2002, over 270 CSG members and supporters convened in Gainesville, Florida, USA, for a very successful working meeting. The meeting was hosted by United States Geological Survey – Biological Resources Division, Florida Wildlife Coop Unit, and Florida Caribbean Science Center, Florida Fish and Wildlife Conservation Commission. Florida Museum of Natural History, University of Florida, and Florida Wildlife Federation.

The organizing committee comprised of H. Franklin Percival (USGS, Chairman), Ken Rice (USGS, program), Kristina Sorenson (USGS/UF, volunteer coordination), Harry Dutton (FWC registration management and treasurer), Allan Woodward (FWC, program), Dwayne Carbonneau (FWC, social), Steve Sieigler (FWC, audio-visual coordination), Pat Linehan (FWC, program and social), Perran Ross (FLMNH, CSG liaison), Manley Fuller (FWF, Fiscal Services), John Thorbjarnarson (WCS, program).

Crocodile Specialist Group and the meeting hosts and committee are very grateful to the many donors and sponsors listed below for their support of the meeting. We particularly appreciate the support of Phil Steel and Jake Puglia for providing the initial seed support beyond their normal CSG donation and to Gene and Dennis Pella for their support of the hospitality room. The University of Florida supported sign language translation enabling the participation of a hearing impaired crocodile enthusiast. The Gainesville Sheraton Hotel, overlooking Biven's Arm Lake and its wild alligators provided a comfortable setting, facilities and amenable and flexible staff for the meeting.

The meeting was opened with a welcome address from Vic Heller, Assistant Executive Director FWC and Russ Hall representing USGS. The first session on market driven conservation presented an overview of the complexities of the relationship between conservation and commercial use by John Hutton and then critical evaluations from several perspectives by John Thorbjarnarson, James MacGregor and Tommy Hines. The afternoon was occupied by reports on alligator conservation and management throughout the USA, one of the success stories of sustainable crocodilian use. Sessions on the following days included wild crocodilian harvest programs; presentations on current conservation action on the Chinese alligator, Siamese crocodile, Philippine crocodile, Orinoco crocodile and Cuban crocodile; advances in crocodilian physiology, techniques; disease and health in both captive and wild populations; Human-crocodile interactions and crocodilian DNA studies. Two workshops were conducted on Wednesday afternoon, one on Latin American issues and the other following up on the opening session on trade issues.

This meeting introduced several innovations to the working meeting format. Participants received a printed collection of abstracts of the presentations on registration and each session concluded with drawing for a door prize, to encourage a good audience for the later papers of each session. A highly popular feature was the meeting hospitality suite, a dedicated room where participants could gather after hours to socialize, converse, discuss issues, and partake of the beverages generously donated by CSG members Gene and Dennis Pella and beer brewed by Harry Dutton. As has become customary at CSG working meetings, the social and personal interactions during the meeting provided a rich medium for friendship and professional connections. An opening cocktail welcome set the standard for good food and copious refreshments. The evening poster session was enriched by the presentation of snacks and drinks, ensuring nearly 100% turnout and spirited discussion of the many projects presented. A dedicated group of cigar smokers inaugurated the Harry Messel cigar Olympics, activating hotel smoke alarms and requiring industrial scale ash disposal.

A high point of the social agenda was the evening barbecue banquet. Served under canvas at the rustic Austin Carey Research forest, and dramatically backlit by a circle of pick-up truck headlights, participants reveled to local traditional music and enjoyed barbecued pork, shrimp, Alligator in several forms and a dramatic strawberry dessert in a setting of rural-chic and great camaraderie. At the banquet the Castillo prize for crocodilian conservation, a handsome silver pitcher, was presented to John Thorbjarnarson in recognition of his multiple and long term efforts in global crocodilian conservation.

The CSG Working Meetings are the primary international meeting dedicated to crocodilian conservation and have become the forum where current events, recent discoveries and new directions are presented. Each meeting has its special highlights, but participants were effusive in their praise for the 16th Meeting for the venue and facilities, excellence of presentations and a very rich and productive social organization.

ACKNOWLEDGMENTS

The Chairman, Steering Committee and all members express their thanks to the meeting organizers and sponsors.

Sponsors of the 16th Working meeting

- United States Geological Survey –Biological Resources Division
- Institute of Food and Agricultural Science (IFAS) Office of the Vice president for Academic Affairs, University of Florida
- Florida Alligator Marketing and Education Council (FAME)
- Louisiana Fur and Alligator Council
- Alachua County Tourist Development Council with the Alachua County Board of Commissioners
- Jake Puglia, Alligator Adventure at Barefoot Landing, North Myrtle Beach SC.
- Phil Steel, Crystal River Alligator Farm, FL
- Center for Natural Resources, University of Florida
- Florida Museum of Natural History, Office of the Director and Natural History Department
- Department of Wildlife Ecology and Conservation, University of Florida
- Genie and Joe Tillman, Lake Placid, FL
- Gene and Denis Pella, Sebring FL
- Robert Young, Alligator Bob's
- Allen Register, Gatorama, Palmdale FL
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- Mark Glass, Glass Enterprises Inc. Moultrie, GA
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[1] The total number of alligator skins in trade each year during the period 1870-1902 may have exceeded 110,000 (R. Elsey, pers. com.).

[2] The taxonomy of the caiman is subject to considerable debate. For the purposes of this paper the term 'caiman' includes all variations of *Caiman crocodilus* including what is sometimes known as *Caiman yacare*.

[3] 14 species and 2 sub species of the 21 species recognised

[4] A country that takes a 'reservation' against the listing of a species in CITES is not bound by that listing decision.

[5] In some cases reservations have played a positive role in conservation and the evolution of CITES (Kievit, 2000).

[6] It was decided that the removal of eggs or young animals from the wild for subsequent rearing in captivity should be termed "ranching" and should not benefit from the trade possibilities provided by 'bred in captivity' exemptions.

[7] In the market, alligator and crocodile skins are known as "classics". Classic skins and caiman skins are usually considered separately.

[8] Notably by TRAFFIC-USA which consistently and successfully focused attention on the illegal and unregulated crocodilian trade during the 1980s.

[9] With species of low value or which are difficult to breed in captivity.

[10] An alleged illegal shipment of Nile crocodile skins into Zimbabwe proved to have legal permits.

Legal Trade Snaps Back: Using the Experience of Crocodilians to Draw Lessons on Regulation of the Wildlife Trade

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ABSTRACT: Using international trade in crocodilian hides as a case study, this paper addresses two competing hypotheses:

a. That legal trade in wildlife can be used to displace illegal trade.
b. That legal trade in wildlife will inevitably encourage illegal trade.

We document that the modern crocodilian trade has seen the replacement of skins from unregulated exploitation with skins from sustainable resource management. Today, at least 30 countries may use wild harvests, ranching or captive breeding to produce crocodilian products from 12 species to supply international trade – but only on the understanding that these programmes do not threaten the future of any species in the wild. As a result, the eleven most commercially valuable species are the species *least* threatened with extinction.

We conclude that conservation incentives can and have been generated by markets; the economic importance of the resource has led directly to stronger institutional arrangements specifically for conservation and sustainable management, and; illegal international trade, which flourished before CITES encouraged legal trade, has been all but eradicated.

INTRODUCTION

Regulation of the international trade in wildlife is undertaken at several different levels. The most well-known regulatory body is the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), which is a multilateral institution. But regional groupings such as the European Community also impose their own regulations, as do individual states. In all cases these regulations, and their enforcement, can evoke strong passions.

Competing explanations are put forward for cases where regulation appears to fail. Is it because insufficient resources are being devoted to enforcement? Or is it because regulation barely touches the real causes of the species' decline? Widely different prognoses are offered of proposals to change regulations. Will tightening trade restrictions save a species, or actually exacerbate its conservation status? Will a partial loosening of existing regulations lead to a massive increase in the illegal trade, or cut the ground from beneath the illegal trade?

Underlying these disputes there may be differences about the goal of regulation. Is the aim simply to conserve wild species? Or are there objections to any trade in (some) wild species, whatever its impact on their conservation? In addition, is there an obligation to consider the equity implications of trade regulations, particularly in developing countries?

Within CITES and domestic regulatory contexts, the question of whether legal trade stimulates illegal trade has persistently emerged. It appears clear that the existence of an unregulated trade has in many circumstances provided the distribution network and the market to enable a flourishing illegal trade. Some have moved from this observation to the proposition that allowing a regulated trade will promote illegal trade. As divergent answers to this question provide central conceptual planks of various opposing arguments within CITES, and substantial conservation and livelihood impacts ride on the answer, answering this question is a high priority.

Using international trade in crocodilian hides as a case study, this paper addresses two competing hypotheses:

c. That legal trade in wildlife can be used to displace illegal trade.
d. That legal trade in wildlife will inevitably encourage illegal trade.

Both hypotheses have their adherents, and in most discussions of wildlife trade the relationship between legal trade and illegal trade will eventually become an issue. For example, the tension between the two competing hypotheses was neatly captured 25 years ago in debate on the conservation and trade in crocodilians:

> "Crocodile farmers have claimed that hides from captive stock, with their steady supply, and uniform size and quality, will replace wild hides in the international market. On the other hand some conservationists fear that the farmed hides will stimulate, but fail to satisfy, increased demands for crocodilian products." (Anon 1976)

This paper:

- briefly addresses the two assumptions, highlighting some of their characteristics.
- presents a case study of the crocodilians, and
- attempts to draw conclusions which may be of relevance to the way we deal with wildlife trade in general.

THE COMPETING HYPOTHESES

Legal trade displacing illegal trade

The idea that legal trade might be a useful tool to displace illegal trade is one commonly advocated by economists who promote market solutions to conservation problems. They seek to link the economic consumptive use of wild resources to incentives for sustainable harvesting. Discussion is usually couched in terms of property rights, the capture of economic rents, discount rates and institutions. For example, with respect to the African elephant it is claimed that:

> "It is not the mere existence of rents from ivory harvesting but who captures these rents which often determines the incentives for over-exploitation." (Barbier et al. 1990)

An alternative but related argument suggests that in some circumstances legal trade from species produced in captivity can directly substitute for illegal or unsustainable trade originating from wild harvests, as follows:

> "Where a wild population is being over-exploited for trade, it is possible that an alternative supply from captive sources could divert some of the trade and reduce pressure on the wild population…increasing the supply so that the market becomes saturated and the price is driven downwards." (Luxmoore & Swanson 1992)

It can be argued that model has been supported by the Articles of CITES where the commercial trade in Appendix I species is allowed provided the products come from captive breeding or artificial propagation of the species [Article VII (4)], but not if they come from sustainable harvesting from the wild.

Legal trade leading to illegal trade

Even if legal trade poses no direct threat to the survival of a species, it is widely recognised, including by the proponents of market solutions, that legal trade may provide increased opportunities for illegal trade. This situation has been well articulated as follows:

> "[g]iving wildlife commercial value is a double-edged sword. Poachers like wildlife with commercial value too." (Michael Sutton 1992, quoted by Keller)

Illegal trade is rightly regarded as both difficult to control and more likely to lead to unsustainable harvesting than legal trade, and there are plenty of examples where illegal trade has flourished under the cover of legal trade. In the past, this was certainly a challenge with crocodilians:

> "Laundering", poaching, and difficulties in identifying species and countries of origin are problems that perpetuate the [illegal] crocodilian trade and make it difficult to monitor" (Roeper 1983).

However, an entirely reasonable concern has often been recast as an immutable assertion that legal trade inevitably leads to illegal trade and that this will, in turn, enhance rates of resource depletion. Support for this argument is based on acceptance of the following assumptions:

1. Any market will result in over-exploitation as the inevitable result of human greed combined with the opportunity for short term financial gain.
2. Legal trade will stimulate demand which it is then unable to meet, leading to an escalation in price thus adding to the incentive for illegal harvesting and trade.
3. Attempts to counter or mitigate the threat to species resulting from trade will be ineffective. The force of markets, once unleashed, is so great that enforcement can never meet the challenge.

In the words of two adherents to this axiom:

- "[I]t is in the nature of individual economic decision making to seek to maximise individual financial return even if it is at the cost of reducing the resource base being used". (Favre 1993)
- "Legal production tends to stimulate and perpetuate the markets for such products, thus *increasing*, or at least maintaining, the poaching pressure on wild populations." (Hoyt 1994)
- "When luxury products from wildlife are legally traded in international commerce, the economic incentives for killing such animals are overwhelming." (Hoyt 1994)

Over the years, the notion that legal trade will inevitably lead to unsustainable, uncontrollable, illegal trade has been at the heart of a great deal of the opposition to proposals to transfer species from Appendix I to Appendix II of CITES. Thus:

> "WWF believes that resuming a legal trade in horn carries many risks. The move would perpetuate a demand that has caused the catastrophic fall in rhino numbers over the last 30 years." (WWF 1992)
>
> "The history of trade in this species clearly indicates that illegal trade in sea turtle products flourishes under the cover of legal trade…. Any legal trade, particularly on a continuing basis, is likely to generate even more demand for illegal products." (IFAW 2000)

In the CITES context, even the discussion of legal trade is sometimes held to be dangerous. Serious consideration of legal trade is said to send the 'wrong signals' to would-be poachers and illegal traders, encouraging their activities:

> "What will happen if the proposals (for elephants) are accepted? Poaching will resume. Indeed the very existence of the proposals has led to increased poaching." (Greenpeace June 1997)

EXPLOITATION AND TRADE IN CROCODILIANS

Of the 23 crocodiles, alligators and caiman species (collectively known as "crocodilians") generally recognised in more then 90 countries, 15 or more have commercially valuable hides and have experienced remarkably similar histories of utilisation, conservation and management, regardless of the countries in which they occur (Ross, 1998). From the 1800s onward, crocodilian skins became commercially valuable in some countries. In the US, for example, trading firms in New York were handling more than 60,000 American alligator *Alligator mississippiensis* skins a year in the late part of the 19th Century (Fuchs et al. 1989)[1]. The demand for many species appears to have increased exponentially after World War II. Thus, in the late 1940s it is reported that 120,000 Nile crocodile *Crocodylus niloticus* skins were being exported annually from Madagascar to tanneries in France (Games, Ramandimbison and Lippai, 1997) while in the mid-1950s, nearly 60,000 Nile crocodile skins were exported from East Africa every year (Fuchs et al., op cit).

By the 1960s almost all wild populations of commercially important species were being exploited for trade to some degree and conventional wisdom holds that, as recently as the early 1970s, over 2 million crocodilian skins were to be found in trade. The vast majority, perhaps as many as 1.8 million, were from the South American caiman *Caiman crocodilus*[2] originating in a wide range of countries including Bolivia, Brazil,

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[1] The total number of alligator skins in trade each year during the period 1870-1902 may have exceeded 110,000 (R. Elsey, pers. com.).
[2] The taxonomy of the caiman is subject to considerable debate. For the purposes of this paper the term 'caiman' includes all variations of *Caiman crocodilus* including what is sometimes known as *Caiman yacare*.

Colombia, Paraguay and Venezuela, with the balance made up of alligators from the USA and crocodiles from many other parts of the world (e.g. Brazaitis, 1989).

Table 1 – List of countries with crocodilian production programs indicating mode of use. Wild harvest is direct harvest of adults from the wild. Ranching is collection of eggs from the wild that are raised in captivity, captive breeding is the production of eggs from adults held in captivity

Country	**Species**	**Mode of use**
United States	*A. mississippiensis*	Ranching, wild harvest and captive breeding
Mexico	*C. moreletii*	Captive breeding, ranching under development
Honduras	*C. acutus*	Captive breeding
Nicaragua	*Caiman crocodilus*	Wild harvest
Cuba	*C. rhombifer*	Captive breeding
Colombia	*Caiman crocodilus*	Captive breeding
Venezuela	*Caiman crocodilus*	Wild harvest and ranching
Guyana	*Caiman crocodilus*	Wild harvest
Brazil	*Caiman crocodilus*	Captive breeding, Ranching under development
Bolivia	*Caiman crocodilus*	Wild harvest
Paraguay	*Caiman crocodilus*	Wild harvest
Argentina	*Caiman latirostris*	Ranching
South Africa	*C. niloticus*	Captive breeding, ranching
Mozambique	*C. niloticus*	Ranching
Botswana	*C. niloticus*	Ranching
Malawi	*C. niloticus*	Ranching
Zimbabwe	*C. niloticus*	Ranching, captive breeding
Zambia	*C. niloticus*	Ranching
Uganda	*C. niloticus*	Ranching
Kenya	*C. niloticus*	Ranching, captive breeding
Tanzania	*C. niloticus*	Wild harvest, ranching
Ethiopia	*C. niloticus*	Ranching
Madagascar	*C. niloticus*	Ranching, captive breeding
Thailand	*C. siamensis*	Captive breeding
China	*Alligator sinensis*	Captive breeding
	C. porosus	Captive breeding
Cambodia	*C. siamensis*	Captive breeding
Indonesia	*C. porosus*	Captive breeding, wild harvest
	C. novaeguineae	Wild harvest
Malaysia	*C. porosus*	Captive breeding
Singapore	*C. porosus*	Captive breeding
Papua New Guinea	*C. porosus*	Ranching, wild harvest
	C. novaeguineae	Ranching, wild harvest
Australia	*C. porosus*	Ranching, captive breeding
	C. johnsoni	Ranching, captive breeding

There is strong anecdotal evidence that by the 1970s many wild crocodilian densities had fallen dramatically, sometimes to levels where populations were in danger of becoming extinct (e.g Cott 1961: p215). Not unnaturally, conservationists concerned about this situation tended to advocate an end to harvesting and trade. It is thus not surprising that when CITES was introduced in 1975 all crocodilian species were listed on the Appendices, most[3] on Appendix I where commercial trade is completely prohibited.

There were, however, conservationists who saw the curtailing of trade only as a short term management tool. Due to their influences, the late 1970s saw the growth of a nascent movement away from "prohibition for ever" towards the development of programmes in which wild crocodilians could be harvested on a sustainable basis to generate ongoing economic and conservation benefits. This happened in several countries with diverse economic, social and cultural settings, notably Australia, the United States of America, Papua New Guinea,

[3] 14 species and 2 sub species of the 21 species recognised

Venezuela and Zimbabwe, where the impetus for sustainable use often came from quite different directions (Webb, Manolis and Whitehead 1987).

CITES AND CROCODILIANS

Because almost all exploitation feeds international trade, the harvesting of crocodilians has been particularly amenable to influence from CITES. On the face of it, the Appendix I listings in place when the Convention came into force meant that legal trade in many traditionally important crocodilian species was technically impossible. In practice, however, trade often did continue through several different mechanisms. Firstly, in the 1970s a number of important producer and consumer nations were not Parties to CITES (including Zimbabwe, France and Italy) and continued to trade. Secondly, when joining in the 1970s and 1980s many new Parties lodged 'reservations'[4] against crocodilian species allowing them to maintain their harvesting and industry programmes (including, for example, Botswana, Zambia, Zimbabwe, France, Italy and Japan). Thirdly, CITES allowed specimens from Appendix I listed species that were bred in captivity for commercial purposes to be traded legally as if they were in Appendix II. In addition to legal trade through these mechanisms, a combination of continuing high demand for crocodilian hide, inappropriate regulation and poor national controls meant that considerable trade continued on an illegal basis.

During the 1980s the possibility for legal trade between non-members was restricted as the majority of traditional producer and consumer countries joined the Convention. In addition, even though it is perfectly legal to trade Appendix I crocodile skins under a reservation, member countries came under pressure to withdraw their reservations when it was argued that these allowed trade in skins taken illegally in their country of origin[5]. On the other hand, new possibilities for legal trade were created when, from 1981, it became possible to transfer some crocodilian populations from Appendix I to Appendix II if certain precautionary measures were adopted, including systems of production based on "ranching"[6] or governed by strict quotas.

By 1989, as CITES began to close down illegal and unregulated sources of crocodilian skins, the number of skins in trade was reduced from an estimated high of 1.5 million a year to a low of about 500,000. During the 1980s an increasing number of countries reintroduced exploitation and turned their attention to ways in which their crocodilian populations could be transferred from Appendix I to Appendix II to allow legal, well regulated trade to continue or recommence. Others focused on captive breeding that could benefit from the exemptions afforded to Appendix-I species under such programmes. As a result, the number of crocodilian skins in trade began to rise again until it reached a new peak of almost 1.4 million skins in 2000 (Figure 1). Trade before the 1980s was dominated by skins harvested from the wild. After the 1980s the vast majority originated from ranching and captive breeding. It is thought that about 300,000 classic[7] crocodile and alligator skins entered trade each year in the early 1970s (Ashley & David 1985), almost all originating from animals harvested in the wild. By 1983, under the influence of CITES, this number had fallen to 43,000 and the number of skins from the wild has hardly changed since then. In 1999 it is reported that 390,000 skins entered trade, but the increase reflects the bias of CITES towards ranching and captive breeding which together supplied 336,000 skins (Table 2). Over the same period the number of wild caiman skins in trade dramatically decreased from 1.4 million to 34,000 while the number of skins produced by captive breeding (principally in Colombia) increased from zero to over 770,000 (Table 2) (McGregor 2001 in prep).

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[4] A country that takes a 'reservation' against the listing of a species in CITES is not bound by that listing decision.
[5] In some cases reservations have played a positive role in conservation and the evolution of CITES (Kievit, 2000).
[6] It was decided that the removal of eggs or young animals from the wild for subsequent rearing in captivity should be termed "ranching" and should not benefit from the trade possibilities provided by 'bred in captivity' exemptions.
7 In the market, alligator and crocodile skins are known as "classics". Classic skins and caiman skins are usually considered separately.

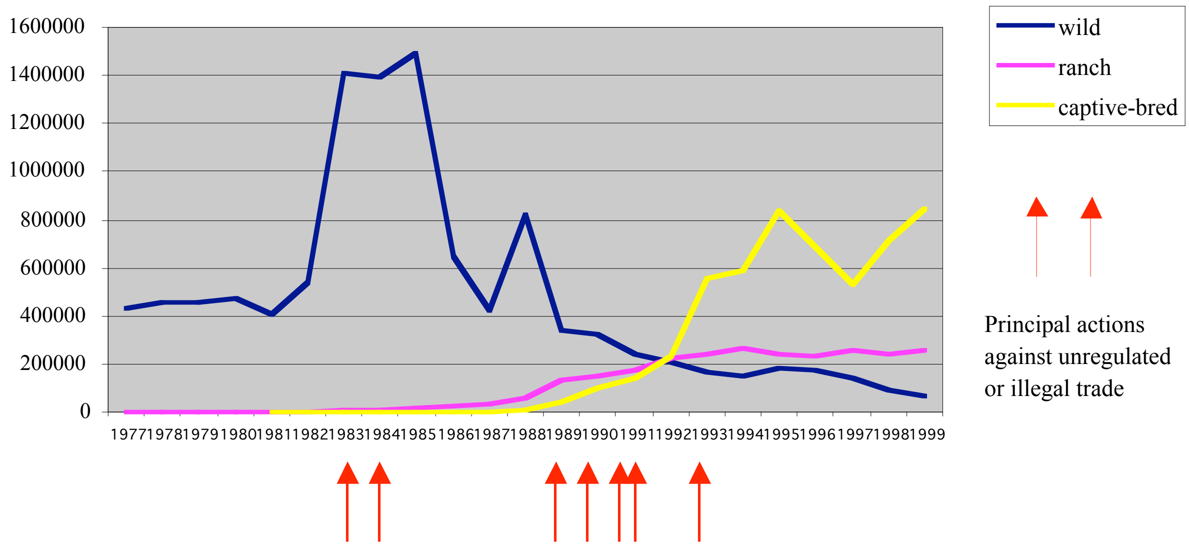

Figure 1 – Changes in the number of crocodilian skins harvested directly from the wild, ranched and captive-bred on farms during the period 1977 until 1999.

Table 2 – Classic and caiman Skins in global trade by method of production during the period 1977–1999 (from McGregor, 2001)

	CLASSICS				CAIMAN			TOTAL
	Captive-bred	**Ranch**	**Wild**	**TOTAL**	**Captive-bred**	**Wild**	**Total**	**TOTAL**
1977	0	1258	38831	**40089**	0	388322	388322	**422013**
1978	0	175	71045	**71220**	0	388322	388322	**451794**
1979	0	991	67902	**68893**	0	388322	388322	**458954**
1980	0	1039	81869	**82908**	0	388322	388322	**514429**
1981	403	3193	66306	**69902**	0	338265	338265	**435219**
1982	2	3339	39839	**43180**	0	223300	223300	**288319**
1983	73	6523	63557	**70153**	0	1349426	1349426	**1439978**
1984	222	11975	56105	**68302**	0	1333281	1333281	**1402293**
1985	640	18473	64653	**83766**	0	1428145	1428145	**1513120**
1986	786	22884	64302	**87972**	0	585080	585080	**681363**
1987	3422	36104	71752	**111278**	0	353012	353012	**469608**
1988	5614	58380	70333	**134327**	0	752933	752933	**896201**
1989	10885	126405	74799	**212089**	31168	265749	296917	**515914**
1990	10284	146569	82298	**239151**	91386	242083	333469	**477345**
1991	11121	173953	64960	**250034**	129521	172704	302225	**483848**
1992	22707	213926	56695	**293328**	208669	151117	359786	**548067**
1993	39719	234298	51487	**325504**	516002	112992	628994	**890520**
1994	49856	264421	52618	**366895**	536762	95668	632430	**944830**
1995	56864	237337	58287	**352488**	781313	120937	902250	**1178181**
1996	33413	236041	56545	**325999**	652528	113691	766219	**979147**
1997	46249	257248	74955	**378452**	483631	64408	548039	**806393**
1998	44219	244506	58455	**347180**	670469	34424	704893	**1040036**
1999	73105	262898	54642	**390645**	771456			**393793**

All crocodilian production programmes, especially ranching and captive breeding, involve the investment of significant manpower and financial resources. As a result of the dramatic growth of ranching and captive breeding since the 1980s an important new constituency has been created amongst governments, NGOs and the private sector whose interests are compromised by illegal trade. We believe that the creation of this constituency was pivotal to the headway that the Parties to CITES began to make against large-scale illegal trade during the 1980s (Anon, 1998) and which appears to have been eliminated during the 1990s. The constituency found a home, coordination and a unified voice in the Crocodile Specialist Group (CSG) of the IUCN Species Survival Commission. From about 1980 this group exerted a strong influence on the evolution of the various CITES mechanisms dealing with crocodilians as well as on the way that the Secretariat and Parties responded to unregulated and illegal trade.

The following examples illustrate the measures through which illegal trade was addressed by the Parties to CITES:

(i) In the early 1980s, a number of important importing countries (notably France, Italy and Japan) were widely criticised[8] for importing Appendix I crocodilian skins under a number of reservations. France and Italy were pressured by the European Community to drop their various reservations in 1984 and Japan dropped its reservation on *Crocodylus porosus* in 1989.

(ii) Although it did not hold any reservations on crocodilian species, Indonesia was implicated in the illegal trade of its indigenous crocodiles (and other wildlife species) during the late 1980s. In 1994, after almost a decade of deliberation, the CITES Standing Committee recommended that trade with Indonesia be suspended. The recommendation was not followed through because Indonesia, working with the IUCN/SSC Crocodile Specialist Group, successfully addressed the problem over a five year period of intensive management in which illegal trade was largely eradicated in favour of a well-regulated legal trade.

(iii) In 1983 there was a great deal of concern that Bolivia was responsible for laundering caiman skins from Brazil. Concerns in this regard continued until 1985 when the CITES Standing Committee recommended that trade be suspended – as a result of which Bolivia voluntarily withdrew from all international trade in wildlife.

(iv) In 1983 it was reported that Japan had imported 45 tonnes of caiman skins from Paraguay, and it was considered likely that these were illegal in origin. A few years later, in 1990, Paraguay re-surfaced again amid concerns that 35,000 caiman skins from Brazil had been laundered through that country. As a result of this, and similar problems, the CITES Secretariat suspended cooperation with Paraguay and shortly afterward a number of reforms were introduced which were considered to have resolved the problems.

(v) In 1990, 6,000 illegal caiman skins destined for Italy were seized in Belgium. Concerns about the role of Italy in the illegal trade of caiman skins were reinforced when evidence emerged that at least a further 9,000 illegal skins reached Italy that year. By 1992 the problem had become so serious that the CITES Standing Committee recommended that trade be suspended with Italy. Once again, this most drastic of compliance actions on the part of CITES resulted in a resolution of the situation, and the closure of yet another loophole for illegal trade.

(vi) Italy was not considered the only ‘leaky cauldron’ as far as the illegal trade in caiman was concerned, both Thailand and Singapore also had their problems. In 1988 it was reported that Thailand imported an estimated 750,000 illegal caiman skins because it had not passed legislation allowing it to enforce its obligations under CITES. In 1990, after further problems, the CITES Secretariat distributed an official notification warning Parties about the consequences of trade with Thailand. In 1991, when it was clear that no progress had been made, the CITES Standing Committee recommended that Parties should adopt stricter domestic measures to suspend trade with Thailand. Once again this mechanism had the desired effect. Domestic legislation was enacted and the illegal trade was eradicated.

(vii) In the early 1990s a great deal of concern was expressed by several South American Parties to CITES about the import of caiman skins under reservation by Singapore. It was suggested that many of these skins might have been taken illegally from Brazil and laundered through a range of intermediary countries, notably Aruba administered by the Netherlands. After a period of negotiation, characterised by a great deal of

[8] Notably by TRAFFIC-USA which consistently and successfully focused attention on the illegal and unregulated crocodilian trade during the 1980s.

recrimination, Singapore decided to drop its reservation on caiman in 1992, closing one of the last of the 'traditional' routes for caiman from 'grey' sources to enter international trade.

(viii) In 1990 concerns were raised that some crocodile ranching operations in Africa were laundering wild skins in order to maintain their economic viability when experiencing declining prices coupled with high investment and production costs (Hutton 1992). These fears have receded, not as a result of enforcement, but because a number of the countries most affected have worked within CITES to reintroduce sustainable cropping from the wild. At the same time they have moved away from ranching. Together these developments have removed many of the incentives for illegal trade.

(ix) In 1992, shortly after Singapore dropped its reservation, the first concerns were raised that wild caiman skins were being exported through captive breeding units (farms) in Colombia. For some years the 'preferred' conservation strategy for crocodilians, and many other species, was "captive breeding". However, it was feared that captive breeding provided incentives for the laundering of illegally-taken wild skins in some circumstances[9]. A decade later, these concerns continue in some circles (D. Ashley, pers.comm.), but no concrete evidence of any wrongdoing has ever come to light.

(x) In response to concerns about the possibility that an illegal trade in crocodilian skins could resurface, the Parties to CITES responded by introducing a universal system for the tagging of crocodilian skins at the points of origin and re-export. First introduced in 1992, this system was refined on two subsequent occasions to take into account the experiences of the various implementing countries. At the time of writing, all crocodilian skins and parts of skins, have to be recorded and tagged in compliance with Resolution Conf. 11.12. This system is considered to have been so successful that the CITES 'TIGERS' database on illegal trade, established in 1997, contained only one report of illegal commercial trade between 1995 and 2000, and on inspection this was found to be in error[10].

WHICH HYPOTHESIS?

Within 20 years the crocodilian trade has seen the replacement of skins from unregulated exploitation with skins from sustainable resource management. Today, at least 30 countries may use wild harvests, ranching or captive breeding to produce crocodilian products from 12 species to supply international trade – but only on the understanding that these programmes do not threaten the future of any species in the wild. As a result, the eleven most commercially valuable species are the species *least* threatened with extinction (Ross, 1998).

In the case of crocodilians, it seems clear that:

1. Conservation incentives can and have been generated by markets;
2. The economic importance of the resource has led directly to stronger institutional arrangements specifically for conservation and sustainable management.
3. Illegal international trade, which flourished before CITES encouraged legal trade, has been all but eradicated.

We can therefore reject the hypothesis that legal trade inevitably leads to illegal trade and adopt the hypothesis that legal trade can displace illegal trade.

THE WIDER LESSONS

The experience of crocodilians demonstrates at least that a regulated trade does not inevitably stimulate an illegal trade. The legal, regulated trade can be seen to have effectively displaced the illegal trade over a period of several decades.

However, this lack of impact does not represent a general rule. The question then becomes: under what circumstances does a regulated trade not stimulate illegal trade? While comprehensive answers to this question remain elusive, some interesting suggestions emerge from the study of crocodilians.

First, legal trade may be likely to suppress illegal trade when the legitimate trade creates a powerful constituency for whom illegal trade is against their economic interests. This certainly appears to have been an important factor in the case of crocodilian skins. As the skin trade both became an important source of revenue

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[9] With species of low value or which are difficult to breed in captivity.

[10] An alleged illegal shipment of Nile crocodile skins into Zimbabwe proved to have legal permits.

in range countries, and represented an increasingly large investment of management effort as well as research and development resources, this was reflected in the level of political will and resources made available to counter the illegal trade.

Second, structural characteristics of trade in some commodities may lend themselves to relatively low cost enforcement. In the case of crocodilians, for instance, the very small number of tanneries through which any high value products are required to pass make for relatively easy control of the vast bulk of the trade.

Third, the crocodilian example emphasises that the availability of effective enforcement measures such as trade suspensions is likely to be a vital component in decreasing the illegal trade.

CONCLUSION

Over the last 10 – 15 years there has been a marked change in the narrative associated with international conservation. From strategies of strict protectionism, which have been coined 'fortress conservation', new approaches have developed which shift the balance from prohibition to positive incentives for conservation. These approaches, including community-based conservation, are based on the post-modernist belief that markets need not be a threat to wild species, rather they can and should be manipulated to deliver effective conservation on the ground.

While the conservation of crocodilians has clearly required and adopted a range of methodologies, including strict protection, the sustainable use approach is particularly tried, tested and well known worldwide. As a result, the experience of the crocodilians is one of the central pillars supporting that belief, in general and in detail, within the international community which ranges from organisations such as the OECD, through the Parties which make up CITES and the CBD to important NGOs and academics who have often bought into this narrative only with some reluctance. At the moment this new narrative faces a challenge from several directions, including a number of influential conservation biologists and international donors who are sceptical of the market and of community involvement in conservation and advocate for a return to more traditional preservationist approaches.

As a result, we can expect the programmes that the CSG has encouraged for the conservation of crocodilians to be under close scrutiny over the next decade. It is time, therefore, for crocodile specialists worldwide to redirect their attention to the many programmes that have been started over the last 20 years or so to make sure they are still the effective conservation tools that they were originally designed to be. Wherever there may be problems, the CSG must redouble its efforts to overcome these. Anything else is surely unthinkable?

ACKNOWLEDGEMENTS

We are grateful to Barney Dickson and Rosie Cooney for allowing us to incorporate some of their thoughts on regulation and enforcement of the wildlife trade.

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Commercial Consumptive Use of Crocodilians: a Conservation Panacea or Pitfall?

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ABSTRACT: Commercial consumptive use (CCU) has been widely touted as a conservation panacea for crocodilians. However, it was actually worldwide efforts to protect crocodilians and limit commercial trade of skins and skin products that led to the remarkable recovery of species such as the American alligator, and certain populations of the Nile and Saltwater crocodiles. In areas where adequate habitat remained it was these increased protective measures that made CCU programs feasible. The role of CCU can be viewed as a supplementary tool for sustaining population recovery by providing economic incentives for nations and/or local people to conserve these otherwise unsavory animals. However, the effectiveness of these economic incentives has rarely been addressed. Today, in fact there is no good evidence that CCU incentives are strong enough to influence land-use decisions concerning wetlands habitats used by crocodilians. Ranching is widely recognized as having the potential for generating income for local communities or landowners, however, worldwide trends suggest that ranching programs tend to evolve into closed-cycle farming programs (Zimbabwe and Papua New Guinea). The CSG has recognized that these farming programs usually have no conservation role, but for certain highly endangered species farming can have potentially disastrous consequences by generating economic incentives to collect and sell the last remaining wild individuals to farmers (Cambodia). CCU programs can be successful moneymaking operations but there is a need to evaluate the role of these programs in terms of conservation.

International Trade in Crocodilian Skins: Review and Analysis of the Trade and Industry Dynamics for Market-based Conservation[11]

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ABSTRACT:

- This study analyses the global trade in crocodilian skins in order to understand the scope and potential for the development of market-based approaches to conservation concerns in this industry.
- The premise of market-driven conservation, employed as a complement or a substitute to formal regulation, is that voluntary regulation may be used to alter or "tweak" incentives to industry stakeholders in order to create conditions that favour conservation.
- A comprehension of incentives facing the skin trade, its industry and its stakeholders lies at the core of an economics approach to conservation
- A number of crocodilian conservation programs have seen some success in harnessing the potential of the market to deliver conservation outcomes.
- The challenge is whether these successes can be extended to the industry as a whole and hence, to all crocodilian populations.

The lack of systematic analysis of global trade in crocodilian skins has been an obstacle to assessing the potential for market-driven conservation, as information fundamental to this approach, such as the transmission of price signals between producers and consumers, has been unreliable or incomplete. This study represents an initial effort to address this challenge and identify the factors that will affect the development and success or failure of market-based approaches to conservation of crocodilian populations.

INDUSTRY FUNDAMENTALS AND CURRENT TRENDS

Trade in crocodilian skins includes crocodile, alligator and caiman, and forms part of the overall trade in exotic leathers supplying fashion accessories to a variety of market segments worldwide. In the fashion industry, the crocodilian segment is typically associated with sophisticated or luxury tastes along with superior product quality upheld by small family-run firms with "traditional" values. In fact, the industry has undergone significant change in the past 15-20 years, particularly in the structure of supply. Regulation and marketplace changes, including market liberalisation and globalisation, technological advances, environmentalism, and fashion trends, have led skin supply to move from unregulated exploitation of wild specimens to increased reliance on ranching and captive breeding.[see Figure 1]

Since the promulgation of CITES, the proportion of skins supply from wild harvests has diminished dramatically, from over 99% in 1983 to only 6% in 1999. At the same time, overall volumes of trade have risen. Demand for crocodilian products has remained robust and, at the high end of the market, apparently resilient to economic climate and fashion trends. Meanwhile, trade in lower-cost caiman products, particularly in Asia, has grown rapidly. The development of ranching and captive breeding has lowered skin supply costs thanks to economies of scale, and introduced commoditisation and increased certainty of supply. [see Figure 2 for historical value trends in the industry]

[11] Presentation at the 16th Meeting of the Crocodile Specialist Group, Gainesville, Florida

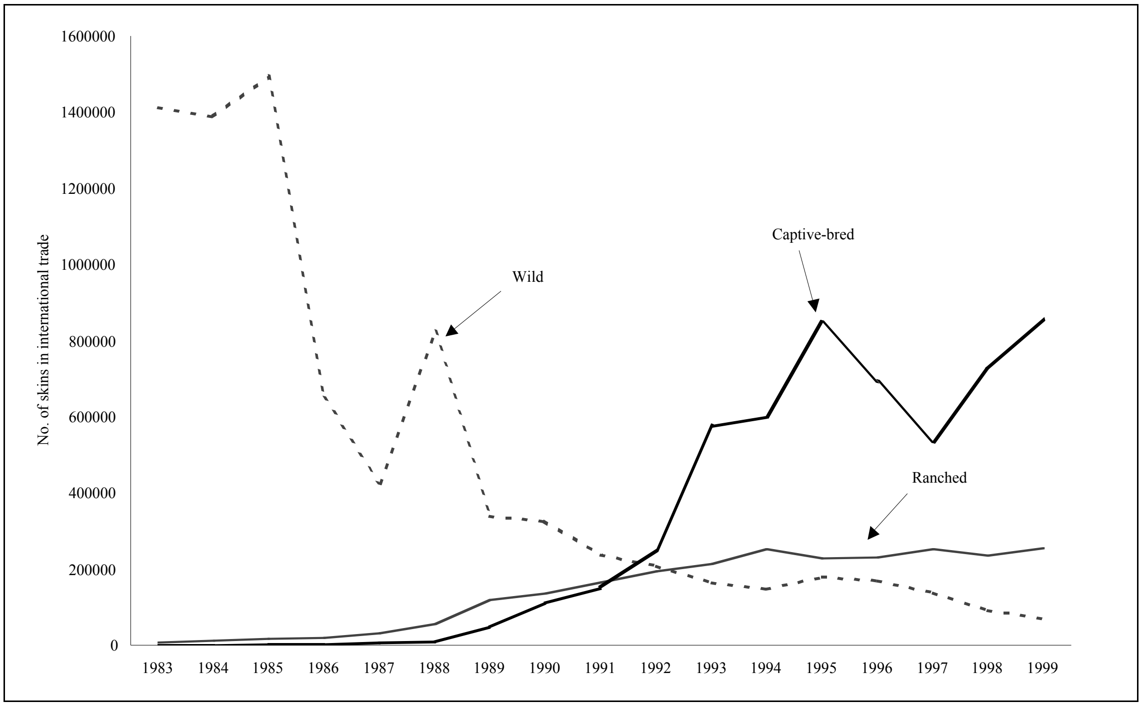

Figure 1. Estimated trade in Crocodilian skin by method of production (including caiman production), 1983–99.

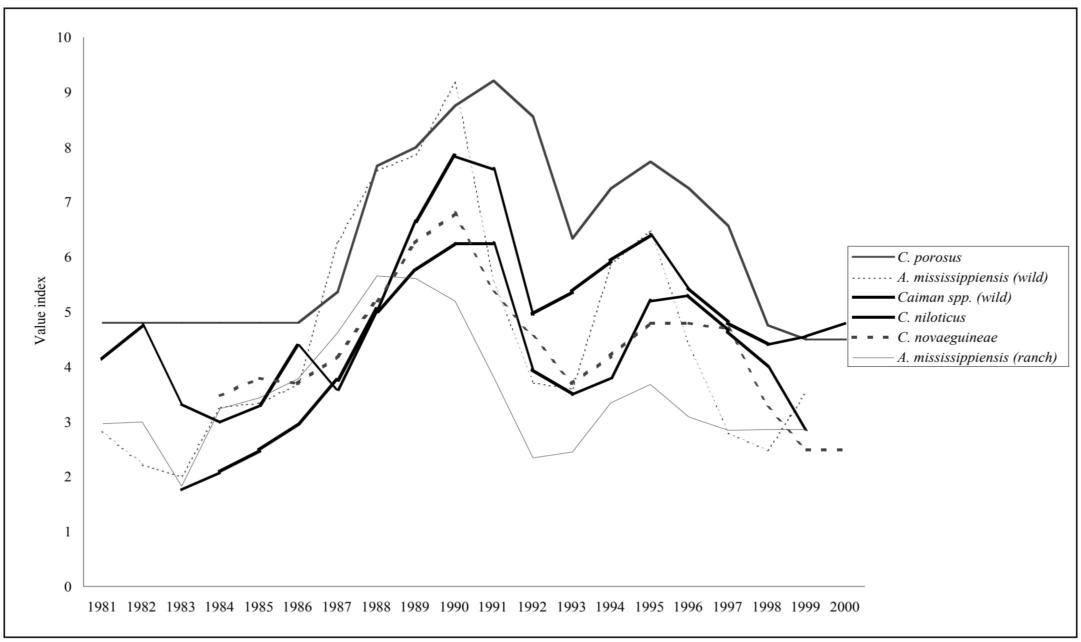

Figure 2. Value indexes for Crocodilian species' skins, 1984–2000.

The structure of the industry remains imperfect, however, in ways that delimit and shape the extent to which changes in retail value and volume of skin demand affect upstream values and incentives. The industry is hourglass-shaped, with numerous producers, manufacturers and retailers, but fewer tanneries [see Figure 3].

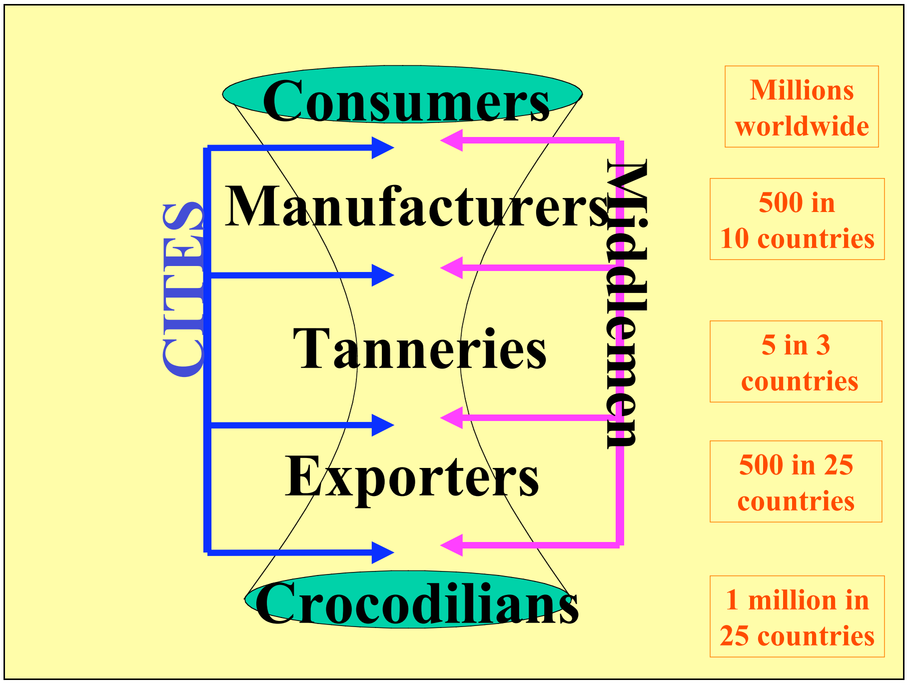

Figure 3. Representative structure of the Crocodilian skin industry (indicating numbers of stakeholders)

Hence tanneries are potentially a bottleneck in the supply chain as well as a potential location of economic power within the industry, although there is no evidence of collusion *per se*. The storability of skins from the tannery on to the manufacturer and retailer introduces the possibility of asset speculation by delaying production and supply decisions at each of these levels. While speculation is a standard entrepreneurial activity, it impacts on the industry's flow of incentives from customer to crocodilian. Other characteristics of the industry, such as the subjective and unregulated tool of "grading" to signify the quality of a skin, appear to operate to the benefit of stakeholders with power and prestige.

MARKET SEGMENTATION AND TRANSMISSION OF PRICE SIGNALS

The effect of the growth of ranching and captive breeding combined with the existing industry structure has been to differentiate market segments with respect to core economic characteristics and the relationship between retail and producer prices [see Table 1].

Table 1. Typical Disbursement of Value in the Crocodilian Skin Industry

Industry Sector	Percentage of Retail Value	Large Item, e.g.: Handbag (USD)
Retail	100%	3,000
Manufacture	42%	1,250
Tanning	17%	500
Export	8%	250
Production	6%	200

In the smaller skins segment, which tends to be captive-bred caiman and ranched alligator, a strong relationship exists between retail price and the price received by landholders and producers of skins. This owes to a combination of lower speculative potential, high and possibly very high demand, practical barriers to managing supply of large numbers of units, and acknowledgement of the minimal gains from doing so.

By contrast, in the market for larger skins, which command higher prices and are primarily "classic" crocodile skins along with wild-harvested caiman, asset speculation appears to be a significant factor in determining both the supply and value of skins. Rent dissipation is not absolute, however; even in this segment, there is evidence that consumer preferences at the retail level filter through the industry and affect the incentives facing landholders over resource utilisation.

PATHWAYS TO MARKET-BASED CONSERVATION

Scope. The dynamics of price signal transmission from the retail market up to the landholder and producer open the possibility of designing mechanisms that use market-driven methods for conservation. They also point to challenges that such mechanisms will need to address if they are to be successful. Although the markets for skins from wild and non-wild harvests are increasingly distinct, their prices still move in tandem. If these markets became more distinct, with fewer cross-price effects, it would encourage greater stability in the value of wild-harvested skins and enable conservation-oriented supply management innovations at producer level. Additionally, the constriction of the market at the tannery level, by diverting excess profits away from those segments in a position to re-invest in the wild resource, may limit the effectiveness of some market-based conservation measures, unless these also tackle the causes of this consolidative tendency in the first place.

Approaches. Given these industry characteristics, a variety of market-friendly methods for conservation are worth considering:

- Supply management: including producer cooperatives, restricting supply to range states
- Resource rent management: redistributive mechanisms to enhance landholders' returns and the translation of demand signals into conservation outcomes, including differentiating those skins that embrace conservation values and subsidization of wild populations by all skins;
- Demand management: including options such as 'certification'.

Issues and concerns. The scope for successful implementation of these measures should be assessed in tandem with formal regulation approaches, and with a sharp eye for exogenous factors and unintended outcomes. For instance, exchange rates play a key role in shaping incentives: evidence from Venezuela and Zimbabwe shows that local currency values rather than international prices are the key indicator for producer and landholder decisions over harvest. Furthermore, the growth of captive breeding might in the future divert production away from the traditional range states, limiting the scope for domestic cross-subsidization of wild populations for conservation, and increasing the imperative for international regulatory interventions. In addition, a closer understanding is required of the complementary and substitution effects between crocodilian skins and other exotics leathers.

Finally, the quality and availability of data within this industry remain short of what is needed to design sophisticated interventions. Further research is needed both at the aggregate, market level and on subtle but important factors such as the effect of changing economic conditions on size, grade and other characteristics of harvest. These and other data must be collected and widely disseminated to support the development and improve the effectiveness of new conservation methods.

Key Issue: Is captive breeding an ambiguous development for conservation?

The main impact on the industry of captive-bred skins: ensuring certainty of supply – hence, diminishing uncertainty/ risk and increasing economic efficiency of trade. Some likely economic impacts are identified:

- *increased price competition* as economies of scale and technology are realised by larger producers. Unit costs decrease and prices might fall
- *horizontal integration*: concentration of production and economic power among selected large-scale producers
- industry supply becomes more certain and stable as disruptive factors such as climate are erased from the production equation, technology is more important
- *comparison*: domestication increases specialisation and homogenisation of supply units, increasing the potential for comparison between the products of different producers – possibly increasing production efficiency and inevitably generating further price competition
- *vertical integration*: any reduction in the number of industry stakeholders in certain sectors will expedite communication between producers and downstream stakeholders.

Potential long-term losers:

- *smaller suppliers of captive-bred skins* to the industry fold as competition favours larger producers
- *suppliers of wild-harvested skins* to the industry *could* suffer a contiguous downward spiral in value. Synchronous fluctuations in value forewarn of cross-price effects: if supply-led effects of captive-bred skins affects its *own* market value in the short-term, this could affect the value for *all* crocodilian skins
- *livelihoods* of those stewards of wild crocodilian resources
- *intermediaries* will be needed less, because fewer transactions will be executed between fewer industry stakeholders.
- *range states* without access to the technology to take full advantage of specialisation and economies of scale.
- *ill*egal trade market consolidation would reduce enforcement costs and possibly raise standards in a sector with fewer stakeholders.

CONCLUSION: INCENTIVES AND OPTIONS FOR CONSERVATION

All too often, conservation relies overly on transfers of international existence value via donor agencies and the goodwill of landholders. Increased emphasis on market-driven conservation fosters the potential to achieve many conservation outcomes by harnessing the power of the market. In this, the crocodilian skin industry is no exception. As this study shows, the specific characteristics of the industry set up particular challenges and incentives, which must be properly understood if market-based conservation efforts are to be successful. Substantial and specific further research is needed into the economics of the industry. Nevertheless, some important preliminary findings may be offered as of now.

Redistributive mechanisms: a prerequisite for success

The crocodilian skin trade as presently organized displays many consolidative features that direct excess profits to specific segments, rather than distributing them all along the value chain. This means that particular stakeholders retain economic power and privilege in the industry. Because these stakeholders are typically not the ones closest to the resource, it is therefore unreasonable to expect that excess profits will automatically lead to re-investment in the wild resource. From a conservation standpoint, therefore, market-based initiatives must be redistributive: i.e. they must be specifically designed to ensure that rents accrue to the resource (through the landholder) rather than being appropriated elsewhere in the industry.

The imperative of redistribution makes the design of effective mechanisms more complex, but it is a necessary consequence of the structure of the industry. The challenge is by no means insurmountable, and further research into industry economics will be of great benefit. A series of simple mechanisms and market interventions could potentially increase rents flowing to the resource and create conspicuous incentives for market-driven utilisation. At the same time, tackling the underlying causes of the consolidative tendency in the industry could prove beneficial in the long term to all wild crocodilian resources.

A value wedge

An attractive overall approach for conservation is to drive a value wedge between those skins that embrace conservation principles and those that are the result of industrial processes. This need not be a fundamental change to the industry, but rather a recognition that the industry needs a new kind of insurance for guaranteed future supply of skins, i.e. conserving *in situ* populations.

The industry context and the imperative of redistribution shape some of the options for specific interventions to establish such a wedge. Fine-tuning interventions will require crucial research along several directions, including:

- own-price effect within species
- cross-price effect including other exotics
- consumer willingness to pay for conservation
- the relative benefit of private and cooperative intermediaries over time

- more sophisticated consumer classification.

In addition, a more complex understanding is required of the economics of landholders and producers, and the discrepancies between local and international incentives for sustainability of the wild resource. The case studies of Venezuela and Zimbabwe suggest several key issues. For one, international value fluctuations are not the most salient indicator of producer incentives. Rather, local currency value is the key indicator. Hence, the demonstration of conspicuous economic incentives for conservation is contingent on exchange rates. Secondly, inflation does not seem to be an important factor in determining wild-harvest effort. Decisions are made in the short term, and discount rates appear to be high. Finally, when economic or regulatory conditions change, so does resource use, often in ways that are very subtle but have important effects on the prospects for sustainability. To understand these effects requires going beyond the volume of skins and into more specific data, including skin size, species, finish, cut, and geography. By combining these dimensions with domestic and international economic data, it should be possible to construct robust indicators and dynamic tools for decision-makers.

Options for implementation

Management of supply. Because it is imperative to direct conservation incentives to the landholder and producer level, management of supply offers the most direct routes for new conservation mechanisms.

- *Producer cooperatives*. Range states with wild-harvested and ranched skins adopt producer cooperative techniques to manage supply. The premise is that restrictions in supply to the market of "large" skins will even the power differentials and allow landholders to appropriate a great proportion of the rents from the *in situ* resource, including the ability to re-invest. "Small" skins may not benefit from such mechanisms, however, because the small-skin segment is demand-led.
- *Private intermediaries*. An industry stakeholder plays the role of a producer cooperative by negotiating the sale of skins to tanneries for maximum profit, and hence maximum returns to landholders. The intermediary must be appropriately incentivised.
- *Auctions*. The use of auctions to sell skins pushes the market to reveal the true current price of skins. Particular types of auction (sealed-bid; Vickrey) mitigate against collusion among buyers.
- *Restrict supply to range states*. From a total economic value perspective, it may make sense to reward those countries that have a comparative advantage in the supply of wild crocodilian populations and habitat. One way to do this would be to restrict skin supply to range states. However, the complexity of determining the total economic value of *in situ* populations and their habitat call for caution.
- *Cross-subsidization*. In theory, levies could be enforced on each specimen or unit in trade. The funds generated could then be disbursed to those *in situ* populations who would benefit the most. In practice, however, this is a huge undertaking that requires new institutional arrangements and complex coordination. Moreover, it is not a long-term solution as it does not rely on market-based incentives to conserve the wild resource.

The understanding of the international crocodilian skin industry is presently at an intermediate stage. Assessing the industry as a global, interconnected system as opposed to a collection of local industries is a relatively new undertaking. The opaqueness of the industry, and the bottlenecks that reside principally at the tannery level, have been obstacles to information flow and to economic analysis. These obstacles are now coming down, and initial analysis strongly suggests that although the crocodilian skin industry possesses many particularities, it is likely to be amenable to new research and to new methods of industrial organization and regulation just as other wildlife-based industries have been. This study has aimed to capture the overall traits of the industry and identify key directions for such research.

The development of market-based mechanisms to support conservation of the wild resource is highly desirable and, in light of analytic progress and examples from other industries, highly promising. At the same time, any such mechanisms will have to confront head-on the consolidative, or non-redistributive, tendencies inherent in the present industry structure. They must clearly assist in directing rents toward the producer and landholder and producing incentives for effective reinvestment of these rents into the resource. At root, this will require not only a technical, but also a strategic understanding of the incentives and challenges landholders and producers in a globalising economy.

Ecuador Ranching Project
Why Did it Fail?

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In 1992, Mr. Pablo Evans who was interested in ranching black caiman in Ecuador contacted me. He was willing to finance surveys in the Amazon Region of Ecuador to determine if population levels were at a level to justify down-listing black caiman, *Melanosuchus niger*, to Appendix II of the CITES Treaty to allow ranching.

The Beginning

In the beginning, the prospects for success appeared favorable. The businessman/prospective rancher was willing to make a substantial investment in surveys and was committed to supporting a biologically sound approach. He familiarized himself with current crocodilian literature and sought the assistance of the Crocodile Specialist Group (CSG). Furthermore, the prospective rancher traveled to various parts of the world to familiarize himself with current husbandry methods. He was also familiar with the Ecuadorian political structure and encouraged government support. In addition, there was strong support from the CSG as well as volunteer efforts from other biologists interested in the success of the project.

Biological Assessment

The original proposal submitted to Mr. Evans and the Government of Ecuador to evaluate the feasibility of ranching black caiman provided the impetus for the first surveys in 1992. The proposal contained the following three objectives; 1) to determine the population status and distribution of black caiman within the Amazon region of Ecuador, 2) To generate information and recommendations concerning the management of black caiman in the wild, including a long term monitoring system, 3) to provide Mr. Pablo Evans with recommendations regarding the feasibility of ranching and/farming black caiman in Ecuador.

Study areas for the initial survey consisted of lagoons, backwaters, and disjunct oxbows associated with the Rio Napo (from Coca to Rocafuerte), and up the Rio Largarto Cocha. Then, in August 1994 we conducted an additional survey along the Rio Curaray, which is one of three remote river systems between the Rio Pastaza and the Napo. Routes were located in the lagoons, oxbows and the actual river from Amarunchocha to the Peruvrian border.

In general, the surveys indicated that there were viable populations of black caiman in the region. Crocodilians were observed along all 12 survey routes (totaling 240km) in the area of the Rio Napo and black caiman were observed on all routes except one. Densities ranged from 0 to14.72 black caiman/km with an average of 4.65 animals/km (Hines and Rice 1992). Thirteen lagoons and 8 river routes were surveyed (totaling160km) along the Curaray. Black caiman occurred in 12 of 13 lagoons and were most abundant in 6. The highest count was 12.43 animals/km with a mean density of black caiman on all surveys on the Curaray of 4.34/km (Hines and Wilkinson 1995).

Conclusions and early recommendations: Following is a synopsis of the recommendations made in the first report (Hines and Rice 1992): 1) Population data from other researchers should be combined with data from this project to provide a more complete picture of population status. 2) Address the effects of annual variation on surveys and train Ecuadorian biologist to perform surveys. 3) Identify and quantify available habitat 4) survey the extensive region south of the Napo. In addition, recommendations were made to implement research on reproduction, mortality and growth, improvement of monitoring, and interspecific competition of *Melanosuchus niger* and *Caiman crocodylus*. It was also recommended that simultaneous with the field research that the practical aspects of captive rearing of black caiman should begin, and that the role of indigenous people in a ranching program should be identified to assure that conservation benefits of the ranching program be maximized.

The second report (Hines and Wilkinson 1995) concluded that viable populations in similar densities to those found in the Napo region occurred along the Curaray. But, for a more complete understanding of caiman status in the region, surveys of the Conanaco and Nashino should be conducted.

Project Funding

The Rio Napo survey, and the subsequent replications of the original surveys were totally funded by Pablo Evans. The Rio Curaray surveys were funded by Evans with some help from the Ecuadorian government. After the first survey effort, it became apparent that the cost of operating in the remote regions of the Amazon region of Ecuador was very high. In addition, we had proposed additional research to compliment the survey effort and to provide a sound base for a long term management program. In February of 1993, I asked the CITES Animals Committee for support and financial assistance to continue the project. We were not able to get funds from this source and very limited assistance from any other source. One workshop was held in Ecuador with the objective of fostering interest in the caiman project within the country and attracting outside funds for continuing the project. None of these efforts generated any funds.

Down Listing

By 1994 the decision to ask for a change in listing from Appendix I to Appendix II Ranched was made. The basis for the decision included the following; we were proposing a ranching program which had little chance of serious impact on population levels. Population densities appeared to be comparable with other known viable crocodilian populations in the world. We were confident that Mr. Evans was a responsible user and would follow the guidelines provided by the CSG. We had not quantified habitat to the extent that was originally proposed. But, significant areas had been surveyed and large areas within the same region were identical habitat, and we were confident similar populations occurred in those. Mr. Evans was willing to fund additional surveys and research if he could generate some cash flow from the caiman project.

Ranching Efforts

After the down listing in 1994, Mr. Evans attempted collection of hatchlings and some contacts were made with indigenous people to buy hatchlings from them. Rearing tanks were constructed, in Coca, upstream from where most of the available caiman were collected. A total of 300 hatchlings were collected and placed in rearing tanks over a three-year period, and 185 animals remained in those tanks in 2002.

Outcome

By 1997, it became apparent that Mr. Evans was having some difficulty in securing enough hatchlings to adequately stock his rearing tanks. He had invested a large sum of money and the number of hatchlings he was obtaining was inadequate. His prospects for a profitable operation appeared to be diminishing, and to date it appears the project was a failure. The major objective of this paper is to examine the facts regarding this effort and find a possible explanation for the failure. Some of the reasons are endemic to Ecuador, but some can be used as a case study for other such projects.

Factors Influencing the Success of the Project

The direction presented in the first report (Hines and Rice 1992) provides a sound basis for a crocodilian management program. However, it is instructive to compare the actions recommended with those actually taken. Further, the possible effects of the action, or lack of it, on the eventual outcome of the project are examined. Those recommendations and their outcome follow.

1. <u>All available population data should be combined:</u> Population data from Ecuador from all sources were summarized, and reported densities were comparable to the population levels we observed. Furthermore, the nightlight counts we reported were comparable to other viable crocodilian populations in other parts of the world.

2. <u>Investigate the effects of annual variation on counts and replicate existing surveys</u>: Some of the surveys were replicated, but there was never any serious investigation of the effects of the dramatic water level fluctuation on survey results. The fact that these investigations did not take place did not contribute to

the failure of the project but an understanding of the effects of these variables on surveys should have been a part of a long term management program.

3. Quantify available habitat in the Amazon Region of Ecuador: The available habitat was never systematically quantified. We became familiar with the relatively large area of the Amazon region and made a judgment as to the quantity of habitat. Even though it was apparent that we were dealing with viable populations of caiman, it was important that we know the amount of available habitat. It was not that we were anticipating a harvest that would jeopardize caiman populations. But, if we had specifically quantified the available habitat, we would have been in a better position to evaluate Mr. Evan's chances of obtaining adequate numbers of hatchlings.

4. Survey other river systems: A major survey was conducted along the Curaray in the large area south of the Napo. These data provided important insights into caiman populations in this region, and there is little reason to believe that the river systems to north of the Curaray harbored populations of black caiman any different than those we observed elsewhere. But, the other systems should have been surveyed to better understand the extent of the caiman population and the potential collection area.

5. Continued research effort: Because funding was limited, none of the research priorities proposed in the first report were implemented. This did not contribute to the failure of the project. However, over the long term, it was important that these research projects be conducted to assure a solid biological basis for future management actions.

In addition to the previously mention factors, there were other considerations which, in retrospect, were very important to the success of the project. They fall into five broad categories:

1. Access to habitat
2. Logistics
3. Relationships with indigenous people
4. Economics
5. Infrastructure

Access to habitat: There were three factors which influenced access to habitat where hatchlings occurred. Large areas in the Amazon region were designated as National Parks or Natural Resource areas where the legality of collections was unclear. These land management categories are unclear in the law, and the application of the law concerning these lands is unclear. Other areas are controlled by indigenous groups, and in some cases, there are overlapping claims of authority by the government and Indian groups. In other cases, areas are remote and simply difficult to access.

Logistics: Closely related to the access problem is the logistics of collecting and moving hatchlings to the rearing tanks. In many cases, the source of hatchlings is in excess of 100 miles by canoe from the rearing station. In other cases, it would require air travel into a site and canoe trips of many miles to collect animals. If the rancher attempted to collect the hatchlings, both the problem of access and the logistical problems associated with distance and remoteness make the collections very expensive and perhaps impractical.

Relationships with indigenous people: In the first report, it was pointed out that the role of the Indian groups in the region should be large. The motivation, in the beginning, was to maximize the conservation benefits. But, it became apparent that without considerable help from the people in the area, it was impossible to be successful. If there had been a more concentrated effort to become involved in the political and social structure of the region, and if the local people had been convinced that it would be profitable for them to collect hatchlings, the access and logistical problems would have been lessened. Then, the chances of success would have been increased considerably.

Economics: With the advantage of hindsight, it has become apparent as a resource manager I viewed the problems we faced from a different perspective than did Mr. Evans as an entrepreneur. My motivation was to build a biological sound management program that was profitable to Mr. Evans. He had a similar goal, but he was investing with the idea that there was a strong probability of a return on his money. When the probability for returns appeared to decrease dramatically, he wisely invested his money in more profitable ventures. I still wanted to look for ways to make the project work. Had I fully grasped the significance of these two points of view, I might have advised him to approach the project in much more conservative manner and wait for more outside funding.

The lack of funding from sources other than Mr. Evan's was one of the major causes of declining commitment at the end of the project. Evan's invested large sums of money up front to finance surveys. This reduced the amount he was willing to invest in searching for the right approach to make the program work in Ecuador later on. His up front investment was the limit of what he was willing to gamble on the prospects of success.

Infrastructure: The Ecuadorian government provided assistance by issuing permits and preparing the proposal to change the listing to Appendix II. They also participated in the one workshop. However, there were numerous changes in government personnel during the life of the project, and their commitment lacked continuity. Also, it is probable that the caiman resource could only support one or two operations. These one or two ranchers would potentially represent a very small political power base, and would have some difficulty attracting serious attention from a government strapped for resources.

The importance of having Ecuadorian biologists working on the project was understood in the beginning. We had contact with some young graduates in biology and Evan's even supported one coming to FL to get some training in survey techniques. In the final analysis, funding was the key issue and Evan's simply could not support the entire program.

Conclusion

The major mistakes made on the ground were an inadequate assessment of the quantity of habitat, failure to grasp the difficulties of access and logistics in regard to collection of hatchlings, and failure to develop close relationships with indigenous people to provide hatchlings. However, the larger problem was a lack of funding. Many of the difficulties might have been addressed if outside funding could have been used to perform the initial surveys. Crocodilian ranching enterprises typically operate on a relatively narrow margin. Consequently, it appears impractical to ask a prospective rancher to fund expensive surveys in remote regions with the prospect of generating enough income from the ranching enterprise to cover his initial expenses. Some governmental commitment in funds and overall support is necessary. The only other alternative is to have strong financial support from the international community. In Ecuador, we had a strong commitment from the prospective user. But a commitment from professionals in the country who have some knowledge of wildlife management, and a governmental infrastructure is equally important

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Florida's Alligator Management Program: an Update 1987 to 2001

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ABSTRACT: Florida's Alligator Management Program has developed around the premise that the economic value derived from consumptive use of Florida's alligator (*Alligator mississippiensis)* resource can provide economic incentives to conserve alligators and preserve their wetland habitat. The expansion of management programs and growth of an industry dependent on the alligator resource has provided a constituency group to serve as advocates for wetland conservation. The major objectives of the program are to implement sustained alligator harvest programs while optimizing the economic, aesthetic, and ecological values of alligators as a renewable natural resource. By emphasizing these values, not only are there incentives for conservation of the alligator, but also the wetland ecosystems they inhabit. The intent of this paper is to provide the current status of this unique and comprehensive management program relative to the last update provided to Crocodile Specialist Group members in 1996 (David et al. 1996).

INTRODUCTION

Alligators have been an important component of Florida's wetland systems for thousands of years, and have also been commercial used in Florida as early as the late 1800's. Because harvesting of alligators went unregulated through the early 1900's, concerns about population declines in easily accessible areas stimulated establishment of a four-foot minimum size limit (the first statewide alligator regulation) by the former Florida Game and Fresh Water Fish Commission in 1943 (now part of the Florida Fish and Wildlife Conservation Commission, and hereinafter referred to as the "Commission"). Alligator populations continued to decline despite regulatory efforts through the late 1950's and early 1960's. As a consequence, the alligator harvest season in Florida was closed in 1962. Wide spread illegal exploitation continued, however, due to an inability to affectively enforce state laws, culminating in American alligators being included on the first federal endangered species list in 1967. In 1970, strict federal regulations were imposed through an amendment to the Lacey Act that made it illegal to ship illegally taken alligators between states. Under this highly effective regulation, illegal trade came to an end, and alligator populations in areas where declines had been observed made impressive comebacks (Hines 1979).

Alligator population surveys conducted by Commission biologists in the mid 1970's indicated that most populations were increasing rapidly (Hines 1979, Wood et al. 1985). Concomitantly, the Commission was receiving 4,000 to 5,000 nuisance-alligator complaints annually. In 1977, the status of Florida's alligator population was reclassified from endangered to threatened by the U. S. Fish and Wildlife Service, following the population status evaluation conducted by the Commission's alligator research staff. This change in status allowed the Commission to initiate management of the nuisance-alligator problem through harvest, resulting in our current nuisance-alligator control program (Hines and Woodward 1980, and Woodward and Cook 2000). The American alligator is currently listed under the Endangered Species Act as threatened due to similarity of appearance (Neal 1985).

In 1980, the Commission's alligator research staff began focusing its efforts on the impact of alligator harvests on wild populations. As a result of these investigations and subsequent experimental alligator harvests on selected wetlands, the Commission created an Alligator Management Program, later to become the Alligator Management Section (AMS) within the Division of Wildlife's Bureau of Wildlife Resources.

The Commission's Alligator Management Program has developed around the premise that the economic value derived from consumptive use of Florida's alligator resource can provide economic incentives to conserve alligators and preserve their wetland habitat. The expansion of management programs and growth of an industry dependent on the alligator resource can provide a new constituency group to serve as advocates for wetland conservation. The major objectives of the AMS are to implement sustained alligator harvest programs while optimizing the economic, aesthetic, and ecological values of alligators as a renewable natural resource. By emphasizing these values, the Commission hopes to provide incentives for conservation of not only the alligator, but also the wetland ecosystems they inhabit.

The following is a summary of the major program components of Florida's alligator management program. A suite of rules adopted, and frequently amended, by the Commission collectively governs each of the program's elements. Although complex, these rules ensure sustainable harvests of the resource and credibility and integrity of this Convention on International Trade in Endangered Species (CITES) based program. Current versions of Florida's alligator management rules can be viewed on the Internet at http://wildflorida.org/gators/ (click on the Data Center link).

PUBLIC WATERS ALLIGATOR HARVEST PROGRAM

Under this program, alligator populations are managed on designated waterbodies ranging in size from 1,000 to over 100,000 acres. These Alligator Harvest Management Units (AMUs) are established by Executive Order (a document signed by our Commission's Executive Director), and the Commission's Executive Director, or his designee, establishes annual harvest quotas via a signed memorandum. Figure 1 depicts the total annual harvest quotas established for all AMUs each year since the program's inception.

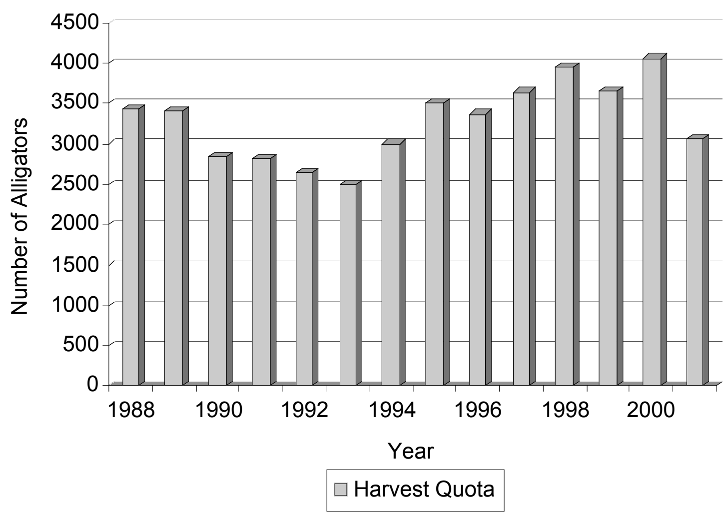

Figure 1. Total annual alligator harvest quotas established on Alligator Harvest Management Units in Florida from 1988 – 2001.

Biologists assigned to the AMS review and recommend AMUs for establishment annually. Procedures for two types of AMUs are used in this evaluation: (1) those for which a harvest quota is established by annual, intensive population monitoring (used on areas referred to as "variable-quota AMUs") and (2) those for which a harvest quota is established by either a one-time alligator habitat inventory or population survey (used on areas referred to as "static-quota AMUs"). Brunell et al. (2002) provides a complete and detailed account of the current protocol used to recommend new AMUs, calculate recommended harvest quotas for AMUs, identify AMUs to be closed to harvest, and determine when closed AMUs should be reopened. Figure 2 depicts the number of AMUs that have been established since the program's inception.

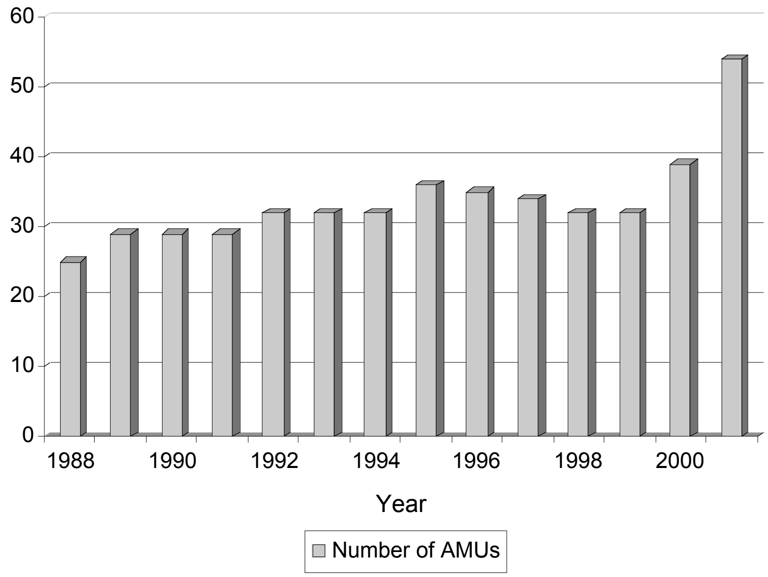

Figure 2. Total number of established Alligator Harvest Management Units in Florida from 1988 – 2001.

The Commission's public waters alligator harvest program continues to be an important component of the overall management strategy. It captures statewide, national, and international interest and provides an excellent opportunity to inform the public about the value of alligators and wetlands, while allowing participants to enjoy harvest benefits from this renewable natural resource. Table 1 summarizes the various participation and harvest trends in this program since its inception. Of particular note is the more than doubling of permits available starting in 2000. This was the direct result of Commission rule changes that decreased the number of tags issued with each permit from five to two, making the program truly recreational in nature as opposed to its former commercial roots. This has increased participation in the hunts and has generated additional revenues to support other recent changes in the other alligator management program elements. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 1. Public waters alligator harvest program summary, 1988-2001

	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Applications Submitted	5,855	20,163	10,122	15,311	12,085	7,380	6,859	8,909	12,685	13,810	11,400	10,006	7,222	7,871
Permits Available	238	229	189	188	176	500	500	583	671	728	789	729	2,031	1,533
Permitted Applicants	230	222	177	186	143	405	464	565	652	709	723	673	1,706	1,524
Tags Issued	3,375	3,330	2,655	2,790	2,145	2,025	2,784	3,390	3,260	3,545	3,615	3,365	3,412	3,048
Alligators Harvested	2,988	3,031	2,502	2,408	1,491	1,571	2,302	2,985	2,900	2,829	2,260	2,340	2,547	2,267
Percent Harvested (%)	88	91	94	86	70	78	83	88	89	80	63	70	75	74
Avg. Carcass Length (ft.)	7.6	7.7	7.9	8.5	7.9	7.9	7.9	8.1	8.2	8.0	8.0	8.2	8.8	8.8

PRIVATE LANDS ALLIGATOR MANAGEMENT PROGRAM

Since a large percentage of Florida's wetlands are privately owned, conservation of alligator habitats on private lands is critical to the continued well-being of alligator populations in the state. The Commission has given landowners an incentive for maintaining these habitats by providing them an opportunity to manage and harvest alligators from their lands. To participate in the program, applicants must own or lease a parcel with a minimum of 1,000 acres of alligator habitat or with a minimum of 100 alligators greater than four-feet in length. A group of landowners or authorized lessees may apply jointly provided the aggregate adjoining properties meet the minimum alligator habitat acreage or population requirements.

Table 2. Estimated producer value and levels of wild alligator harvests in Florida during 1978-2001.

	No. Alligators Harvested							Hide Price			Meat Produced (lbs)				
Year	Nuisance	Public Waters	Private Lands	Total	Hides Tagged	Total Ft. Hides	Ave. Hide Length (ft.)	per linear ft.	per belly cm	Hide Value	Ave. per Alligator	Aggregate Total	Meat Price	Meat Value	Total Value
1978	1,871	0	0	1,871	1,556	11,005	7.07	$8.17	$1.40	$89,876		0		$0	$89,876
1979	1,679	0	0	1,679	0	0				$0		3,600	$4.00	$14,400	$14,400
1980	1,590	0	0	1,590	3,562	25,112	7.05	$11.47	$1.96	$287,939		36,900	$4.50	$166,050	$453,989
1981	1,871	350	0	2,221	2,732	19,179	7.02	$18.37	$3.14	$352,285		66,650	$5.00	$333,250	$685,535
1982	2,169	379	0	2,548	748	5,354	7.16	$22.42	$3.84	$120,060		60,900	$5.00	$304,500	$424,560
1983	1,871	277	0	2,148	2,261	16,045	7.10	$9.23	$1.58	$148,122		62,400	$5.00	$312,000	$460,122
1984	2,201	271	0	2,472	4,325	32,409	7.49	$18.24	$3.12	$591,101		83,500	$5.00	$417,500	$1,008,601
1985	3,023	1,052	39	4,114	2,689	20,219	7.52	$20.59	$3.53	$416,383		134,700	$5.00	$673,500	$1,089,883
1986	3,049	1,121	76	4,246	5,206	39,113	7.51	$22.72	$3.89	$888,548		135,000	$5.00	$675,000	$1,563,548
1987	3,853	1,016	0	4,869	5,320	39,847	7.49	$35.99	$6.16	$1,434,057		150,600	$5.00	$753,000	$2,187,057
1988	4,464	2,988	180	7,632	7,632	59,606	7.81	$45.15	$7.73	$2,691,207	31.1	237,125	$5.00	$1,185,625	$3,876,832
1989	4,263	3,031	577	7,871	7,871	60,685	7.71	$46.25	$7.92	$2,806,700	29.7	233,859	$5.00	$1,169,295	$3,975,995
1990	4,053	2,502	1,117	7,672	7,672	59,151	7.71	$58.04	$9.93	$3,433,131	29.7	227,946	$4.50	$1,025,759	$4,458,890
1991	4,228	2,408	1,600	8,236	8,236	65,311	7.93	$41.97	$7.18	$2,741,123	32.8	269,791	$4.50	$1,214,060	$3,955,183
1992	3,564	1,491	875	5,930	5,930	45,839	7.73	$23.91	$4.09	$1,096,008	30.0	177,780	$4.00	$711,118	$1,807,127
1993	4,019	1,571	1,523	7,113	7,113	55,410	7.79	$20.71	$3.55	$1,147,547	30.8	219,043	$4.00	$876,171	$2,023,718
1994	4,488	2,302	2,872	9,662	9,662	75,750	7.84	$35.30	$6.04	$2,673,978	31.5	304,216	$4.00	$1,216,864	$3,890,842
1995	4,752	2,985	4,210	11,947	11,947	94,262	7.89	$39.18	$6.71	$3,693,178	32.2	384,549	$4.50	$1,730,470	$5,423,649
1996	4,799	2,900	5,002	12,701	12,701	98,941	7.79	$32.00	$5.48	$3,166,105	30.8	391,124	$5.00	$1,955,618	$5,121,723
1997	5,138	2,829	3,667	11,634	11,634	89,349	7.68	$16.00	$2.74	$1,429,586	29.3	341,020	$4.50	$1,534,590	$2,964,175
1998	5,088	2,260	2,200	9,548	9,548	68,841	7.21	$16.89	$2.89	$1,162,726	23.5	224,814	$5.00	$1,124,068	$2,286,793
1999	5,022	2,340	3,037	10,399	10,399	75,913	7.30	$22.00	$3.77	$1,670,079	24.6	255,618	$5.00	$1,278,089	$2,948,169
2000	6,254	2,547	3,804	12,605	12,605	93,277	7.40	$27.25	$4.66	$2,541,798	25.8	324,818	$5.25	$1,705,295	$4,247,093
2001	7,204	2,259	4,164	13,627	13,627	100,022	7.34	$28.25	$4.84	$2,825,627	25.1	341,376	$4.50	$1,536,190	$4,361,817

Hides tagged may differ from alligators harvested in some years due to sales of confiscated skins, loss of damaged skins, and year of tagging.
Total Ft. Hides: Actual footage during 1977-87, calculated as (Total Hides * Ave. TL) after 1987.
Ave. Total Length: Based on actual length data from hide validations.
Hide Prices: Actual hide prices during 1977-87. Estimates of price for average size (7.5 ft.) alligator based on trapper and dealer interviews after 1987.
/belly cm.: Calculated from (price/lin. ft. / 5.842)
Hide Value: Actual price received during 1977-87. Calculated as (Total Ft. Hides * Hide Price) after 1987.
Meat Produced: Actual figures from 1977-1987; After 1987, yields were estimated from Woodward et al. (1992) formula (assumes meat yield of 30% of total weight).
Meat Price: Derived from verbal trapper reports.

Private lands participants may choose from several available harvest options, depending on the acreage of alligator habitat on their properties and/or alligator population information provided to the Commission. Private landowners may elect to harvest alligators, hatchlings, and eggs from their properties.

Participation in the private lands program has proliferated since 1988. Being a truly commercially oriented harvest program, property enrollment should be directly tied to the status of the alligator hide and meat markets. Despite chronically depressed alligator hide market conditions, this program has continued to expand. Table 3 summarizes the participation and harvest trends of this program since its inception. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 3. Private lands alligator management program summary, 1988-2001.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
# Participating Properties	7	21	35	104	73	63	84	114	124	144	112	142	143	152
Total Enrolled Acres (M)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.943	1.055	1.232
Tags Issued	225	700	1,276	2,099	1,592	1,999	3,619	5,055	6,191	6,436	5,234	5,035	6,633	7,663
Alligators Harvested	180	577	1,117	1,600	875	1,523	2,872	4,210	5,002	3,667	2,200	3,273	3,804	4,169
Percent Harvested (%)	80	82	88	76	55	76	79	83	81	57	42	65	57	54
Avg. Carcass Length (ft.)	N/A	7.7	7.1	7.8	7.6	7.7	7.6	7.6	7.3	7.1	6.8	6.9	7.1	7.2
Eggs Collected	567	1,038	2,701	4,078	1,968	998	6,944	14,225	14,544	18,663	8,148	14,996	13,755	16,576
Hatchlings Collected	72	160	160	51	0	0	0	0	0	0	0	0	0	0

NUISANCE ALLIGATOR CONTROL PROGRAM

This program is administered by the Commission's Division of Law Enforcement through contracts between the Commission and professional alligator trappers, and is designed to permit the harvest of alligators that are determined to be a threat to the welfare of the public, or their pets or property. Approximately 40 professional trappers are contracted to remove specific nuisance alligators. Members of the public call a Commission office to submit complaints regarding nuisance alligators, which are evaluated by Commission staff to determine if the alligator should be removed by a contracted nuisance-alligator trapper (Hines and Woodward 1980, Jennings et al. 1989, Woodward and Cook 2000). The program has helped to hold alligator attacks at a low level and has proved to be a quick and cost effective response to nuisance-alligator complaints (Woodward and Cook 2000). Therefore, the program has been viewed as a success and has remained virtually unchanged since its 1978 inception. Table 4 provides a summary of program trends since its inception. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 4. Summary of Florida's Nuisance Alligator Harvests from 1978 to 2001

Year	Complaints Received	Permits Issued	Tags Issued	Alligators Harvested	Alligators Harvested/ Complaint	Meat Yield (lbs.)
1978	4,914	2,346	3,124	1,871	0.38	N/A
1979	4,639	2,486	3,321	1,679	0.36	3,617
1980	4,024	2,216	2,856	1,590	0.40	36,907
1981	4,931	2,622	3,318	1,871	0.38	58,656
1982	6,124	3,209	3,826	2,169	0.35	50,911
1983	5,955	3,003	3,550	1,871	0.31	53,528
1984	7,289	3,536	4,272	2,201	0.30	71,262
1985	6,432	6,187[c]	6,187	3,023	0.47	90,100
1986	6,018	5,458	5,458	3,049	0.51	95,568
1987	7,288	6,618	6,618	3,853	0.53	110,625[d]
1988	10,305	7,978	7.978	4,464	0.43	121,297[d]
1989	9,867	7,076	7,076	4,263	0.43	116,000[d]
1990	9,950	7,787	7,787	4,053	0.41	97,712[d]
1991	11,965	8,297	8,297	4,228	0.35	N/A
1992	10,480	7,880	7,880	3,564	0.34	82,735[d]
1993	12,089	9,032	9,032	4,019	0.33	96,858[d]

Year	Complaints Received	Permits Issued	Tags Issued	Alligators Harvested	Alligators Harvested/ Complaint	Meat Yield (lbs.)
1994	13,431	9,812	9,812	4,632	0.34	115,911[d]
1995	13,615	10,171	10,171	4,931	0.36	106,382
1996	13,220	10,123	10,123	4,799	0.36	109,952
1997	14,984	12,019	12,019	4,305	0.29	128,825
1998	15,616	12,866	12,866	5,149	0.33	113,344
1999	14,828	12,412	12,412	5,263	0.35	127,412
2000	14,954	12,343	12,343	6,254	0.42	158,737
2001	16,749	14,085		7,279	0.52	153,019

PUBLIC WATERS ALLIGATOR EGG AND HATCHLING COLLECTION PROGRAM

This program permits the collection of alligator eggs and hatchlings from public waters by licensed farmers who have met specific requirements established by Commission rule. However, the number of farms allowed to participate is restricted due to the limited availability of eggs and hatchlings in the wild. Restricted access effectively guarantees continued access to a finite source of eggs and hatchlings and avoids diluting the availability of "raw materials" to farmers who have made significant capital investment in rearing facilities.

AMS staff review and recommend alligator egg collection areas for establishment annually. Candidate areas are located based on staff familiarity with their region and suggestions provided by other personnel and the public. Commission biologists conduct aerial nest surveys by helicopter over each egg collection area during late June and early July and establish a collection quota of 50% of the non-depredated, non-flooded nests observed (Rice et al. 1999). Egg collections follow and are conducted under direct supervision of Commission biologists. Table 5 summarizes trends in egg collections under this program element since its inception.

Table 5. Public waters egg collection program summary, 1988-2001

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
No. of Collection Areas	3	5	7	7	14	14	14	14	14	14	14	18	17	19
Nest Quota	146	296	271	506	708	926	786	894	1,118	1,339	1,187	1,326	1,338	753
Eggs Retained	4,302	7,895	6,594	9,735	13,945	9,017	16,803	23,050	26,947	27,739	25,684	27,420	32,409	19,451

Hatchling collection quotas were established in 1987 based on the quantity and quality of alligator habitat in 65 of the state's 67 counties, and have remained unchanged. Quotas range from 50 to 400 hatchlings per county. Eligible farmers identify the total quota (number) of alligator hatchlings and the counties that they prefer on applications provided by the Commission. Hatchlings are permitted for collection from September 15 through November 30. Permitted farmers are allowed to collect hatchlings independently of Commission oversight, but are required to tag hatchlings immediately upon capture. Table 6 summarizes participation and collection trends under this program element since its inception.

Table 6. Public waters hatchling collection program summary, 1988-2001

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
# of Counties Permitted	63	57	62	20	6	11	17	21	22	21	23	27	38	50
Total Collection Quota	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200
Hatchlings Collected	4,172	4,959	4,820	1,944	330	1,437	535	1,605	1,439	1,822	1,947	1,662	2,793	3,080
% of Quota Collected	41	49	47	19	3	14	5	16	14	18	19	16	27	30

ALLIGATOR FARMING

Alligator farming in Florida has increasingly relied on wild egg and wild hatchling stock to support the continued growth of the industry, despite depressed alligator hide market conditions over the last several years. The number of licensed farms and the number of active farms producing hides increased through 1991, and has since remained relatively stable. Inventories have continued to be sustained at around 100,000 animals. Participation and production trends under this program element are summarized in Table 7.

SUMMARY

All of these programs allow the Commission to manage alligators on a sustained yield basis and recognize them as an ecologically, aesthetically, and economically valuable renewable natural resource. Revenues generated through user-fees provide funding for alligator management and research. Most importantly, the economic value of the species gives user groups a vested interest in the welfare of wild alligator populations. Therefore, beneficiaries become political advocates for wetland preservation, which ultimately conserves habitat not only for alligators, but for a wide variety of Florida's wildlife. The protection and recovery of the American Alligator is touted as a success story in U.S. wildlife conservation efforts, and now it is generally recognized by resource professionals that sustained use of alligators has the greatest conservation benefits.

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Table 7. Estimated producer value and levels of alligator harvest on Florida farms during 1977-2001.

				Est.	Ave. Hide Size		Hide Prices			Est.			
	Licensed	Active	Hides	Total Ft.	Length	Width	per linear	per belly	Hide	Meat Prod.	Meat	Meat	Total
Year	Farms	Farms	Produced	Hides	(ft)	(cm)	ft	cm	Value	(lbs)	Price	Value	Value
1977	4	0	0	0					$0			$0	$0
1978	4	3	335	2,345	7.00	43.8	$8.17	$1.40	$19,159			$0	$19,159
1979	4	2	220	1,430	6.50	40.6	$11.47	$1.96	$16,402			$0	$16,402
1980	4	1	89	534	6.00	37.5	$11.86	$2.03	$6,333	1,349	$4.50	$6,070	$12,403
1981	6	2	284	1,704	6.00	37.5	$18.37	$3.14	$31,302	4,304	$5.00	$21,521	$52,824
1982	10	2	244	1,464	6.00	37.5	$22.42	$3.84	$32,823	3,698	$5.00	$18,490	$51,313
1983	13	2	184	1,012	5.50	34.4	$9.24	$1.58	$9,351	2,054	$5.00	$10,269	$19,620
1984	19	4	738	4,059	5.50	34.4	$18.24	$3.12	$74,036	8,238	$5.00	$41,189	$115,225
1985	26	12	1,339	7,365	5.50	34.4	$20.59	$3.52	$151,635	27,962	$5.00	$139,810	$291,445
1986	30	14	3,921	21,566	5.50	34.4	$22.72	$3.89	$489,968	58,107	$5.00	$290,535	$780,503
1987	40	19	6,479	35,635	5.50	34.4	$31.52	$5.40	$1,123,199	69,997	$5.00	$349,985	$1,473,184
1988	48	20	7,529	41,410	5.50	34.4	$32.50	$5.56	$1,345,809	71,099	$5.00	$355,495	$1,701,304
1989	48	23	16,385	81,925	5.00	31.3	$35.56	$6.09	$2,913,253	128,379	$5.00	$641,895	$3,555,148
1990	58	24	20,007	100,035	5.00	31.3	$38.18	$6.54	$3,819,336	130,490	$4.50	$587,205	$4,406,541
1991	58	31	18,092	90,460	5.00	31.3	$32.56	$5.21	$2,945,604	135,342	$4.50	$609,039	$3,554,643
1992	56	32	33,219	166,095	5.00	31.3	$17.19	$2.75	$2,854,758	182,401	$4.00	$729,604	$3,584,362
1993	55	32	38,505	173,273	4.50	28.1	$13.56	$2.17	$2,350,008	184,953	$4.00	$739,813	$3,089,821
1994	48	32	37,113	167,009	4.50	28.1	$21.88	$3.50	$3,653,311	178,267	$4.00	$713,068	$4,366,379
1995	47	24	27,303	122,864	4.50	28.1	$25.94	$4.15	$3,186,772	131,146	$4.50	$590,157	$3,776,929
1996	56	24	23,308	111,878	4.80	30.0	$23.13	$3.70	$2,587,188	140,466	$5.50	$772,562	$3,359,750
1997	52	22	26,970	133,771	4.96	31.0	$18.75	$3.00	$2,508,210	182,390	$4.50	$820,756	$3,328,966
1998	58	28	30,789	147,787	4.80	30.0	$18.75	$3.00	$2,771,010	185,550	$5.00	$927,751	$3,698,761
1999	57	24	25,069	120,331	4.80	30.0	$18.75	$3.00	$2,256,210	151,079	$5.00	$755,393	$3,011,603
2000	59	23	27,417	140,375	5.12	32.0	$22.63	$3.62	$3,175,985	207,303	$5.25	$1,088,343	$4,264,329
2001	63	21	25,208	129,065	5.12	32.0	$23.44	$3.75	$3,024,960	190,601	$4.50	$857,704	$3,882,664

Active Farms: Farms that produced hides that were subsequently tagged with CITES tags.
Hides Produced: Number of hides that were tagged with CITES tags.
Total Ft. Hides: Calculated from [Hides Produced * Ave. Size (ft.)].
Ave. Size - Length: Average total length from interviews with farmers and dealers. Based on ave. belly width after 1995.
Ave. Size - Width: Converted from ave. length based on a conversion factor of 6.25 cm belly width per linear ft. After 1995, prices were based on reports from dealers.
Hide and Meat Prices: Ave. wholesale value based on interviews with farmers, dealers, and tanners.
Meat Produced: Derived from farm reports during 1985-92. Before 1985 and after 1992, derived from estimated weight of alligators (Woodward et al. 1992) and an assumed 30% meat yield.

Louisiana's Alligator Research and Management Program: an Update

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ABSTRACT: Louisiana's vast wildlife resources are managed and regulated by the state operated Louisiana Department of Wildlife and Fisheries. The headquarters for the alligator program is Rockefeller Wildlife Refuge, an 76,000 acre refuge located in coastal southwestern Louisiana, which primarily serves as a wintering area for waterfowl. Years of research at the refuge led to development of marsh management techniques for multi-species use; particularly waterfowl, alligators, furbearers, and fisheries organisms.

Extensive research on the biology of the alligator was undertaken years ago by refuge staff. Management practices developed and regulations enacted led to the recovery of the alligator from low populations of the early 1960's, and this is generally recognized as success in wildlife management.

Further research and legislation led to alligator programs based on sustained utilization, managing the alligator as a renewable resource. The objectives of this paper are to review Louisiana's alligator management program; and present updated research findings since the last presentation at a CSG meeting. Reports will be given on several ongoing research projects including evaluation of a wildfire on alligator nesting, studies on natural egg incubation temperatures/hatchling sex ratios, DNA studies, reproductive research, and other studies. Coastal Louisiana's alligator nest data, current farm inventories, and ranching results will be presented. Research being conducted on farm alligators released to the wild will be reviewed.

The Status of the American Alligator *(Alligator mississippiensis)* in Texas

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ABSTRACT: The decline in the population of American alligators, which began in the mid-1800's and continued through the early 1900's, was the result of excessive exploitation and degradation of wetland habitats. Texas provided complete protection for the alligator in 1969. State and federal protection measures remained in effect in Texas until 1983 when significant increases in alligator populations were observed throughout most of its range. Since 1984, statewide harvests of wild alligators have been allowed based on recommendations derived from aerial nest counts and night-count surveys. In 1986, Texas licensed the first alligator farmer and initiated the nuisance alligator program. In 1988, Texas began permitting the collection of eggs from the wild. Currently, alligators generate approximately $10,000,000 annually in Texas. Results from up to eighteen years of night counts, nest surveys, wild harvests on public and private lands, nuisance alligator complaints, egg collection from the wild, and alligator farming in Texas will be discussed.

Current Status and Management of the American Alligator (*Alligator mississippiensis*) in Arkansas, U.S.A.

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ABSTRACT: The American Alligator (*Alligator mississippiensis*) has long been a component of Arkansas' fauna. Precipitous population declines, due to habitat loss and unregulated hunting, prompted the Arkansas Game and Fish Commission (AGFC) to enact regulations to protect the alligator from take in 1961, six years prior to federal protection in 1967. Between 1972 and 1984 the AGFC released 2840 wild-caught Louisiana alligators within the presumed historic range. Arkansas' alligator population has since recovered to the point where "nuisance" alligator complaints are a common occurrence. To improve handling and coordination of nuisance alligator complaints the AGFC has recently adopted a nuisance alligator protocol. The AGFC administration called for an examination of the potential for an alligator sport hunt as a means to reduce nuisance alligator complaints. During May-June 2002 efforts were undertaken to initiate a 3-5 year alligator population survey. Results of this initial survey revealed that alligators were widespread in their distribution. However, the observed densities appear to be insufficient to sustain a sport hunt on a regional scale. Only two localities had densities in sufficient number to support a biologically sustainable harvest. Based on these preliminary data a sport hunt would not have an impact on the number of nuisance alligator complaints and the two should be addressed as separate management issues, i.e. a sport hunt will not supplant the need for an effective nuisance alligator control program.

The American Alligator (*Alligator mississippiensis*) has long been a component of Arkansas' natural heritage in the Coastal Plain and Mississippi Delta. Strangely though, few if any early settler's accounts speak to the presence of alligators in Arkansas. One of the earliest recorded accounts is from the *Arkansas Gazette,* May 1828, which reported the killing of an 11-foot specimen on the north side of the Arkansas River at Little Rock. Between 1860 and 1960 alligator populations throughout Arkansas and the southeast were severely depleted, primarily due to habitat loss and unregulated hunting. Alligator populations have since recovered in Arkansas through state and federal protection and restocking efforts. A combination of factors (i.e., increased alligator population, drought, limited habitat) has likely been the cause for a recent increase – within the past three years – in nuisance alligator complaints. The AGFC has recently adopted a nuisance alligator protocol in an effort to improve handling and coordination of nuisance alligator complaints. The increased volume of complaints resulted in a request from the AGFC administration for an examination of the potential for an alligator sport hunt as a means to reduce nuisance alligator complaints. The first step in assessing a sport hunt potential was to initiate an extensive alligator population survey. This paper will present information on the historic and current status and management of the American Alligator in Arkansas.

HISTORICAL PERSPECTIVE

Regulatory History

For over one hundred years extensive habitat loss through the draining of wetlands, coupled with the added pressures of direct take by hunters, caused alligator population numbers to reach an all time low in Arkansas by 1960. As a result the AGFC enacted a regulation to protect the alligator in 1961. Congress passed legislation in March of 1967 listing the alligator as an endangered species, thus protecting the animal from "take", six years before enactment of the Endangered Species Act of 1973. In January 1977 the alligator was downlisted to threatened status. In June 1987 it was delisted to recovered status and subject to a five-year monitoring program. At present, it is listed by the U.S. Fish and Wildlife Service (USFWS) as "Threatened due to Similarity of Appearance", as a means to ensure proper regulation of the legal trade in crocodilian products.

History of Restocking Efforts

By the mid-1960's Arkansas' alligator population was severely depleted. At that time the greatest populations persisted in the southwestern corner of the state. In 1973 it was estimated that 1,900 alligators occurred in approximately ~12 mi^2 of habitat in Hempstead, Lafayette, and Miller counties (Joanen 1974). The AGFC attempted an initial restocking effort in 1970 and 1971 utilizing native stocks taken from Grassy Lake, a privately owned 3,000 acre cypress swamp in western Hempstead County. At that time Grassy Lake harbored the largest native population of alligators in the state, as it does to date. However, this proved unsuccessful due to an inability to capture enough individuals of appropriate size class to supply the restocking effort. Shortly thereafter an agreement between the Louisiana Department of Fisheries and Wildlife and the AGFC was established to provide alligators for the restocking program. This agreement provided wild caught sub-adult alligators to restock areas within the presumed historic range, in the Mississippi Delta, Coastal Plain, and Arkansas River Valley (Fig. 1). Between 1972 and 1984 a total of 2,841 alligators were captured in Louisiana and released in Arkansas. Approximately 80% of restocked alligators were released on private lands, at the owner's request, in the belief that they would control nuisance animals such as beaver, rough fish, snapping turtles, and venomous snakes. Since 1984 no subsequent population survey or monitoring has been conducted to assess Arkansas' alligator population.

As a result of restocking efforts the current distribution of alligators in the northeastern corner of the state may be more extensive than at the time of European settlement. Two recent reports (summer 2002) of alligators from Greene County, Arkansas pushes the distribution even further north than mapped in Figure 1. The first report was of an individual that was poached from an aquaculture pond and subsequently eaten at a wedding party. The second report was of an individual captured in a commercial fishing net in a barrow ditch immediately adjacent to the St. Francis River in the southeastern corner of Greene County. Receipt of more specific locality data on these records is forthcoming.

On the basis of these reports, the possibility exists that records of the American Alligator may yet turn up in the St. Francis River floodplain of Missouri's bootheel. Recent reports of alligators in western Tennessee (A. Peterson, Pers. Comm.), from wetlands bounding the Mississippi River between Memphis and Reelfoot Lake National Wildlife Refuge, may likely be the result of dispersal from Arkansas' restocking efforts.

MANAGEMENT

Alligator – Human Conflicts

Arkansas' alligator population has increased as a result of state and federal protection and restocking efforts. They have re-colonized historically occupied areas and observations of large >6.5 feet in total length (ft TL) individuals are a common occurrence. However, the amount of prime alligator habitat has either decreased or remained at a constant level since it was listed as recovered 15 years ago. A finite amount of optimal habitat forces emigration of recruitment-aged individuals from source populations in search of suitable habitat, such as aquaculture ponds, agricultural drainage ditches and irrigation reservoirs, thereby greatly increasing the probability of encounters with humans. In 2000 a prolonged regional drought reached severe levels and it is believed that it forced many alligators to move from their home ranges in search of new habitat as water sources dried up. Over 100+ nuisance alligator complaints were received in 2000. Thus, a combination of factors, e.g., increased alligator population, constant or decreasing level of optimal habitat, and severe drought, has resulted in an increased number of alligator-human conflicts. Several of these alligator-human conflicts garnered statewide and national radio, television, or newspaper coverage. This exposure elicited many email messages and telephone calls from citizens wanting to know what the AGFC was going to do about this "perceived" overabundance of alligators. The flurry of public inquiry was the impetus for the AGFC administration to consider an alligator harvest (i.e., sport hunt) as a means of managing this "overabundance" of alligators. However, to answer the question of a "perceived" versus "real" overabundance of alligators can not be determined until a thorough population survey has been conducted.

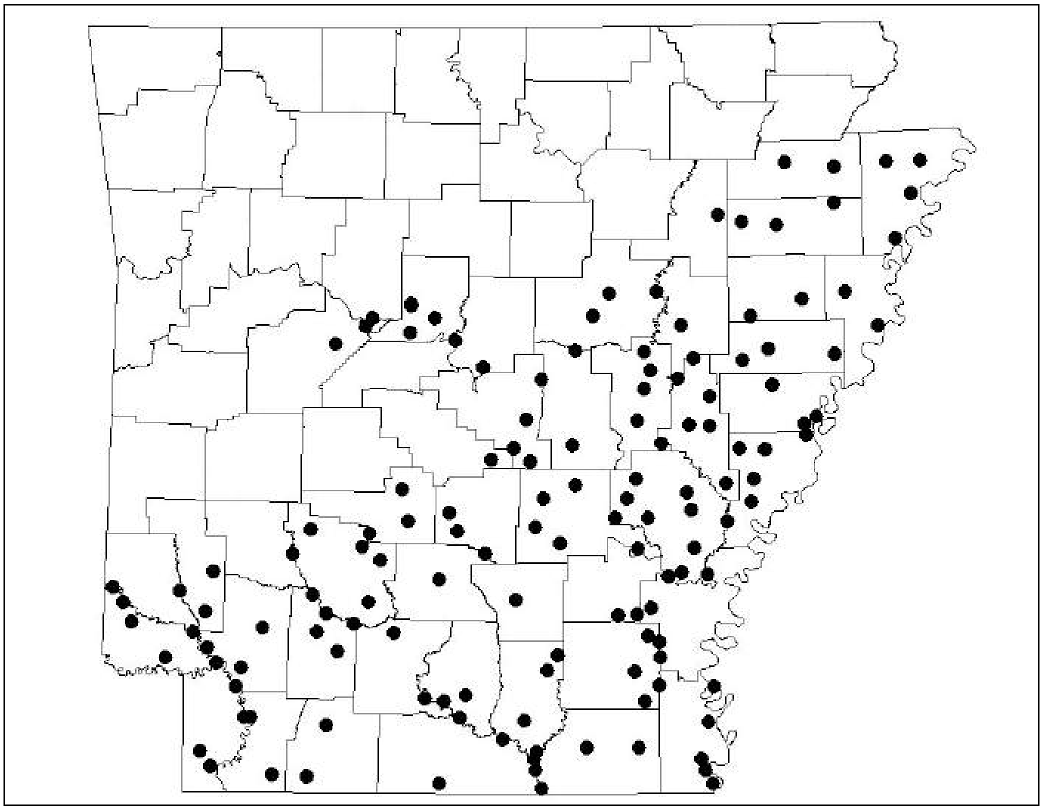

Figure 1. Distribution of the American Alligator in Arkansas, based on restocked and native populations. Localities are derived from various sources, [i.e., AGFC personnel, citizen reports, and Trauth et al., (in prep)].

Nuisance Alligator Protocol

Due to the increasing number of nuisance alligator complaints it became apparent that improved coordination and documentation of such complaints was needed. To address this problem the AGFC approved a Nuisance Alligator Protocol (NAP) in 2001. The format of this protocol was patterned after the agency's existing Nuisance Black Bear Protocol. Historically, various AGFC personnel (i.e., wildlife officers, district biologists) would receive and deal with nuisance alligator complaints without having the benefit of standardized documentation or coordination of complaints. This resulted in the capture and translocation of alligators without a system of recording and tracking these actions.

The NAP provides criteria for assessing the urgency of the complaint; procedures for receiving and recording complaints; data forms for translocated or destroyed alligators; and detailed capture and handling procedures. The Alligator Handling Procedures, which standardize agency approved capture and handling techniques for use by all AGFC personnel, provides uniformity of handling and safety procedures to increase the safety of both personnel and alligators. The NAP established a network of regional Nuisance Alligator Coordinators (NAC), who are responsible for receiving and coordinating all nuisance alligator complaints within their respective regions.

ALLIGATOR POPULATION SURVEY

In response to the growing number of nuisance alligator complaints, the AGFC administration requested an examination of the feasibility of an alligator sport hunt, as a means to reduce the number of complaints. Irwin (2001) proposed that a 3-5 year alligator population survey be conducted to provide the requisite data for review by the USFWS, before the AGFC could establish a regulated alligator hunt. To that end, a contract wildlife biologist, with alligator population survey experience was hired to train AGFC personnel proper survey technique and conduct an initial population survey in southern Arkansas. The following information is either summarized or modified from the population survey report by Wooding et al, (2002).

Survey Methods

At total of 28 localities in 12 counties were surveyed from 20 May – 26 June 2002. Alligators were surveyed using night-light counts (Chabreck 1966; Woodward and Marion 1978; Murphy and Coker 1983; Wood et al. 1985; Woodward and Moore 1993). Surveys were conducted by boat (n = 25), truck (n = 2), and ATV (n = 1) using a 200,000 candlepower spotlight. A variety of habitats were surveyed: large impoundments (n = 8); rivers, bayous, and creeks (n = 7); oxbows and brakes (n = 4); canals (n = 3); agricultural reservoirs (n = 2); river slough (n = 1); hardwood swamp (n = 1); and cypress swamp/lake (n = 1). The majority (n = 21) of survey localities were surveyed once and replicate surveys were conducted at (n = 7) localities. Length of survey routes was measured using handheld GPS units. Survey routes ranged from 0.6 - 18.1 miles in length, most (n = 18) were 3-9 miles in length. Length of survey routes was used to calculate the statistic (number of alligators observed per mile); this allows relative densities to be compared between localities. For replicated surveys, the mean ($\bar{x}$) number of alligators observed per mile was calculated. Data on variables such as water level (i.e., high, low, normal), water temperature, rainfall, presence of aquatic vegetation, wind, waves, visibility, and boat traffic were taken as these can influence counts, and can affect the interpretation of survey results. Alligator body length was estimated to the nearest foot in total length (ft TL), and was recorded to the nearest two- (2) foot size class if size could only be estimated with moderate accuracy. If the size of an individual could not be estimated with any degree of accuracy it was recorded in more general terms (e.g., “6+” size class) or classified as “size unknown”, depending on the degree of observability. This provided data for assessing age class structure. Sighting proportions were estimated at 25%, based on the similarity of habitat and water temperature between, Arkansas and South Carolina (Murphy 1977).

Survey Results

A total of 251 alligators were observed on 24 of the 28 survey routes (Table 1, Note: the larger count number was used on replicate surveys). The mean number of alligators observed, using data from all repetitions, was 239.5 alligators. Assuming a 25% observability proportion (Murphy 1977), the surveyed routes would contain 958 alligators.

Two localities had significantly greater relative densities than all others did. Grassy Lake had 13.5 alligators/mile (n = 97; 7.2 miles) in a natural cypress swamp/lake and Moore Bayou had $\bar{x}$ = 9.2 alligators/mile ($\bar{x}$ = 32 individuals; $\bar{x}$ = 3.5 miles) in a backwater lake, created by a navigation dam on the Arkansas River. The third and fourth highest densities were observed in isolated wetlands in the Bayou Bartholomew watershed of Drew County – Tillar Farm (5.0 alligators/mile) and McClendon Reservoir (3.3 alligators/mile). The mean ($\bar{x}$ = 3) alligators per replicated survey for each locality, with survey distances of 0.6 and 0.9 miles respectively. While neither locality is considered to be a regionally significant population, these local populations are part of what is considered to be a metapopulation, which is dispersed throughout the brakes and reservoirs of the Bayou Bartholomew watershed.

The other 20 survey localities contained <2.5 alligators/mile; the majority of which (n = 12) contained ≤1 alligator/mile (Table 1). Low densities were found in large impoundments ($\bar{x}$ = 0.8 alligators/mile, SD = 0.6, n = 7), excluding Moore Bayou from the sample. Values were lower still in creek, river, and bayou habitat ($\bar{x}$ = 0.6 alligators/mile, SD = 0.7, n = 7). Whereas, oxbows ($\bar{x}$ ÷ = 1.75 alligators/mile, SD = 0.9, n = 4), and canals ($\bar{x}$ = 2.6 alligators/mile, SD = 1.5, n = 3) tended to support more alligators.

On replicated surveys the number of alligators increased at (n = 4) sites, remained the same at (n = 2), and decreased at (n = 1). Differences in counts appear to reflect normal variation, but reveal the value of conducting multiple surveys to produce a truer sample of the population. Multiple survey repetitions increases confidence when making comparisons of population densities between localities and over time. If trend data were sought, multiple repetitions of survey routes would enhance the ability to detect trends over shorter periods of time (Woodward 1996, Nickerson and Brunell 1997). Twenty-one out of the 28 surveyed areas is accessible to the public, all other localities (n = 7) were on private land. In terms of density (i.e., alligators/mile) four of the top five localities were on private land, and all but one of the privately owned localities was in the top 10.

Juvenile alligators were rarely observed during the surveys. In fact, only 14 alligators ≤ 2 ft TL were observed, of which 10 were at Grassy Lake. The majority (78%) of alligators observed were > 4 ft TL. Seven alligators were estimated to be ≥ 9 ft TL; the two largest individuals were 10-11 ft TL.

Habitat Assessment and Limiting Factors

Alligators were widely distributed throughout southern Arkansas, occurring in a variety of wetland habitats. However, their densities were relatively low compared to other populations in the southeast. The exceptions were the Grassy Lake and Moore Bayou localities where densities compared to the mid-range densities observed in Florida and Texas populations.

Localities with low densities had poor quality habitat and were void of aquatic vegetative cover. This was the case in the bayous and rivers, such as Bayou Meto and portions of the Arkansas River and canal. Densities observed in these habitats (0.6 alligators/mile) was comparable to low densities observed in riverine habitat in South Carolina (0.4-1.6 alligators/mile) (Murphy and Coker 1983); Mississippi (1.32 alligators/mile) (Duran, 2000); and North Carolina (≤0.1 alligators/mile) (O'Brien and Doerr 1986).

Alligators tend to reach their highest densities in lentic habitats, such as lakes and marshes. For example, alligator densities in premium lake habitat in Florida have exceeded 48 alligators/mile (Woodward and Moore 1990). However, low densities were observed in most impoundments during this survey (0.8 alligators/mile), even in lakeshore habitat with good stands of emergent aquatic vegetation. Portions of these lakes appeared to contain abundant suitable habitat, yet relatively few alligators were observed and populations seemed to be below carrying capacity, relative to the quality of available habitat. Conditions such as this were observed at Mercer Bayou, White Oak Lake, Lake Erling, Merrisach Lake, Coal Pile, and Arkansas Post. O'Brien and Doerr (1986) found similarly low densities in lake habitats in North Carolina (≤0.2 alligators/mile).

There appear to be several limiting factors that could influence alligator densities in Arkansas. Cold temperatures are certainly one such factor and limit the northern distribution of the American Alligator. After a hard winter in 2000-2001 the AGFC received many reports of dead alligators without any apparent signs of trauma. Alligators are severely cold-stressed when temperatures drop below 38° F for extended periods of time and can die of hypothermia (Brisbin et al. 1982). Smaller alligators are more susceptible to hypothermia because their body temperatures respond more quickly to temperature fluctuations. Large alligators are less susceptible due to their large surface to volume ratio (Smith and Adams 1978, Smith 1979). Cold stress can cause death by reducing blood supply to the brain and other vital organs and by severely reducing enzyme activity necessary for organ function. Further, chronic cold stress can suppress the immune system, thereby increasing susceptibility to disease. The greater susceptibility of smaller alligators to cold stress may be the reason why so few juvenile alligators were observed during this survey. Although our survey was not timed to see the maximum number of juvenile alligators, timing alone does not explain the low number observed. High relative mortality of the juvenile segment of the population could suppress recruitment rates into reproductive size classes. Further, cold stress and a sub-optimal thermal environment can adversely affect reproductive physiology. The endocrine system of the alligator is profoundly dependent on temperature. It is possible that the endocrine system of alligators in colder regions fails to function normally during years with extreme cold spells, and thus, may reduce egg viability or nesting frequency.

The northernmost alligator populations also have slower growth rates, increasing the age of sexual maturity. A study in North Carolina estimated that male alligators reach sexual maturity at 14-16 years of age and females at 18-19 years (Fuller 1981). Murphy and Coker (1983) estimated that male alligators in South Carolina do not reproduce until 20 years of age and 9 ft TL. In contrast, Florida alligators reach sexual maturity at 6-6.5 ft TL and 10-12 years of age (Woodward 1996). There are no data for growth rates of Arkansas alligators, but given the similarity in climate, growth rates may be as slow as those found in the Carolina's. A late age of sexual maturity normally decreases recruitment and a population's ability to recover from increased mortality.

Alligators must find shelter from the cold to survive a harsh Arkansas winter. They may find shelter in an underground den, or alternatively, they may survive a cold spell submerged in deep water. Metabolism slows and the heart rate is reduced to a murmur during cold spells, and they can remain submerged for hours (Grigg and Gans 1993). However, they still have to surface to breathe, and ice can trap alligators under water where they drown. The danger of ice would be more of a factor for alligators wintering in open water than it would for alligators in dens where temperatures would be slightly warmer, and even in partially flooded dens, less likely to ice over. Winter den sites may be a critical component of the habitat for survival of Arkansas alligators.

Fluctuating water levels may also limit alligator densities in Arkansas. Winter floods could force alligators out of dens, perhaps exposing them to lethal cold. This would be especially detrimental if severe cold and ice occurred while dens were flooded. Conditions similar to this occurred during the winter months of 2000-2001, and there were numerous reports of dead alligators throughout the range in Arkansas in late winter and early spring of 2001 (K. Irwin, Pers. Obs.).

In a normal year drought would be more likely in summer than flooding. Summer droughts can strand alligator nests on dryer ground, increasing the probability of nest predation by raccoons, skunks, and opossums (Fleming et al. 1976). Further, drought conditions can lead to increased hatchling predation if the young are forced to travel over land to find water. Potential predators include raccoons, coyotes, opossums, otters, foxes, domestic dogs, great blue herons, red-shouldered hawks, etc. Late summer droughts could also increase cannibalism due to habitat constriction and resultant crowding, thereby increasing the chances of encounters between small and large alligators (Rootes and Chabreck 1993). Nest predation in Arkansas may be a significant cause of mortality even in areas with stable water levels. We observed raccoons, opossums, and skunks in abundance during the night-light surveys. These animals prey on the eggs of ground nesting species and it is possible that they pose a significant predation risk on alligator eggs.

In addition to mortality from cold, drought, and predation, humans kill alligators. Accidental mortality such as roadkills, or drowning in fishing nets or lines, is probably infrequent enough to be insignificant. Intentional killing is probably more widespread and potentially more significant. There have been a few cases in which alligators were killed for their meat. But it is more common for humans to kill alligators out of intolerance or because they view the alligator as a competitor for fish. Some may shoot alligators with a firearm or with bow and arrow because they offer an easy target. Numerous alligators were encountered during this survey that were extremely wary, which is often a sign that they have been harassed. Alligators were more abundant on private property than on public access property, and there could be a number of explanations for this, the one that seems most likely is that alligators on private property receive better protection from humans.

The combination of factors: extreme cold, floods, drought, predators, and human intolerance; may be responsible for the low density of animals observed during this survey. This, coupled with a limited quantity of optimal habitat, may explain the overall low density of alligators in Arkansas, in comparison to other southeastern states.

The abundance of alligators at Grassy Lake is the result of several factors: (1) the area contains fairly stable water levels, freeing the alligators from the extremes of flood and drought: (2) extensive amount of habitat (3,000 acres) can harbor a large number of individuals; (3) the habitat contains an interspersion of open water and cypress swamp, providing the habitat diversity needed for nesting, brood rearing, foraging, and denning; and (4) the property has been managed as a privately owned hunting club for 100 years, thus protecting the alligators from exploitation. In short, the area contains extensive, high quality habitat, and the alligators have been protected. The Grassy Lake population still has to contend with cold weather extremes but their abundance indicates that cold weather alone is not as important if the other limiting factors are minimized.

The reason for a high population density on Moore Bayou, relative to adjacent areas, is an enigma. Water levels are not as stable as they are on Grassy Lake, although the dam on the Arkansas Canal provides more stable water levels than occurred historically when the habitat was a free flowing bayou. The area is accessible to the public, is heavily fished, and thus, does not have the protection afforded at Grassy Lake. The puzzling thing is that the Arkansas Canal – Arkansas Post and Merrisach Lake survey localities contained similar habitat and conditions, yet had lower densities. Researchers from the University of Arkansas, Monticello, are currently engaged in alligator research on Moore Bayou, Arkansas Post, and Merrisach Lake, which may ultimately reveal the disparity in densities between these nearby localities.

Management Implications of the 2002 Survey Data

The impetus for this survey was an interest in assessing the possibility of establishing a sport hunt for alligators, in response to an increase in the number of nuisance alligator complaints. An alligator harvest of sufficient magnitude to significantly reduce the number of nuisance alligator complaints would result in a substantial population reduction, and would not be biologically sustainable. The possible establishment of an alligator sport hunt and control of nuisance alligators are viewed as two separate management issues.

The current AGFC nuisance alligator protocol for relocating problem alligators appears to be functioning well and there appears to be little reason to change it at this time. The program provides beneficial public relations for the agency and translocated alligators provide a source of stock for areas where more alligators are deemed desirable.

Nuisance alligator complaints usually occur in locations that are not conducive to regulated alligator harvests. They are typically at scattered locations and may occur in residential areas. These factors make it difficult to design a harvest program that would effectively resolve nuisance alligator problems without substantially reducing the number of alligators over a broad area. Based on our data there are too few alligators to support a system of licensed private trappers such as in Florida (Hines and Woodward 1980). It may be appropriate to issue a depredation permit to the landowner, similar to those issued for nuisance deer, as a practical solution to persistent nuisance alligators on aquaculture farms.

Alligators were practically extirpated from the state prior to the stocking program. This provides evidence that alligators in Arkansas are more vulnerable to exploitation than in areas like southern Louisiana and Florida, where in spite of unregulated commercial harvest alligators were able to persist in large numbers. Arkansas is at the northern periphery of the alligator's range, and due to limiting factors, recruitment rates do not appear to be as great as in more southern populations. Therefore, Arkansas alligator populations do not appear to have the capability to sustain the same levels of harvest that they can in more southerly states, where both productivity and quantity of habitat is greater.

Based on the densities derived from 2002 survey data, the number of alligators taken in a sustainable harvest would be minimal. More data is needed on alligator demographics in Arkansas before a rigorous harvest rate could be determined. However, an annual sustainable rate would probably be less than 2% of the harvestable-sized individuals (i.e., ≥4-ft TL). This estimate is based on the combination of sustainable harvest rates in other parts of the range and presumed lower reproductive rates and greater age of sexual maturity of the Arkansas population. The 2002 survey revealed only two localities that exhibited densities sufficient to support a harvest – Grassy Lake and Moore Bayou.

We will use the data from the Grassy Lake survey as an example for deriving a 2% harvest quota. The following data were recorded: total number of individuals ($n = 97$); harvestable-sized individuals (i.e., ≥ 4 ft TL) ($n = 67$); those ≤ 4 ft TL ($n = 12$); and unknown size class ($n = 18$). Therefore $67 + 12 = 79$ known size class individuals; and $67 \div 79 = 85\%$, the proportion of harvestable size class individuals in the known size class sample. We then apply the 85% proportion to the unknown size class ($n = 18$) for a total of 15 individuals, giving us $67 + 15 = 82$ harvestable size class individuals. If we assume a 25% observability proportion (Murphy 1977) of ($n = 82$), then the population contained 328 alligators ≥ 4 ft TL. Therefore, Grassy Lake could sustain a 2% annual harvest rate of 6-7 alligators ≥ 4-ft TL.

The use of sighting proportions to set harvest quotas should be applied with caution. There is an obvious risk of unsustainable harvests if sighting proportions overestimate population size. The safe approach to setting quotas is to use survey data without adjustments, but the drawback is that harvests will not be maximized. For example, the harvest quota for Grassy Lake with the safe approach would be 1-2 alligators/year, rather than the 6-7 alligators/year by using extrapolated survey results. If an alligator hunt were initiated in Arkansas, it would be best to set harvest quotas using the safe approach until further data can produce sighting proportions specific to the Arkansas population.

In conclusion, an alligator sport hunt would involve considerable planning and administration, and concomitant long term monitoring of the populations to insure that harvests are sustainable. Moreover, such a hunt will have little if any impact on the number of nuisance alligator complaints and the two should be addressed as separate management issues – an alligator sport hunt will not supplant the need for an effective nuisance alligator control program.

ACKNOWLEDGEMENTS

For providing pertinent information, assistance in the field, and innumerable other courtesies we want to thank Harry Dutton, Tommy Hines, Stephen Stiegler, Allan Woodward, and the personnel of the Arkansas Game and Fish Commission.

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Table 1. Arkansas alligator survey data for 20 May-26 June 2002.

Area	County	Habitat	Access	Miles Surveyed	# Alligators Observed	Alligators/Mile
Grassy Lake	Hempstead	Lake/Swamp	Private	7.2	97	13.5
Moore Bayou	Arkansas	Impoundment	Public	3.3, 3.7	35, 29	9.2[a]
Tillar Farm	Drew	Canal	Private	0.6, 0.6	3, 3	5.0[a]
McClendon Reservoir	Drew	Reservoir	Private	0.9, 0.9	3, 3	3.3[a]
Kuykendall Lake	Miller	Oxbow	Private	1.7	4	2.4
Kingfisher Lake	Yell	Impoundment	Public	1.8	4	2.2
Bois d Arc (Canals)	Hempstead	Canal	Public	1.9	4	2.1
McClendon, Oxbow	Drew	Oxbow	Private	3.6, 3.6	4, 11	2.1[a]
Willow Lake	Miller	Oxbow	Private	2.1	4	1.9
Beard Lake	Hempstead	Creek	Public	4.1, 3.9	5, 8	1.6[a]
Bois d Arc	Hempstead	Impoundment	Public	5.0	7	1.4
Merrisach Lake Plus	Arkansas	Impoundment/River Slough	Public	18.1	22	1.2
Coal Pile	Desha	River Slough	Public	4.0	4	1.0
Lake Bragg	Ouachita	Impoundment	Public	2.3	2	0.9
Rogers Reservoir	Arkansas	Reservoir	Private	5.3	4	0.8
Lake Millwood	Little River	Impoundment	Public	8.3	6	0.7
Mercer Bayou, Lower	Miller	Bayou	Public	5.7, 5.0	2, 5	0.7[a]
Miss. River Levee	Chichot	Canal	Private/Public	17.2	12	0.7
Bayou Bartholomew	Drew	Creek	Public	4.6	3	0.6
Little River	Little River	River	Public	5.3	3	0.6
Long Lake	Union	Oxbow	Public	1.8	1	0.6
Lake Erling	Lafayette	Impoundment	Public	7.4	4	0.5
Mercer Bayou, Upper	Miller	Bayou	Public	5.4, 5.0	0, 4	0.4[a]
White Oak, Upper	Ouachita	Impoundment	Public	7.1	1	0.1
Bayou Meto	Arkansas	Creek	Public	6.4	0	0.0
Champagnolle Creek	Union	Creek	Public	5.3	0	0.0
Lake Georgia Pacific	Ashley	Impoundment	Public	7.3	0	0.0
Seven Devils	Drew	Swamp	Public	5.7	0	0.0

[a] Average of the alligators/mile for the two surveys for these areas.

Everglades Alligator Production Differences between Marsh Interior and Marsh Canal Habitats at A.R.M. Loxahatchee National Wildlife Refuge

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ABSTRACT: Restoration planning is currently underway under the Comprehensive Everglades Restoration Plan (CERP). This plan includes the proposed removal of specific canal structures. Canals compartmentalize this wetland landscape. Effects of landscape decompartmentalization on American alligator (*Alligator mississippiensis*) populations largely are not understood. Recent research has revealed that: (1) adult alligator densities are higher in marsh canal habitats than in marsh interior habitats; (2) adult alligators appear to be bound to their home ranges within either canal or interior habitats; (3) adult body health condition may be better in canals than in the interior; (4) canal alligators appear to have a metabolic thermal advantage in some seasons.

Acquiring information about alligator production requires research in all Everglades habitats. Key variables that affect alligator production were analyzed during this study. Specifically, clutch and hatchling survival in canal and interior habitats at A.R.M. Loxahatchee National Wildlife Refuge were calculated during 2000 and 2001. Data was collected from 112 measured nests and associated clutches and 779 hatchling alligators. Individuals from 57 hatchling pods were recaptured during this study. No sampled clutches in the marsh interior experienced flooding at any level during 2000 (n = 35) and 2001 (n = 24). However, 10 of 13 (77%) and 30 of 30 (100%) clutches in marsh canal habitats experienced flooding during 2000 and 2001, respectively. Nests experienced higher depredation rates by raccoons (*Procyon lotor*) during 2001 (14 of 24 (58%) in interior and 1 of 29 (3%) in canal habitats) than during 2000 (4 of 33 (12%) in interior and 0 of 13 (0%) in canal habitats). The percentage of sampled clutches that were observed to successfully produce at least 1 hatchling was higher during 2000 (33 of 36 (92%) in interior and 5 of 13 (38%) in canal habitats) than during 2001 (20 of 35 (57%) in interior and 3 of 30 (10%) in canal habitats). Cormack-Jolly-Seber (CJS) survival probability estimates for 2000-generation hatchlings after the 1st 6 and 13 months of life were 44 and 20%, respectively. The estimated percentages of nests that produced hatchlings that survived for at least 3 months after hatch were lower in canal (38% and 10%) than in interior habitats (86% and 57%), during 2000 and 2001, respectively. The 95% confidence intervals for production per nest (values < 1 included) 3 months after hatch events averaged 7.85 alligators ± 1.49 and 4.01 alligators ± 1.51 in interior habitats during 2000 and 2001, respectively. For the same period of time, the 95% confidence intervals for production per nest (values < 1 included) averaged 2.68 alligators ± 2.51 and 0.69 alligators ± 0.88 in canal habitats during 2000 and 2001, respectively. The 95% confidence interval for production per nest (values < 1 included) 13 months after hatch events averaged 2.42 alligators ± 0.46 and 0.83 alligators ± 0.78 during 2000 in interior and canal habitats, respectively.

Marsh canal nests were subjected to a larger range of water levels during clutch incubation, and were thus more susceptible to clutch flooding pressures than nests in interior habitats. The greatest risk to canal nests at LOX NWR was shown to be flooding. Interior habitats offer higher elevations due to general marsh elevation and the presence of elevated tree islands. Marsh canal habitat at LOX NWR represents a population sink,

reproductively speaking. That is, due to low values of clutch fate and pod size in canal habitats and overall low mean hatchling survival at LOX NWR, canal habitats exhibited biologically insignificant production levels during 2000 and 2001. In Everglades areas lacking a multitude of elevated tree islands, flooding could be responsible for long-term population sustainability problems via clutch mortality. The building of spoil mounds on the interior side of marsh canal habitats to facilitate reproductive success could be considered as an alternative to the changing of current water management schedules. This alternative could significantly reduce flooding pressures on alligator nests in canal habitats at LOX NWR.

PROCEEDINGS

Everglades annual rainfall is seasonal with approximately 75 percent of the mean annual precipitation of 136 centimeters occurring from June through October. However, due to the constant human requirement for water, Everglades hydropatterns are managed according to many requirements. Alligators, though a keystone species, are not necessarily at the top of this requirement list. Subsequently, clutch failure rates have changed from low and predictable to high and variable in certain habitats (Kushlan and Jacobsen 1990). Marsh canals at LOX NWR may very well be one of these habitats. Everglades canals presently serve as alligator habitat in many areas, including LOX NWR. Adult alligator densities are higher in canal habitats than those in the natural marsh interior (Morea 1999).

Hydrologic restoration alternatives are now being developed and proposed in response to the many decades of adverse water management practices. Input of these results into ATLSS modeling will help predict and compare future effects of alternative hydrologic restoration scenarios on the alligator populations in Everglades habitats similar to those at LOX NWR. This information is key to addressing the significance of canal removal to alligator population ecology.

Alligator production may be estimated with the variables clutch fate (survival or failure of a clutch), pod size (the number of alligators to successfully hatch out of a nest), and mean hatchling survival. Knowledge of production, estimated as the number of alligators produced by each nest, is necessary when managing populations. Wildlife biologists and resource managers can use production estimates specific to habitat types to estimate the possible impacts of specific water management plans on these populations.

Canals may act as population sinks as defined by Hanski and Simberloff (1997) for this long-lived species in that canal populations sustain negative growth rates. In fact when considering the negligible production rates in canal habitats during this study at LOX NWR, rare and random immigrants from the interior may be the only recruits that survive to be adults in canals. Morea (2000) revealed that Everglades alligators are exclusively bound to their homeranges, whether these be in canal or interior habitats. Everglades alligators have relatively small home ranges (Morea 1999) and probable infrequent emigration from interior to canal habitats.

The survival of alligator embryos and hatchlings is directly associated with water levels that may flood the nest and kill embryos during a vulnerable incubation period (Hines *et al.* 1968). Effects of variable rainfall and water management practices can impact clutch fate in different habitats to different degrees. Other detrimental factors such as clutch depredation (Fleming *et al.* 1976; Deitz and Hines 1980) and cannibalism (Nichols *et al.* 1976) may increase or decrease according to environmental conditions.

Habitat-specific management and restoration requires an understanding of the degree to which the above-mentioned variables affect production in LOX NWR canal habitats where no elevated tree islands exist. This knowledge will provide a better perspective of population differences between habitats, as well as the uniqueness of LOX NWR populations to those of other areas in the Everglades.

OBJECTIVES

The objectives of this study were to estimate production values and differences in these values for Everglades alligators between years (2000 and 2001) and habitats (canal and interior). Included in these analyses were the necessary calculations and estimations of clutch fate (CF), pod size (PS), and mean hatchling survival (MHS).

STUDY AREA

The Arthur R. Marshall Loxahatchee National Wildlife Refuge (hereinafter 'LOX NWR') comprises approximately 57,234 hectares of northern Everglades marsh that includes thousands of tree islands that are elevated above the marsh floor. The vegetative communities characteristic to this northern Everglades region consist of sawgrass (*Cladium jamaicense*) marsh, wet prairie, slough, and tree islands (Brandt and Mazzotti 2000). This refuge is surrounded by one contiguous canal structure. Canal water levels periodically and drastically rise over short periods of time due to human demand for water, and not necessarily in proportion to local rainfall. Unlike refuge canal habitats, water levels in interior habitats at LOX NWR are largely determined by rainfall (Brant and Mazzotti 2000).

Methods

Nests were located during 2000 and 2001 in refuge marsh interior areas in randomly chosen 2.59 km^2 quadrats in refuge manager-designated areas (Fig. 1). Research locations also included points along the entire refuge canal system, excluding the 1st 10 km north of refuge headquarters (Fig. 1). Observers measured and candled the eggs. Clutch fate (CF) was measured throughout the clutch incubation period with periodic nest status checks, and was given a value of either "0" or "1". The value, "0" represents clutch failure due to flooding, depredation, or other detrimental environmental factors. The value, "1" represents the fact that at least 1 egg survived the incubation period to hatch at hatch time. Nest status checks took place at the time of initial nest location (July 11-19), at nest processing events (July 20-Aug. 22), and at scheduled hatch-time mark-recapture events (Aug. 16-Sept. 21) for respective nests constructed during 2000. For nests constructed during 2001, nest status checks took place at initial nest location (July 5-19), at nest processing events (July 19-Aug. 5), at an additional nest status check (Aug. 20-24), and at scheduled hatch-time mark-recapture events (Sept. 1-21). With the exception of the nest processing event, all nest status checks were visual observations of nest (and assumed clutch) structural integrity and inundation status. These nest observations were taken from up to 10 meters away from an airboat, from a helicopter 200 feet away from the nest, and at closer distances from "on foot" personal observations when necessary.

Pod size (PS) is defined here for each nest as the observable number of hatchlings to successfully hatch from a nest and remain alive until the 1st capture occasion of the mark-recapture study. PS was calculated by counting all hatchlings captured at or near the respective nest site during the 1st or 2nd week of life, after the clutch hatch date.

This study focused on the proportions of individuals in both marsh canal and marsh interior habitats that survived during their 1st year during 2000 and 2001. Mark-recapture methods were used to estimate mean hatchling survival (MHS). The sample unit for MHS estimates was a hatchling individual. The necessary sample unit for MHS estimates initially was thought to be a hatchling individual *within* a pod. For this reason, sample size power analyses were performed for MHS *within pods*. The sample size of pods required to achieve the desired power of 0.90 with an _ value of 0.05 with a population (marsh canal vs. marsh interior) sample mean difference of 0.10, 0.15, and 0.20 with respect to the MHS was calculated (SAS Inst. Inc. 1999). The MHS standard deviation of 0.08 (Temsiripong pers. comm. 2000) was used specifically for the MHS estimate standard deviation value in these power analyses. Temsiripong (2000) calculated this standard deviation during a study of hatchling survival in 3 central Florida lakes. MHS > 0 for hatchlings from 15 pods in each treatment area (marsh canal and interior habitats) were required for adequate MHS estimates in each of the 2 field season years. Sample sizes of n = 25 and n = 20 hatchling pods were used for 2000- and 2001-generation datasets, respectively for the study described in this document. Because point estimates of MHS probability were not compromised when MHS was calculated (Williams *et al.* 2002) without consideration of pod identity, the effective sample size that was later used for analyses for the 2000- and 2001-generation dataset in this study in the Everglades was n = 339 and n = 252 hatchling individuals, respectively.

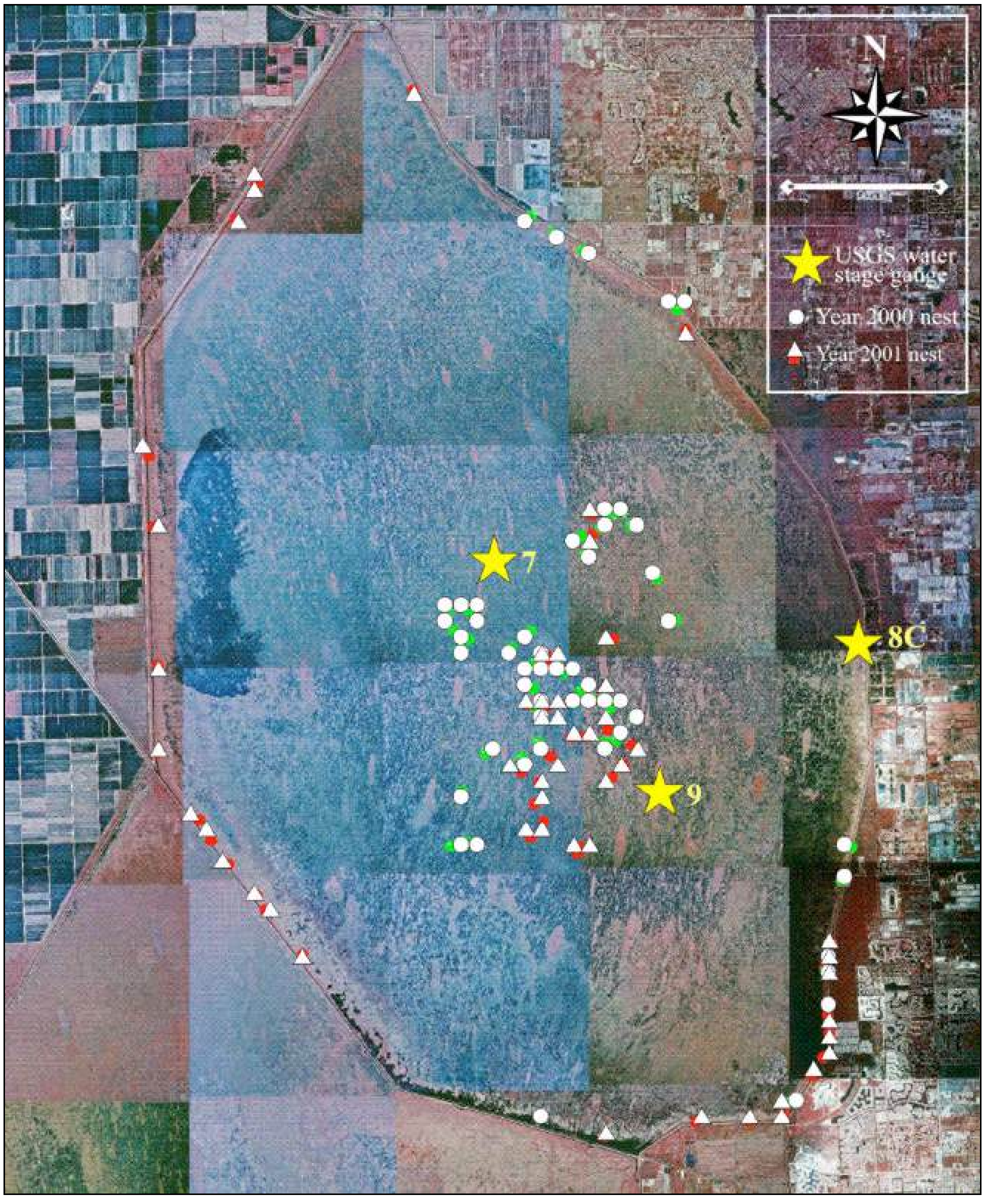

Figure 1. Alligator nests sampled during 2000 and 2001 in A.R.M. Loxahatchee National Wildlife Refuge. Two USGS water stage gauges (Fig. 1) in marsh interior habitats (Gauges 7 and 9) and 1 in marsh canal habitats (Gauge 8C) were used to acquire daily mean water level data during 2000 and 2001.

Hatchlings were marked individually and identified with a nest pod only at the initial capture event. Hatchlings were only marked at the initial capture event because of suspicions, later verified during this study, that hatchlings may emigrate to other local pod groups during their 1st year. That is, hatchlings located in any one pod may not be automatically assumed 'siblings' after the initial capture event. The respective hatchlings were recaptured at night from an airboat, measured, and released immediately during each capture event. Identical procedures were used to mark and search during each mark-recapture event, beginning in September of 2000 and 2001. Fifty minutes was allotted to hatchling searches for each of the hatchling pods during each of the search events. The indirect light from a spotlight (400,000 candle power) was used to locate hatchlings by their eye reflections. Hatchlings were captured using Pilstrom tongs (Pilstrom Tong Co., Ft. Smith, AR) or by hand from an airboat or on foot. All hatchlings were marked by dorsal scute clipping with cuticle scissors prior to their release. This involved clipping the thin scutes on the tail with scissors, in an ordinal fashion. Individuals were also marked with sequentially numbered #1 Monel tags (National Band and Tag Co., Newport, KY) provided by the Florida Fish and Wildlife Conservation Commission, 4005 South Main Street, Gainesville, Florida 32601. These tags were inserted through the web between the 2nd and 3rd digits of the right rear foot.

Hatchlings were marked and released immediately at their original capture sites. Effects of these marking techniques on alligator hatchling survival have been shown to be negligible (Jennings *et al*. 1991), and thus not an important consideration during this study.

A 200-meter radius was searched around each alligator nest during each search event. If individuals from the target pod were located 180 meters distance or more from the pod's natal nest, an additional 100-meter radius was searched around that point of hatchling capture. This was done to ensure that the recently located group of hatchlings was a group of individuals "far away from their nest," and not just individuals on the edge of a group perimeter that had a center point even further away and outside the 200-meter natal nest radius.

Production (P) was calculated for each nest with the equation:

$$P = [(CF) \times (PS) \times (MHS)]$$

The use of this equation allowed comparisons of production values between nests, habitats, and years (2000 and 2001). The above-mentioned mark-recapture studies provided enough data to estimate production after the 1st 13 and 3 months of hatchling life for 2000 and 2001 datasets, respectively.

Data Analyses

CF and PS values for each nest were not analyzed directly, but were instead incorporated into the production value equation described above. As PS only included *observable* hatchlings, PS represents the minimum number of hatchlings alive.

Only those capture histories from individuals that were included in 4 2000-generation and 2 2001-generation mark-recapture search events were used in MHS and MHR estimation. Therefore, recapture efforts were equal for all pods analyzed for parameter estimation purposes. Analyses of mark-recapture data used capture histories from 339 2000-generation hatchlings and 252 2001-generation hatchlings. Capture histories from 2000 and 2001 were not combined during data analyses.

Probability models were developed for the biological and temporal processes that gave rise to the hatchling capture history data (Williams *et al*. 2002). Specifically, this method included conditioning on the initial capture of animals, and then statistically modeling subsequent capture history entries as functions of parameters associated with both real population change (survival probabilities) and sampling (capture probabilities) (Williams *et al*. 2002). Recapture data was in the 'live recapture' (Cormack-Jolly-Seber) format for this open population of alligator hatchlings. The fully parameterized CJS model is represented here with the notation (ϕ_t , ρ_t), thus showing these parameters are time-specific as defined in this model's structure (Lebreton *et al.* 1992). These mark-recapture data were analyzed in program MARK (White and Burnham 1999). This required use of the CJS model as a baseline model. Assumptions that typically accompany the CJS model are as follows (Seber 1982; Pollock *et al.* 1990):

1. All marked animals present in the population at sampling period i have the same probability ρ_i of being recaptured.
2. All marked animals present in the population immediately following the sampling in period i have the same probability φ_i of survival until sampling period $i + 1$.
3. Marks are recorded correctly, and are neither lost nor overlooked.
4. Sampling periods are relatively instantaneous (they are very short periods in reality) and recaptured animals are released immediately.
5. All emigration from the sampled area is permanent
6. The fate of each animal with respect to survival and capture probability is independent of the fate of any other animal.

All of the above assumptions were adequately met during this study.

Hatchling mortality prior to initial tagging of marked pods was assumed insignificant. This assumption, related to the above assumption (2), allowed subsequent survival probability estimates to represent a time interval beginning at a hatchling's hatch date. This was possible because the initial mark/capture event occurred during the first two weeks after clutch hatch dates for all nests involved in capture history datasets. Because of this short sampling period, it was not necessary to test for early mortality occurring prior to the first mark/capture event, as was performed in the study by Woodward *et al.* (1987) at Orange Lake, Florida. Furthermore, initial mark/capture event durations only ranged a maximum of 24 and 19, and 23, and 13 days in interior and canal habitats during 2000 and 2001, respectively. The CJS model-averaged estimates presented in this Everglades study are therefore representative of MHS from the approximate hatch date.

The estimation of MHS required our addressing dependence issues inherent in this dataset. The objective of modeling these data was to estimate MHS probabilities. However, after hatching from the nest, hatchlings remained in "pod" groups (a localized group of siblings) for the duration of the study. This means that an individual's survival probability was possibly dependent on its pod identity (see assumption (6)). That is, some dependence of fates was probable in our population of hatchlings. However, violation of assumption (6) commonly does not result in bias of the point estimates of survival and recapture probabilities. Dependent fates do violate the assumptions of the underlying multinomial distribution and thus lead to biased estimates of variance (Williams *et al.* 2002). However, estimated variances and subsequent confidence intervals were not used when MHS point estimates were used in equations to calculate production values specific to each nest in the dataset as described below.

Temporary emigration does not represent a possible explanation for "no recapture" values in the capture history dataset (see Results section below). In addition to the assumption that all emigration from the sampled area was permanent, permanent emigration rates were assumed approximately equal among pods, habitat types, and years. The rest of the above-mentioned CJS assumptions were not compromised by the research design or biology involved in this study.

Apparent MHS (ϕ_i) and MHR (ρ_i) probability parameters were estimated separately for each sampling period with these conditional modeling procedures (Williams *et al.* 2002). Apparent MHS (ϕ_i) uses the combination of the probability of survival and the probability of no permanent emigration out of the study area between sampling occasions (Williams *et al.* 2002). That is, the estimated "apparent MHS" (ϕ_i) compliment included both mortality and emigration. Though the parameter is still recognized as including both factors, the term (ϕ_i) shall be referred to as "MHS" in the remainder of this document, for simplicity.

The computer program MARK (White and Burnham 1999) was used for the general CJS and related reduced-parameter modeling. The above-mentioned parameter estimates and related variances were also computed in program MARK. Models were not run specific to habitat type because sample sizes were too small in marsh canal habitats.

The RELEASE program Goodness of Fit test was used to ensure that the starting CJS model adequately fit the data. The starting CJS model fit the 2000-generation hatchling dataset well (χ^2 = 2.5216, DF = 2, P = 0.2834). Therefore, a quasilikelihood approach and corrected variance inflation factor (c-hat) values were not applied to these respective parameter estimate analyses (Burnham and Anderson 1998). This eliminated the possibility that a lack of independence of survival and recapture events occurred due to the grouping of hatchlings into genetically-related pods (Williams *et al.* 2002). That is, a lack of fit for the above-mentioned models to the 2000-generation hatchling dataset was not apparent, so the possibility of overdispersion of data due to survival and recapture event dependence was dismissed (Burnham *et al.* 1987). Goodness of Fit testing was not possible for the starting CJS model of the 2001-generation hatchling dataset because these data only contained 2 capture events.

Three time intervals were created from the 4 mark-recapture events performed on the 2000-generation hatchlings. All of the 2000-generation time intervals had approximately equal (3-month) duration, with the exception of interval 2. Time interval 2 covered 6 months. Thus, the use of models for data with such variable time intervals may not be associated with the assumption $\phi_i = \phi$. However, it is biologically reasonable to query whether MHS probability estimates during 3-month time intervals (ϕ_2) between the 2nd and 3rd mark-recapture events were statistically similar to the other time intervals (ϕ_1 and ϕ_3), which also covered 3-month periods of time (Williams *et al.* 2002). One time interval that covered 2 months was created for 2001-generation hatchlings. MHS probability estimates for the 1st time interval for the 2000-generation, which covered 3 months, and 1st interval for the 2001-generation, were compared.

In addition to using the general CJS model, reduced-parameter models were developed with MHR parameters set constant over time. This enabled the improvement of MHS estimate precision, through the reduction of respective parameter estimate variance size (Williams *et al.* 2002; Burnham and Anderson 1998). Indeed, models were created so that MHS probability was time specific, while MHR probability remained constant over time for the last 2 time intervals (out of 3 total time intervals). Such models included $K - 1$ (= 3) unique MHS and $K - 2$ (= 2) unique MHR probabilities. That is, MHR probability was assumed constant over the last 2 intervals. This measure meant that MHR estimation for the last time interval was not necessary, and the MHS probability for the last ($K - 1$) interval therefore could be estimated (Williams *et al.* 2002).

Apparent MHS probability parameters as defined here include both the probability of survival and the probability of not permanently emigrating out of the study area between sampling occasions. As such, apparent MHS probability was used in the characterization of the continued presence of individuals over time (Williams *et al.* 2002). Losses and/or gains to the sampled population are expected during the times between sampling occasions with this open population dataset (Williams *et al.* 2002). MHS probabilities were estimated in MARK from hatch to 3, 3 to 9, and 10 to 13 months old for 2000-generation hatchlings. MHR probabilities were estimated in MARK from hatch to 3 and 3 to 9 months old for 2000-generation hatchlings. MHS probabilities were calculated for hatch to 6, and hatch to 13 months old for 2000-generation hatchlings by multiplying together some of the parameter estimates that corresponded to the 4 3-month long time intervals. MHS probabilities were estimated in MARK from hatch to 3 months old for 2001-generation hatchlings. Parameter estimates were calculated in MARK for only 3 time intervals for 2000-generation hatchlings. Respective parameter estimates for the 2nd (6-month long) interval were calibrated to intervals representing 3 months each.

Optimization methods were used for model selection (Williams *et al*. 2002). Specifically, Akaike's Information Criterion (AIC) (Akaike 1973; Burnham and Anderson 1998) was used to judge the parsimony of a model's parameterization, and to select the best probability model for these data in program MARK. Smaller AIC values usually correspond to the better models in the candidate set (Williams *et al.* 2002). Furthermore, the ΔAIC criterion and Akaike weights were used to compare the best model with reduced parameter models (Burnham and Anderson 1998). Akaike weights were interpreted loosely as weights of evidence in favor of certain models being more appropriate than others, given both the data and the model set (Williams *et al.* 2002). Another purpose of AIC weights is to incorporate model selection uncertainty into parameter estimation procedures (Buckland *et al.* 1997). All models used for the 2000-generation hatchling dataset were deemed useful enough to be included in the model averaging procedure (Burnham and Anderson 1998).

Real function parameter estimates specific to each time interval from these models were then averaged in program MARK (for 2000-generation hatchling dataset only) to produce unconditional weighted average MHS and MHR estimates with 95% confidence intervals. These estimates were then used to calculate MHS and MHR probability estimates for the 1st 3 months and 1st 13 months of hatchling life (Burnham and Anderson 1998).

Comparisons of relative P values between habitat types and years were possible, as permanent emigration was assumed to occur with approximately equal rates between habitat types and years. Production was calculated for 2000 and 2001 between a clutch's hatch date and the 1st 3 months of respective hatchling survival. P was analyzed by year and by habitat in frequency tables with Cochran-Mantel-Haenszel odds ratio tests (PROC FREQ, SAS Inst. Inc. 1999). Chi-square tests were used to test for independence between the occurrence of P (values of $P \geq 1$) and year and habitat type (PROC FREQ, SAS Inst. Inc. 1999). Production values were separately analyzed for each year because years and respective drought conditions were possibly associated with unique P levels.

Once differences in P were revealed, we focused on the nests that produced hatchlings that survived for at least 3 months. That is, variables were analyzed as to their effects on P. Therefore, values < 1 were eliminated from the dataset because these values are equivalent to P = 0 values, biologically speaking. Tests for normality (Shapiro-Wilk) were performed on these data (PROC UNIVARIATE; SAS Inst. Inc. 1999).

ANCOVA analyses were used to measure the effects of year, habitat, depredation, CS, and the habitat-year interaction on P during 2000 and 2001, where $P \geq 1$, 3 months after hatch events (PROC GLM, SAS Inst. Inc. 1999).

Most of the nests in this analysis on positive P values came from the marsh interior (n = 37 observations used) because many nests in marsh canal habitat (n = 7 observations used) had P values < 1 or missing values for at least one of the variables in the model. Furthermore, P in canal habitats could only be analyzed when combined with interior data, as only n = 7 marsh canal nests were suitable for these analyses.

P values representing the time interval between a clutch's hatch date and the 1st 13 months of respective hatchling survival were obtained only for 2000-generation hatchlings. For this reason, P among years could not be compared during the time interval between a clutch's hatch date and the 1st 13 months of respective hatchling survival. Thus P was only analyzed by habitat in frequency tables with Cochran-Mantel-Haenszel odds ratio tests (PROC FREQ, SAS Inst. Inc. 1999). Chi-square tests were used to test for independence between the occurrence of P (values of P ≥ 1) and habitat type (PROC FREQ, SAS Inst. Inc. 1999).

Once differences in P were revealed, we focused on the nests that produced hatchlings that survived for at least 13 months. That is, variables were analyzed as to their effects on P. Again, values < 1 were eliminated from the dataset. Tests for normality were performed on these data (PROC UNIVARIATE; SAS Inst. Inc. 1999). ANCOVA analyses were used to measure the effects of habitat, depredation, and CS on P during 2000, where P ≥ 1, 13 months after hatchling birth (PROC GLM, SAS Inst. Inc. 1999). Most of the nests in this ANCOVA analysis came from the marsh interior (n = 27 observations used) because many nests in marsh canal habitat (n = 4 observations used) had P values < 1 or missing values for at least one of the variables in the model. Furthermore, P in marsh canal habitats could only be analyzed when combined with marsh interior data, as only 4 marsh canal nests were suitable for these analyses.

RESULTS

Sampled interior nests were almost exclusively built on small tree islands (n = 32 and 22) that provided elevated, dry nest sites during 2000 and 2001, respectively. However, some nests were built on floating peat mats (n = 3 and 3) and in clumps of *Cladium jamaicense* (n = 1 and 1) during 2000 and 2001, respectively. All canal habitat nests (n = 13 and 30) were located in emergent marsh within 100 meters distance of the canal on the interior side of the refuge canal during 2000 and 2001, respectively. No nests were observed on the exterior side, which included only levee habitat.

Observations of CF revealed that no clutches in the marsh interior experienced flooding at any level during 2000 (n = 35) and 2001 (n = 24) (Table 1). However, 10 of 13 (77%) and 30 of 30 (100%) clutches in marsh canal habitats experienced flooding to some extent during 2000 and 2001, respectively (Table 1). Nests experienced higher depredation rates by raccoons during 2001 (14 of 24 (58%) in interior and 1 of 29 (3%) in canal habitats) than during 2000 (4 of 33 (12%) in interior and 0 of 13 (0%) in canal habitats) (Table 1). The percentages of sampled clutches that were observed to successfully produce at least 1 hatchling were higher during 2000 (33 of 36 (92%) in interior and 5 of 13 (38%) in canal habitats) than during 2001 (20 of 35 (57%) in interior and 3 of 30 (10%) in canal habitats) (Table 1).

Table 1. Percentage of sampled nests that experienced each of the following occurrences in each habitat and year

	INTERIOR 2000	INTERIOR 2001	CANAL 2000	CANAL 2001
Successful hatch	33 of 36 (92%)	20 of 35 (57%)	5 of 13 (38%)	3 of 30 (10%)
Flooding	0 of 35 (0%)	0 of 24 (0%)	10 of 13 (77%)	30 of 30 (100%)
Depredation	4 of 33 (12%)	14 of 24 (58%)	0 of 13 (0%)	1 of 29 (3%)

The 95% confidence intervals for mean PS in marsh canal habitats were 4.2 ± 4.0 (n = 13) and 1.2 ± 1.6 (n = 30) during 2000 and 2001, respectively. Mean PS in marsh interior habitats was 12.4 ± 2.3 (n = 36) and 7.2 ± 2.7 (n = 35) during 2000 and 2001, respectively.

Study site marsh interior nest locations were virtually all on small tree islands in open water sloughs, so resighting and recapturing the required number of pods was possible in marsh interior habitats. However, study site marsh canal nest locations were often in dense *Typha spp.* prairies adjacent to the canal where hatchling observability was low and 2001 drought conditions prevented completion of recapture events.

Four encounter occasions occurred for 2000-generation hatchlings and 2 encounter occasions occurred for 2001-generation hatchlings. Thus, 6 encounter occasions were used in total to mark and recapture individuals born during 2000 and 2001. The 1st marking occasion for 2000-generation hatchlings was during September. The 2nd (recapture) occasion was during November/December 2000. The 3rd recapture occasion was during June 2001. The 1st marking occasion for 2001-generation hatchlings was during September 2001. The 4th recapture occasion for 2000-generation hatchlings was during October 2001. The 2nd (recapture) occasion for 2001-generation hatchlings was during November 2001. Three time intervals were created from the 4 mark-recapture events performed on the 2000-generation hatchlings. All of the 2000-generation time intervals had approximately equal (3-month) duration, with the exception of interval 2. Time interval 2 covered 6 months. One time interval, covering 2 months, was created for 2001-generation hatchlings.

Four models were deemed biologically acceptable for the 2000-generation dataset. These were used in model-averaging procedures. Again, Akaike weights are used in model-averaging calculations, so model estimates that are obviously not from the best models are minimally influential in model-averaged MHS estimates. The full set of models is as follows:

		Delta	AICCc	Model		
Model	**AICCc**	**AICCc**	**Weight**	**Likelihood**	**#Par**	**Deviance**
{Phi(.) p(t)}	984.211	0.00	0.51122	1.0000	4	4.564
{Phi(t) p(t2=3)}	984.944	0.73	0.35435	0.6931	5	3.259
{Phi(t) p(.)}	987.123	2.91	0.11920	0.2332	4	7.476
{Phi(.) p(.)}	991.238	7.03	0.01523	0.0298	2	15.644

where "(.)" denotes the fact that only one parameter estimation was performed as parameters were considered constant over time, "(t)" denotes the fact that parameter estimates were performed for each different time interval as parameters were considered to vary over time, "t2=3" denotes the fact that MHR for the 2nd and 3rd intervals were assumed equal. This assumption eliminated the need to estimate MHR for the last time interval, and allowed MHS for the last time interval to be estimable (Williams *et al.* 2002). The model [ϕ(t) ρ(t)] was not included in the acceptable model set because confidence intervals for real parameter point estimates of MHS and MHR probabilities covered the approximate interval (0, 1) and were thus not acceptable.

The above models were then averaged to provide unconditional weighted averaged parameter estimates with 95% confidence intervals. The resulting model-averaged MHS estimates for each time interval were then used in production value equations for each nest in the 2000-generation sample. MHS estimates for the 1st and 2nd intervals were multiplied together to get an estimated mean value of MHS probability for an individual during the 1st six months of life as follows:

$$\boldsymbol{\phi_{1\text{-}6} = [(\phi_1) \times (\phi_2)]}$$

MHS estimates for the 1st 13 months of life for the 2000-generation dataset were similarly calculated:

$$\boldsymbol{\phi_{1\text{-}13} = [(\phi_1) \times (\phi_2) \times (\phi_2) \times (\phi_3)]}$$

where (ϕ_1) represents the MHS probability estimate for the 1st interval (1-3 months); (ϕ_2) represents the MHS probability estimate for the 2nd interval where parameter estimates for this interval (4-9 months) were calibrated to a 3-month interval; and (ϕ_3) represents the MHS probability estimate for the 3rd interval (10-13 months).

MHR estimates are described in this document as specific to each of the 4 time intervals. Therefore, MHR estimates were not multiplied together to get parameter estimate values for 6 and 13 months of hatchling life. MHR probability estimates for each of the 4 3-month time intervals are represented as:

$$\boldsymbol{(\rho_1) \text{ and } (\rho_2) \text{ and } (\rho_2) \text{ and } (\rho_2)}$$

where (ρ_1) represents the MHR probability estimate for the 1st interval (1-3 months); (ρ_2) represents the MHR probability estimate for the 2nd interval where parameter estimates for this interval (4-9 months) were calibrated to a 3-month interval; and (ρ_2) also represents the MHR probability estimate for the 3rd interval (10-13 months) that was set equal to that of the 2nd interval. The last MHR estimate (ρ_3) was assumed equal to (ρ_2) both because this seemed reasonably acceptable and also because the MHS probability estimate for the last interval (ϕ_3) was needed. There are no sampling periods after the last mark-recapture event (during month 13) with which to identify a subset of animals known to have been alive during that last mark-recapture period. Because of this, only the joint probability of MHS and MHR ($\phi_{K-1}\rho_K$) can be estimated for the final sampling time interval when using the CJS model (Williams *et al.* 2002). However, when (ρ_3) was assumed equal to (ρ_2), the need to estimate (ρ_3) was eliminated, thus allowing adequate estimation of the (ϕ_3) parameter.

The best model for the 2000-generation dataset was the model [ϕ(.) ρ(t)], where MHS probability did not vary over time and MHR probability did vary over each time interval. However, 3 of the 4 models that were used had ΔAICc < 4 and Akaike mass values no greater than 0.5112. This means that there is weak evidence that any of these 3 models were not the best model. However, there is definite ΔAICc and Akaike weight evidence that the 4th model [ϕ(.) ρ(.)] is not the best model for these data (Burnham and Anderson 1998). Therefore, when comparing the best and worst models in the model set, it is shown that MHR probability did vary over time during this study. It is important to note that the model including a variable MHR probability parameter over time fit the dataset much better than the model that held the MHR probability parameter constant over time.

Unconditional weighted averaged MSE and MHR estimates with 95% confidence intervals were calculated for each of the 2000-generation dataset time intervals from the above models (Figs. 2 and 3). MHS estimates for the 1st 6 and 13 months of life were 0.44 and 0.20, respectively.

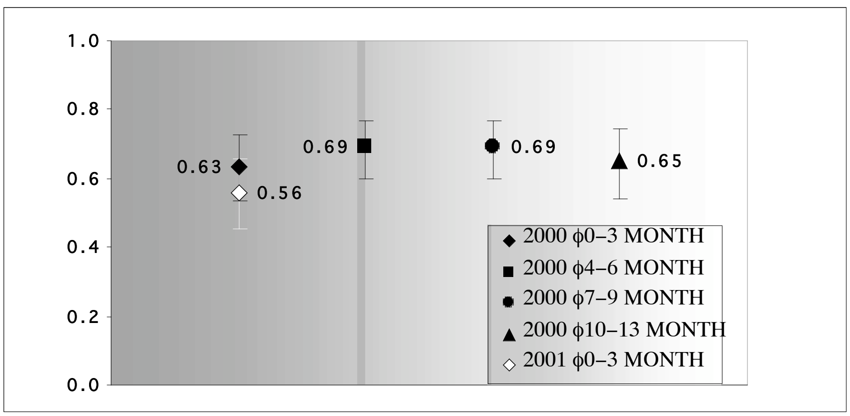

Figure 2. 2000- and 2001-generation weighted averaged MHS estimates with 95% confidence intervals

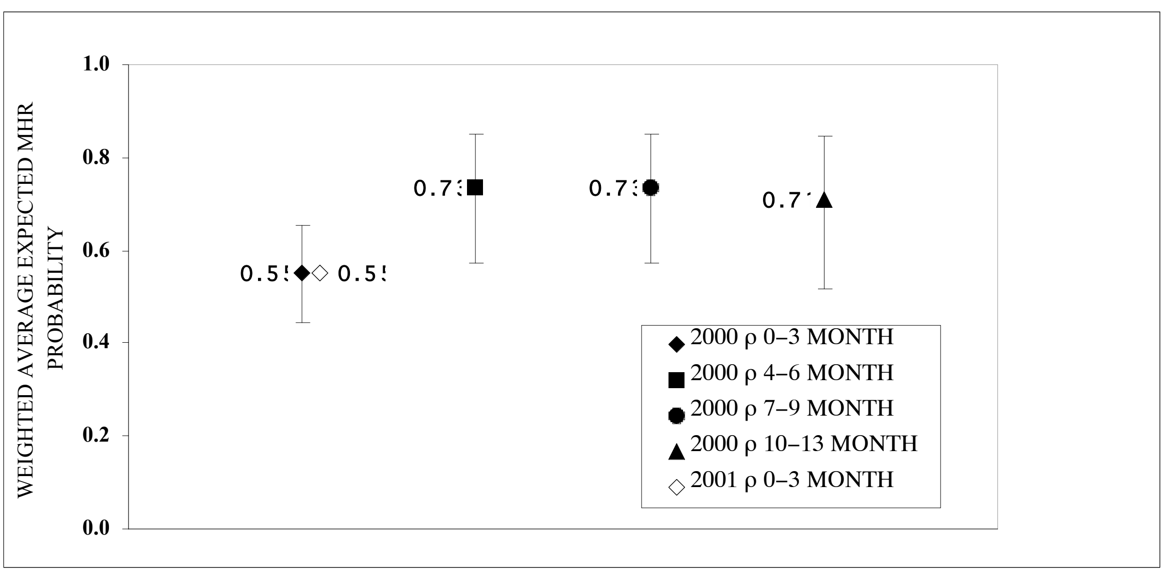

Figure 3. 2000- and 2001-generation weighted averaged MHR probability estimates with 95% confidence intervals

2000-generation MHR probability estimates were not calculated for the 1st 6 and 13 months of life because these values were not useful in this study.

One biologically acceptable model was used for the 2001-generation dataset. Parameter estimates were calculated for 1 time interval, as only 2 capture events were completed for this dataset. Therefore, time effects were not included in models created for this dataset. The acceptable model is as follows:

		Delta	AICCc	Model		
Model	AICCc	AICCc	Weight	Likelihood	#Par	Deviance
{Phi(.) p(fixed=0.554)}	313.850	0.00	1.00000	1.0000	1	0.000

where "fixed" denotes the fact that MHR was not estimated during these procedures, but were fixed at the listed 2000-generation value specific to the MHR unconditional weighted averaged probability estimate for the 1st 2000-generation time interval. This assumption that the action of fixing these values is biologically sound may be justified with the fact that interior water levels ranged 0.45 and 0.27 m during "1st" time intervals in August and September of 2000 and 2001, respectively. It is possible that the small difference in water level ranges between years may have resulted in different behavior patterns by hatchling alligators that could have affected observability during capture events. However, all areas maintained standing water in interior open sloughs and canal marsh habitats, and were still accessible to searches with an airboat. Also, all microhabitats were searched equally during both years.

The above model fit the 2001-generation dataset well, judging by the relatively low AIC value. MHS estimates with 95% confidence intervals were calculated for the 2001-generation dataset time interval from the above model (Fig. 2). These MHS estimates were used in production value equations for each nest in the 2001-generation sample. The 2001 MHS and MHR probability estimates for the 1st 2 months of hatchling life are represented as follows:

$$\phi_{1\text{-}3} = [(\phi_1)]$$

and

$$\rho_{fixed} = 0.554$$

This hatchling mark-recapture dataset provided little evidence of permanent emigration in marsh interior habitats. Emigration was not observed in marsh canal habitats during this study. Indeed, when considering all occurrences of emigration in this dataset, no evidence of temporary emigration was apparent. That is, all animals that emigrated away from their natal pod and respective home range either remained away or were never recaptured again. Also, only 48 out of 600 (or 8%) hatchlings sampled in the 2000-generation mark-recapture dataset were found to have emigrated outside the 200-meter search radius that surrounded respective natal nests during their 1st 13 months of life.

Observations were made of individual hatchlings merging with non-natal pods. Individual hatchlings emigrated and immigrated to and from pods during this study. However, these occurrences were assumed to be permanent, occurring in relatively equal proportions among pods within similar habitat types (interior or canal). That is, most nests were located within 300 meters of another known nest in marsh interior habitats during 2000 and 2001. Indeed, during 2000 in marsh interior habitats, 27 of 36 nests whose clutches survived to hatch were located within 300 meters distance of another sampled nest. Most nests were at least 500 meters from another known nest in marsh canal habitats during 2000 and 2001. The majority of sampled hatchling individuals were never observed more than 300 meters away from their natal nest. For example, only 12 out of 600 hatchling captures took place outside the 300-meter nest radius in 2000 marsh interior habitats. Furthermore, A general trend of spatial dispersion was measurable over time during both years in marsh interior habitats (Fig. 4). Sample sizes regarding hatchling recaptures were not large enough in marsh canal habitats to reveal spatial dispersion trends. Approximately 30% of pods involved in at least 2 search events in 2000 interior habitats experienced emigration and/or immigration of marked hatchlings (Table 2). No pods sampled in other areas during both 2000 and 2001 experienced any observable emigration or immigration.

Table 2. Percentage of pods (sampled during at least 2 search events) that experienced emigration and/or immigration of marked hatchlings in each habitat and year. Note: 4 search events occurred for 2000-generation hatchlings and only 2 search events occurred for 2001-generation hatchlings.

INTERIOR 2000	INTERIOR 2001	CANAL 2000	CANAL 2001
n = 27	n = 18	n = 5	n = 3
30%	0%	0%	0%

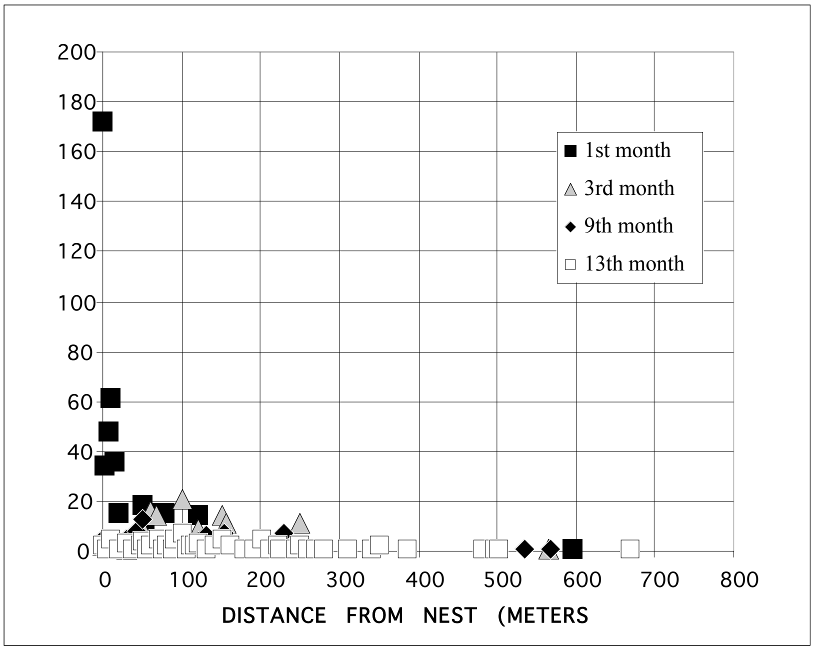

Figure 4. Marsh interior 2000-generation hatchling capture locations

The following concerns P after the 1st 3 months of hatchling life for the 2000 and 2001 dataset. The 95% confidence intervals for production per nest (values < 1 included) 3 months after hatch events averaged 7.85 alligators ± 1.49 and 4.01 alligators ± 1.51 in interior habitats (n = 36 and 35) during 2000 and 2001, respectively. For the same length of time, the 95% confidence intervals for production per nest (values < 1 included) averaged 2.68 alligators ± 2.51 and 0.69 alligators ± 0.88 in canal habitats (n = 13 and 30) during 2000 and 2001, respectively. P occurrence and habitat type were not independent during 2000 (n = 50, χ^2 = 11.5320, DF = 1, P = 0.0007) and 2001 (n = 65, χ^2 = 15.7021, DF = 1, P < 0.0001), or when both years of data were combined (n = 115, χ^2 = 31.0170, DF = 1, P < 0.0001). The frequency of observed P occurrence among nests was much higher in marsh interior habitats (72.22 %) than in marsh canal habitats (18.60 %). The odds of producing in canal habitats were 91.2% lower than in interior habitats, when both years of data are included in the analysis (Mantel-Haenszel odds ratio value = 0.0879). Estimated P occurrence frequency probability was approximately 5 times greater in 2000 than in 2001 (Mantel-Haenszel odds ratio value = 5.1973). Production occurrence and year were not independent (n = 115, χ^2 = 16.8884, DF = 1, P < 0.0001). P occurrence data (n = 115 nests; SAS Inst.Inc. 1999), controlled by year, revealed a Mantel – Haenszel odds ratio value of 0.0888. This value tells us that the odds of a nest producing hatchlings that survive for at least 3 months after birth were approximately 91.1% lower in marsh canal habitats than in marsh interior habitats during 2000 and 2001. Indeed, these data also revealed that the percentages of nests that did produce hatchlings that survived up to 3 months after birth were lower in marsh canal (38.46% and 10%) than in marsh interior habitats (86.49% and 57.14%), during 2000 and 2001, respectively. The multitude of "0" values for P in the dataset led to a skewed distribution that was not normal (n = 114, Shapiro-Wilk statistic = 0.8123, P < 0.0001). The P data (values <1 excluded) were normally distributed (n = 60, Shapiro-Wilk statistic = 0.9763, P = 0.2936; Fig. 5). Production mean (7.96 alligators) and median (7.82 alligators) values were almost identical. ANCOVA analyses on 2000 and 2001 data (n = 44 nests) where P ≥ 1 3 months after hatchling birth revealed any relationships between P and year, habitat, depredation, CS, and the year-habitat interaction (PROC GLM, SAS Inst. Inc. 1999). Given that a PS ≥ 1, habitat type did not significantly affect predicted P values (F-value = 0.39, DF = 1, P = 0.5373). Because these analyses were performed only on nests that successfully produced hatchlings on the hatch date (PS ≥ 1), the effects of total clutch mortality (P = 0) due to flooding are not considered here. Year, CS, and the interaction of habitat and year did not strongly affect predicted P values (F-value = 0.16, DF = 1, P = 0.6925; F-value = 1.30, DF = 1, P = 0.2619; F-value = 1.99, DF = 1, P = 0.1668).). Depredation occurrence did significantly affect predicted P values (F-value = 9.76, DF = 1, P = 0.0034). The above model includes a set of variables that is not highly correlated with P (R^2 = 0.3033).

The following results concern P after the 1st 13 months of hatchling life for the 2000 dataset. The 95% confidence interval for production per nest (values < 1 included) 13 months after hatch events averaged 2.42 alligators ± 0.46 in interior habitats. The 95% confidence interval for production per nest (values < 1 included) for the same length of time averaged 0.83 alligators ± 0.78 in canal habitats. P occurrence and habitat type were not independent for during 2000 (n = 50, χ^2 = 9.7170, DF = 1, P = 0.0018). The frequency of P occurrence was much higher in marsh interior habitats (78.38 %) than in marsh canal habitats (30.77 %). Indeed, the odds of producing hatchlings that survive for at least 13 months after birth in canal habitats were 87.7% lower than in interior habitats (Mantel-Haenszel odds ratio value = 0.1226). These data also revealed that the percentages of nests created during 2000 that produced hatchlings that survived up to 13 months after birth were lower in canal (30.77%) than in interior habitats (78.38%), respectively. The multitude of "0" values for P in the dataset led to a skewed distribution that was not normal (n = 49, Shapiro-Wilk statistic = 0.9297, P = 0.0060; Fig. 6). The P data (values < 1 excluded) were normally distributed (n = 33, Shapiro-Wilk statistic = 0.9677, P = 0.4185; Fig. 7). Production mean (2.88 alligators) and median (2.74 alligators) values were almost identical. ANCOVA analyses on 2000 data (n = 44 nests) where P ≥ 1 13 months after hatchling birth revealed any relationships between P and habitat, depredation, and CS (PROC GLM, SAS Inst. Inc. 1999). Most nests involved in these analyses came from the interior (n = 27 observations used) because many nests in canal habitat (n = 4 observations used) had P < 1 or missing values for at least one of the variables in the model. Furthermore, P in canal habitats could only be analyzed when combined with interior habitat data, as only 4 canal nests were suitable for these analyses. Results showed that, given a nest produced hatchlings on the hatch date, habitat type did not significantly affect predicted P (n = 31, F = 2.12, DF = 1, P = 0.1573). Because these analyses were performed only on nests that successfully produced hatchlings on the hatch date (PS ≥ 1), effects of total clutch mortality (P = 0) due to flooding are not considered here. Depredation occurrence and CS did not significantly affect predicted P values (n = 31, F = 2.60, DF = 1, P = 0.1187; n = 31, F = 1.80, DF = 1, P = 0.1907). The above model includes a set of variables that is not highly correlated with the P values from this study (R^2 = 0.1971).

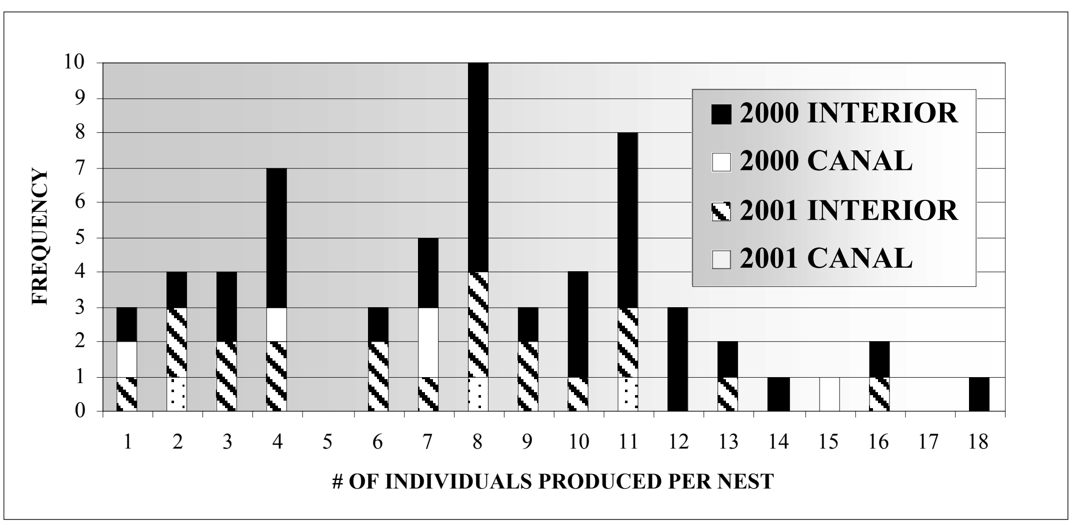

Figure 5. Positive production (P ≥ 1) rounded to the nearest whole value and frequencies, 3-months post hatch time in marsh canal and marsh interior habitats during 2000 and 2001 (n = 61 nests).

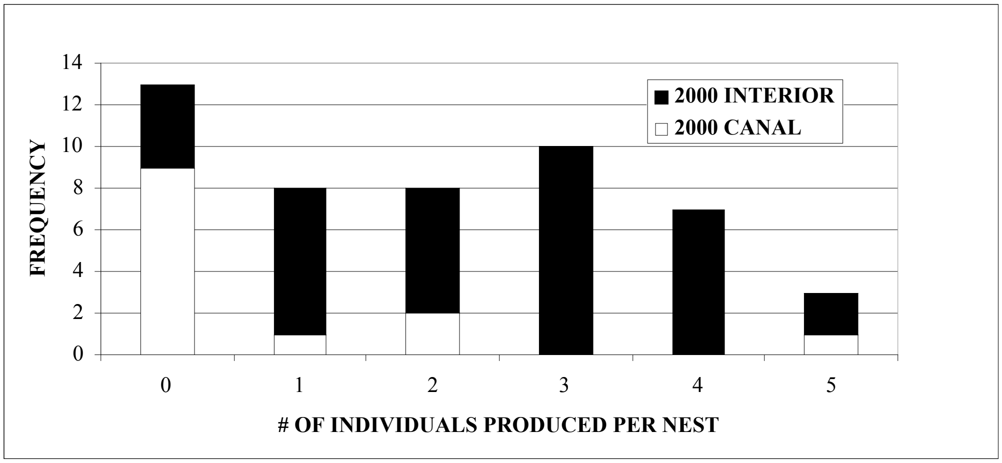

Figure 6. Production values rounded to the nearest whole value and frequencies, 13-months post hatch time in marsh canal and marsh interior habitats during 2000 (n = 49 nests).

At LOX NWR during incubation periods (late June through mid-September), water levels ranged approximately 0.22 and 0.41 m in marsh interior habitats and 0.69 and 0.62 m in marsh canal habitats during 2000 and 2001, respectively. However, during the 2 months preceding incubation, water levels ranged approximately 0.28 and 0.24 m in marsh interior habitats and ranged approximately 0.85 and 0.94 m in marsh canal habitats during 2000 and 2001, respectively (Fig. 8). Lower elevation along marsh canal habitats as compared to sampled marsh interior habitats also contributed to the vulnerability of canal clutches to these water level fluctuations. Though water levels fluctuated significantly in marsh interior habitats, no nest flooding occurred during this study. However, water level fluctuations did result in massive clutch flooding in marsh canal habitats during 2000 and 2001.

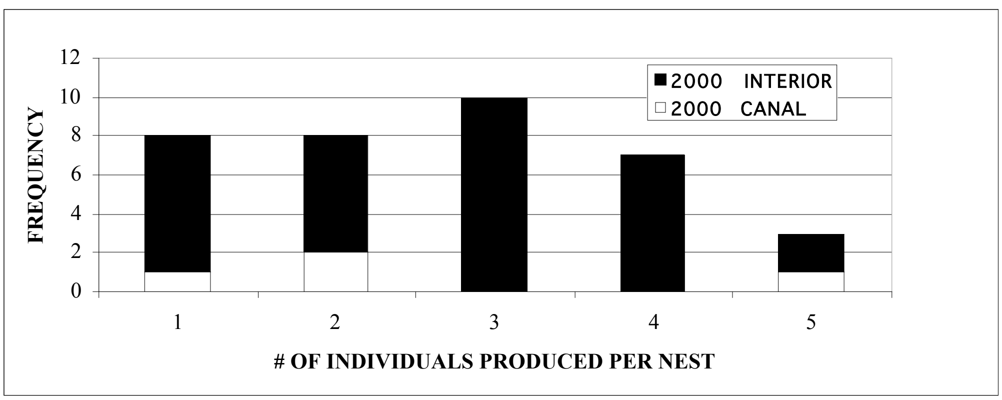

Figure 7. Positive production ($P \geq 1.0$) rounded to the nearest whole value and frequencies, 13-months post hatch time in marsh canal and marsh interior habitats during 2000 (n = 36).

DISCUSSION

Results from this LOX NWR study agree with information from other studies in that hatchling pods usually stay within 200 to 300 meters from their natal nest site during the 1st year of life (Deitz 1979) if adequate pools of water are available (Woodward *et al.* 1987). Furthermore, during 2000 in marsh interior habitats, 27 of 36 nests whose clutches survived to hatch were located within 300 meters distance of another sampled nest. This is no surprise, as Rice (1992) found the spatial distribution of nests (n = 591) on Lake Okeechobee to be non-random, with a mean nearest-neighbor distance of 145 meters. This is an important fact because it means that an observer's chances of locating a hatchling that emigrated to another local pod were probably high because most other local nests and respective pods were also sampled during mark-recapture events. Hatchling movement patterns may have varied with the different hydropatterns of 2000 and 2001. Emigration and immigration probably occurred at lower rates in marsh canal habitats due to the fact that observable nests were usually separated by distances greater than expected hatchling dispersal distances common during the 1st year of hatchling life. It is important to note however that each hatchling individual's survival probability estimate was not compromised by the hatchling's adoption of another pod, as these estimates were considered independent during data analyses. This is significant in MHS estimation, as emigration of hatchlings away from natal pods occurred as early as 3 months after respective hatch dates during this LOX NWR study. This fact has been overlooked in previous studies where hatchling dispersal from a natal pod was assumed to occur only after 1 year had passed since respective hatch dates (Deitz 1979; Woodward *et al.* 1987). Furthermore, because most nests were located in sampled areas, the probability of locating any emigrated hatchlings was high in these habitats due to the fact that all observed nests and respective pods were sampled within sampled areas. It is important to remember that the suspicion that hatchlings may emigrate to other local pod groups during their 1st year was verified during this LOX NWR study. That is, hatchlings located in any one pod may not be automatically assumed 'siblings' after the initial capture event.

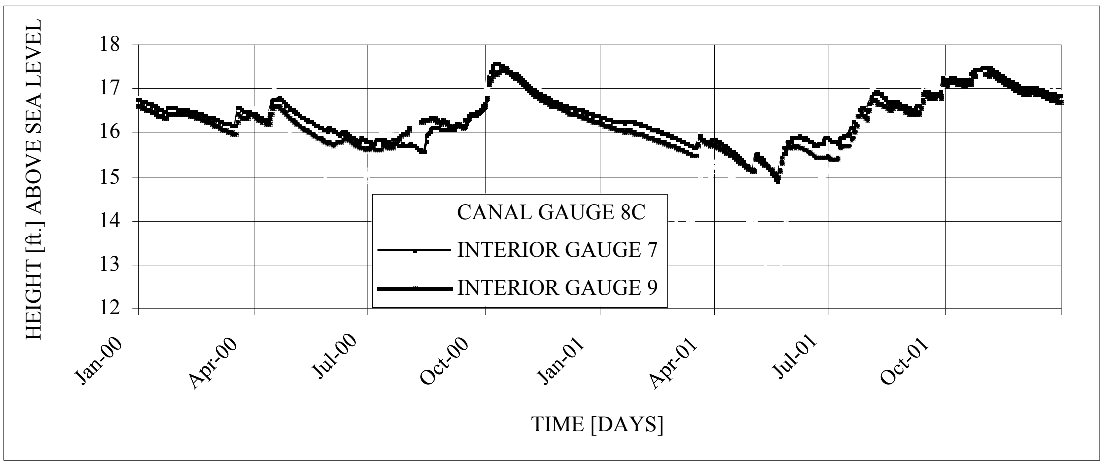

Figure 8. Stage gauge water levels at A.R.M. Loxahatchee NWR (January 2000 to December 2001)

During the 1st time interval during 2000, water levels were high both in marsh interior and marsh canal habitats. While these environmental conditions may have facilitated hatchling recapture, the point estimate of MHR probability for this LOX NWR study was lower during the 1st time interval than during subsequent intervals. These results are in contrast to Jolly-Seber (JS) estimate results experienced at Orange Lake, Florida by Woodward *et al.* (1987). That is, these results are in contrast to field observations where alligators became more difficult to capture with increasing age. This difference may be due to the fact that, during this LOX NWR study, airboats were used on an almost daily basis in study areas from June to December during both years of the study. Hatchling avoidance behavior therefore may have occurred at lower frequencies during the 3rd and 4th search/recapture events during this LOX NWR study, as hatchlings were not always hunted for capture when an airboat was in their general habitat area. The relatively lower MHR probability estimate for the 1st time interval therefore may be explained by a heightened awareness and avoidance of the airboat by hatchlings during the 2nd search/capture event, when compared to the 3rd and 4th events. In similarity to results from the north-central Florida study by Woodward *et al.* (1987), statistical evidence that MHR probability varied with time and/or age was revealed during this LOX NWR study. Hatchling observability and resulting MHR probability may have been lower in canal habitats, where nest areas completely dried up during the spring of 2001. However, due to small canal mark-recapture sample sizes, these differences between habitats could not be explored.

Again in contrast to results from the study by Woodward *et al.* (1987), this LOX NWR dataset was best supported by the statistical model [$\phi(.)\ \rho(t)$], which did not include survival probability variation with age and/or time. Specifically, this mark-recapture study did not reveal seasonal hatchling mortality variability. This may be explained by the relatively stable environments of marsh interior habitats at LOX NWR when compared to the more northern habitats studied by Woodward *et al.* (1987). Another cause for these results may be the fact that LOX NWR marsh interior habitats are comprised of many deep, open-water sloughs that may be easily accessible throughout the year to adult male alligators acting as predators. That is, Woodward *et al.* (1987)

hypothesized that higher hatchling survival during the first few months of life may occur only in habitat types that provide substantial sanctuary habitat such as many small pools and alligator trails. Again, these habitat types are infrequently used by large male alligators (> 1.8 m total length) (Goodwin and Marion 1978).

Cannibalism may be a major cause of mortality in alligators. Nichols *et al.* (1976) considered cannibalism to be a major density-dependent factor in alligator populations, representing estimated rates of 2-6% of annual mortality for some populations. Cannibalism was documented via alligator regurgitation and stomach content analysis by Chabreck (1996) in Louisiana and Delany and Abercrombie (1986) on Orange Lake, Florida, respectively. However, this evidence only concerned known cannibalized alligators of sizes larger than hatchlings; specifically 1.2-1.5m total length (Chabreck 1996). These larger size classes were likely exposed to different cannibalism pressures. Namely, density-dependent related factors such as territoriality may account for some of the cannibalism on alligators in the 1.2 to 1.5m size class. Hatchlings are probably not cannibalized because of any threat to an adult male's territory. It still remains to be seen whether the majority of hatchling mortality is definitely due to cannibalism. Seasonal stress due to lack of water and food resources may also be a constituent element of hatchling mortality at LOX NWR.

Previous mark-recapture studies have produced survival rate estimates for young age classes of crocodilian species including the American alligator (Deitz 1979, Messel *et al.* 1981, Temsiripong 1999, Woodward *et al.* 1987; Table 3). However, many of these previous studies used the Minimum-Known-Alive (MKA) survival rate estimator. This MKA estimation method is popular among crocodilian researchers largely because of its ease of use with elusive crocodilian species. Unfortunately, MKA estimates are biased (Nichols and Pollock 1983). Woodward *et al.* (1987) used both the MKA and JS estimators. MHS probability estimates for the 1^{st} 6 and 13 months of life for 2000-generation hatchlings of this LOX NWR study were computed in program MARK using the CJS model. The CJS model is different than the JS model. That is, in addition to the apparent MHS and MHR probability estimates of the CJS model ('recaptures only' model), the JS model allows estimation of the population size at the start of the study, plus the rate of population change (λ) for each time interval. It can be difficult to get numerical convergence of the parameter estimates when using the JS model (White and Burnham 1999).

Table 3. Alligator survival estimates for the 1^{st} 6 and 12 months of life

AUTHORS	FLORIDA REGION	LOCATION	ESTIMATE TYPE	AFTER 6 MONTHS	AFTER 12 MONTHS
Woodward *et al*. (1987)	North-central	Orange Lake	JS	76%	41%
Woodward *et al*. (1987)	North-central	Orange Lake	MKA	53%	19%
Deitz (1979)	North-central	Orange Lake	MKA	52%	35%
Deitz (1979)	Central	Lake Griffin	MKA	47%	30%
This study (2002)	South (Everglades)	LOX NWR	CJS	44%	20% (after 13 months)

Variation in MHS and/or MHR probabilities between pods may have existed during this study. Indeed, effects of PS, which often comprised observable values unique to each pod group, were explored with respect to MHS and MHR estimates in models that included PS as an individual covariate. However, while the use of 'PS' covariates in MHR estimation makes sense with respect to hatchling observability in the field, the data did not support this hypothesis. The lack of independence of hatchling fates violates the assumptions of the underlying multinomial distribution and thus leads to biased estimates only of variance, and not of the point estimates of MHS and MHR probabilities (Williams *et al.* 2002). The PS covariate was therefore not included in models used in parameter estimation results. Estimated variances and subsequent confidence intervals were not used when MHS point estimates were used in equations to calculate P and 6 and 13-month MHS estimate values specific to each nest in the dataset.

Aspects of this study's design may have lead to some of the unexpected results and parameter heterogeneity (Williams *et al.* 2002). Mark-recapture sampling methods covered the marsh interior population with adequate homogeneity. The duration of mark-recapture periods (generally ~ 2 weeks) were short relative to the time interval over which MHS was estimated. This should have helped reduce the probability of mortality during mark-recapture periods and subsequent heterogeneity of MHS estimates among released hatchlings (Williams *et al.* 2002). However, the few available hatchling pods in marsh canal habitats that were used during the mark-recapture study may have given rise to some parameter heterogeneity, partly by virtue of respective small sample sizes and partly due to the apparently lower hatchling observability in these thickly vegetated and periodically dry marsh canal habitat sites. The unknown probability of hatchling pod cannibalism by larger alligators may have also added to parameter heterogeneity as well.

Future study methods should eliminate the need to set or fix MHR probability estimates for the last time interval for the purpose of computing a sound MHS estimate for the last time interval. Rather than compromising the power of desired parameter estimates with the above methods that include more assumptions in the estimation process, it is better to perform a mark-recapture fieldwork event for an additional time interval. Again, estimates for both MHS and MHR are not estimable for the last time interval. Thus, if one wants parameter estimates for a specific time interval, it is better to perform mark-recapture fieldwork and parameter estimation on one more time interval than is desired for usable parameter estimates, so that parameter estimates for the desired (no longer the 'last') interval may be calculated.

Analyses of data representing P sustained after the 1st 3 and 13 months of hatchling life showed marsh canal habitats to be greatly inferior to marsh interior habitats at LOX NWR with respect to P. Prior to the water management practices that have occurred in concert with increased nest flooding in the Everglades, a predictable correlation occurred between the increment of water level rise during the incubation period and water level at the time of nest construction (Kushlan and Jacobsen 1990). This is no longer the case. The hydropattern has changed in the Everglades. In agreement with Kushlan and Jacobsen (1990), these results suggest that preservation of healthy alligator P in marsh canal habitats at LOX NWR depends on the restoration of more predictable hydrological fluctuations in these habitats. Alternately, compensatory management methods such as island or spoil plot construction in marsh canal habitats could provide nesting sites protected from flooding. However, resulting P trends may not change much from the present, as cannibalism by the dense population of large adult male alligators is expected to result in extremely low MHS in these marsh canal habitats. The observed difference between P sustained after the 1st 3 and 13 months at identical nests indirectly revealed the substantial effects of MHS on P. That is, low MHS can significantly reduce P over time, as more and more hatchlings are eliminated from the population.

One may be interested in the sustainability of populations and/or harvest of adult alligators and eggs in canal habitats. Therefore, attention must be focused on sustaining population age structure. Kushlan and Jacobsen (1990) found that Everglades nest flooding changed the size distribution of juvenile alligators (total length < 1 m) over a period of 7 years. High clutch mortality due to nest flooding can and has been an important determinant of population age structure when flooding is repeated such as it is in marsh canal habitats at LOX NWR. Models of crocodilian populations have shown that variables reducing survival of young alligators have a greater effect on long-term population sizes and stability than do variables detrimental to adult survival (Nichols *et al.* 1979; Blomberg *et al.* 1982; Rice 1996).

Considering data where P ≥ 1 after the 1st 3-months of hatchling life, clutch depredation was shown to be the only tested variable that significantly affected P. Depredation effects on P were therefore in reflection on PS. That is, P is initially dependent on PS, and subsequently dependent on MHS. Thus, flooding is the first and apparently the greatest obstacle in canal habitats in achieving high P because of it's detrimental effects on CF proportions. While flooding is not a threat in interior habitats at LOX NWR, depredation has been shown in this study to significantly affect resulting PS. However, as depredation does not always mean the death of all individuals in a clutch, MHS is still a factor in achieving high P in interior habitats.

Kushlan and Jacobsen (1990) found that the rise in water level during incubation has been the major cause of clutch flooding in Everglades National Park (ENP). Further analyses from this Kushlan and Jacobsen (1990) study found a correlation between high water levels that flooded clutches during incubation and water level conditions prior to clutch incubation, when nest construction took place. Kushlan and Jacobsen (1990) also concluded that the percent of clutches lost to flooding was dependent on clutch elevations and on maximum water depths during the incubation period. This is certainly true in sampled areas at LOX NWR where elevation is higher in marsh interior habitats both due to general marsh elevation and the increased elevation of tree islands, which were the most common locations for alligator nesting in these habitats. Also, incubation water levels ranged on average approximately twice as much in canal habitats than in interior habitats, when considering data from the last 10 years (Chopp unpub. data). Canal nests were subjected to a larger range of water levels during clutch incubation, and were thus more susceptible to clutch flooding pressures than nests in the interior habitats at LOX NWR.

CONCLUSION

Everglades alligators produce relatively small clutch sizes and reduced nesting effort when compared to other populations in north Florida and Louisiana (Kushlan and Jacobsen 1990). These traits result in lower annual baseline reproductive potential for Everglades populations when compared to other populations. High clutch mortality due to nest flooding can and has been an important determinant of population age structure when flooding is repeated such as it is in marsh canal habitats at LOX NWR. The greatest risk to canal nests at LOX NWR was shown to be flooding. Egg position within the clutch is known to significantly affect the predicted probability of an egg being flooded in canal habitats at LOX NWR (Chopp unpub. data). Therefore, even a small change in elevation could mean a significant annual decrease in flooded alligator nests, especially during years like 2000 when all nests are not completely flooded. No flooding occurred in interior habitats, and none of the nests in interior habitats were constructed of the poor nesting materials that were used in canal habitat nests (Chopp unpub. data).

The survival of an alligator clutch to its hatch date may be the most important factor regulating production in Everglades marsh canal habitats similar to those at LOX NWR. However, because Everglades water levels are largely controlled by human water management practices, the opportunity exists to sustain high clutch success rates on an annual basis. Interior habitats provide better conditions for clutch survival via protection from fluctuating water levels on tree islands. However, the plentiful tree islands that comprise the landscape of interior habitats may facilitate increased mammalian predatory pressures during drought years. Also, in Everglades canal habitats lacking a multitude of elevated tree islands, flooding could be responsible for long-term population sustainability problems via clutch mortality. Marsh canal habitat at LOX NWR represents a population sink, reproductively speaking. That is, due to low values of CF and PS in canal habitats and overall low MHS at LOX NWR, canal habitats exhibited biologically insignificant P levels during 2000 and 2001. The building of spoil mounds on the interior side of marsh canal habitats to facilitate reproductive success could be considered as an alternative to the changing of current water management schedules. This alternative could significantly reduce flooding pressures on alligator nests in canal habitats at LOX NWR.

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Images of the American Alligator from Travels in Louisiana and Florida

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Good afternoon ladies and gentlemen of the Crocodile Specialist Group. It is a pleasure to be here with my photographs. I had the delightful time of being able to spend many days over the last two years looking for the American Alligator. Travels to do a book and an exhibit, and I must say in spite of this cartoon, my luggage and equipment was much more than the alligator carries. Being able to swim with ease and wade thru the muck, eating about anything it wants. Remarkable creatures, perhaps better designed than a stealth bomber. In my travels I must carry and/or wear boots, raingear, mosquito repellant, cameras, tripods, ice chests of food. That's not me but you get the "beast of burden" point. That's what we photographers are. Oh well. I did not suffer too much and became smitten with this interesting reptile.

I wanted to see more than I had seen over the last 30 years of my photography. In the past I had photographed a few hunts and the occasional alligator laying on a bayou's edge, and swimming or resting in a duckweed covered pond.

On this project I planned to see more alligators in the wild, to visit attractions, travel with biologists and learn about the industry. All in all I took thousands of photographs and at least broke the surface of alligator imagery. What comes first? Dangers.

How many fisherman have looked up ahead to ask their partner is that a log or a gator. Maybe they think they'll be swamped and eaten. Fear of alligators, snakes, spiders, bears and sharks is often fueled by the media, especially tabloids.

Most every conversation I have about alligators leads to the dangers. And dangers there are. For a wide-open mouth with big teeth that can chomp down with up to 3000 pounds of pressure per square inch. That's formidable.

In my book I tell a story of Kermit George at this pond in July of 1986. While swimming, a 550-pound American alligator ripped his arm off. Last summer while looking at this sign with him he commented, "Who molested who?" and also said, "The gator got my arm, I got away. It was a good trade." Kermit gave me this picture taken after the sheriff shot the guilty gator.

People want to hear these stories, but I tried to even it out, explaining how more people die on the highways a couple of hours into New Years morning than ever by alligators. Breast cancer, lightening, car crashes into white tail deer, even mosquitoes these days are much more dangerous than alligators. In a lecture by John Stossel, he had some figures in a way I have never heard before. They were for hours or days taken off an average life by various dangerous activities. Flying deaths average out to 1 hour off your life, fire 18 hours, murder 113 hours, driving 182 hours, and smoking 5 years. I imagine if you figured out the 12 alligator deaths in U.S. history, it would be a few seconds off the average life or maybe even less.

Now we got the scary part out of the way, let's see what the average tourist gets to see at alligator attractions. Gleeful passengers on an airboat tour near Orlando. Annie Miller learned to catch reptiles from her parents, who trapped alligators in the 1930s, and was one of the first to start wildlife tours in Louisiana. Here in 1984, then in 2001. Annie's the same. The gator just got bigger. Here's Rob, a New York City firefighter who was at the World Trade Center disaster, holding an alligator on a swamp tour during a visit to Baton Rouge. Remember all the media last summer about shark and gator attacks? George Burgess of the International Shark Attack Files said the calls that kept him totally busy stopped on 9/11.

Here's Jim Ragland with Alligator Bayou Tours, and a quite active female near her nest.

Bruce Mitchell of Kleibert's Alligator Farm does the same. He told me the story of being dragged into the pond by a similar size alligator 10 years ago and escaping with only 73 stitches. He's still out there barefoot with cell phone attached. A full boat at Honey Island Tours views a gator. A jet ski shares an alligator tour. Cajun Pride Tours does a feeding show and then lets the kids touch a hatchling. The same is done at Jungle Adventures in Florida, where kid friendly signs draw in the tourist. The feeding show at Gatorland is fun to watch. They even have an American Crocodile Jumping here. Jungle Adventures feeding show and hungry reptiles waiting at St. Augustine's Alligator Farm for a whole nutria. Wide open for a big bite. The show gets out of hand at another farm where the gators take over the bucket of chicken. A big leaper at the Audubon Zoo. Tim Williams at Gatorland trained wrestlers there to educate the crowd as they entertained them. Kids get to pose as wrestlers too. A Wakulla Spring kids jump and swim while 500 alligators inhabit the next 4 miles of river.

There's even an alligator bed and breakfast in South Louisiana where you can feed juveniles below your deck. In Lake Charles you can view 70 gators on the geaux. That's GEAUX. Such as the irrigator and the litigator. Florida tourist stops attract you with signs saying 13-foot alligator; not telling you it's stuffed. Fried alligator at festivals and restaurants that have cutouts to photograph your kids. There's alligator objects everywhere, and some of the tours pretty sunsets too.

Before we go on I just hope the LSU Tigers do better next weekend against Florida. As you can see the score was not favorable to a tiger fan. So I used another picture without the scoreboard for my book. All this tourism, knick knack and mascot stuff draws attention to the American alligator and educates some. But more important in making this animal the good citizen of the wetlands are all the biologists that helped bring the population from a low of about _ a million in the 60s and 70s to over 3.2 million today.

Biologists study reproduction, courtship, feeding habitat, effects of drought and many other serious scientific studies. In the 70s I got to meet Ted Joanan at Rockefeller Refuge where he and others started the studies expanded on by many today. I enjoyed his stories of research in pens such as this one with the very large Jimmy. More recently I spent time with Noel Kindler doing the aerial surveys and Dr. Ruth Elsey with her associates marking nests via helicopter too. Airboats and helicopters are important tools in alligator research. Ted told me part of the reason for the decline of alligators was the marsh buggies that allowed post WWII oil and survey workers the chance to get into the dense marsh nesting area. Very hard to get to before these machines.

Once the nest is marked the airboat finds it to catch the female, for various studies or egg collection. Some mother gators were very aggressive when the eggs were taken. Caught females are secured, measured, tagged, and sometimes implanted with a chip for telemetry studies. The same goes on in Florida where our host Woody Woodward collected eggs after taking accurate measures of the nest. Hot work in the Florida sun as Walt Rhodes helps Woody with passive traps. Part of the work they are doing also has to do with an alligator die off.

Nighttime work was cooler in spite of marsh burning behind these Rockefeller biologists. A little more difficult due to the darkness, but more alligators to catch for Dr. Elsey's research.

Smaller alligators can be caught and loaded into the boat. Larger ones require research done on the bank. Again data collection including blood work, sexing and other measurements. Night catching starts as stealth and ends up as Helter Skelter. Baby Alligators pop out of their shells so fast it would be better shown on video. The egg tooth helps them break the shell. If they can survive an onslaught of predators such as this garfish below or a heron's beak that they share the wetlands with they grow to be a valuable part of the ecosystem. Some end up hunted. I got to go on a few hunts in the early 70's and again last year. People wise it has changed some. Garland Richard was a trapper fisherman that made most of his living off the land. He would skin and salt his own hides. Use blackbirds for bait and even go to the trouble to make sure the alligator was dead so he could reach in the mouth and retrieve his hook. Last year I went on three good hunts, the men all had regular jobs but loved the wetlands. One was a retired storeowner, another a clerk of court and this man was a port president, but like Garland he wasted nothing. His bait was the carcass of Coots he had breasted for Gumbo the fall before. The hunting is the same. An alligator is hooked and shot. Then taken to a processing house where the meant and the skin are taken. And the skins are off to market for a boot or some a whole mount.

Good citizens of the wetland, sharing there home with lots of other wildlife. Helping to keep marsh and swamp wild. A habitat for all. I am fascinated by these creatures and will continue to photograph them. Thanks and Good Afternoon.

LOUISIANA'S WILD ALLIGATOR HARVEST PROGRAM

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ABSTRACT: The Louisiana Department of Wildlife and Fisheries initiated its current wild alligator management program in one parish in 1972. The program was expanded to nine coastal parishes in 1979 and opened statewide in 1981. Since the progam's inception, over 569,500 alligators have been harvested averaging 7.14 feet in length. Since 1990, an average of 28,336 alligators have been harvested annually.

The alligator in Louisiana is managed as a commercial species and the regulations developed since the 1970's were promulgated to provide for a long term sustainable harvest of wild alligators. A relatively complex application procedure provides that only people who own land or lease land that is considered alligator (wetland) habitat can qualify for alligator harvest tags on an annual basis. Limited areas of public land are allocated tags on annual basis and these are distributed either through a bid or lottery system. Revenue generated from the harvest and sale of wild alligators is shared by the landowner and the harvester, thereby encouraging both parties to protect and enhance wetland habitats and the alligator population.

Harvest quotas are established on over 50 individual areas that are based on a combination of political (Parish boundaries), land ownership and habitat delineations. The primary data input into development of harvest quotas is an annual coast wide alligator nest survey. Secondary data factors include various harvest parameters including average length, size class frequency distribution, sex ratios and hunter success.

Population Monitoring and Quota Establishment Considerations for Achieving Sustainable Harvests of American Alligators in Florida

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ABSTRACT: Wildlife managers often struggle to develop effective techniques for achieving sustainable harvests of wild populations. This is especially true with crocodilian management, given the vulnerable history of many of the species. The Florida Fish and Wildlife Conservation Commission's approach to managing hunted American alligator (*Alligator mississippiensis*) populations includes monitoring population trends, establishing harvest quotas, and determining when areas should be added, dropped or reestablished as hunt areas. Guidelines and procedures were compiled into a protocol that serves to remove much of the subjectivity of decision-making. The protocol is quantitatively based, but allows for decisions that may have administrative, political, economic, or biological implications. Examples of population trends following the initiation and, in some cases, discontinuation of harvesting are provided. The protocol continues to evolve as circumstances change and as knowledge is gained. As a result, Florida has successfully managed a sustainable harvest of wild alligator populations that involves public participation and support.

Key words: *Alligator mississippiensis*, Florida, population trends, quotas, sustainable harvest.

Effect of Sustained Cropping on Wild Population of *Caiman crocodilus* (Baba) in Venezuela

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ABSTRACT: Venezuela's commercial caiman use program begins in 1983, allowing the harvest of wild mature males with a total length superior to 1.80 m (class IV males), inhabiting private lands. Currently, approximately One Million hectares are included in the program, distributed throughout several ecological regions, but not the entire areas are under harvesting. Surveys of wild populations have been carried out in three opportunities on each ecological region, to estimate density values and size classes. In areas with crops the abundance and percentage of class IV individuals resulted higher than in not harvested areas. A total of 1,139,832 animals have been harvested since 1983 up to 2000, and approximately 96.23% of the total skins produced have been exported to the international market.

RESUMEN: El programa de aprovechamiento comercial de la baba se inicia en 1983, permitiéndose cosechar individuos que conforman la clase IV, con una longitud total superior al 1,80 mt, representados únicamente por machos adultos, en tierras de propiedad privada. El área de implementación es aproximadamente Un Millón de hectáreas, divididas en regiones ecológicas, pero no toda la superficie se cosecha el recurso. Se han censado en tres oportunidades cada región ecológica, para estimar valores de densidad y clases de tamaño. En las áreas bajo cosecha las abundancias y proporción de individuos de la Clase IV resultaron superiores que en áreas sin cosecha. Se han cosechado un total de 1.139.832 animales desde 1983 al 2000 y se han exportado al mercado internacional aproximadamente el 96,23% de las pieles cosechadas.

Introduction

The program of Commercial Use of Baba (*Caiman crocodilus*) in Venezuela begins in 1983, allowing the harvest of wild mature males with total longitude (Lt) higher to 1.80 m, grouped as class IV of size (Ayarzagüena 1983). The harvest can be done on private properties located in seven Ecological Regions, characterized by their abundance and structure of the population sizes (Velasco & De Sola 1999).

Since 1995 the Ministry of Environment and Natural Resources (MARN), through the General Direction of Fauna, signed a cooperation agreement with the Central University of Venezuela, Faculty of Sciences, Coordination of Extension. This agreement is the scientific framework to carrying out the monitoring of the Baba populations in the different ecological regions by the University staff.

These monitoring has as main objective the evaluation of the wild population status, subjected or not to annual crops. The abundance, structure of sizes and habitat type was evaluated, recommending on this basis the yearly harvest on each ecological region. The results are reported to MARN, which take the final decision to offer harvest permissions to land owners on legal and technical basis.

The whole seven ecological regions have been evaluated in three consecutive opportunities (Velasco & Ayarzagüena 1985; UCV-IZT-MARNR 1995, 1996; UCV-MARNR 1998, 1999; UCV-MARN 2000, 2002). There are remarkable variations in the results of monitored land and water surface (table 1).

Table 1. Land (in hectares) and water (in % of land) surfaces monitored in each ecological region

Ecological region	1st census Land surface (ha) (water surface in %)	2nd census Land surface (ha) (water surface in %)	3rd census Land surface (ha) (water surface in %)
Alto Apure	251,460.26 (0.63)	104,143 (0.63)	322,211 (0.08)
Bajo Apure	78,174 (1,85)	68,198 (1.81)	91,533 (2,99)
Cajón de Arauca	61,945.66 (0.27)	22,391 (0.12)	30,632 (0.08)
Aguas Claras	172,180.85 (0.69)	91,545 (0.23)	87,830 (0.12)
Llanos Boscosos	193,873 (0.24)	125,515 (0.22)	117,840 (0.07)
Hoya de Arismendi	95,154 (2.58)	97,320 (0.30)	131,322 (1.40)
Guárico	69,297.14 (0.22)	288,420 (*)	114,805 (0.16)

(*) No available data

The water surface varied in each census, indicating the grade of savanna flooding and the permanence of the sheet of water in each ecological region. This variation indicates how dried or flooded each ecological region is, affecting the observation of individuals at the moment of census and the results of abundance estimations (figure 1).

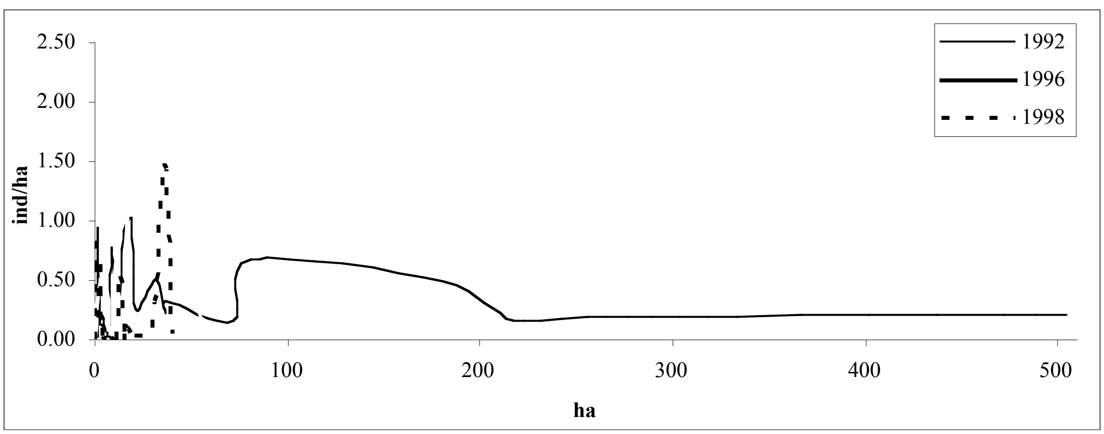

Figure 1. Net density versus aquatic surface

This figure summarizes, for one of the ecological regions, the results of density (ind./ha of land) obtained in the three censuses carried out, related to the water surface in hectares of the observed water bodies. The small water surfaces show high variability in density values, and the increasing of aquatic surface stabilizes the density value. The density is very affected by the extension of the aquatic surface, because the Baba populations are more or less dispersed, depending on the magnitude of the water body.

Population trends

The density (figure 2) was similar between the first and second census for all the ecological regions, with the exceptions of Cajón Arauca and Hoya de Arismendi, with relatively low values in comparison to the previous census, probably related with a decrease of flood level on the savannas (table 1).

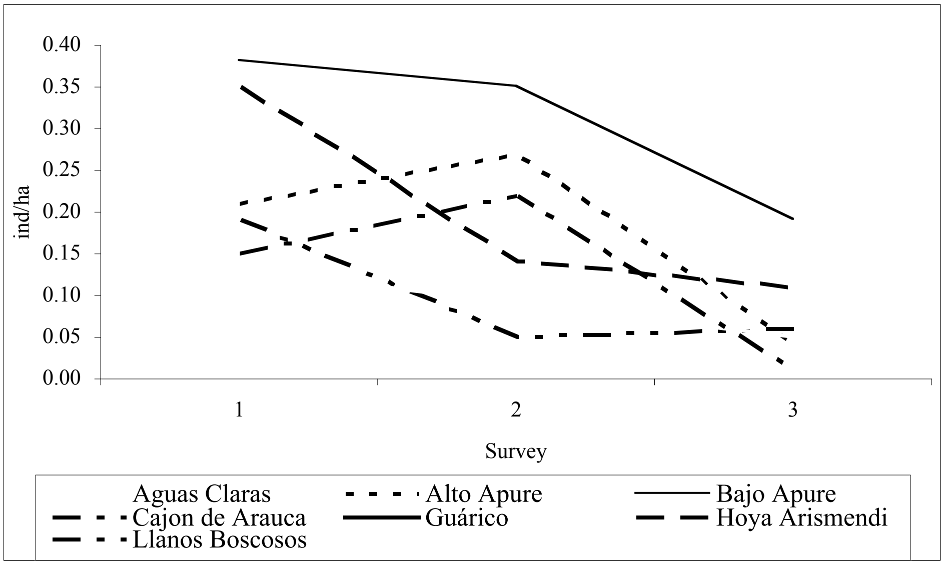

Figure 2. Net density in ecological region

The third census in all the ecological regions were affected by El Niño and La Niña Phenomenons, which influenced in the periods of rain and drought in Venezuelan Llanos, producing high levels of flooding in Bajo Apure and severe droughts in other regions (table 1). Both extreme weather conditions produced a general decrease in the densities for all ecological regions observed in the third census.

However, the percentage of class IV individuals in general increased in time (figure 3), probably related with the fact that the maximum annual crop represents 20% of the individuals of the class IV for each ranch/farm participant in the program (De Sola *et. al.* 2000). This amount possibly is lower than the rate of recruitment of class III males to the class IV (Velasco *et. al.* 1994), which favors the class IV proportion in relation to the whole population.

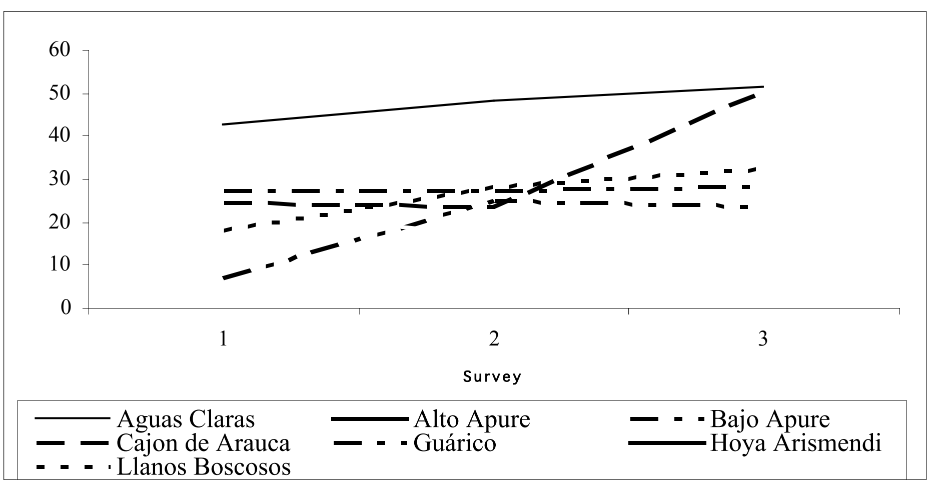

Figure 3. Percentage Class IV

Harvest effect

In general, the obtained results allow three observations: the first one is that the density of individuals per hectare of land was superior in the areas with crop (figure 4). This result points out that the program is being implemented in those areas where the populations are more abundant, which guarantees to obtain the resource with a smaller effort. Equally, it is a clear demonstration that the controlled activity of extraction is not currently reducing the total densities of individuals.

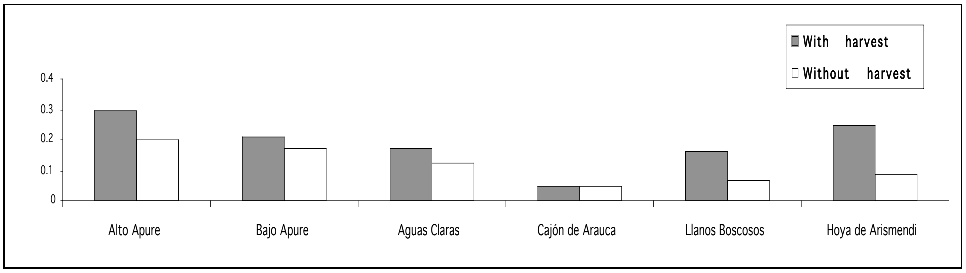

Figure 4. Density in ecological region with or without harvest

The second observation is that the proportion of individuals belonging to the Class IV was higher in harvested areas, with more than 18% of the total population (figure 5). This result is an indicator that the harvested quantity of mature males is not affecting its proportion inside the population. Equally, the recruitment of individuals of lesser sizes is favored, diminishing the intraspecific pressure with several consecutive crops (Nichols *et al.*, 1976; Craig *et al.*, 1992; Velasco & Ayarzagüena, 1995; Velasco *et al.*, 1994).

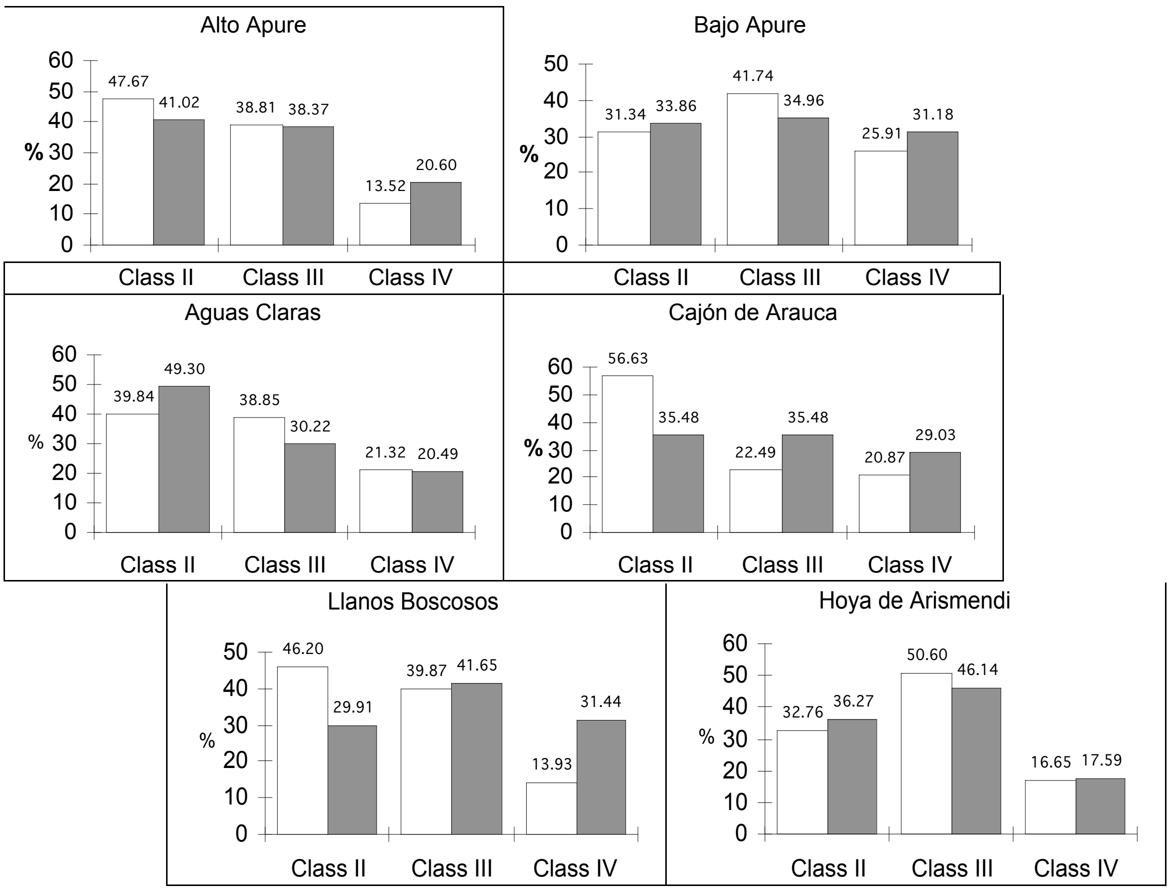

Figure 5. Size class histogram for ecological region in areas with or without harvest. Closed bars with harvest. Open bars without harvest.

The third observation is that the histograms in harvested areas of most of the ecological regions tend to reach the pyramidal form, indicator that the populations maintain a condition near to the composition of sizes corresponding to not harvested populations (Velasco & Ayarzagüena, 1995).

None of these results was presented in the Aguas Claras region, where the gross density and the proportion of Class IV are smaller in harvested areas in comparison with those not harvested, while the histogram has staggered form with higher proportion of the smallest sizes. These results can be related with the fact that in this region the censuses were practiced one year after the last crop (Thorbjarnarson & Velasco, 1999).

Caimans harvest

The calculation of the assigned crop for each ranch/farm take into account the total population, estimated with a multiplication of the land surface of the property (in ha) and the mean density of the correspondent ecological region (ind/ha). The amount of class IV individuals will depend on the percentage value estimated in censuses for each ecological region. The annual crop is determined up to 20% of the Class IV individuals (Velasco & De Sola 1999 and De Sola *et. al.* 2000).

Since 1983 to 2001, 1.170.652 animals have been harvested (figure 6), but the annual crops show variations. In 1986 and 1996, ecological pauses were declared to evaluate populations subjected to use (Seijas 1986; Velasco *et. al.* I and II 1997). These evaluations demonstrated that the program of commercial use has not affected the natural populations.

The yearly variations observed in the amount of harvested individuals can be related to external factors. In 1992, the decrease of the crop was very influenced by the impact on the international market caused by war in Persian Gulf. The decrease since 1998 to the present is related with the South Asia economic crisis.

Also, domestic taxes can be taken into account. The taxes to the producers established in the Law of Fiscal Stamps, increases every year. Part of the revenues was applied to fund population-monitoring studies.

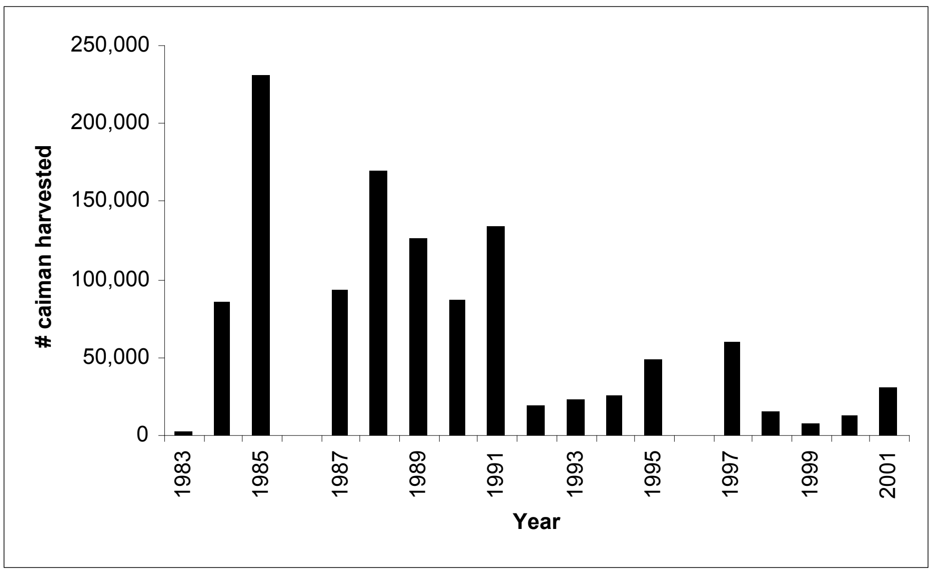

Figure 6. Caiman harvested by year in Venezuela

Industrial Categories	Length Interval
Super	> 140 cm
First	130. 140 cm
Second	120. 130 cm
Third	110. 120 cm
Fourth	100. 110 cm
Fifth	90. 100 cm
Sixth	< 90 cm

Another useful way to evaluate the crops and its impact on the wild populations is the skin size obtained annually. From 1988 to 2000, skins have been measured under the system of the tanneries, carried out in Storing Centers of MARN at the moment of purchase:

It is important to remark that the Sixth category represents the minimum size of crop, equivalent to male individuals belonging to the class IV with total length of 1,80 m. This category also includes damaged and very small skins. The Super category represents individuals with more than 2.8 m of total length.

The tendency of the obtained flanks is shown in figure 7. The Second, First and Super categories approximately represented 75% of the flanks obtained in 12 years of crop. This means that a major proportion of produced skins were above 2.4 m of total length, superior to the minimum size required in the Venezuelan program.

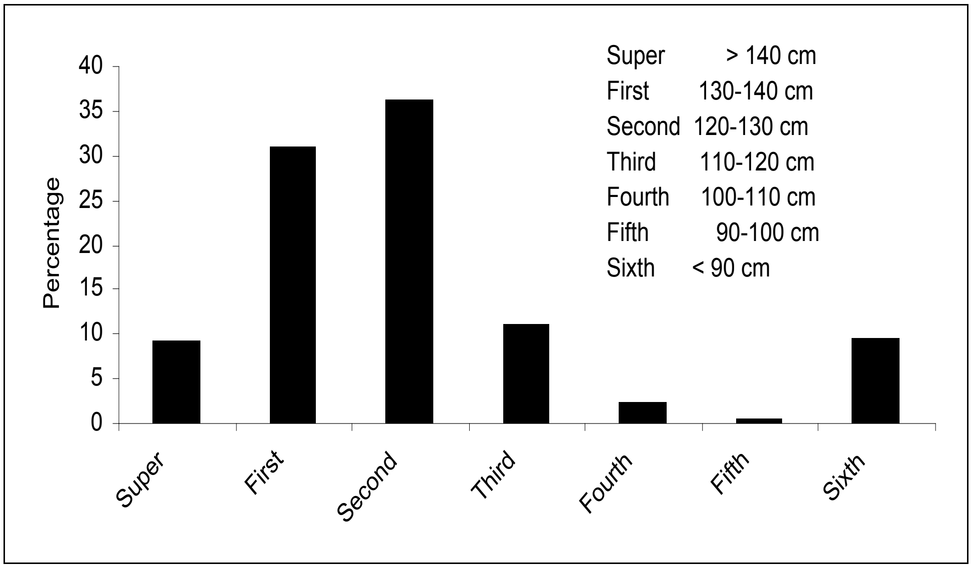

Figure 7. Means flanks sizes produced by Venezuela between 1988-2000

Costs of harvesting

The following items are used to calculate crop costs for the program users:

1. Government tax per each harvested animal fixed by Law of Wildlife Protection.
2. Payment per each harvested animal fixed by the Law of Fiscal Stamp.
3. Payment for wildlife protection service which depends upon the land extension of the ranch/farm, used for funding wild population monitoring.
4. Payment to hunters.
5. Maintenance of harvested skins and meat.

The first three payments refer to taxes that users should cancel to obtain a license of commercial hunt, and the last two are direct costs associated to hunting and preparation of skins and meat.

Calculation of payment to hunters and product maintenance is difficult to estimate, because several systems are applied. One of the most used is that intermediaries charge to the landholders with approximately 10% of the revenues obtained from the product sale, to pay costs of hunting, meat and skin preparation, preservation and transport. The intermediary do negotiates directly the products with landholders and manufacturers.

Figure 8 show the tendency of crop costs observed in Venezuela from beginnings of the program until 2001.

The tendency of crop costs in local money (Bolívares) increased through the time. This increase is divided in three stages, 1983-1989, 1990-1996 and 1997-2001. In the first lapse the increase is related exclusively to the increment in intermediaries payment for hunt and to maintenance of products. The cost increase during the second period is due to the application of the payment of wildlife service to landholders by government to grant licenses. In the last lapse, is due to a mixture among the increase of taxes and hunt costs.

The costs in US Dollars show the same tendency of increase, due to the continuous devaluations of Venezuelan currency.

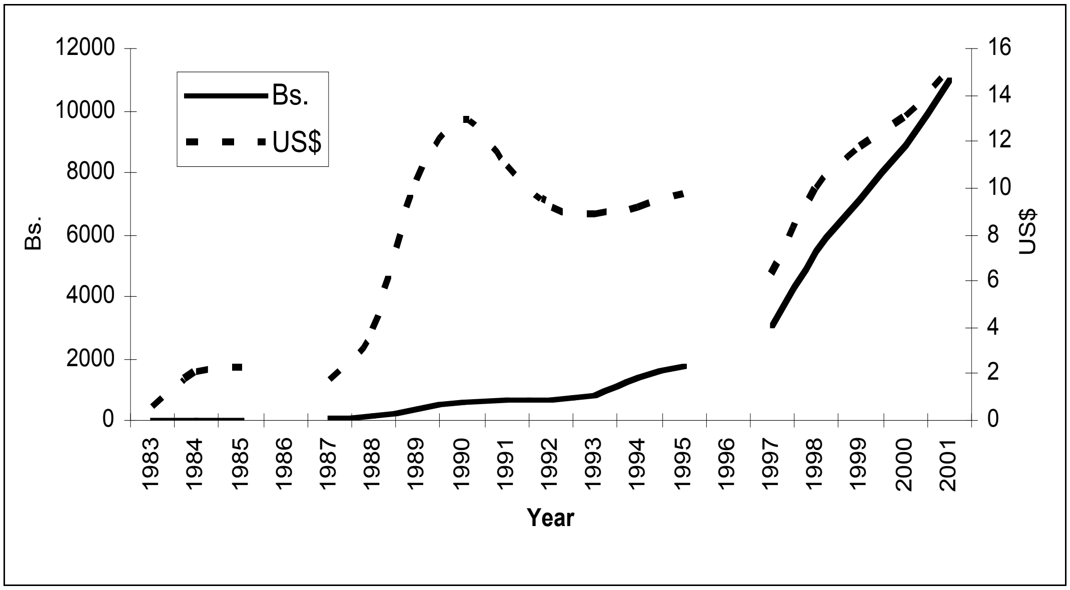

Figure 8. Cost of harvesting

Commercialization

The commercialization of the skin at domestical level is carried out for vests, piece made up of two flanks united by the intermandibular section, sale that is carried out among the owners of the ranches that obtain a license of commercial hunt and the tanneries or their representatives. These harden the skin in crosta and they market those at international level the flanks and measured in squared foot.

Venezuela like a Party country integrate of the Convention on the International Trade of Threatened Species of Fauna and Flora Wild (CITES), has the commitment of presenting a annually report before the Secretariat on the international trade of the fauna and flora in the country that contains the statistics of the exports, imports and re-exports of the specimens or their products allowed by the Convention.

One of the utilities of these reports is to know the tendencies of the international trade of the different species and their products which are the main countries buyers of the raw material, as well as the monitoring of the production levels and their bid and ask at world level.

This information is available and reflective the statistics of the international trade, with base to that reported by each Party of the CITES. However differences are observed when the information is revised offered by WCMC and the national reports, like in the case of Venezuela for the species *Caiman crocodilus* (Babas).

We reviewed all the annual reports on the trade of the wild fauna and of its products, presented before the CITES Secretariat for the Ministry of the Environmental and Natural Resources of Venezuela, analyzing the Cayman crocodilus flanks exports, from the year 1994 up to the 2000 (MARN 1995, 1996, 1997, 1998, 1999 and 2000).

In Venezuela have been harvested until the year 2000, in 17 years of the Baba program in the inundables plains and 5 years in of the Orinoco Delta, approximately about 1,153,488 animals, equivalent to 2,306,976 flanks (table 2).

Table 2. Caiman skins and flanks harvested in Venezuela.

Year	Skins Harvested Plains	Flanks Harvested Plains	Skins Harvested Delta	Flanks Harvested Delta	Total Skins Harvested	Total Flanks Harvested
1983	2,319	4,638			2,319	4,638
1984	85,233	170,466			85,233	170,466
1985	231,453	462,906			231,453	462,906
1986						

Year	Skins Harvested Plains	Flanks Harvested Plains	Skins Harvested Delta	Flanks Harvested Delta	Total Skins Harvested	Total Flanks Harvested
1987	92,530	185,060			92,530	185,060
1988	169,878	339,756			169,878	339,756
1989	126,662	253,324			126,662	253,324
1990	86,365	172,730			86,365	172,730
1991	133,392	266,784			133,392	266,784
1992	18,682	37,364			18,682	37,364
1993	23,147	46,294	274	548	23,421	46,842
1994	25,621	51,242	915	1,830	26,536	53,072
1995	48,592	97,184	2,837	5,674	51,429	102,858
1996			5,025	10,050	5,025	10,050
1997	59,882	119,764	4,605	9,210	64,487	128,974
1998	15,139	30,278			15,139	30,278
1999	8,112	16,224			8,112	16,224
2000	12,825	25,650			12,825	25,650
Total	**1,139,832**	**2,279,664**	**13,656**	**27,312**	**1,153,488**	**2,306,976**

Of the total of flanks taken place by Venezuela, they have been exported to the international market about 2,219,508 flanks, what represents 96.23% of the Babas production in Venezuela (table 3), the difference 87,468 flanks has been used in the domestic trade.

These results contrast with that reported by Asley (1998) and Ross (1998) where the quantities differ considerably of the analysis of the trade annual reports, presented by Venezuela before the CITES Secretariat (table 3).

Table 3. *Caiman crocodilus* flanks exported by Venezuela

Year	Flanks exported	Skins exported	Skins Ashley 1998	Skins Ross 1998
1983				
1984	103,221	51,610.5		3,487
1985	211,787	105,893.5		125,566
1986	251,026	125,513	128,095	128,095
1987	128,025	64,012.5	73,990	73,990
1988	173,159	86,579.5	224,650	224,650
1989	194,850	97,425	170,347	170,347
1990	285,209	142,604.5	204,206	204,206
1991	168,640	84,320	117,687	117,687
1992	141,363	70,681.5	123,594	123,594
1993	84,840	42,420	87,314	87,314
1994	110,633	55,316.5	73,909	54,038
1995	99,880	49,940	65,856	55,195
1996	52,692	26,346	32,108	29,996
1997	73,645	36,822.5		
1998	67,991	33,995.5		
1999	25,238	12,619		
2000	47,309	23,654.5		
Total	**2,219,508**	**1,109,754**	**1,301,756**	**1,398,165**

The reasons to these differences can be several, as Ross expressed in 1998:

1. Errors, mis-reporting and poor records in both production estimates and CITES export reports. It i unclear why such errors would be so consistently in the direction of an excess of exports.
2. Introduction of illegal skins into trade within the country of export. E.g. illegal wild skins claimed ace farmed and issued false documents and tags.
3. Introduction of illegal skins into trade from other sources which decetively claim to be from the country. E.g. illegal skins from country X presented with false documents and tags indicating from country Y.
4. Double (Multiple?) reporting of re-exported legal skins. E.g. Skins from Venezuela exported to USES, re-exported to Italy reported on Italian reports ace" origin Venezuela.." with legal documents and VZ tags and therefore counted twice in CITES reports ace exported from Venezuela.

The main countries that have cared Babas flanks from Venezuela are: Italy (42%), Japan (16%), it USA (13%) and France (10%) (figure 9), the rest composes it Switzerland, Spain, Germany, Panama, England, Singapore, Thailand, India, Honk Kong and Colombia.

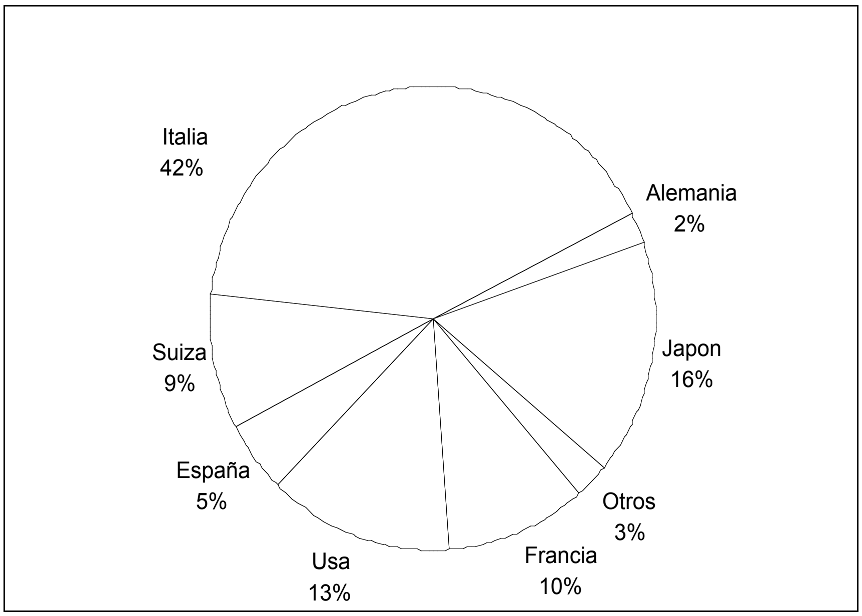

Figure 9. Countries imported Caiman crocodilus flanks

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The effect of harvest on population ecology of *Caiman yacare* in the Brazilian Pantanal

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ABSTRACT: The use of manipulative experiments is highly recommended in wildlife management. In this paper, results of a large scale field experiment (500 km^2) designed to study density-dependent mechanisms regulating growth of caiman population are presented. Information on population spatial structure, feeding ecology, body condition, somatic growth and reproduction obtained in control (unharvested) areas was used as a background against which data obtained in treatment areas, where density was manipulated by harvesting large males, was compared. Most of the studied variables were directly or indirectly related to harvesting and density. Harvesting affected feeding success, type of food consumed and movement rates which, ultimately, affected population fertility. Population growth was estimated by simulating different scenarios which represented the possible size of the population after 12 consecutive years of drought in the Pantanal (from 1962 to 1973) and assuming present densities as the carrying capacity. The mean annual rate of increase ranged from 5.5 to 13.7%, representing safe estimates which could be used for future management decisions.

Differential Harvest of American Alligators on Private Lands in Coastal South Carolina

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ABSTRACT: American alligator (*Alligator mississippiensis*) populations in South Carolina recovered following season closure in 1964 and subsequent state and federal protection during the 1970s. A program permitting a limited harvest of alligators on private lands in 7 coastal counties was established in 1995. Following night-light surveys and habitat evaluations, participating landowners were issued a quota by 61-cm size classes for alligators $122 cm. The objective of the differential-harvest approach was to harvest alligator size classes in proportion to their occurrence. Approximately 45, 34, 14, and 7 percent of the tags were issued for the four size classes, respectively, during 1995-2001. Overall annual success ranged from 42-80 percent. The 244-cm size class exhibited the highest average success (80 percent) whereas success was lowest (45 percent) in the 122-cm size class. Average total length (TL) was 216 cm (range = 207-225 cm). Annual sex ratio averaged 70.3 percent male (range = 60-75.6 percent). Despite the reluctance of trappers to harvest small alligators, the differential-harvest approach is a tool wildlife biologists can use to prevent the over-harvest of adult alligator size classes.

INTRODUCTION

American alligators have been harvested for over two centuries in the Southeastern United States. For the most part, the exploitation of these animals has occurred with little regard to age, sex or size of harvested animals. More recently, certain cohorts of alligators have been protected from harvest by use of regulations, primarily minimum sizes and harvest techniques, but little work has investigated within-size class harvest rates.

Crocodilians exhibit very complex behavior and social patterns (Lang, 1987), despite their lethargic and solitary appearance. Social organization favors breeding by larger animals of both sexes, which results in a higher and more successful reproductive output. Lang (1987) stated that the harvest of large crocodilians destabilizes long-term social relations, and if continued over a long enough period, reproductive success could decline.

Various studies have determined that adult alligators exhibit sex-specific habitat requirements (Joanen and McNease, 1970, 1972; Rootes and Chabreck, 1993). As such, harvest regulations in several states were designed to minimize harvest of adult female alligators, a mindset that theoretically protects the major breeding segment of populations. Under this harvest approach and effective law enforcement, alligator populations have flourished across their range since legal harvest was reinstated in the early 1970s.

Despite the success of alligator programs across the Southeast, the current harvest approaches have been questioned. Taylor and Neal (1984), Taylor et al. (1991), and Kinler and Taylor (1992) demonstrated that alligator populations could withstand a higher harvest rate. By increasing tag allotments, they found that by default trappers increased harvest of smaller size classes. Nichols et al. (1976) suggested a more direct approach, called proportional harvest rate, where animals are harvested in proportion to their occurrence. Lang (1987) recommended the same strategy, stating it would result in minimal disruption to the existing social order of a population.

Alligators were harvested with essentially no regulations in South Carolina until the season was closed in 1964. Disposal of an occasional nuisance alligator was the only legal harvest that took place over the next 20 years. South Carolina's alligator population continued to expand as did coastal development, resulting in a formal nuisance alligator program in 1987.

Rural landowners were also burdened with an increased alligator population. Most forwent relief under the nuisance alligator program, and attempted to illegally reduce alligator populations. Recognizing the problem, the South Carolina Department of Natural Resources (SCDNR) began development of a private lands alligator program in 1991. State harvest programs in Florida, Louisiana and Texas were reviewed. A common recommendation was to implement a proportional harvest approach if possible. Regulations were drafted and approved, and South Carolina's first alligator season in 31 years was implemented in 1995. The objective of this paper is to provide an overview of the season from 1995-2001, with particular emphasis on the proportional harvest approach.

STUDY AREA

There are roughly 204,142 ha of coastal wetlands in South Carolina, of which approximately 14 percent (70,541 ha) are impounded (Tiner 1976). Historically, impoundments were used for the production of tidewater rice (Doar 1936), whereas, presently they serve as waterfowl hunting areas (Strange 1987). The majority of the alligator population in South Carolina is associated with intact wetland impoundments (Wilkinson and Rhodes 1992). Impoundments are primarily brackish and support the highest densities of alligators in South Carolina (Rhodes, unpubl. data).

The open area for the South Carolina private lands season targeted abundant alligator populations in these coastal habitats (Fig. 1). All or a portion of Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, and Jasper counties were open for harvest. Locations further inland were not included in the harvest area because of difficulties with surveying alligator populations in these habitat types.

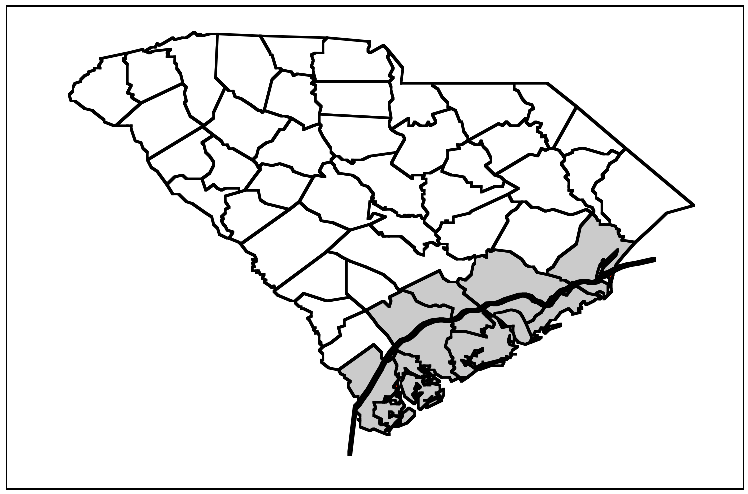

Figure 1. Counties open for private lands harvest, 1995-2001. Shaded portion to right of line is open area.

METHODS

Various media outlets announced the opening of the season in the spring of 1995, and subsequent springs. Landowners submitted an application, which included a map and aerial photograph, to enroll in the program. Biologists reviewed the property during the summer, and conducted a night-light survey if needed. Night-light surveys had already been conducted for several years on representative properties in anticipation of the alligator season opening.

Landowners were mailed a tag quota in late August. The quota included total number of alligators ∃122 cm, by 61-cm size class, which could be harvested on the property. To achieve a 15-percent harvest rate, night-light surveys indicated that impoundment alligator populations could sustain a harvest of 1 tag per approximately 50 acres of habitat. Further, estimated 61-cm size class proportions for alligators ∃122 cm from night-light surveys were 50, 30, 15, and 5 percent. Property tag quotas were distributed among size classes by these proportions. Rounding of acreage or number of tags within a size class caused proportions to be shifted slightly on some properties.

Landowners were mailed tags in early September. The four-week season was held from mid September to mid October, and usually included five weekends. Trappers were permitted to harvest alligators from sunrise to 11:00 p.m. by live-capture methods only, such as baited trip snares or snagging. Legal-sized alligators could be dispatched with a firearm no larger than a .22 caliber. A non-CITES tag was placed in the tip of the tail of harvested alligators. Alligator skins were measured and validated after the season, and the harvest tag was replaced with a CITES tag.

RESULTS

An average of 16 properties participated in the private lands season from 1995-2001. Annual statewide quotas ranged from 159-395 tags (Fig. 2). Annual statewide harvest was 90-211 alligators. Overall annual success ranged from 42-80 percent, and averaged 59 percent. Average total length (TL) was 216 cm (range = 207-225 cm). Annual sex ratio averaged 70.3 percent male (range = 60-75.6 percent).

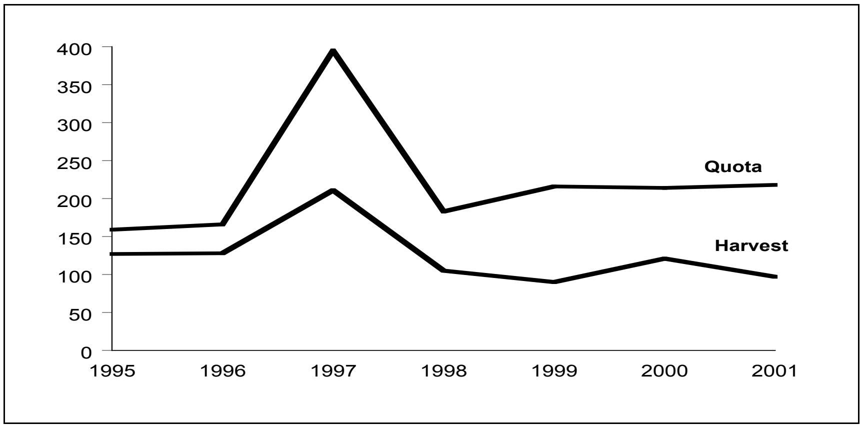

Figure 2. Alligator tag quota and harvest on private lands in South Carolina, 1995-2001.

Approximately 45, 34, 14, and 7 percent of the tags were issued for the four size classes, respectively, during 1995-2001. Percent of total harvest among the four size classes was 34, 40, 19, and 7, respectively, from 1995-2001 (Table 1). Trappers had the highest average success (80 percent) in the 244-cm size class, whereas success was lowest (45 percent) in the 122-cm size class (Table 2).

Table 1. Percent of total alligator harvest among four size classes under a differential-harvest approach, South Carolina, 1995-2001.

Size Classes	1995	1996	1997	1998	1999	2000	2001	Avg.
122/153cm	39.4	37.5	29.4	34.3	32.2	37.2	30.9	34.4
183/213cm	42.5	41.4	44.5	40.0	36.7	34.7	38.1	39.7
244/274cm	12.6	14.8	22.3	17.1	24.4	21.5	21.6	19.2
305cm+	5.5	6.3	3.8	8.6	6.7	6.6	9.3	6.7

Table 2. Percent of alligator tag quotas filled among four size classes under a differential-harvest approach, South Carolina, 1995-2001.

Size Classes	1995	1996	1997	1998	1999	2000	2001	Avg.
122/153cm	64.1	60.0	33.9	43.9	31.5	48.4	31.6	44.8
183/213cm	98.2	93.0	69.6	68.9	46.5	56.8	50.5	69.1
244/274cm	100.0	100.0	83.9	66.7	62.9	81.2	65.6	80.0
305cm+	70.0	72.7	38.1	69.2	33.3	53.3	52.9	55.6

DISCUSSION

Using a differential-harvest approach, also called proportional harvest, is not a new concept but it is rarely used. Nichols et al. (1976) demonstrated that adult alligator in Louisiana were exploited at a higher rate than their occurrence in the population and was the first to suggest proportional harvest. Taylor and Neal (1984), Taylor et al. (1991), and Kinler and Taylor (1992) verified that alligator populations could withstand an overall higher harvest rate if the 122- and 153-cm size classes were more heavily exploited.

South Carolina was the first state to implement it on a statewide basis. Louisiana indirectly investigated the concept on several occasions (Taylor and Neal,1984; Taylor et al., 1991; Kinler and Taylor, 1992) before employing “bonus tags” statewide in 1999 in an attempt to harvest additional alligators less than 183 cm.

Overall success (defined as percentage of tags filled) in South Carolina was lower than success rates reported elsewhere. Success in South Carolina averaged 59 percent under the differential-harvest approach. Success rates in Louisiana without a differential harvest have annually averaged over 90 percent since 1973, and have consistently been above 95 percent since the mid 1980s (Kinler, 2002). Woodward et al. (1992) reported an 84 percent success rate for three lakes in Florida without differential harvest from 1981-90.

The lower success rate observed in South Carolina under differential harvest results not from the lack of alligators but trapper habits. Harvesting alligators is a strong tradition in Louisiana and Florida whereas it was historically only practiced by a small core of people in South Carolina. Most of the applicants in South Carolina's private lands season participate for recreation and novelty rather than as a commercial means. Although the 122-cm size class had the lowest success rate (45 percent), other size classes were also substantially under-utilized, particularly the 305-cm-plus size class that had only a 56 percent success rate. Based on these success rates, it is theorize recreational trappers have a stigma against harvesting small alligators. Louisiana trappers utilized over 90 percent of bonus tags issued (Kinler, 2002), which is expected where a more commercial attitude is in place; however, trappers still tended to take the largest animals permitted under the bonus tag program. Additional time demands from other recreational activities probably contributed to the lack of harvest of larger alligators in South Carolina.

Other biological measurements of harvested alligators in South Carolina were similar to harvested populations reported elsewhere. Average TL (216 cm) and sex ratio (70 percent males) in South Carolina was comparable to populations in Florida (Woodward et al., 1991), Louisiana (Kinler, 2002), and Texas (Cooper and Slaughter 2001). Average TL and percent males was lower in South Carolina when more alligators < 183 cm were harvested, which would be expected when harvest is directed towards smaller size classes. Although a differential-harvest approach is in place in South Carolina, the current rate of effort appears to mimic alligator populations not under differential harvest, which is probably under-utilizing the alligator resource in South Carolina.

The best measure to determine if a differential-harvest approach is fully utilizing the alligator resource would be size-class distribution of harvested animals versus population size distribution. Approximately 45, 34, 14, and 7 percent of the tags were issued for the four size classes, respectively, during 1995-2001 in South Carolina. This was based on size classes observed during night-light surveys during pre-harvest years. The average size-class distribution of harvested alligators was 34, 40, 19, and 7 percent, for the four size classes, respectively. This indicates that harvest in South Carolina was still skewed towards larger alligators but the largest size class was not over-exploited, which is a goal of the differential-harvest approach.

The distribution of the 2001harvest for the same four size classes in Louisiana was 11, 62, 21, and 6 percent (Kinler, 2002). This contrasts to the South Carolina harvest, especially for the first two size classes. Even when bonus tags are figured in the statewide harvest, the <183-cm size class only approaches 15 percent and could probably be even higher without impacting populations (Kinler, pers. comm.).

Woodward et al. (1992) also found harvest of alligators in Florida were skewed towards larger alligators. For Lochloosa, Newnans and Orange lakes, harvest distribution over the four size classes was 45, 27, 15, and 13 percent from 1981-90, which contrasts to both Louisiana and South Carolina data. They reported the proportion of bull alligators harvested decreased with time relative to smaller alligators (< 274 cm), but it varied by area. They concluded this could have been related more to wariness of large alligators rather than an actual decline. Further, they stated that size distributions of harvests conformed relatively well night-light survey distributions on two of the three lakes.

Whether under a non-differential- or differential-harvest approach, alligator populations in all three states are reported to be stable or increasing. Alligator biologists have felt that the <183-cm size classes were the most exploitable cohorts, however, this logic could include animals less than 244 cm. These data indicate that alligator populations may be able to sustain a harvest favoring the larger size classes, no matter what harvest approach is implemented, as long as the population harvest rate is biologically acceptable (i.e. 15 percent or less) and the total harvest distribution for alligators >244 cm does not exceed approximately 25 percent.

Woodward et al. (1992) stated proportional harvests with respect to size classes are disproportionate with respects to levels of growth rates, and therefore, result in under-harvest of smaller, faster growing alligators relative to larger, slower growing individuals. They suggested that harvests might be sustainable by progressively weighting the harvest toward smaller alligators. An alligator growth study in South Carolina by

Wilkinson and Rhodes (1997) showed disproportionate growth rates by size classes. If harvest pressure in South Carolina increases in the future an adjustment of harvest rates for larger size classes might be needed to further conserve large, adult alligators.

Alligator trappers will always want to harvest the most and largest alligators possible. In many cases, harvest methods condition large animals to be wary (e.g. light shy) and avoid harvest. Reduced disturbance, habitat types, and other harvest methods, usually involving bait, may not instill the same level of wariness. Therefore, large alligators might be over-exploited. This is potentially the situation in South Carolina. Given these conditions, utilizing a differential-harvest approach that applies a 15-percent harvest rate by 61-cm size classes for alligators ∃122 cm under appears to produce a sustainable supply of large alligators for trappers and wildlife viewers alike.

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The Current Status and Conservation of Chinese Alligator

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ABSTRACT: Chinese alligator is an endemic species in China and has been listed as category one species under the key state protected wildlife. It is also considered as the most endangered species of 23 crocodiles in the world by IUCN. Since 1980s, the Chinese Government has launched a serial conservation measures and scientific researches. So far, the captive population has reached over 10,000 individuals with annual increasing rate of 2,000 individuals. However, with land exploitation change, illegal hunting, environmental pollution and natural disasters, the wild population is challenging the threats of extinction. The recent survey shows that the current wild population is less than 200 individuals and decreasing at the annual rate of 4-6%. To save China ancestor dragon, with supports of international organizations and interested individuals, State Forestry Administration of China commenced on some conservation projects including habitat restoration, ranching, captive breeding and reintroduction. This paper presents the detailed progresses of China for saving Chinese Alligator within recent two years and the active actions behind two international workshops in Heifei and Guangzhou, 2001.

1 CURRENT POPULATION STATUS

1.1 Wild Population Decreasing

According to historical records, until the middle of 20th century, Chinese alligators could be found along the middle and lower reaches of Yangtze and Shaoxing river basins. The evidence shows this species was abundant and widely distributed from Shanghai on the lower reach of Yangtze River up to Jiangling County of Hubei Province. 300-500 (Chen, B. H, et al, 1981) individuals were recorded in the early of 1980s. With land reclamation, illegal poaching, environmental pollution and natural disasters, the wild population is decreasing rapidly. So far, the wild population is only restricted to small, narrow and isolated plots which belong to Jinxian county, Guangde county, Nanglin county, Xuanzhou district, Ningguo city, Maanshan city and Dangtu county of the southern Anhui Province, as well as Changxing county of Zhejiang Province. It was also reported that the species was found in Yixing County of Jiangshu Provinces (no record in the recent survey). Thorbjarnarson (2000) reported that the wild population is less than 200 individuals with annual decreasing rate of 4-6%. The largest population size in one site only consists of 10-11 individuals (total 4 sites) and usually only one of them is female. Most colonies consist of 2-5 individuals.

1.2 Captive population increasing

With the success of the captive breeding techniques in 1982, the captive population reached over 10,000 individuals till the end of 2001. Among them, about 10,000 individuals in Anhui Breeding and Research Center for Chinese Alligator (ABRCCA) and 366 individuals in Yingjiabian Nature Reserve of Zhejiang Province. The annual increasing rate of ABRCCR is about 1500-2000 individuals. So far, the second filial generation of captive bred Chinese alligator of ABRCCR can be successfully bred. In addition, there are more than 100 Chinese alligators in zoos around China.

2 CURRENT CONSERVATION STATUS

2.1 Legal supports

In 1972, the Chinese Alligator was listed as the state protected species. In 1988, Wildlife Protection Law of People's Republic of China was issued and brought into implementation. Meanwhile, the State Council also formulated the list of category one and two species under the key state protected wildlife. The Chinese Alligator was listed as category one species. After then, related regulations and rules were also issued at national, provincial and local levels.

2.2 Establishment of Nature Reserves

Anhui Chinese Alligator Nature Reserve covering a total area of 43,300 hm^2 was established by provincial government in 1982 and promoted as national nature reserve by State Council in 1986. The reserve includes 13 protection and management stations covering 41 hm^2 distributed in five counties, which is co-managed by Anhui Breeding and Research Center for Chinese Alligator.

The resident of Changxing County of Zhejiang Province spontaneously fenced the habitat for the remained wild Chinese alligators. In 1988, Department of Forestry of Zhejiang Province confirmed it as a provincial nature reserve, which covers 120 hm^2 with core area of 3 hm^2.

2.3 Establishment of captive breeding centers

To prevent the Chinese Alligator from field extinction, Department of Forestry of Anhui Province established Anhui Breeding and Research Center for Chinese Alligator in 1979. The Center collected 212 wild individuals from random distribution sites for captive breeding. With continued efforts of experts from Anhui Normal University and the staff of ABRCCR, a set of captive breeding technique was developed in 1982. Meanwhile, 147 hatchlings were successfully hatched out in this year. The second filial generation was successfully born in 1987. From that time, the number of the captive-bred alligators has being increased continuously. At present, the rate of hatching, surviving and preserving are 90.5%, 97.9% and 85% respectively. The research has reached international level and awarded the Second Class Prize for Science and Technology Development by State Forestry Administration (SFA) (former Ministry of Forestry) of China.

Zhejiang Changxing Breeding Center for Chinese Alligator was founded in 1979. The first filial generation was hatched out in 1984 and the second filial generation was born successfully in 1997.

2.4 Public Education

Since the end of 1970s, the Chinese government has commenced on public education on wildlife conservation, especially to students. With the formulation of Wildlife Protection Law, governmental departments at national, provincial and local level initiated Wildlife Conservation Month all over the country. To improve the conservation awareness and good understanding of the Chinese Alligator, the local departments have conducted serial activities such as poster setting, legal popularization, media exposure, workshop, materials distribution, eco-tourism and so on.

2.5 Scientific Researches

Some scientific researches on the Chinese Alligator have been launched since the end of 1970s. So far, the main research fields include population counting, distribution, burrow selection, home range, captive breeding, physiology, morphology and conservation genetics etc. The results provide scientific basis for the upcoming projects of Chinese Alligator protection.

2.6 Commerce Management

I n 1992, the 8th meeting of Parties of CITES approved the commercial utilization of the individuals of second filial generation of captive bred Chinese Alligator. SFA of China has strictly taken measures to efficiently manage its commercial activities including strict control of the number of individuals for commercial purposes, strict limitation of the number of units of utilization and trade, and fund raising from the commercial activities by the utilization to the conservation and captive breeding of Chinese Alligator.

2.7 International Cooperation

International cooperation played an effective role in development of Chinese Alligator protection. The Chinese Government always keeps a positive attitude to the international cooperation concerning Chinese Alligator protection.

By the end of 1970s, the experts of China and U.S.A. jointly conducted a cooperative survey on Chinese alligators, which preliminarily recognized the population size and distribution of the Chinese Alligator. Since the end of last century, with the supports of WCS, we have conducted some researches on biological conservation. In 2001, with the supports of some international organizations including CSG, WCS, WWF and Australia-China Council, SFA sponsored two international workshops in Anhui and Guangzhou concerning re-introduction of Chinese alligators and commerce management in crocodiles.

3 MAIN ACHIEVEMENTS WITHIN RECENT TWO YEARS

Since the approval and release of 'China Action Plan for Conservation and Reintroduction of Chinese Alligator' and 'Guangzhou Advocation on Coordination Between Crocodile Protection and Industry Development', which were separately developed in Hefei and Guangzhou International workshops in 2001, SFA has strictly implemented the proposed activities step by step and made a great of progress on saving Chinese Alligator project. The specific activities were completed as followings.

3.1 Developing two conservation planning documents

With scientific and technical supports from some relevant institutes/universities/colleges, two plan documents including Construction Plan of Saving Chinese Alligator and Construction Plan of Chinese Alligator Breeding Base have been developed at the end of 2001, which are guideline document for saving Chinese Alligator project. With rationale of efficiency, innovation and cost, the Chinese government is planning to launch related activities in Anhui, Jiangsu and Zhejiang Provinces step by step.

3.2 Habitat restoration project

So far, we have negotiated with the local governments on the land-use within 6 proposed re-introduction sites of Anhui Province and got approved. One of the proposed sites, Gaojingmiao Forestry Farm (a state-owned forestry farm) is in the process of habitat restoration. The captive alligators will be re-introduced according to the original plan.

3.3 Re-introduction project

In the ABRCCA, some wildness ponds have been established and some re-introduced alligators will be released for semi-wildness before the implementation of the full project. So far, a total of 1.8 million US$ has been invested to improve the infrastructures and instruments of ABRCCA, most of investment come from the central governmental finance.

Another reintroduction site in Zhejiang Province is Taohuagou at Changxing County, covering 467 hm^2, which is also a state-owned forestry farm. The local forestry department with the support of the central government initiated the re-introduction project at this place. A total of 1.45 million US$ has been invested to establish a captive breeding base.

3.4 Habitat evaluation project

At the beginning of this year, with the financial support of SFA, Habitat Quantization Evaluation of Chinese Alligator is undertaken by National Research and Development Center of Wild Fauna and Flora, and cooperated by Anhui Normal University. The project aims to recognize the wild population size and distribution, surveys and evaluates wild habitat, probes habitat selection pattern, determines suitable habitat standard, and put forward protection and management strategy. The final results will provide reasonable basis for the reintroduction site selection and habitat management.

3.5 The proceeding of two international workshops

The proceeding of the International Workshop on Conservation and Re-introduction of Chinese Alligator, Heifei, China, 2001 & International Workshop on Captive Breeding and Commerce Management in *Crocodylia*, Guangdong, China, 2001 was published by China Forestry Publishing House in September of 2002, which named Status Quo and Future of Conservation for Chinese Alligator and Crocodiles in the world.

3.6 Establishment of volunteer group for technical supports and consultants

In response to the advocation of two international workshops, SFA has appointed Mr. Jiang Hongxing as contactor of this volunteer group and national coordinator, whose correspondence address is: National Research and Development Center of Wild Fauna and Flora, P.O Box 1928, PC: 100091, Beijing, P.R. of CHINA. For further information, please browse the website: www.wildlife-plant.gov.cn

4 NEXT URGENT ACTION PLAN

To efficiently promote implementation of saving Chinese Alligator project and rehabilitate its wild population, some pilot actions have been identified and will be put into practice step by step by State Forestry Administration of China consulted with experts at home and abroad.

4.1 Seek related technical supports for saving Chinese Alligator project

Effective technical supports are the foundation for the success of project implementation. Considering the current situation, key techniques include monitoring technique for the current wild population, ranching population, wildness population; wildness technique, especially on raising foraging capacity of captive alligators; conservation and management technique; and commercial utilization and management technique for the captive Chinese Alligator and other introduced crocodiles.

4.2 Launch pilot scientific researches

The results of scientific researches provide reasonable basis for conservation and management business. It is imperative to initiate habitat evaluation and conservation genetics projects to guide identification of suitable reintroduction sites and released population structure. Meanwhile, monitoring for the current wild population and released alligators including behavior, viability, habitat selection and activity range, also should be done to review the project progress.

4.3 Conduct training and field tour

With regards to the related techniques, SFA prepare to dispatch one or two delegation to visit some overseas famous farms, ranching farms, nature reserves and colleges/institutes to learn advanced techniques and experience in 2003. Meanwhile, domestic training should also be enhanced.

4.4 Enhance capability building for the breeding bases and nature reserves

To address the needs of re-introduction project and saving enough genetic resources, some related departments have been developed construction plan and approved by the authority. The current infrastructures and instruments will be further improved by the implementation of the project.

4.5 Develop community co-management model

Saving Chinese Alligator project needs concert efforts and contributions from local communities, international society and Chinese governmental departments. How to coordinate and mitigate human-alligator conflicts is a key factor to the success of the project. A reasonable community participatory model will be established with consultation of some experts and stakeholders, as well as public awareness increasing.

4.6 Widen the channels of international cooperation

International cooperation promotes international society recognize China protection business, and China catch up with international progress as well. The Chinese government will continue to enhance international cooperation. The main activities include: to strength information exchange with relevant international organization; to cooperate to run staff training courses; to promote favorable cooperation mechanisms and implement multi-formal cooperation; and to introduce advanced scientific and technical measures, and management experiences.

EPILOGUE

We appreciate all of your continuous supports of finance and technique, and concerns on the Chinese Alligator. We believe, with the close attention and cooperation from related international organizations and colleague, the Chinese Alligator will get rid of the edge of extinction beyond all doubt, and the crocodiles in the world will have a prospective future, and China will contribute greatly to the wildlife conservation and sustainable utilization.

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Crocodile Conservation at Work in Vietnam; Re-Establishing *Crocodylus siamensis* in Cat Tien National Park

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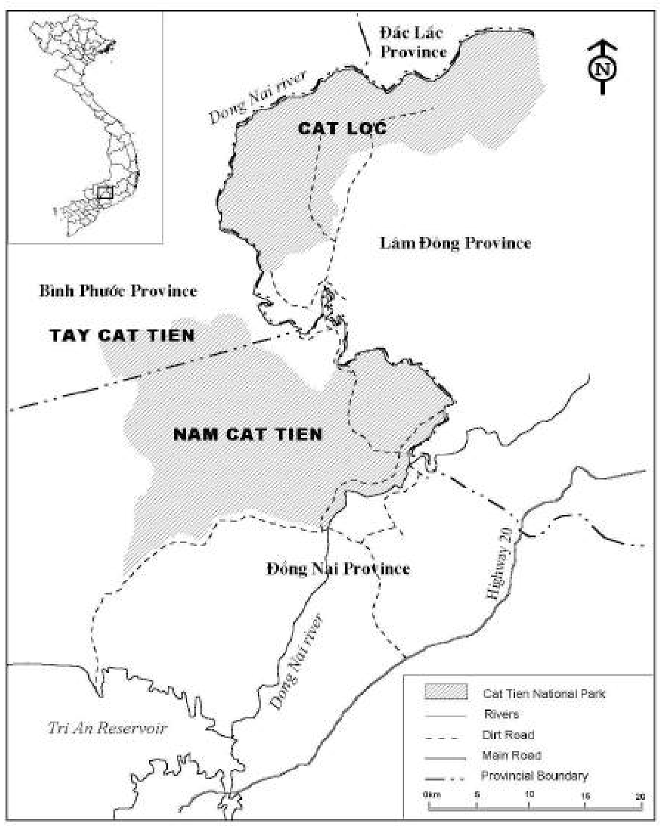
ABSTRACT: The Siamese Crocodile *Crocodylus siamensis* is classified by IUCN as globally critically endangered. Up to two decades ago, the species was abundant in a wetland ecosystem currently located in Cat Tien National Park – southern Vietnam. Hunting for meat and to stock crocodile breeding farms decimated the population and the species was regarded to be extinct from the Park. This paper presents the activities undertaken to re-establish the species in Cat Tien National Park over the last two years. Crocodiles, donated by a private farmer in Ho Chi Minh City, have been DNA tested to avoid the release of mixed breed individuals (*C. siamensis* x *C. porosus* and *C. rhombifer*). From December 2001 onward, nineteen crocodiles have been released in the Park. Initial monitoring data suggests a stable population has been established. The programme is scheduled to continue over the next two years.

INTRODUCTION

Cat Tien National Park is located about 150 km North of Ho Chi Minh City, on the plains of the Dong Nai River, South of Vietnam's Central Highlands. It is situated in Dong Nai, Lam Dong and Binh Phuoc Provinces but management is in the hands of the central Government's Ministry of Agriculture and Rural Development). The Park measures about 75,000 ha but is divided in two separated sectors; Cat Loc in the North and Nam Cat Tien in the South (see Map 1). Since 1998, the Park receives substantial financial and technical support from The Netherlands Government through the WWF - Cat Tien National Park Conservation Project.

Cat Tien National Park is located in the monsoon tropical region with a distinct wet and dry season. The topography is characterised by areas with steep hills and flat areas. Although altitudes range only from 200 to 600 metres above sea level, slopes are relatively steep. The Dong Nai River borders the Nam Cat Tien sector in the East and the Cat Loc sector in the West and North. The northern central section of Nam Cat Tien is poorly drained and contains an area of small streams, lakes and seasonally inundated grasslands (Cox et al., 1995).



Map 1. Cat Tien National Park

The Park harbours the last remaining sizeable lowland rainforest in southern Vietnam which consists of a wide variety of habitats. These include:

- primary and re-growth evergreen tropical lowland rainforests dominated by Dipterocarpaceae,
- primary and re-growth semi-evergreen tropical lowland rainforests dominated by *Lagerstroemia* spp.*,*
- freshwater wetlands with open lakes and seasonal floodplains containing *Saccharum spontaneum*, *S. arundinaceum* and *Neyraudia arundinacea*,
- flooded forests dominated by *Hydnocarpus anthelmintica* mixed with *Ficus benjaminica*, and
- areas severely denuded by warfare dominated by bamboo and open grasslands.

The Park hosts a rich variety of wildlife. A total of 99 mammal, 311 bird, 69 reptile and 30 amphibian species have been confirmed to occur in the Park. These include rare and endangered species such as Javan Rhinoceros *Rhinoceros sondaicus annamiticus*, Asian Elephant *Elephas maximus* and Gaur *Bos gaurus* and nine primate species, albeit all in rather low numbers (Polet et al., 1999; CTNP, 2000). Orange-necked Partridge *Aborophila davidi* is endemic to the Park area (Atkins and Tentij, 1998).

SIAMESE CROCODILES IN CAT TIEN NATIONAL PARK

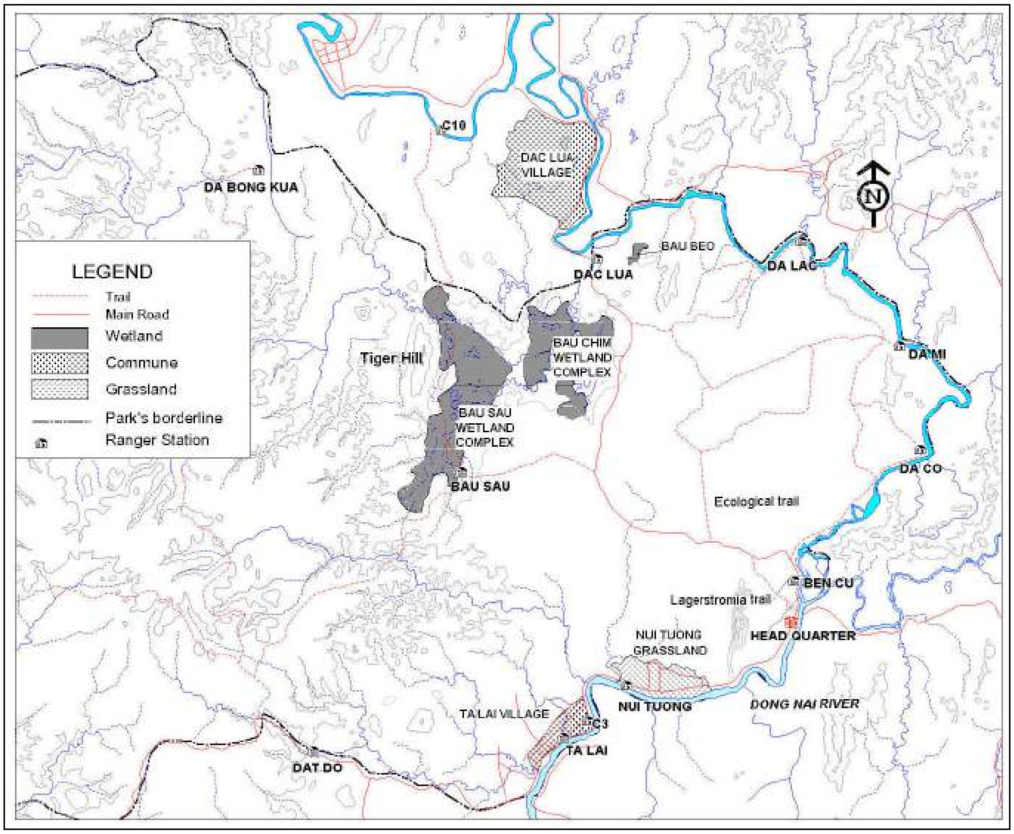
Cat Tien National Park hosted large numbers of Siamese Crocodile *Crocodylus siamensis* in earlier times. They occurred on the Dong Nai River but high concentrations could be found in the wetland complex in the northern section of Nam Cat Tien (see Map 2). One of the lakes in this complex is called Bau Sau (Crocodile Lake). The Bau Sau wetland complex has a wet-season maximum circumference of about 2,670 ha and a minimum dry-season circumference of about 150 ha (Wuytack, 2000). Large areas of the Bau Sau wetland habitat are intact and currently well protected.

Ho Thu Cuc (1994) reported that wild populations of Siamese crocodile in Vietnam were restricted to Suoi Trai Nature Reserve in Khanh Hoa Province, Lac Lake in Dak Lak Province and Nam Cat Tien National Park and that no more than 100 individuals survived in the wild in Vietnam. A crocodile was caught in the Dong Nai River in 1989 when fishermen were using explosives. In the same year a small crocodile was observed by Cat Tien National Park staff in the Dong Nai River near the Park's headquarters. Villagers from Dak Lua village reported to have last seen an 80 kg crocodile in 1996 and in the same year they caught a 50 kg crocodile in the Bau Sau wetland complex (Bembrick and Cannon, 1999). In 1994 a Russian scientist claims to have seen a crocodile in a small pond inside the forest (Andrei Kouzenetsov, pers. comm.). Cat Tien National Park staff have not observed crocodiles since 1996 and it has been concluded that there are no Siamese crocodiles remaining in Cat Tien National Park although there is a possibility of a few animals surviving in areas which are difficult to access (Bembrick and Cannon, 1999). Platt and Ngo Van Tri (2000) came to the same conclusion after a brief survey in Cat Tien National Park. The Siamese crocodile is now regarded to be one of the most critically endangered crocodiles in the wild in the world although captive populations in breeding farms number many thousands (Ross, 1998).

The decline of the Siamese crocodile in Cat Tien National Park was due to vigorous hunting of adults for their skin and sub-adults sold live to crocodile breeding farms; eggs were never harvested (Bembrick and Cannon, 1999). Since the mid-1970's, the crocodile population in Cat Tien National Park has dwindled, most dramatically between 1975 and 1985. Hunters came from the Mekong Delta and Dak Lua village; the latter reported to have caught one crocodile per day on average. Hunting took place year-round, but most intensively during the wet season, using baited hooks and lines, nets in the water and rope traps on land (Bembrick and Cannon, 1999). Habitat destruction does not appear to have contributed significantly to the decline of Siamese crocodiles in Cat Tien National Park.

In the 1980's Cuban crocodiles (*Crocodylus rhombifer*) have been imported into Vietnam. They were distributed between zoos and also ended-up in crocodile farms. Hybridisation between *C. siamensis* and *C. rhombifer* produces larger egg clutches and offspring which seem to grow faster than pure breeds. These features are advantages for the leather industry and most captive crocodiles in southern Vietnam are now hybrids. Hybrid animals remain fertile. Second and third generation off-spring can not be distinguished by eye from pure *C.*

siamensis. Therefore, most of the captive crocodile stock available in southern Vietnam is not suitable for a re-establishment programme which requires pure *C. siamensis* to be released within its historic range.



Map 2. Crocodile Lake Wetland Complex

BACKGROUND TO THE RE-INTRODUCTION PROGRAMME

The Cat Tien National Park authorities have been seeking to re-establish a Siamese crocodile population since early 1999. Such a move was inspired from a desire to secure an ecosystem which is as complete as possible as an example for future generations.

Under the auspices of the WWF-Cat Tien National Park Conservation Project, a short survey was conducted by Bembrick and Cannon in January 1999 whose main findings have been presented above. Their survey included several visits to crocodile farms in and around Ho Chi Minh City. The owner of one of the farms visited contacted the authorities of Cat Tien National Park later in 1999 and offered to donate a number of crocodiles for release into the Bau Sau wetlands. Based on his breeding records, he was quite certain that the crocodiles he offered were related to crocodiles which were captured live in the same Bau Sau wetlands a few decades earlier and should therefore be pure *C. siamensis*.

In Vietnam, confiscated wildlife is often released in protected areas. Because there are very few wildlife rehabilitation centres in the country, most wildlife is simply released in a protected area nearest to the confiscation site. It thus happens regularly that species are released outside their natural range. Also, quarantine rules are not observed and thus these releases pose a real threat to indigenous populations of wildlife. Apart from the lack of facilities, most wildlife officials in Vietnam seem to be simply un-aware of issues such as wildlife diseases and introducing non-indigenous species. As a result, many officials tend to believe that re-introducing wildlife is simply a matter of opening a cage or bag.

When the WWF-Cat Tien National Park Conservation Project was invited to support the re-establishment programme, issues such as pure breeds, indigenous species and re-introduction guidelines were discussed at some length. It was agreed that the re-establishment of the Siamese crocodiles would be conducted on the basis of sound science. WWF put forward three requirements for its involvement:

- As hybrids can not be distinguished from pure animals using external features, all crocodiles should be DNA tested and confirmed to be of pure *Crocodylus siamensis* before being transferred to the Bau Sau area.
- The Bau Sau wetland complex has to be strictly patrolled in order to reduce the current high incidence of illegal fishing in the area, where opportunistic fisherman in the area thought to pose a threat to released crocodiles.
- A feasibility study should be conducted to assess the suitability of the Bau Sau wetlands as a re-establishment site before release.

The re-establishment programme was conceived and formulated in 1999 by different organisations working together informally. These were:

- Cat Tien National Park as the host and release site of crocodiles.
- A private company crocodile farmer from Ho Chi Minh City who would donate about 20 crocodiles.
- The Saigon Zoo which would provide technical advice and who would be the intermediary with Queensland and Canberra Universities – Australia.
- Queensland and Canberra Universities which would conduct DNA testing under an agreement with the Saigon Zoo.
- The WWF-Cat Tien National Park Conservation Project which would provide financial support and technical advice based on contacts with the IUCN-SSC Crocodile Specialist Group.
- At a later stage, the MARD of the Vietnam Government joined as a stakeholder when they made an additional budget available.

GOAL, OBJECTIVES AND PLANNED ACTIVITIES

By late 1999, the following set of objectives were formulated and agreed by the stakeholders to guide the re-establishment programme. The goal to re-establish a population of Siamese crocodile in Cat Tien National Park is to ensure that an ecosystem that is as complete as possible and which represents a natural southern Vietnamese lowland ecosystem will remain as an example for future generations. The objectives to reach this goal are as follows:

1. To re-establish Siamese crocodile in Cat Tien National Park in a careful and scientifically sound manner.
2. To maintain a viable wild population of Siamese crocodile in Cat Tien National Park.

In order to reach the above objectives, aiming at achieving the above goal, a number of activities have to be deployed.

To re-establish Siamese crocodile in Cat Tien National Park in a careful and scientifically sound manner.

- A **feasibility study** has to be executed, assessing the suitability of - and food-availability in the prospective area to host Siamese crocodile, i.e. Bau Sau wetland complex in Cat Tien National Park. The study should include an assessment of impacts of crocodile on the remainder of the ecosystem as well as an assessment on whether crocodiles in the area will be safe from poaching. Of concern is the heavy under-water vegetation which can hamper the movement of young crocodiles. Also the risk of having crocodiles leaving the National Park through the Dak Lua creek, during high water levels and over land has to be assessed.
- The founder population has to be checked on being pure Siamese crocodile breed. Apart from Siamese crocodiles, breeding farms in Vietnam hold large numbers of Cuban crocodiles (*Crocodylus rhombifer*) as well. *C. siamensis* and *C. rhombifer* are known to produce fertile offspring. Release of crocodiles into the wild is only acceptable if pure *C. siamensis* are used. Although there are a number of exterior signs distinguishing *C. siamensis* and *C. rhombifer* (CITES, 1995), second and third generations are hard to distinguish from pure or mixed breeds. Therefore, a **DNA analysis** is essential to ensure that pure *C. siamensis* stock is being used in the re-establishment programme. If this is not done, Cat Tien National Parks runs the risk of ending-up with a crocodile population of unknown composition, which may have far-reaching (negative) ecological effects.
- At least two **staff** of Cat Tien National Park have to receive a minimum 2-month **training** in crocodile handling at the private crocodile farm and the Saigon Zoo.

- Crocodiles transferred to Cat Tien National Park will be held in a temporary facility at the head quarters. Here they will gradually be weaned from saltwater fish and will get used to live freshwater fish.
- Only after completion of the feasibility study, DNA analysis and when the crocodiles are used to fresh water fish, the animals will be **released** in the Bau Sau wetland complex.

To maintain a viable wild population of Siamese crocodile in Cat Tien National Park.

- **Strict and effective protection** must be ensured prior to a complete release in the wild. With a guard station at Bau Sau, basic facilities are available. However, continued entrance of fishermen into the Bau Sau wetlands complex (who use various kinds of gear including hook lines and nets) is a point of great concern. Released crocodiles may get entangled in the fishing gear and drown if not purposely hunted by poachers. Therefore, a strict control of the area by the Cat Tien National Park Forest Protection Department staff is a prerequisite for the implementation of this programme.
- **Monitoring** of released crocodiles (numbers, dispersment) has to be continued over an extensive period of time.
- An **information campaign** has to be held amongst the people living in the vicinity of the Bau Sau wetland complex (i.e. Dak Lua Commune) and amongst visitors to the National Park. This campaign should aim at disseminating general information about the crocodiles, their value as a member of the National Park's ecosystem and at avoiding possible crocodile-human conflicts.
- **Small-scale tourism** facilities should be established in the Bau Sau area. These could be a canoe and boardwalks along parts of the perimeter of the wetland. These should facilitate safe crocodile viewing opportunities. In order not to disturb the animals too much and not to put too much pressure on the fragile Bau Sau wetland ecosystem, only small groups of a maximum of 10 people per day should be allowed to visit the Bau Sau area. Special fees should be levied to permit visitors entering the Bau Sau area. The fees should be utilised to maintain strict protection and tourism facilities.

PROGRESS AND EXPERIENCES SO FAR

In early 2000, two staff of Cat Tien National Park were trained in crocodile handling at the crocodile farm. A holding cage for the crocodiles was built at the headquarters of Cat Tien National Park. On October 25, 2000 a handing-over ceremony took place in Ho Chi Minh City whereby the Park received 25 crocodiles from Hoa Ca Crocodile Farm. All of them were born in 1998. Saigon Zoo took the responsibility of taking samples for DNA testing to be sent to Queensland University and tagging the individual crocodiles with a micro-chip so that individuals can be recognised when matching test results with individual crocodiles. Unfortunately the samples were not sent to Australia before the animals arrived in the Park. Also, the crocodiles arrived while a habitat feasibility study had not been executed yet. DNA samples of 20 crocodiles were sent to Australia in November 2000 as part of a larger number of samples taken in southern Vietnam. Meanwhile the Vietnam Government provided support for this activity and the Park bought 15 additional crocodiles of unknown breed from crocodile farms. After arrival in the Park, the diet of the crocodiles shifted from eating dead sea-fish to dead freshwater fish, then to live freshwater fish over a period of 2 months.

Members of the IUCN-SSC Crocodile Specialist Group visited the Park in May 2001 and assessed the intended release site (Crocodile Lake) and the different ideas held by different stakeholders on how to proceed with the re-introduction programme. Their expert opinion was discussed with Park and Project authorities and it was concluded that the following line of action was to be followed.

- All crocodiles will have to be DNA tested. Non-pure *Crocodylus siamensis* have to be taken out of the release programme.
- There is no need to buy more crocodiles as the stock available should be adequate to re-populate the wetlands in Cat Tien National Park. Also, buying additional stock is likely to bring non-pure *C. siamensis* to the Park as there are few pure-bred animals available in Vietnam.
- While awaiting DNA test results, the crocodiles should be kept at the Park's headquarters. Young individuals and DNA tested animals have to be separated from older and un-tested animals. Therefore two additional cages have to be build at headquarters.

- Animals should be released directly into Crocodile Lake and do not need to be kept there in a temporary cage as the habitat at Crocodile Lake is ideal for crocodiles (adequate quantities of fish and no natural predators).
- The best time for release is when flood-waters recede (December – February) and the Crocodile Lake is confined by dry land. As when released, the animals can establish home ranges within a confined area and are more likely to stay there when the next flood increases their potential range.
- In the coming dry season (2001-2002), a group of 10 – 15 animals should be released. The other animals should be kept at headquarters awaiting DNA test results for subsequent releases in 2003.
- The released animals should be monitored using a simple spotlight method. Trials with radio collars (undertaken in May 2001) show that the effort required to locate a signal will render the method in-efficient. Additionally, the amount of manpower required to execute a radio-tracking programme is probably not available. Spotlighting should not commence before 10 days after release so that the animals can get used to their new environment undisturbed. Over the subsequent two months, weekly spotlight surveys should be undertaken. After this intensive survey period, the spotlight surveys should be cut back to monthly surveys in order to limit disturbance and to establish a realistic routine within the limited manpower available at the Park.
- The aim for monitoring should be to assess whether the crocodiles remain in Crocodile Lake or whether they will immediately range deeper inside and / or outside the Park. Additionally monitoring information will establish a baseline of the population and will in due time hopefully find a population increase due to natural growth.

The assessment of the habitat and the feasibility for release conducted by the IUCN-SSC Crocodile Specialist Group members confirmed earlier findings (Polet and Tran Van Mui, 1999; Platt and Ngo Van Tri, 2000) that the Crocodile Lake of the Bau Sau wetland complex is an excellent release site. There are no large predators which will cause mortality amongst released crocodiles, fish are available in abundance and the vegetation cover is good. Protection of the area has been greatly improved by stricter control of the Park's forest protection staff. One concern remaining is the risk that crocodiles can get entangled in abandoned fishing nets floating underwater in the lake.

In June 2001, DNA test results came back from Queensland University. A detailed description of findings is being presented elsewhere (Fitzsimmons, et al. in press). One of the animals held in Cat Tien National Park was proven to be a cross between *C. siamensis* and *C. rhombifer*, despite care taken by the crocodile farmer to keep proper stud-books. This animal has been removed from the release programme.

On December 18, 2001 the first batch of 10 crocodiles were released in the Bau Sau wetland complex. On March 12, 2002 five more animals were released and on March 13, 2002 the last four of the DNA tested animals were released (Table 1). At the time of release the animals were about 3.5 years old and measured 1.55 to 1.92 metres.

Table 1. Number and Sex of Released *C. siamensis* in Cat Tien National Park

Release Date	Males	Females	Total
December 18, 2001	5	5	10
March 12, 2002	2	3	5
March 13, 2002	1	3	4
Total	**8**	**11**	**19**

POST RELEASE MONITORING

Methods

Monthly spotlight surveys are used as a baseline index of the crocodile population in Bau Sau (Crocodile Lake). Every month a two-man team, consisting of an observer and boatman, circumnavigate the lake searching for the eye-shine of crocodiles following the methods described by Messel et al. (1981), Ratanakorn et al. (1994), and Perran Ross (pers. comm.). Each survey is carried out as close to the new moon as possible as crocodiles are more wary on the full moon (Perran Ross pers. comm.). Before the start of each survey data on the lake level, cloud cover, wind, air and water temperature are recorded, as these variables can affect crocodile observability (Woodward and Moore, 1993; Pacheco, 1994).

In 2002 the monthly spotlight surveys can be separated in to two phases where alterations to the method were made in May. In the first phase (January-April) the two-man team would circumnavigate the whole lake using a Q-beam spotlight. In May three members of the CSG (Paul Moler, C. L. Abercrombie, and Phil Wilkinson) visited Bau Sau and suggested circumnavigating each of the two lobes of the lake separately and using a weaker spotlight that would not wash out the eye-shine of any nearby crocodiles. In the second phase (June-current) these suggestions have been incorporated.

Results

For the first two monthly surveys there was a low number of crocodiles observed with one or two seen per survey (Table 2). In March, when another 9 animals were released in Bau Sau, the number observed increased sharply. From April to September the number of crocodiles seen each survey has been between 3 to 6 (Table 2), which represents 16 to 32% of a total released population of 19 (Figure 1). Crocodiles have mainly been observed in the smaller lobe, closest to the forest guard station, which is deeper. In February one crocodile has been seen in the large lobe of the lake, and two at the same location in September, which is characterised by large shallow areas of tall reeds around its perimeter. The greater distance travelled by canoe in September was because of the higher lake level after flooding at the end of August.

Table 2. The number of Siamese crocodiles observed, km travelled, number of crocodiles observed/km travelled, and % of the total released population observed during monthly spotlight surveys at Crocodile Lake, Cat Tien National Park, in 2002

	Number of crocodiles observed	Km travelled	Number of crocodiles observed/Km travelled	% of the total released population observed
January	1	5.5	0.18	10
February	2	5.5	0.34	20
March	6	5.5	1.10	32
April	3	5.5	0.55	16
May	5	5.5	0.92	26
June	4	5.5	0.73	21
July	3	5.5	0.55	16
August	3	5.5	0.55	16
September	6	7.2	0.83	32

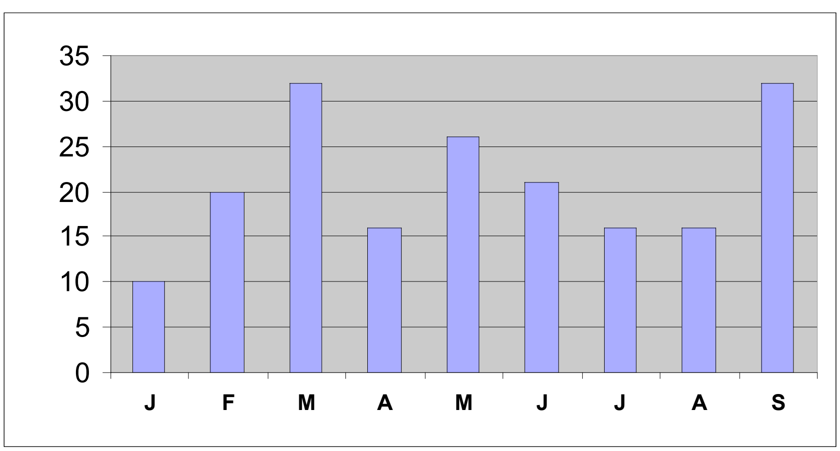


Figure 1. The percentage of the total released population of Siamese crocodiles observed during monthly spotlight surveys at Crocodile Lake, Cat Tien National Park, in 2002

DISCUSSION

The 10 to 32% of the crocodile population observed in Bau Sau is comparable to other spotlight studies with a known population size where 9 to 19% of the population was observed (Woodward et al., 1996). This suggests that the spotlight surveys are a suitable index of the local crocodile population. The small variance in the observed number of crocodiles between months indicates a relatively stable population. The high count of crocodiles in March was soon after the second release and was probably influenced by newly released crocodiles still habituating to their new environment. The high count in September was when the lake level had risen above some of the shoreline vegetation potentially improving the chances of seeing crocodiles. The September count also suggests a stable population in Bau Sau and no crocodiles have emigrated to other adjoining wetlands and the Dong Nai River that connect with Bau Sau during flooding at the height of the monsoon season (August-September). The more crocodiles observed in the smaller lobe of the lake is possibly a preference for the deeper water for easier feeding, or because crocodiles were missed in the larger lobe of the lake where the tall reeds reduced visibility.

Spotlight surveys have been an easy method to implement because their simplicity and low time-commitment have allowed them to be incorporated into busy existing schedules. However, as observers have changed, with monitoring activities being transferred to park staff and with changes in park staffing, results cannot be reliably used for any analysis of trends in the observed population (Woodward and Moore, 1993) until standardised observers are maintained at the park. Maintaining standardised observers (from changes in staffing), and a monthly routine, are the focal areas for the future of crocodile monitoring by Cat Tien National Park staff.

FUTURE PLANS

On August 1, 2002, the Park and a new crocodile farmer signed an agreement in which the Park is to receive 100 crocodiles over a period of three years. Samples for DNA testing of these animals were taken on last August 29. A CITES export permit has been applied for and the samples will be sent to Canberra University – Australia for DNA testing. A new batch of 30 to 40 animals is scheduled to be released during the coming dry season (December 2002 – March 2003).

As responsibility for monitoring is being transferred to park staff, monthly spotlight surveys should continue, executed by Park staff, with the aim to detect population trends and habitat use. It is hoped that young crocodiles will be encountered which would proof natural growth of the population. It will also be interesting to see whether there are indications of crocodiles having moved-out of the area after the flood season or whether some crocodiles maintained their home range at the lake despite their larger potential range during the floods.

LESSONS LEARNED

Some lessons can be learned from the experience gained in the crocodile re-establishment programme in Cat Tien National Park – Vietnam.

The programme has a wide range of different partners; from the private sector to governmental organisations to international conservation organisations and specialists. This set-up has its strengths and weaknesses. Most of the expertise and logistical support for the programme is available amongst its partners. However, working with so many different organisations, each with different priorities and with different powers, is a complicated matter. Working towards the success of the re-introduction programme depends on each partner's willingness to contribute and accommodate other partner's points of view. This can only be achieved, and geared towards getting results, if the objective of the re-introduction programme is spelt-out right from the start of the activity. This has been the case in the Cat Tien National Park re-introduction programme and well defined goals and activities were formulated at the beginning of the programme.

But even with such clearly defined activities and timetables, different implementation sequences were followed in Cat Tien National Park. The crocodiles arrived in the Park before DNA test results were obtained. An informal feasibility study of the release site was conducted after the animals arrived in the Park. This experience illustrates on-the-ground complexities to implement a programme according to agreed timetables and in a scientifically sound manner. It is due to the partners willingness to consider and re-consider different ideas and priorities that this specific programme has not resulted in the pre-mature release (i.e. crocodiles which have not been confirmed to be pure *C. siamensis* through DNA analysis) of crocodiles in Cat Tien National Park.

The need to conduct DNA analysis is also evident from the experience in Cat Tien National Park. Although the crocodile farmer kept a stud-book and was convinced that his crocodiles were pure *C. siamensis*, DNA testing concluded that 1 of the 20 tested animals was in fact a hybrid of *C. siamensis* x *C. rhombifer*. If DNA testing would not have been conducted, this animal would have been released and thus an alien species would have been introduced in the Park's ecosystem.

Spotlight surveys are a suitable index of the crocodile population at Bau Sau as the results in 2002 are comparable to other studies of a known population. Spotlight surveys indicate a stable population of released Siamese crocodiles in Bau Sau before and after the height of annual flooding of the Bau Sau wetland complex (though more surveys are required to assess the post-monsoon population).

Spotlight surveys have been an easy method to implement because their simplicity and low time-commitment have allowed them to be incorporated into busy existing schedules. The only possible problems for the future of monitoring in Cat Tien National Park is maintaining a monthly routine, and non-standardized observers from rapid changes in park staffing.

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The Current Status of the Philippine Crocodile, *Crocodylus mindorensis* Schmidt, in the Wild

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ABSTRACT: We are currently monitoring the population status of *Crocodylus mindorensis* in the wild. This paper presents the results of population surveys we conducted from 1999 to 2001. We discovered three previously unrecorded populations of *C. mindorensis* in Abra Province and Isabela Province, Luzon Island, and Bukidnon Province, Mindanao Island. We did not encounter crocodiles in Busuanga and Negros Islands. Crocodiles are present in Agusan Marsh, Mindanao Island, but we were not able to identify the species . Our research indicates that there are viable populations of *C. mindorensis* remaining in the wild.

The Status and Conservation of the Philippine Crocodile *Crocodylus mindorensis* in the Northern Sierra Madre, Luzon, the Philippines

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ABSTRACT: The Philippine crocodile *Crocodylus mindorensis* is an endemic freshwater crocodile. *C. mindorensis* is the most severely threatened crocodile species in the world, caused by over-hunting and the alteration of its habitat. A previously unknown population was found in the Northern Sierra Madre on Luzon in 1999. At this moment, 7 distinct localities are known with confirmed *C. mindorensis* presence in the Northern Sierra Madre. A total of 41 crocodiles have been found in these localities. In 3 of these sites, successful breeding has been confirmed. The Philippine crocodile seems to be a generalist in the choice of habitat. It is found in fast-streaming mountain rivers, small lakes, stagnant lowland creeks and even in coastal habitats. The locality with the highest human disturbance also has the highest number of crocodiles. Hunting and killing of crocodiles is the main reason for its very low population size in Northern Luzon. The Northern Sierra Madre Natural Park – Conservation Project set up a conservation program which included awareness raising campaigns and meetings with local residents to design a co-management system to protect the crocodiles and their habitat. The support was won of the local government of San Mariano which declared *C. mindorensis* their flagship species and established the first ever Philippine crocodile sanctuary. These initial positive results have led to a proposal to extend the conservation program to a larger area, for a longer period. Whether the used approach is successful on the long term will be closely monitored.

INTRODUCTION

Crocodiles in the Philippines

There are two species of crocodiles in the Philippines, the Estuarine crocodile *Crocodylus porosus* and the Philippine crocodile *Crocodylus mindorensis*. The Philippine crocodile is an endemic species, it occurs only in the Philippines. The Estuarine crocodile is widespread from Northern Australia to India and although it is threatened in the Philippines it is still common in several of these other countries.

The Philippine crocodile is a small crocodile generally living in inland lakes and the headwaters of rivers. The Estuarine crocodile lives in brackish water, sea and lower river systems. The Philippine crocodile can reach a maximum length of about 2.5 m while the Estuarine crocodile can grow up to 6 m. Apart from size and habitat, the best identification characteristic is the presence of enlarged scales in the neck of the Philippine crocodile. The Estuarine crocodile has a smooth neck.

Status and conservation of the Philippine crocodile

The Philippine crocodile is listed in the IUCN Red List (Hilton-Taylor, 2000) as critically endangered (a continuing declining population of fragmented sub-populations in declining areas of occupancy, an adult population of less then 250 individuals, and a population decline bigger than 80 percent in 3 generations). Philippine crocodiles are protected under Philippine law (WCSP, 1997). International trade in Philippine crocodiles is banned under Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (CITES, 1998).

The wild population was estimated at 1,000 individuals in 1982 (Ross, 1982) and at 100 non-hatchling individuals in 1993 with Mindanao and possibly the Sulu archipelago as the last remaining stronghold of the species (Ross, 1998). That was before the rediscovery of the species in Luzon. Because of the continuing adverse security situation in these areas, there is little hope for effective conservation of the Philippine crocodile in Mindanao and Sulu. The discovery of the Philippine crocodile in the Sierra Madre, however, offers new possibilities for conservation and survival of the species in the wild.

Conservation initiatives

In 2000, the Philippine Crocodile Recovery Team was created. Its members include officials of the Department of Environment and Natural Resources (DENR), the Director of the Palawan Wildlife Rescue and Conservation Center (PWRCC), which is a captive breeding facility for *C. mindorensis*, and several persons that are professionally involved with *C. mindorensis* conservation or captive breeding. The recovery team prepared a national recovery plan for the Philippine crocodile (Banks, 2000). The primary goals of this recovery plan are to re-establish viable wild populations of *C. mindorensis* and to ensure its long-time survival. The IUCN/SSC Crocodile Specialist Group recommended in 1998 that captive breeding offers the best chance for the species' survival (Ross, 1998). A large number of *C. mindorensis* have been bred in the PWRCC but so far no crocodiles have been reintroduced to the wild. It must be noted that both the IUCN Crocodile Action Plan (Ross, 1998) and the Philippine Crocodile Recovery Plan (Banks, 2000) do not include the here presented information on *C. mindorensis* in the Sierra Madre as these data have only been gathered during the last two years. A new priority in *C. mindorensis* conservation might now be the identification and study of other sites in Northern Luzon and conservation and recovery of these wild populations.

The Northern Sierra Madre

The Sierra Madre mountain range runs from the Northeastern tip of Luzon all the way south to Quezon province near Manila. The portion in Northeastern Luzon is called the Northern Sierra Madre. The highest summits are about 2,000 meters above sea level. On the eastern side, the mountains dip steeply into the Pacific Ocean, sometimes with small coastal plains and valleys that are sparsely inhabited. On the western side in Northern Luzon, below a steep ridge, a rolling hilly landscape can be found into the Cagayan Valley. Cagayan river is the largest river of the Philippines and is fed by run off from the Sierra Madre mountains in the West and the Cordillera mountains in the East. Annual precipitation in Cagayan Valley is about 2,000 mm. There is no distinct dry period although there is much less rain from March to June. Most rain falls during typhoons, which strike the area yearly between July and November. Because the Sierra Madre is so steep, the area escaped large scale commercial logging in higher elevations during the logging boom in the Philippines of the 1960's and 70's. Lower areas however have been logged over extensively. Upland farmers followed the clearing of the land and established themselves in the foothills of the Sierra Madre during the past 40 years. Before that time the area was sparsely inhabited by the Agta, an indigenous hunter/gatherer people.

The remaining forest cover of the Sierra Madre attracted the attention of conservationists. In 2001 the portion of the Sierra Madre mountains in Isabela province was declared a protected area: the Northern Sierra Madre Natural Park (NSMNP). It is the largest protected area of the Philippines with an area of about 360.000 Ha. It is also one of ten priority sites for biodiversity conservation in the country and several international NGOs have started conservation projects in the area.

The Northern Sierra Madre Natural Park – Conservation Project (NSMNP-CP)

The NSMNP-CP is funded by the Dutch government and implemented by Plan International, an organization better known for its child-focused projects. The project started in 1996 and the first phase will end in October 2002. Most probably it will then continue in a second phase, with another implementer. The main objective of the NSMNP-CP is to assist the Philippine government with biodiversity conservation in the Northern Sierra Madre through biodiversity studies, awareness raising, alternative livelihood development and setting up (co-)management structures of natural resources and the park itself. The biodiversity research component consists of a flora, marine and fauna team. In March 1999, Samuel Francisco, a local fisherman of the small village of San Isidro in the periphery of the NSMNP, accidentally caught a hatchling crocodile which was turned over to field staff of the NSMNP-CP. The hatchling was identified as *Crocodylus mindorensis*, which was later confirmed by a team from the PWRCC. Following the discovery, the fauna team of the NSMNP-CP started to look for remaining wild populations of the Philippine crocodile in the Northern Sierra Madre. Once these populations were found, all components of the NSMNP-CP were mobilized to work on their conservation.

METHODS

Since the discovery in 1999, a number of crocodile surveys have been carried out in the Northern Sierra Madre by the NSMNP-CP. Two of these surveys were conducted together with co-workers of the PWRCC and Frederick Pontillas. Two in-depth studies were carried out by Dutch MSc. students in co-operation with the Cagayan Valley Program on Environment and Development (CVPED), which in its turn is a scientific co-operation program between Isabela State University and the University of Leiden. Recently, surveys are also being carried out by students under the CROC project (Crocodile Research, Observance and Conservation) which is funded by British Petroleum and implemented by CVPED. The data presented in this paper is a summary of the results of these studies (Pontillas, 2000; Tarun, 2000; Van Weerd, 2000a; Van Weerd et al., 2000a; Van Weerd, 2000b; Tarun, 2001; Van Weerd et al., 2001; Oppenheimer, 2001; Oudejans, 2002; Tarun and Guerrero, 2002; Van Alphen and Telan, 2002).

Interviews were carried out in all settlements of the Northern Sierra Madre Natural Park (NSMNP) to gather secondary information on current and historic presence of crocodiles. Information on current presence was checked in the field, often by hiring the informant as guide and visiting the sites he or she mentioned. Day light track searches were carried out along riverbanks as well as night surveys using strong flashlights. Of crocodiles observed, size was estimated and individuals were placed in the following categories: (1) hatchling (very small crocodiles up to 0.3 m), (2) juvenile and sub-adult (0.3 to 1.5 m), and (3) adult (longer than 1.5 m). Night surveys were repeated and the maximum number of one night was taken as population count. Secondary information on crocodile numbers that could not be confirmed in the field, or of sites that could not be visited, was categorized as "estimated" if the information was given by several independent informants and sounded reliable. Habitat was mapped and described following a standard protocol. The results presented here are a brief summary of the main habitat characteristics.

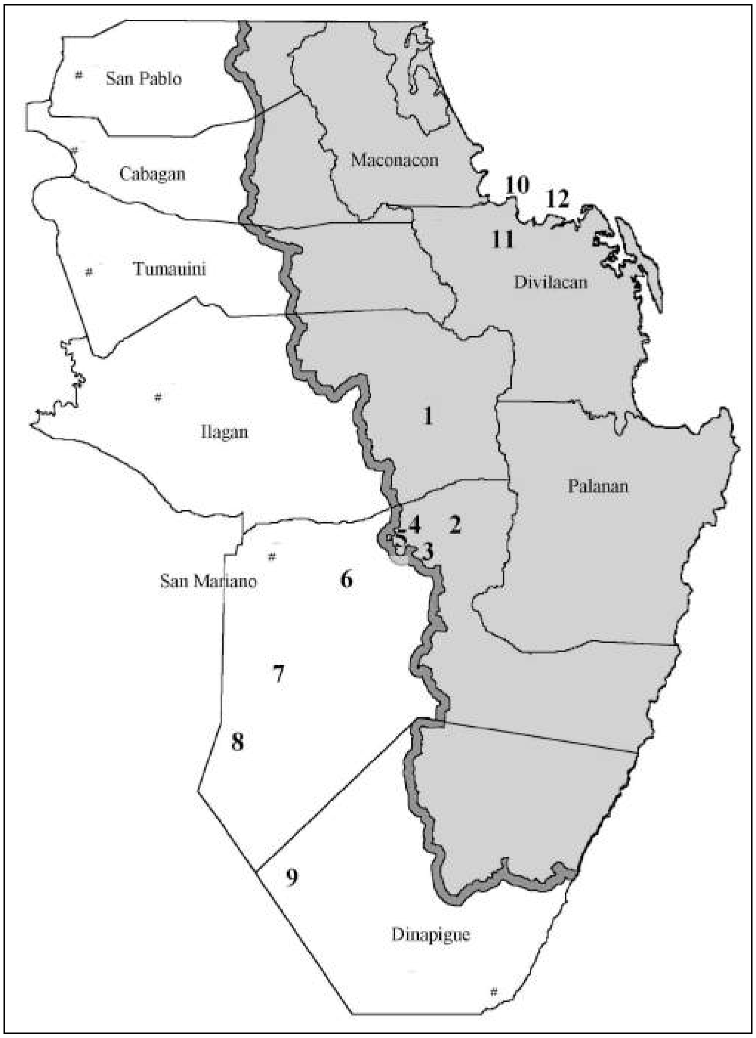
PHILIPPINE CROCODILE DISTRIBUTION AND POPULATION SIZE IN THE NORTHERN SIERRA MADRE

In 1999, the presence of *C. mindorensis* was confirmed in the Northern Sierra Madre (van Weerd, 2000). This area was previously identified as a probable *C. mindorensis* locality based on secondary information (Ross, 1982) but hard evidence was lacking. A thorough survey of wildlife species of the area during the early 1990's, of which the spectacular results certainly helped to establish the park, had not recorded the Philippine crocodile for the Northern Sierra Madre (NORDECO and DENR, 1998).

Estuarine crocodiles are still present in coastal wetlands on the eastern side of the Sierra Madre, though in very small numbers (NORDECO and DENR, 1998; Oppenheimer, 2001; Van Weerd, 2001). However, *C. mindorensis* was also observed near and even in the ocean. One specimen was captured leading to a positive identification (van Weerd, 2000) and another adult *C. mindorensis* was caught by fishermen in a mangrove area in May 2001 and photographed. Within the municipality of San Mariano there are 6 localities with confirmed Philippine crocodile presence. The total population ranges from 41 confirmed individuals in these 6 localities (Tarun and Guerrero, 2002) to an estimated 77 based on secondary information (Oppenheimer, 2001), and probably more than 100 in a larger area including the Cordillera part of Cagayan Valley (Oudejans, 2002). However, recent surveys conducted by van Alphen and Telan (2002) suggest that *C. mindorensis* can no longer be found in many of these localities. 26 hatchlings, 8 juveniles and 7 adults were observed. *C. mindorensis* has been confirmed breeding in 3 sites: Lake Dunoy, Disulap River (in 2000) and Dinang Creek.

At several other localities in San Mariano, crocodiles have been observed but these are probably not breeding areas because hatchlings were never observed. Two localities long suspected to hold significant *mindorensis* populations, based on interview results, in and near San Mariano were surveyed in July 2002: Abuan River and the upper stream of Ilaguen River. Unfortunately no crocodiles were found and disturbance by illegal loggers/hunters along Abuan river is of such a magnitude that it is unlikely that a significant population of crocodiles can survive here. Ilaguen river remains a suspected site since the habitat seems to be very suitable for crocodiles: large deep ponds and little disturbance. But, during the July 2002 survey no crocodiles or tracks were found.

Lake Dicatian and surrounding creeks in the coastal municipalities of Maconacon and Divilacan are confirmed as *C. mindorensis* localities (Oppenheimer, 2001) although reliable population estimates are lacking.



Map 1: Philippine crocodile locations in and near the Northern Sierra Madre Natural Park. Numbers correspond with locality numbers in Table 1.

Fishermen caught two adult Philippine crocodiles in the Pacific Ocean at the mouth of creeks in this area. Both crocodiles died.

Table 1 shows the confirmed population size per age class in the various localities as well as localities that are suspected to harbor crocodiles but which could not (yet) be confirmed. Localities that were visited based on secondary information but which surely do no longer hold crocodiles are also shown. Most of these localities were very recently visited as part of a survey program under the CROC Project. Map 1 shows the localities with confirmed or suspected Philippine crocodile presence in and around the NSMNP. There are two distinct sub-populations: (1) Lake Dicatian and surrounding rivers in Divilacan, and (2) Ilaguen River and its tributaries and lakes in San Mariano and Ilagan. The numbers placed before localities in Table 1 refer to the same location numbers in Map 1.

Table 1. Identified Philippine crocodile localities and confirmed population size per age class as well as suspected crocodile localities and localities which do no longer hold crocodiles. Localities in bold font are confirmed to hold crocodiles. Numbers refer to localities in and near the NSMNP and are equal to numbers in Map 1.

Location	**Hatchling**	**Juvenile /sub-adult**	**Adult**	**Total**	**Site visited but no crocodiles anymore**	**Site visited, no crocodiles observed but suspected**
Cagayan Valley, NSM						
Isabela Province						
1. Abuan River						X
2. Kamalaklakan			1	1		
3. Pagsungayan						X
4. Lake Dungsog			1	1		
5. Lake Dunoy	12		2	14		
6. Disulap River			1	1		
7. Disabungan River		2		2		
8. Dinang creek	14	6	2	22		

Location	Hatchling	Juvenile /sub-adult	Adult	Total	Site visited but no crocodiles anymore	Site visited, no crocodiles observed but suspected
9. Ilaguen River						X
Dinamag creek					X	
Cagayan Province						
Lake Manga					X	
Baggao					X	
Bical					X	
Quirino province					X	
Madella					X	
Wasid					X	
total Cagayan Valley NSM	26	8	7	41		
Pacific Ocean, NSM						
Isabela Province						
10. Lake Dicatian				X		
11. Dibol						X
12. Divilacan						X

Oudejans (2002) identified several other localities in the Cordillera mountains, outside the coverage area of the NSMNP-CP, with possible *C. mindorensis* populations on the basis of interviews. These are Magat River with an estimated total of 10 crocodiles and Siagot River with another 10 crocodiles. These localities were not yet visited to confirm the presence of crocodiles. The fact that new crocodile localities were identified during many of the surveys in new areas, and the fact that Philippine crocodiles are easily overlooked, lead to the conclusion that *C. mindorensis* might very well still occur in low numbers in many localities in North Luzon. During the recent surveys of Van Alphen and Telan (2002) however, no new areas were found and most informants mention recent local disappearance of crocodiles in sites visited.

Habitat

Detailed habitat characterization studies were carried out in Lake Dunoy, Disulap river and Dinang creek in January to March 2001 (Oppenheimer, 2001). Table 3 and 4 summarize the findings.

Table 3. The general characteristics of Dunoy, Diwakden and Dinang

Location	Wetland Type	Size	Turbidity	Flow	Banks	Human activity
Dunoy	Lake	100 x 50 m	Clear, vegetated	Stagnant	Not steep, dense vegetation of shrub and trees	Slash and burn farming, rice paddies nearby. No fishing.
Disulap	River	Average width: 24 m	Clear	Rapid	Cliffs and pebble beaches, cliffs forested	Few cultivated fields, moderate fishing/hunting activities
Dinang	Creek	Average width: 7 m	Turbid	Nearly stagnant, small rapids	Steep clay banks, small strip of shrub	Cultivated all along creek. Creek used by bathing cows. Fishing

Table 4. Physical characteristics of Dunoy, Diwakden and Dinang in the period January to March 2001.

Location (N)	Temp (°C)	pH	Flow velocity (m/s)
Dunoy (11)	23.0 - 25.0	4.34 - 6.09	0
Disulap (21)	22.5 - 25.0	6.85 - 7.25	0.01 - 0.67
Dinang (20)	24.0 - 29.0	6.49 - 7.74	0.02 - 1.55

The variation in habitat characteristics between the sites is striking. *C. mindorensis* occurs in small lakes, fast streaming rivers and stagnant creeks. pH varied from acid (4.34) to slightly basic (7.74). Riverbank substrate and vegetation varied from cliffs with pebble beaches to clay banks with shrub and secondary forest vegetation. Dinang Creek is surrounded by cultivated fields with a very high disturbance level from cultivating farmers and bathing cows. Disulap River is much less disturbed. None of the localities is really secluded or undisturbed. *C. mindorensis* is found in both fresh and sea water environments though the occurrence in the sea has to be studied further and is based on two accidental catches by fishermen in coastal waters. It seems that *C. mindorensis* is much more of a generalist than a specialist and does not totally depend on undisturbed freshwater habitats. Why then is the species so rare?

Threats

In the Municipality of San Mariano, Isabela, the decline of the crocodile population is thought to be linked with poaching and destruction of crocodile habitat such as illegal fishing, slash and burn farming up to the edge of rivers and lakes, and deforestation. Many areas where crocodiles historically occurred but disappeared show these human activities. However, in Dinang Creek this theory seems to be debunked as both sides of the creek are intensively cultivated (rice and corn), grasses and shrub along the riverbanks are burned, and fishing activities are regular occurrences. Dinang creek has the highest number of crocodiles of all localities known in the Northern Sierra Madre.

Most respondents of interviews on the reasons of decline of *C. mindorensis* in San Mariano do mention that hunting decimated the former crocodile populations, notably commercial hunting during the 1960s by crocodile hunters from Mindanao (Oudejans, 2001). During the period March 1999 to August 2002, several incidents in which crocodiles were captured or killed were reported. Two adult Philippine crocodiles were accidentally caught by fishermen in the coastal waters of Isabela and died after being kept tied to ropes for weeks. The DENR, responsible for the release or confiscation of captured Red List species, was not able to convince the fishermen to release the crocodiles and did not enforce the law. Several juvenile crocodiles were caught in San Mariano and sold as pet. They could not be retrieved, as the source did not want to disclose the names of clients. At least one adult crocodile was killed in Dinang creek out of fear or ignorance. Another adult crocodile was killed here in July 2002 by the Philippine army and eaten as snack. One juvenile crocodile was caught in Ilaguen River and kept as pet.

It seems that killing and capturing of crocodiles is the main reason for the continuing decline of C. mindorensis in Northern Luzon, and probably the Philippines as a whole. Habitat alteration and food competition might play a role as well but less so then hunting. Currently, the remaining population of C. mindorensis in the Northern Sierra Madre is also threatened by fragmentation and by being too small. Stochastic effects (flashfloods, extreme droughts, reduced chances to find a mating partner) and genetic effects (inbreeding) become large threats in very small populations.

Because of its shy nature and small size, the Philippine crocodile offers no real danger to humans. Indeed, in all localities where crocodiles are found in San Mariano, they share the river and natural resources with humans living nearby. There are no reported attacks of Philippine crocodiles on humans from direct sources. All stories about crocodile attacks are "hear-say" and could refer to attacks by Estuarine crocodiles, which are believed to have been present in Cagayan river until fairly recently (Oudejans, 2002). In the San Mariano area all crocodiles present are Philippine crocodiles. Acceptance of co-habitation with crocodiles and sharing of freshwater habitats might therefore be easier to achieve compared to areas where crocodiles pose a danger to people. Fighting ignorance by providing information and winning the support of the local farmers, fishermen and hunters is of utmost importance for a successful conservation program.

CONSERVATION OF THE PHILIPPINE CROCODILE IN SAN MARIANO

In San Mariano, *C.mindorensis* is mainly found outside the NSMNP and its buffer-zone. A conventional conservation program based on minimizing people-crocodile interactions and totally protecting natural crocodile habitats can therefore not be employed. Removing people from the crocodile inhabited areas is, in our time, no longer a socially acceptable option and would not be accepted by the local population and local government. It would also work counter-productive as local inhabitants would start to see the crocodiles as a threat to their livelihood and law enforcement in protected areas in the Philippines is currently generally lacking.

Therefore, any long term conservation and protection program for *C. mindorensis* will have to employ a co-management approach wherein all stakeholders play a serious role and share responsibilities. A long-term program should definitely include mitigating measures to lessen the impact of anthropogenic factors, which will always be present at various intensities but it should also include benefits for affected local communities to solicit their active support and compensate for any adverse impact.

After the discovery of *C. mindorensis* in San Mariano in 1999, a short-term conservation plan was prepared and executed by the NSMNP-CP and the Local Government Unit (LGU) of San Mariano from July 2000 to May 2002. This conservation program was focused on Disulap River and the surrounding communities of San Jose and San Isidro. Disualp River was the first location with confirmed presence of crocodiles and also the first site where breeding was confirmed. The main goal was to establish a crocodile sanctuary which would be accepted by the local communities. The conservation plan was drafted by the NSMNP-CP but revised with inputs from local communities who formally accepted the final version. The proposal was also presented to the Protected Area Management Board (PAMB), which is the multi-sectoral body responsible for decisions about the NSMNP, and was subsequently approved. The objectives of this conservation plan were the following:

1. Generating data on Philippine crocodile distribution, population size, basic ecology and threats in the Northern Sierra Madre.
2. Increasing the awareness among the local population with regards to the status and need of protection of the Philippine crocodile.
3. Involving the local population in co-management of the Philippine crocodile and establishment of community declared crocodile sanctuaries.
4. Involving all stakeholders in planning and writing of a long-term action plan for the conservation of the Philippine crocodile in the Northern Sierra Madre and securing funding for the execution of a long-term conservation plan.

To increase the support of local communities an integrated conservation and development approach was used with attention and budget for the provision of alternative livelihood options to target communities.

Activities conducted leading towards co-management and sanctuary establishment

Information, Education, Communication (IEC)

Information campaigns were conducted with the objective of educating the people on the nature and status of the Philippine crocodile and its possible imminent extinction, if conservation and protection efforts would not be implemented immediately. 5 awareness sessions were held in the villages of San Isidro and San Jose. Posters, produced by the NSMNP-CP, were used during these sessions, which were left behind in the community for display.

Two thousand flyers in Tagalog were produced as well as colored posters (1,000 in English and 1,000 in Tagalog), which were distributed to all villages in and near the NSMNP. Additional copies were given to the People's Organizations (PO) for distribution to people passing by their villages. The Philippine crocodile has been featured several times in the Tagalog newsletter that the project is distributing among local communities and in radio broadcasts on popular local radio stations. A comic album on environmental issues was produced and distributed featuring a story about the Philippine crocodile. *C. mindorensis* is one of the topics of the community theatre groups (*Dalaw Turo*) that were established in the Sierra Madre by the NSMNP-CP and the DENR. The general theme of the campaigns was "the Philippine crocodile, something to be proud of". The mayor of San Mariano took the initiative to have t-shirts printed with this slogan in Tagalog and with a picture of *C. mindorensis* to present to visitors of his town.

Community dialogues and public consultations

Following the IEC sessions, a proposal for a Philippine crocodile conservation program was drafted. The draft proposal was discussed with the community residents of San Isidro and San Jose during meetings and informal discussions. The need to regulate human activities within the proposed sanctuary and the need to form a community protection group were discussed. Both got the approval of the local residents. The residents came with suggestions to balance the need to have transportation access and some fishing activities with crocodile conservation within the proposed sanctuary. This resulted in well-defined areas within the sanctuary where regulations became site-specific. After the public consultation sessions, attendees were given survey forms wherein they could signify whether they were in support of the Philippine crocodile conservation program or not. The proposal got an overwhelming support both in San Isidro and San Jose.

Lobbying for local government support

When the first retrieved hatchling was identified as the Philippine crocodile, the LGU of San Mariano was informed and provided with an orientation on the need of its conservation. The LGU responded immediately and passed several ordinances in support of Philippine crocodile conservation.

Following the public consultation sessions in San Isidro and San Jose, the LGU of San Mariano held a committee hearing wherein all the queries on a proposed ordinance to declare a sanctuary were explained and clarified. Additional public consultations were then conducted by the LGU. The draft copy of the ordinance was discussed and the map of the proposed sanctuary was shown to the local stakeholders. Getting the approval from the community residents living near the sanctuary, the ordinance was passed and approved by the LGU of San Mariano on September 7, 2001.

The following ordinances and resolutions were passed and approved by the LGU of the Municipality of San Mariano, Isabela:

1. Ordinance No. 99-025: an ordinance identifying the Philippine crocodile as an endangered species occurring in San Mariano and prohibiting the collection and annihilation of *C. mindorensis* (Municipality of San Mariano, 1999).
2. Ordinance No. 2000-002: an ordinance prohibiting the catching, hunting, collecting, or killing of the Philippine crocodile for pets, sports, collection or personal consumption. This ordinance also declared the Philippine crocodile as the wildlife flagship species of the municipality (Municipality of San Mariano, 2000a).
3. Resolution No. 2000-133: a resolution earnestly requesting the NSMNP-CP and DENR to put up a crocodile rescue center in the municipality (Municipality of San Mariano, 2000b).
4. Ordinance No. 2001–17: an ordinance declaring the identified crocodile areas in *sitio* San Isidro, Disulap and parts of *barangay* San Jose, municipality of San Mariano, as Philippine crocodile sanctuary (Municipality of San Mariano, 2001).

Protection and co-management of crocodile habitats inside and outside the NSMNP

An environmental management plan for the NSMNP was produced in 2000. This plan includes crocodile habitat management zones in identified crocodile areas within park boundaries. These zones are totally protected and cannot be used for any development purposes (DENR, 2000).

Outside the park, Disualp river is currently the only Philippine crocodile sanctuary. In collaboration with the LGU of San Mariano billboards have been produced and installed along the sanctuary to provide information about the sanctuary and the Philippine crocodile. A community protection group will be set up to protect and control the sanctuary. Alternative livelihood support is being provided by the NSMNP-CP to local residents that are affected by the establishment of the sanctuary.

Disulap River was selected as one of the Biodiversity Monitoring System (BMS) sites, which is the official monitoring system for protected areas in the Philippines. The NSMNP-CP assisted DENR with the development of a crocodile monitoring protocol and the establishment of the BMS in Disulap River.

Long-term conservation of the Philippine crocodile in the Northern Sierra Madre

The IEC campaigns, the meetings and consultations, and finally the declaration of the Disulap River Philippine crocodile sanctuary are a first step in the direction of a long-term conservation strategy for *C. mindorensis* in the Northern Sierra Madre. The lessons learned are very useful for a continuation of a co-management approach to implement this strategy and show that it is possible to win community support for the conservation of threatened species, even if these are crocodiles. The real success can only be measured in crocodiles. The monitoring system, which has been set up, should provide this information.

In May 2002, a workshop was held in Cabagan and San Mariano, Isabela, to design a long-term conservation plan for *C. mindorensis* in Northern Luzon. Stakeholders present included local residents, LGUs, regional and national DENR officials, the Director of the PWRCC and the members of the Philippine Crocodile Recovery Team as well as members of the IUCN Crocodile Specialist Group. The output of this workshop will be a five-year plan, based on the inputs of all stakeholders present, with a comprehensive integrated co-management strategy for development and conservation of crocodile sites and nearby communities in San Mariano. A co-management group is to oversee the implementation of this plan with funding expected to be coming from the Dutch government through the second phase of the NSMNP-CP.

A research proposal was prepared earlier by the Cagayan Valley Program on Environment and Development (CVPED) in collaboration with the NSMNP-CP. The aim of this proposal was to get funding for the involvement of local students of the Isabela State University in crocodile research activities and to extend crocodile surveys in Northern Luzon beyond the coverage area of the NSMNP-CP. This proposal, the CROC: Crocodile Research, Observance & Conservation project (CVPED, 2002), won the British Petroleum (BP) Conservation Program Gold award in April 2002 and research activities funded by this program are currently ongoing (September 2002). Research activities will have to continue during the coming years with a strong collaboration between the DENR, the PWRCC, CVPED, ISU and the NSMNP-CP. Development of a long-term research strategy by these partners was part of the crocodile workshop of May 2002.

The best incentive for the stakeholders to make the conservation and research plan work was the observation of a juvenile crocodile, in full daylight on the bank of Dinang creek, during the field visit of the workshop. Whether this juvenile will once breed in San Mariano depends especially on the people of San Mariano. There is certainly hope that it will.

ACKNOWLEDGEMENTS

A large number of people were involved in gathering the data which is presented here. The most valuable contributions were made by Bernard Tarun, Dominic Rodriguez, Jessie Guerrero, Yaron Oppenheimer, Petra Oudejans, Mario Sotto Jr., Mario Sotto Sr., Richard van Alphen and Sammy Telan. Frederick Pontillas and the team from the PWRCC shared their knowledge on crocodiles and crocodile surveys during the two very pleasant co-operative field trips. IEC materials and strategy were designed by Gwen van Boven and the IEC campaigns were conducted by Gwen van Boven, Nito Nemenes and Ar-En Favie. The entire San Mariano Field Team provided indispensable support to fieldwork and community consultations, most notably Ruel Lazaro, Ronnie Balbas and Maritess Gatan. Area Manager Alex General was crucial in getting LGU and community support and played a very important role in the overall conservation program. He also contributed to a draft version of this paper. The Mayor of San Mariano Jesus Miranda and the Environmental Officer Jerome Miranda were fine partners in the design and implementation of the conservation plan. Resti Antolin and PASu William Savella were, among many others, important partners from the regional DENR. Chris Banks provided advise and encouragement to the program from a distance. Jan van der Ploeg took the initiative to write with me the CROC proposal for the BP conservation award. British Petroleum funded part of the surveys of which the results are presented here and also provided funding for a plane ticket for me to attend the Crocodile Specialist Group meeting in Florida of October 2002. The Dutch government, through the Royal Netherlands Embassy in Manila, funded the NSMNP-CP. Residents and officials from *barangays* Disulap and San Jose contributed greatly to the initial success of the conservation program and always welcomed us warmly in their homes. Vicente Anog from San Isidro has to be mentioned specifically for his hospitality and inspirational visions of a green and prosperous future for his *sitio* San Isidro. Finally I thank all my colleagues at the NSMNP-CP for their professional assistance and friendship and Vic Magno, Dr Roberto Araño and John Acay for their support and guidance.

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Update on the Status of the Cuban Crocodile

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ABSTRACT: The last full CSG meeting was held in Cuba, home of the endemic *Crocodylus rhombifer*, where considerable discussion was devoted to its conservation. Here we present an update on work that has been carried out, as well as plans for future projects, in the two remaining areas for this species, the Zapata Swamp and the Lanier Swamp.

Population Status and Management Guidelines for the Orinoco Crocodile (*Crocodylus intermedius*) in the Capanaparo River, Venezuela (Progress Report)

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ABSTRACT: In order to define management strategies oriented towards the conservation and recovery of the Orinoco Crocodile (*Crocodylus intermedius*) in the Capanaparo River, the abundance and population structure were determined, including temporal and spatial variations. Night surveys were conducted along 185 km of river between October 2000 and June 2001. Abundance indices between 0.39 and 2.92 individuals/km were recorded, with significant statistical differences between river sections ($P < 0.01$); the overall mean for all sections was 1.43 individuals/km. The population size was estimated as 536 non-hatchling individuals for all the Capanaparo River basin. No differences were recorded on the population structure between river sections, with a general structure mainly composed by juveniles (58.0%), followed by adults (24.1%), and subadults (17.9%). A significant negative correlation (-0.52, P = 0,0002) between crocodiles and caimans (*Caiman crocodilus*) in different river sections was obtained. One of the main problems for the conservation of crocodiles at Capanaparo River is the local practice of harvesting eggs and hatchlings. Considering our results, reducing the actual pressure on the species and accomplishing the recovery of this crocodile, may be possible by incorporating local human communities in the conservation efforts in combination with a crocodile release program.

Keywords: Abundance, conservation, *Crocodylus intermedius*, population structure.

INTRODUCTION

The Orinoco Crocodile (*Crocodylus intermedius*) is one of the most critically endangered species of crocodile in the world (Thorbjarnarson 1992). Commercial overexploitation from 1930 to the end of 50's, decimated its populations in most of its original area of distribution (Medem 1983, Seijas 1998). Even though crocodiles have been legally protected in Colombia and Venezuela for almost 30 years, and the international trade has been prohibited by the Convention of International Trade in Endangered Species (CITES) (King 1989), the species is still threatened by a combination of factors including habitat destruction, egg harvesting, incidental and intentional killing, and collection of animals to be sold as pets (Thorbjarnarson & Hernández 1992). Other factors affecting the recovery of the Orinoco Crocodile are related with the expansion of *Caiman crocodilus* populations, a species which could have some degree of competition with the crocodiles, in particular in those places where *C. intermedius* maintains very low population levels (Thorbjarnarson & Hernández 1992, Llobet 2002).

The Orinoco Crocodile is present just a small fraction of the territory which represented its original area of distribution. The commercial hunting of this species eliminated the populations from the most of rivers originally occupied by crocodiles. This is the only crocodilian species in the world with a distribution restricted to one basin, The Orinoco River Drainage (Medem 1981, 1983, Thorbjarnarson & Hernández 1992). This basin comprises approximately 1100000 Km^2, which represents 70% of Venezuelan and 30% of Colombian territory (Lewis 1988, Hamilton & Lewis 1990). Historical information stated that the primary habitat of this species was in the major rivers of the Llanos region of Colombia and Venezuela (Humboldt 1975, Páez 1980, Wickham & Crevaux 1988), especially the Meta, Arauca and Guayavero-Vichada rivers in Colombia, and Apure, Portuguesa, Arauca and Orinoco rivers in Venezuela (Seijas 1998).

Apparently in Venezuela, the Orinoco crocodile populations extended (in low densities) up stream of many Llanos rivers even into surrounding areas close to the foothills of the Andes, and also in some of the southern tributaries of the Orinoco in heavily forested regions of the Cuchivero and Caura rivers (Ramo & Busto 1986, Thorbjarnarson & Hernández 1992, Arteaga *et al*. 1994). Unconfirmed information exists about the presence of this species in the Casiquiare and Ventuari rivers. Nevertheless, it is probable that these regions contain very low population levels of crocodiles.

In Venezuela, during the last twenty five years, scattered individuals and small populations have been reported. However, the most important and probably the only viable populations are found in two very different areas: the Capanaparo River in the state of Apure, and the Cojedes-Sarare system river in the states of Cojedes and Portuguesa. Prior data suggested that a population of more less 1000 individuals could be found in both rivers (Godshalk 1978, 1982, Thorbjarnarson & Hernández 1992, Seijas & Chávez 2000).

The compicated situation of crocodile populations led to the development of an Action Plan (FUDENA 1993) and a Strategic Plan (PROFAUNA 1994), each with a groups of midterm strategies and goals for the recovery of the Orinoco crocodile populations (Program for the Conservation of the Orinoco Crocodile in Venezuela – PCOCV) (Seijas *et al*. 2001). After eight years of the development of this program (PCOCV), it is considered that the goal of consolidating at least ten viable populations of the species is still to far from being achieved. Except for the Santos Luzardo National Park, and the Aguaro-Guariquito National Park, the situation of the species is not known for certain in the entire Venezuelan system of protected areas. Moreover, there is evidence that small crocodile populations (Tucupido, Anaro, and North Cojedes rivers) are experiencing a serious decrease in size (Seijas *et al*. 2001), while no actions have been taken to protect the major two populations of the species (Capanaparo and Cojedes rivers), which could not assure, by themselves, the conservation of *Crocodylus intermedius* in Venezuela.

The crocodile population of Capanaparo River (within Santos Luzardo National Park) still face several threats by egg collecting and the sale of hatchlings, carried out by local people (Thorbjarnarson 1992, Llobet 2002). The importance of this population was previously mentioned by Godshalk (1978, 1982), and confirmed by later research (Thorbjarnarson 1988, Thorbjarnarson & Hernández 1992). These authors emphasized the good habitat conditions of Capanaparo River for the crocodile population, and reported sections of the river with high population densities. Following these results reintroductions of almost 500 non-hatchling individuals, collected previously from the Capanaparo River and raised in captivity for almost a year, were carried out (Arteaga et al. 1997).

After these management actions were occurred, some conflicts between local people and the office in charged of the national parks administration (INPARQUES) started at Santos Luzardo National Park. These conflicts led to the end of the administration of the Park, and blocked any chance to continue with the ongoing conservation activities. This situation probably had a significant effect on the wildlife, and particularly on the crocodile population. The major threat represented bay collecting the eggs and hatchlings (for local consumption and for sale to tourists), was certainly increased due to the lack of administration of the Park. No control mechanisms or conservation activities could be applied as long as the Capanaparo River was not recovered as an *in situ* conservation area. This situation, continuing for the last ten years, delayed the realization of any effort to accelerate the recovery of the species or to obtain information on the ecology.

Careful and reliable monitoring of crocodile populations is an essential requirement for the implementation of a management program for its conservation. In this study, we attempt to update the population status of *C. intermedius* in the Capanaparo River and recommend some guidelines for future management actions intended to accelerate the recovery of crocodile populations in the area.

STUDY AREA

The Santos Luzardo National Park is located in the southwest Llanos of Venezuela; the northern boundary of the Park is the Capanaparo River. The south border of the Park is the Cinaruco River, the east border is the Orinoco River, and the west border is also the boundary between Achaguas and Pedro Camejo municipalities (Figure 1).

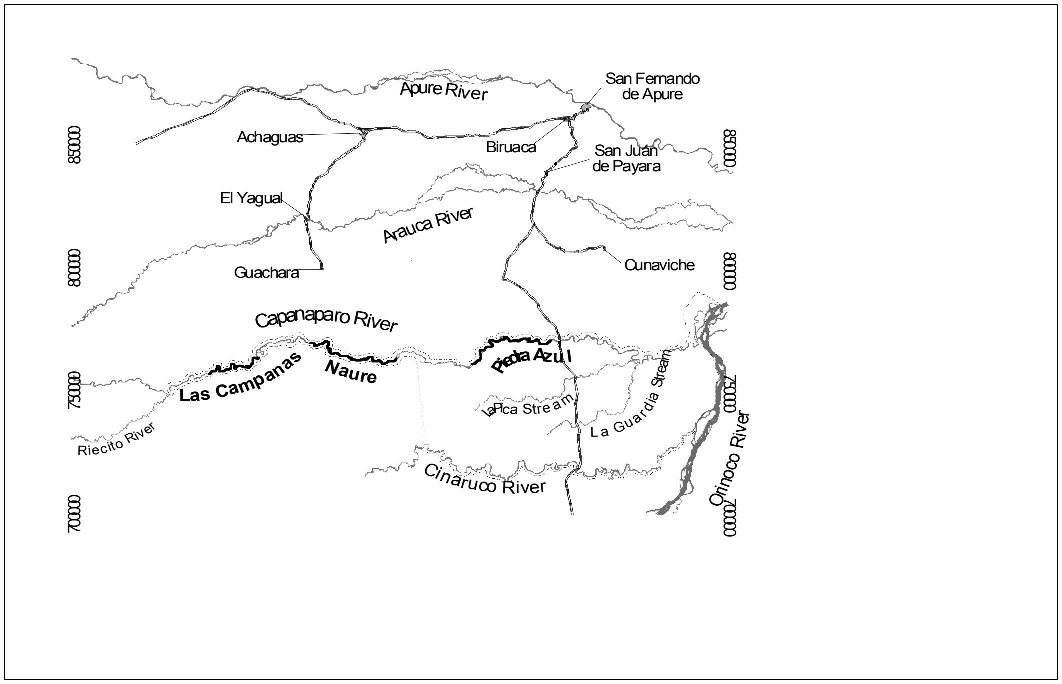

Figure 1. Capanaparo River at Santos Luzardo National Park (state of Apure, Venezuela). Rivers flow toward the east.

The Capanaparo River is an effluent of Orinoco River and it drains the lowlands of South Apure. Its waters contains an important amount of silts and receive many tributaries with black water (and low productivity) whose origin is in the lowlands. This situation makes the Capanaparo River a mixture between clear waters and black waters (Thorbjarnarson 1988, Thorbjarnarson *et al*. 1993). Along the river is a gallery forest, aften associated with oxbow lakes or old meanders of the river. During dry season, long beaches alternate with deep pounds, this situation makes the Capanaparo River a good habitat for crocodiles, it provides a great number of places for basking and nesting. Conductivity varies from 27.1 a 45.3 μS, with an average of 34.5 μS, and the average temperature of water is 29 °C (Muñoz & Thorbjarnarson 2000).

According to data from the Environment Ministry (MARN) of San Fernando de Apure, in the area there is a precipitation range from 1640 to 1644 mm. These data were collected in two stations situated approximately 15 km to the north and 20 km to the south of Capanaparo River respectively, both along the road which connects the cities of San Fernando with Puerto Páez (Fig 1). The dry season occurs from December until March, and the rainy season starts during April producing the higher precipitation level during the month of July. This precipitation regime influences the dynamic of Capanaparo River, which presents the highest water level during August, and the lowest level during April.

From a socioeconomic point of view, the Santos Luzardo National Park has a low human population density, with the presence of some cattle ranches, and communities inhabited by campesinos and indigenous people (most of them belonging to Pume or Yaruro tribe). The livelihoods (beside extensive cattle raising) are basically subsistence activities. The poverty levels of local people (especially indigenous people) are very high.

For the purposes of this study, three sectors of Capanaparo River were selected. The first, called Piedra Azul by the presence of a community with that name, had an approximate length of 45 Km. The second one, called Naure by the presence of that community, also had an approximate length of 45 Km. The third one, called Las Campanas (the community Las Campanas was located in the middle of the sector) had an approximate length of 30 km (Fig. 1).

METHODS

To determine population status of crocodilians at Capanaparo River, night surveys were made from October 2000 to June 2001, using a 12 foot boat powered by a 30 hp outboard engine. Monthly repetitions were made, surveying approximately a section of 15 km of river each night. The distance of the surveys was measured with the odometer of a Global Positioning System (GPS Garmin 12).

As we stated before, the entire study area was divided into three sectors named Piedra Azul, Naure and Las Campanas due to the nearest human communities. Piedra Azul and Naure sectors were subdivided into three sections each (P1, P2 and P3 for Piedra Azul, and N1, N2 and N3 for Naure). Las Campanas sector was divided into two sections (C1 and C2). Every section of the entire study zone had approximately 15 km length. The complete surveyed length of river was approximately 120 km, within a 185 km section of Capanaparo River (Fig. 1). Due to the characteristics of Capanaparo River, surveys were made first for one shore and then for the other one. Because of the low water level during dry season, it sometimes was not possible to survey the entire 15 km section. Only surveys longer than 10 km were considered for later analysis.

During surveys, a 500,000 candles power light connected to a 12 V battery was used to locate the crocodilians by means of reflective eye shine. All crocodilians sighted were approached as close as possible to allow a positive identification of the species (*C. intermedius* or the sympatric *Caiman crocodilus*) and to estimate the body size (total length, TL). In the field, 10 cm size-class intervals were used, but for analyses of size class distribution, 60 cm size-class categories were used (Seijas 1998, Seijas & Chávez 2000):

Class I: TL < 60 cm
Class II: 60 cm < TL < 120 cm
Class III: 120 cm < TL < 180 cm
Class IV: 180 cm < TL < 240 cm
Class V: 240 cm < TL

Hatchling crocodiles (Class I individuals, generally less than 6 months old) and caimans were counted but not considered in this study. Based o previous studies (Seijas 1995, 1998, Seijas & Chávez 2000), non-hatchling crocodiles less than 180 cm in total length were considered as juveniles; crocodiles in Class IV (major than 180 but less than 240 cm in total length) were regarded as sub-adults, and those individuals major than 240 cm in total length were classified as adults. To compare our results with those obtained by Thorbjarnarson & Hernández (1992), a second 50 cm size-class intervals were used. When an individual could not be identified as crocodile (*C. intermedius*) or spectacled caiman (*C. crocodilus*), it was placed in a "Not identified" category (NI). These individuals were not considered for the analysis.

The analyses of abundance and population structure were realized considering the results from surveys undertaken from November 2000 to June 2001. The month of October of 2000 was used to investigate the river and to standardize the survey methodology. The relative population abundance index (PI) of crocodilians was expressed as number of individuals per kilometer of river. To analyze how the fraction of crocodiles sighted changes as the dry season progresses, the PI obtained in every survey (individuals/Km) was expressed as a percentage of the PI obtained during April (taken as 100%) in the same river section. April is usually the last month of the dry season, a time when the river reaches its lowest level. This method allows the comparison of results from localities with different PI values. A correlation analysis was used to describe the relationship between theses percentages and the days after November 21 (first day of surveys considered in the analysis), as an indirect measure of water level (Seijas 1998, Seijas & Chávez 2000).

The spatial variation in abundance was analyzed comparing the obtained PI (ind/Km) between sectors of the river, and also between different sections of each sector. The comparisons were carried out using a Kruskal-Wallis test. The average values of PI of every studied section of the river were used to calculate the minimum size of the crocodile population. We estimated the density of crocodiles in unsurveyed sections of the river as a value intermediate of its immediate upper and lower sections for which information was available.

The population structure of crocodiles for the entire river, and for every sector was calculated using the maximum number of individuals in a particular size category, regardless of the survey in which they were observed, as minimum number of individuals corresponding to that category. This method is referred to by Messel *et al*. (1981) as the maximum-minimum (MM) method. Comparison of the population structure among river sections were made using contingency tables (X^2). On the other hand, monthly data of population structure were used for comparison between three hydrological periods (falling water, low water and rising water levels) according with fluctuations of the Capanaparo River during the study period. This comparison was carried out again using contingency tables (X^2).

RESULTS

Population indices

From October 2000 to June 2001, 44 nocturnal spotlights surveys were conducted in the three defined sectors (eight sections) of the Capanaparo River. Between five to seven repetitions (one per month) were made for every section. Results obtained during October were not considered for further analysis, because survey methodology was standardized during that month. The study area was not surveyed from July until September. During those months the high water period occurs, and the surveys would have been hindered due to the dispersion experienced by crocodilians populations. Additionally, the plains surrounding the river were flooded and the access to many places was difficult.

The lowest index of relative population abundance (PI) of crocodiles were found in Piedra Azul sector, P2 section with a value of 0.37 ind/km in February, and P3 section with a value of 0.39 ind/km in May. In contrast, higher PI values were recorded in Naure sector (N3 section during May) and Las Campanas sector (C1 section during June) with values of 2.92 ind/km and 2.73 ind/km respectively.

Although the fraction of the crocodile population that was seen during surveys showed a slight tendency to increase as the dry season advanced, the PI values were nearly constant during all the fieldwork. A correlation analysis among the fraction of crocodiles sighted and days after November 21 (established as first day of surveys) indicates that this positive relationship was not statistically significant ($r = 0.21$, $P = 0.16$).

Different months of working were grouped in three hydrological periods according with fluctuations on water level: falling waters (from November to February), low waters (March and April) and raising waters (May and June). Kruskal-Wallis test suggested that no one of the three sectors showed statistical differences related to crocodile abundance among these periods.

To analyze the spatial variation on crocodile abundance, a Kruskal-Wallis test was performed comparing the PI of each sector. Highly statistical differences resulted from the comparison of Naure and Las Campanas sectors related to Piedra Azul sector ($H = 29.80$, $P < 0.01$). The same test was performed considering every section of each sector. In this sense, we observed three groups of PI values with highly statistical differences ($H = 38.30$, $P < 0.01$). The first group (low PI values) was composed by the three sections of Piedra Azul Sector (P1, P2 and P3); the second group (intermediate PI values) was integrated by N1 section of Naure sector, and C2 section of Las Campanas sector. Finally, the third group (high PI values) was composed by N2 and N3 sections of Naure sector, and C1 section of Las Campanas sector.

The minimum population size of non-hatchling crocodiles in the entire study area was estimated to be 332 individuals (Table 1). The estimation was made using the medium PI values of every section. This is a conservative calculation because it is based on PI that was below the maximum obtained for all river sections. If the maximum PIs had been used, the estimated population would be 382 non-hatchling individuals, a 13.1% increase.

This estimation includes the portion of Capanaparo River from the confluence of Riecito River to the outlet of Capanaparo in the Orinoco River. Nevertheless, if we consider the same approach used by Thorbjarnarson (1988), to estimate the crocodile population in all the Capanaparo basin it would be necessary to consider: 1) the river portion that flows by Venezuelan territory from the Colombian border to the outlet of Riecito river into the Capanaparo, 2) the Riecito river, 3) the floodplain lagoons of Capanaparo river, and 4) other tributaries of Capanaparo river. If we assign to the high potion of Capanaparo River (from the Colombian border to the confluence of Riecito River) the lowest PI value of all surveys (0.37 ind/km), a total of 70 non-hatchling crocodiles could be estimated in that portion of river (Thorbjarnarson 1988, estimated 76). On the other hand, Thorbjarnarson (1988) estimated 71 individuals in Riecito River, 23 individuals in lagoons (oxbow and old meanders of Capanaparo River), 40 individuals belonging to other tributaries of Capanaparo River (Naure, Casanarito and La Pica streams). If these values are added to the results of our study, we could estimate that the entire non-hatchling crocodile population of the Capanaparo basin has at least 536 individuals.

Table 1. Estimated number of non-hatchling Orinoco crocodiles in different sections of Capanaparo River.

SECTION	Length (km)	Mean density (ind/km)	Estimated number	Maximum density (ind/km)	Estimated number
La Pica – Piedra Azul P1 [a]	54.2	0.19	10	0.19	10
Piedra Azul P1	18.2	0.55	8	0.87	13
Piedra Azul P2	15.2	0.90	14	1.18	18
Piedra Azul P3	15.9	0.56	9	0.82	13
Piedra Azul P3 – Naure N1 [b]	40.6	0.37	15	0.37	15
Naure N1	15.5	1.41	22	1.68	26
Naure N2	14.1	2.18	31	2.54	36
Naure N3	11.9	2.11	25	2.92	35
San Luis – Caño Amarillo [c]	32.6	3.09	101	3.09	101
Las Campanas C1	14.2	2.19	31	2.73	39
Las Campanas C2	47.0	1.40	66	1.61	76
TOTAL	**279.4**		**332**		**382**

[a] Just one 15 km survey was carried out during November of 2000.
[b] Not surveyed. Assigned the minimum density of all surveys
[c] Just one 6.15 km survey was carried out during May of 2001.

Population structure

In Piedra Azul sector the population was composed by a major proportion of Class II individuals (38.24%), followed by Classes V, III and IV (29.41%, 23.53% and 8.82% respectively). In Naure sector we also observed a major proportion of Class II crocodiles (35.8%) followed by Classes III and IV (22.22 % each one) and finally Class V (19.75%). In Las Campanas sector, in contrast, a major proportion of adult crocodiles was observed (30.61% of Class V individuals), followed by Class II (28.57%), III (24.49%) and IV (16.33%) (Figure 2).

The differences between sectors structure were not statistically significant (X^2 = 5.026, P = 0.54). The same comparison was carried out grouping crocodiles in categories (juveniles, sub-adult and adult), however this new frequency distribution used in the analysis, no statistical differences were obtained (X^2 = 4.55, P = 0.33).

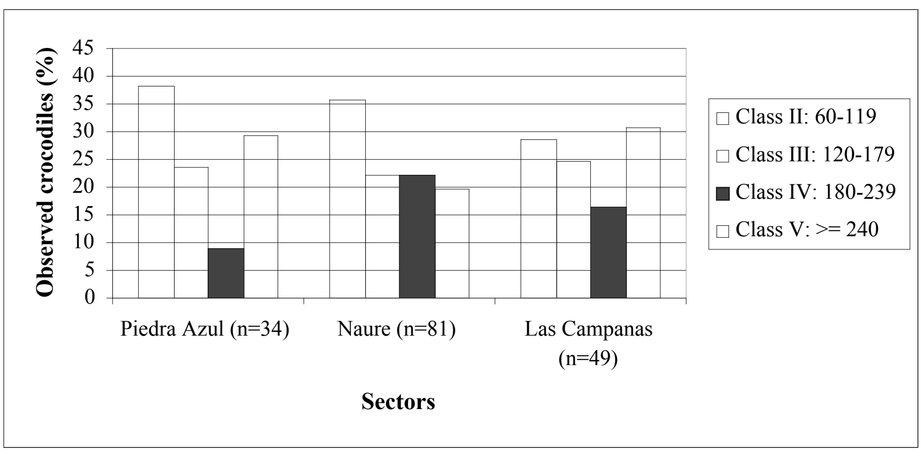

Figure 2. Population structure of Orinoco crocodile population in different sectors of Capanaparo River. Size-Class categories are expressed in cm of total length.

DISCUSSION

Godshalk (1978, 1982) highlighted the Capanaparo River as one of the places were could be found a relatively important population of Crocodylus intermedius in Venezuela. This was confirmed later by the works carried out by Thorbjarnarson (1988), and Thorbjarnarson & Hernández (1992). We found an Orinoco crocodile population with a minimum size of 332 non-hatchling individuals, from the outlet of Riecito river to the confluence of Capanaparo in the Orinoco river. This value is notably higher than the 233 non-hatchling individuals reported by Thorbjarnarson (1988) for the same segment of Capanaparo river. On the other hand, at least 40% of the crocodile population is composed by sub-adult and adult individuals, situation which also overcomes the estimation of 100 individuals longer than 150 cm (TL) made by Thorbjarnarson & Hernández (1992). These differences could principally due to two factors:

1. The survey methodology used. The anterior authors based their results for the major portion of the river in airplane censuses, and made night surveys just in one 25 km section of river (between Caño Amarillo and San Luis community).
2. The fact that between 1991 and 1993, 571 individuals were released in Capanaparo River (Arteaga *et al*. 1997).

Even though is difficult to make an exact comparison between Thorbjarnarson (1988) and Thorbjarnarson & Hernández (1992) and our results, because both studies considered sections with differences in length, we estimate that in Naure sector exist at least 60 more non-hatchling crocodiles in relation to anterior researches. This increase (25.75%) in the crocodile population size, could be due to a several release activities carried out in anterior years (all made in zones near or within Naure sector). This could be a measure of the successful of that release program for the recuperation (slowly yet) of the crocodile population in Capanaparo river.

It is necessary to consider that is very difficult to estimate the real size of a population. Besides, the monitoring of crocodiles presents some problems which have been analyzed by several authors (Woodward & Marion 1978, Messel *et al*. 1981, Magnusson 1982, Larriera *et al*. 1993, Abercrombie & Verdade 1995, Pacheco 1994, Pacheco 1996). It is theoretically possible to control the effect that most of the environmental variables have over night surveys always carrying out them under similar conditions, but it is more difficult to control biological variables as wariness and population density (Pacheco 1994, 1996). In areas where animal hunting with different porpoises has been (or still is) a common practice, crocodiles tend to be more shy, that which can hinder their observation and to produce a bias when calculating the abundance. The tendency to sub-estimate the real population size is present to in populations with very low abundance index or low density, since it diminishes significantly the probability to observe an individual. Finally, the relative abundance indices are going to sub-estimate the real size of that population because a part of this is remains usually undetected, and is too difficult to establish the relationship between abundance index and the real density of the population in the zone (Hutton & Woolhouse 1989).

The environmental factor that could have more effect over night counts of crocodilians is the water level (Woodward & Marion 1978, Messel *et al*. 1981, Llobet & Goitia 1997). However, this variable can be related with behavioral changes which could affect also the results of surveys. Seijas & Chávez (2000) in Cojedes River System reported variations in the number of crocodiles observed as the dry season occurred; on the other hand, this same authors observed an increase of adult crocodiles (most of them females) at the beginning of the reproductive season. In the present study there were no significant variations in the number of crocodiles sighted as the dry season lapsed, probably because the particular conditions of Capanaparo river, where all the crocodiles (widespread in a large area) count with many basking zones from November to June; this situation could reduce the intra-specific competition, so juvenile animals are not forced to seek for refuges.

Other factors that may explain the variability in abundance index (PI) are related with differences in visibility among sectors, which could introduce some bias in the results (Hutton & Woolhouse 1989, Da Silveira *et al*. 1997). The Capanaparo river, besides having extended sand beaches, shows step banks many times covered with riparian vegetation, which could serve to crocodilians as a refuge avoiding them detection during night surveys. Differences in visibility of crocodiles in relation to water level have important implications for monitoring of population status (Seijas & Chávez 2000). According to Seijas (1998), the best period to conduct surveys to determine population size is from November to January, when a major proportion of crocodiles can be sighted, and the number of spectacled caimans (*Caiman crocodilus*) is relatively low, which reduces survey time, therefore, limiting observer fatigue (Thorbjarnarson & Hernández 1992). In Capanaparo River, the monthly variation of the number of crocodiles was no significant, alternatively, the number of spectacled caimans sighted increased from month to month, which had an effect in the survey effort.

The Orinoco crocodile population in the Capanaparo River is not uniformly distributed. Highest densities were observed in N2 and N3 sections of Naure sector, C1 section of Las Campanas sector, and the section between San Luis and Caño Amarillo (surveyed just once during all the study). The access to the river into these sections is more difficult because the “sabana” roads only can be used during dry season. On the other hand, human communities are widespread and are not too much populated. The crocodile density in Piedra Azul sector (were lowest values were registered) could be affected by a bigger human pressure due to the easy access to this part of the river. These results in general agree with those reported by Thorbjarnarson (1988) and Thorbjarnarson & Hernández (1992) who reported major crocodile densities in river sections between Naure and Las Campanas sectors.

Population structure showed no statistical differences among river sectors, even though Piedra Azul and Naure sectors had a major proportion of juvenile crocodiles, and Las Campanas sector showed a population structure dominated by adult crocodiles. Population structures dominated by juvenile size-classes could suggest that the population may be recovering from overexploitation (Webb & Messel 1978, Seijas 1986). However, we also must considerate that this kind of structures could due to actual human pressure exerted over adult crocodiles of the population.

The population structure could be shaped by human activities present in a zone (Seijas & Cháves 2000). Large crocodiles are more conspicuous and probably more frequently killed by people than small crocodiles. This situation, besides bad perception that local people have over crocodiles, could affect the population structure of the Orinoco crocodile in the Capanaparo River. Under these circumstances, few adult crocodile could remain in the river; meanwhile less conspicuous juveniles could escape from detection. If we consider, on the other hand, that there is a relationship between crocodiles wariness and human pressure (Pacheco 1996), we could expect to register larger escape distances in zones with major human pressure. In this sense, large crocodile individuals, and probably more experienced about activities directed to its hunting or capture, will be more shy than juveniles, so a new bias could be introduced over the population structure results. In those sectors with some access troubles (as Las Campanas sector), larger crocodiles could have more chances to survive, and also would behave less shy or cautious in the presence of an observer.

ACKNOWLEDGEMENTS

This study was made possible by the economic support of Wildlife Conservation Society (WCS) and U. S. Fish and Wildlife Service. Satellite images were donated by BIOCENTRO (UNELLEZ). Jesus Silva served as guide during all the field work. We appreciate the help of Carlos Chávez, Arnaud Lyet, Mariana Escovar and Andy Urdaneta for their assistance during the field work. Thanks to the hospitality offered by Juan Betancourt, Custodio Herrera (and family), Jin Rodríguez and the workers of Agropecuaria Capanaparo. Mariana Escovar, Magddy Jimenez and Fredy Garavito reviewed early versions of this manuscript. Robert Godshalk reviewed the final version of this manuscript.

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Reproductive Status and Nesting Ecology of the Orinoco Crocodile (*Crocodylus intermedius*) in the Cojedes River System, Venezuela

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ABSTRACT: During 1996-1997, ninety-one reproductively active Orinoco crocodiles (males and females) were estimated for the Cojedes River System (CRS), Venezuela. In those years at least 48 different female crocodiles nested in 45.7 km of surveyed sections of the CRS. The reproductive population was mostly found in Caño de Agua (63.2%) and in the lower Sarare River, areas with the best quality nesting habitat. Egg-laying starts during the months of lowest precipitation (January-February) and hatching takes place at the onset of the rainy season (late April-early May). The average number of hatchlings per pod was 26.0±13.9. The distribution of nests along the rivers suggests a polygynous system, in which dominant males form groups with two or more females. Lack or scarcity of good nesting substrate seems to be an important factor determining the current distribution of the species in the CRS. Most frequently selected nesting sites are composed of a high proportion of sand (>70%). There are no evidences that the species toward the south end of Cojedes and in La Culebra, river sections with relatively poor nesting habitat. Several km of good nesting habitat have been lost since 1991 due to river diversion. Data collected from 1998 to 2002 indicated a high variability in hatching success, presumably related to changes in the level of river at the end of the incubation period.

Keywords: Orinoco crocodile, *Crocodylus intermedius*, reproduction, nesting habitat.

RESUMEN: Durante 1996-1997 se estimó en 91 el número de cocodrilos del Orinoco reproductivamente activos (machos y hembras) en el sistema del río Cojedes (SRC), Venezuela. En esos años al menos 48 hembras de cocodrilos anidaron en 45,7 km muestreados del SRC. La población reproductiva se concentra en Caño de Agua (63,2%) y en la sección baja del río Sarare, áreas con los mejores hábitat de anidación. La postura de huevos comienza en los meses de precipitación más baja (enero-febrero) y la eclosión ocurre al comienzo de la estación lluviosa (finales de abril- comienzos de mayo). El número promedio de crías nacidas por nidada fue 26.0±13.9. La distribución de nidos a lo largo de los ríos sugiere un sistema polígamo, en el cual un macho dominante se agrupa con dos o más hembras. La falta o escasez de buen sustrato de anidación parece ser un factor importante en la determinación de la distribución actual de la especie en el SRC. Los lugares de anidación más frecuentemente utilizados están compuestos de una gran proporción (>70%) de arena. No hay evidencia de que la especie se reproduzca en la sección sur del Cojedes y en Caño La Culebra, secciones con baja calidad de hábitat de anidación. Varios km de buen hábitat de anidación se han perdido desde 1991 debido al desvió del río. Datos colectados entre 1998 y 2002 indican una gran variabilidad en el éxito de eclosión, presumiblemente debido a cambios en el nivel del río en la etapa final del periodo de incubación.

Palabras claves: Cocodrilo del Orinoco, *Crocodylus intermedius*, reproducción, hábitat de anidación.

INTRODUCTION

Little have been published on the reproductive ecology of the Orinoco crocodile (*Crocodylus intermedius*), one of the most critically endangered crocodilian species of the world (Ross, 1998). Basic information on this regard was published by Medem (1981, 1983). Thorbjarnarson and Hernández (1993a, b), working both with captive and wild crocodiles, shed some light on several aspects of the reproductive ecology of the species.

The largest populations of the Orinoco crocodile is found in the Cojedes River system (CRS), at the periphery of the Orinoco crocodile distribution (Seijas and Chávez, 2000). Ayarzagüena (1987) and González-

Fernández (1995) reported data on the reproductive status and ecology of the Orinoco crocodile in the CRS, an area currently under heavy anthropogenic pressure due to its proximity to some of the important agricultural, urban and industrial centers in the country (Godshalk, 1978, 1982; Ayarzagüena, 1987, 1990; Seijas, 1998). In the last 40 years, human activities have changed the characteristics of the Orinoco crocodile habitat in the CRS. Some changes have modified the water quality of the river. Others have altered the physical characteristics of the river through damming, dredging, and canalization (Seijas, 1998). To what extent have these alterations affected reproduction of the Orinoco crocodile? It has been suggested (Ayarzagüena, 1987) that dredging and canalization, for example, have a negative impact on crocodiles because it destroys nesting beaches. This should translate into a reduced nest density in modified sections in comparisons to sections where the river maintains its meanders. The main objectives of this study were (1) to answer basic questions on the reproductive ecology of *C. intermedius* in the CRS in reference to nesting chronology, nesting habitat, reproductive success, reproductive status, parental care, and (2) discuss the reproductive ecology of the species in the context of the anthropogenic modifications of the CRS.

STUDY AREA AND METHODS

This study was conducted in the mid and lower reaches of the Cojedes River System of north-central Venezuela (Figure 1). In the CRS rivers flow from the northeast to southeast through several types of landscapes that vary in relief, land-cover types, and main human activities. In the northern part of the CRS, agricultural lands dominate the landscape and are interspersed with large-and medium-sized urban centers and cattle ranches. The southern part of the region (south of the Lagunitas-Santa Cruz road) is a matrix of forested savannas and cattle pastures intermixed with forest relicts, scattered agricultural lands, wetlands, and other less extensive land-cover categories. The CRS has zones of relatively high human population densities in the north, where the cities of San Carlos (>80,000 people) and Acarigua (~200,000 people) are located and the rivers there have been modified by damming, canalization, dredging, contamination, and deforestation. Human population densities are lower downstream, in the south, with El Baúl (~6,000 people) as the largest town. Human impact in this part of the study area is less apparent.

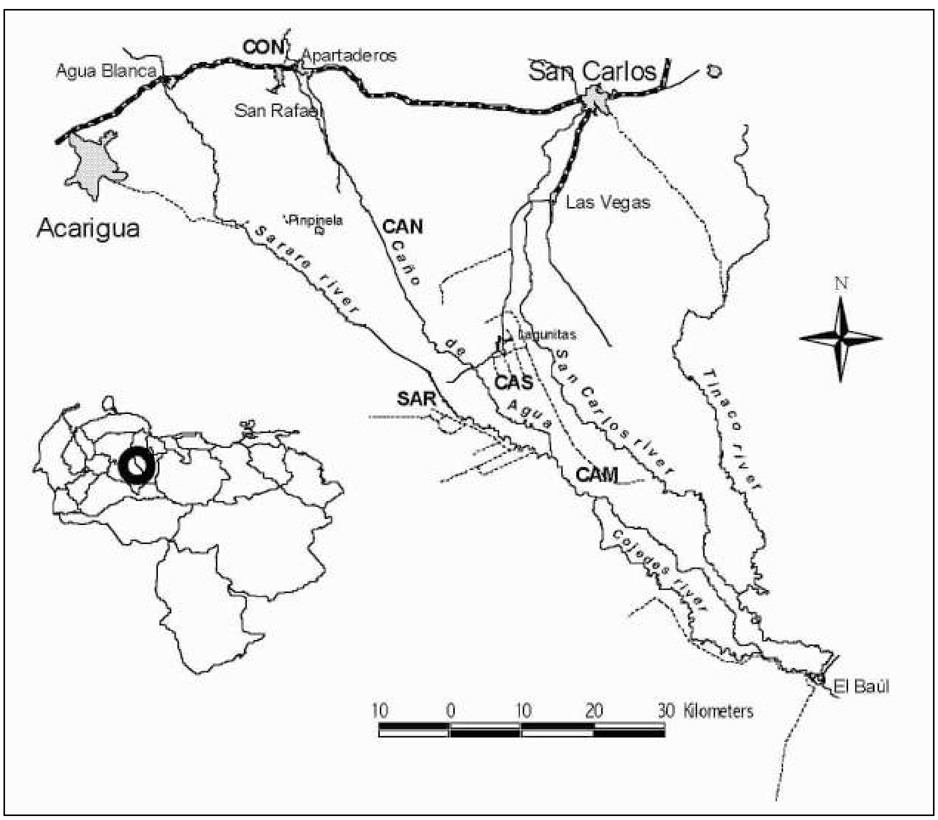

Figure 1. Map of the study area (Cojedes river system) Venezuela, indicating the position of landmarks, reference points, and main river reaches surveyed.

There are two clearly defined seasons in the study area. The rainy season extends from May to October, and the dry season from December to March. April and November are transitional months. The annual mean precipitation (1975-1996) is 1323 mm in the middle part of the study area and a little higher (1514 mm) toward the south at El Baúl (MARNR, 1997). During the rainy season the river discharge increases (Figure 2) and frequently overflows its banks and inundates the floodplain, particularly in the southern portion of the study area. The annual range between the absolute minimum and maximum temperatures is 11.6 °C (21.7°-33.3 °C)(MARNR, 1995).

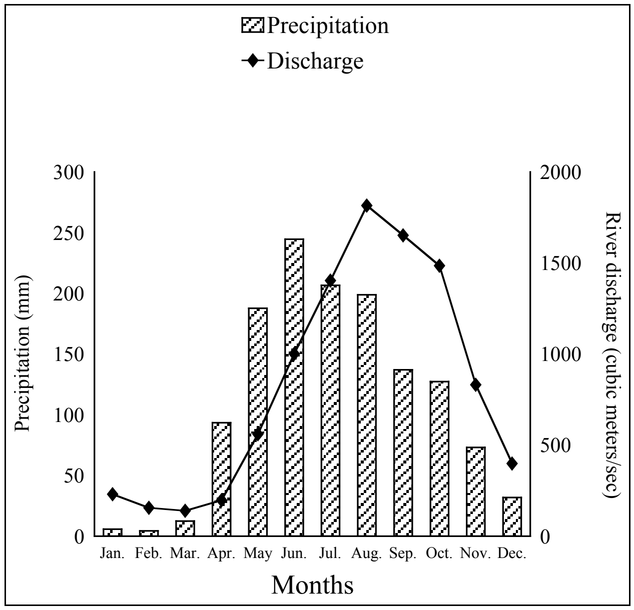

Figure 2. Pattern of precipitation in the Cojedes river system area of Venezuela

During nocturnal spotlight surveys and daylight reconnaissance, we collected information on aspects of reproductive ecology of the Orinoco crocodile in the CRS, such as nest location, nesting and hatching chronology, and clutch size. A part of the river shore was subjectively considered as potential nesting place for *C. intermedius* if it had one or more of the following characteristics: (1) It consisted mostly of lightly compacted material and generally had excavations made by other reptilians such as iguanas (*Iguana iguana*) or turtles (*Podocnemis unifilis*), species with similar nesting requirements in terms of soil texture; (2) The shore was bare or sparsely covered by vegetation; (3) it was 1.5 m or more above the water level, and (4) there was a record of previous utilization of the place by nesting females. The number of beaches adequate for nesting of Orinoco crocodile was counted in two sections of Caño de Agua, and in the section between Merecure and Caño Amarillo opening (see Figure 1).

The soil composition of samples of the substrate from nesting beaches was determined, as was the substrate from the river bank in sections where nesting beaches (according to the preceding criteria) were not present. The proportion of silt, clay and sand in those samples was determined following the hydrometer method of Bouyoucos (Foth, 1978) at the *Universidad Nacional Experimental de los Llanos Occidentales* 'Ezequiel Zamora' (UNELLEZ) in Guanare, Venezuela.

After hatching from the nest, neonates remained in well defined groups or ‘pods’ for several weeks. During the nocturnal surveys, the location and number of pods, and the number of hatchlings in each pod were recorded. When a particular pod was counted more than once, the maximum number of hatchlings recorded was taken as the pod size. A preliminary measure of hatching success was obtained by comparing the average number of hatchlings per pod against the average number of eggs per clutch. The average clutch size was calculated combining our own data with information found in the literature. Due to predation and dispersion of hatchlings, pod size decreases with time and only those pods found in April or early May were considered in the analyses.

The presence or absence of an adult crocodile in the proximity of the pod was recorded and taken as an indication of parental care. A contingency table analysis was used to establish if parental care of hatchling pods differed between river sections under different human pressure.

The nesting chronology of the species was determined based on reports of Ayarzagüena (1987) and González-Fernández (1995) and our own observations on dates of nest construction, banding of eggs, hatching period, sizes of the hatchlings, and size of the umbilicus of the hatchlings.

During 1996 and 1997, the position of each nest (or pod of hatchlings) was recorded with a Global Positioning System (Magellan 4000 and 4000xl). We assumed that females tend to nest in the same spot year after year, a behavior that is well documented for many crocodilian species (Garrick and Lang,1977; Ogden, 1978; Thorbjarnarson and Hernández, 1993a). The minimum number of nesting females in the survey area was determined by comparing the relative position of nests and pods from 1996 and 1997.

The size of the reproductive population was estimated based on the number of nesting females. The number of dominant males was calculated as one per female for relatively isolated females, and up to one male for every four females for localities with several females, depending on the relative proximity of the nests. The last estimate is conservative if we take into account that the sex ratio reported by Thorbjarnarson and Hernández (1993b) is 1_:2.2__. In non-surveyed sections of the CRS the number of nesting females was subjectively estimated based on the characteristics of the section and the known nest densities in contiguous upper and/or lower reaches of the river.

RESULTS

Nesting Habitat

Three river segments were examined for the presence of potential nesting habitat (Table 1): (1) A 4.7 km section of Caño de Agua south of Puente Nuevo (PN). There, the river was very narrow (8-12 m) and has numerous meanders despite having been dredged an unknown number of times in the past. Both margins of the river have been deforested and grasses and bushes cover the banks down to the water's edge. Most of this part of the river (60%) was lost during the rainy season of 1996 (see below).(2) Caño de Agua Sur (CAS) is also very narrow (in general less than 12 m) and it is the most meandering river segment of the entire study area. Most of the banks were forested and grasses were less abundant than in the PN section and usually did not reach the water's edge. Scattered groups of logs and branches of fallen trees were found along the river. Dense clumps of the riparian shrub (*Alchornea castaneifolia*) also were frequently found along the river edge. (3) The part of the Cojedes river from Merecure to Caño Amarillo opening (CAM), where the Cojedes River was relatively wide (15-20 m) with ample meanders and with the banks covered mostly by forest. The shrub *A. casteneifolia* was very common in this part of the river. Most of the beaches counted along this section were found approximately in the first 4 km downstream from Merecure. In the remaining downstream part of this river section appropriate beaches were almost nonexistent; grasses and *Heliconia* plants were abundant and reach the water's edge.

Table 1. Number of beaches considered as potential nesting habitat in three river reaches in the Cojedes River system

Place	Length (km)	Number of beaches	Beaches per kilometer
Caño de Agua, downstrem from Puente Nuevo (PN)	4.7	16	3.40
Caño de Agua Sur (CAS)	5.2	20	3.85
Merecure-Caño Amarillo (CAM)	8.4	9	1.07

In the sections of the river that had been canalized, river banks that fulfill the criteria as potential nesting beaches were scarce or absent. Caño de Agua Norte (CAN), upstream from Puente Nuevo, has been dredged and partially canalized over the last 20 years but in some parts it has recovered its meandering condition. In those latter reaches the characteristics of the river were the same as downstream from the bridge, but in the river segments that remained canalized, banks were very steep and nesting beaches were absent. In the southern part of the study area near Sucre (SUC) and at Caño La Culebra (CUL) adequate nesting habitat was also scarce.

In early February 1997, a small number of beaches (15) from CAS and CAM were more carefully scrutinized to determine their use by iguanas and turtles. Twenty percent of the beaches had clutches of turtles' eggs (*Podocnemis unifilis*). Most of these beaches (73.3%) also had nest excavation made by iguanas. The count for turtle nests was clearly an underestimation, because it is much more difficult to find turtle clutches than iguana excavations. On the other hand, it was probably too early in the nesting season of *Podocnemis* and many turtles may not have nested yet. González-Fernández (1995) found turtle nests in 38% of the beaches with crocodile nests. In a nocturnal survey conducted from La Batea to Merecure on 27 April 1997, the remains of eight turtle nests were found. Turtles or turtle nests have never been observed in the northern part of the study area at CAN and Cojedes Norte (CON).

In SUC, turtles were seen frequently basking on logs or branches of fallen trees. They may nest in that area, although nesting was never observed. Iguanas were very rare in this part of the river, which had its banks profusely covered by trees. This suggests that iguanas may be limited by scarcity of nesting substrate. Adequate nesting substrate in CUL seemed to be also scarce, but the presence of iguanas cannot be used there as an indicator of quality of nesting habitat, because that part of the CRS is almost devoid of arboreal vegetation, which may signify a more important limiting factor for iguanas.

Another criterion for evaluating the suitability of a section of the river for nesting was through the analysis of soil texture. Samples from the northern sections of the study area showed a preponderance of sand in their composition (65.5-89.5%; Figure 3). In two samples from CAS, close to Merecure, sand accounted for 58.5% on average. A lower percentage of sand was found in La Culebra (54.8%), and the lowest percentages of sand in all the samples were obtained in Sucre (range 11.5 to 23.5%).

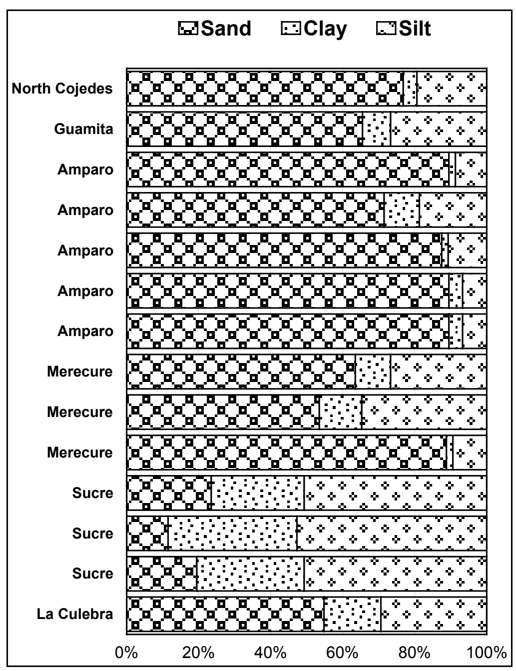

Figure 3. texture of river bank soil samples collected at different locations along the Cojedes river system, Venezuela. Locations are ordered from north to south (top to bottom)

Although vast parts of the study area were not evaluated for their suitability for nesting, a pattern of decrease in the quality of the substrate on the banks from north to south was apparent.

Nest density and nesting success

Based on the comparisons of the positions of nests and pods from 1996 and 1997, we estimated that there were at least 48 nesting females in the surveyed sections of the study area. Those sections represent a total of

45.7 km of river with a density of 1.03 nests (or nesting females) per km (Table 2). Although Cojedes Norte was never surveyed during the time when hatching occurs (late April early May), the size of many of the crocodiles seen there indicated that successful reproduction has taken place in that part of the river in previous years. CON is isolated from the rest of the study area by a dam. That dam constitutes a barrier that effectively blocks passage from downstream.

Table 2. Number of Orinoco crocodile females that nested in several river sections of the Cojedes river system during 1996 and 1997.

River section	Length (km)	Nesting Females	Density (female/km)
Caño de Agua Norte (CAN)			
Retajao[1]	--	1	--
Doncella-Guamita	5.5	4	0.73
Guamita-Puente Nuevo	10.5	12	1.14
Caño de Agua Sur (CAS)			
Puente Nuevo-Carama[2]	4.7	8	1.70
Pte Lorenzo-Confluence	7.6	12	1.58
Merecure-Caño Amarillo (CAM)	9.0	4	0.44
Sarare (SAR)	8.4	7	0.83
Total	45.7	48	1.03

[1] The nest from Retajao was a casual observation in a non-surveyed section. It was not considered for the calculation of density.
[2] Most part of this river section disappeared during the 1996 flooding

Nesting females were not uniformly distributed along the river. In the river section La Doncella-Guamita only four nest (0.73 nest/km) were observed. This river reach was completely canalized and had steep banks. Downstream from it, in the Guamita-Puente Nuevo section of Caño de Agua, the river had recovered its meandering conditions. Nest density there increased to 1.14 per km.

The highest density (1.7 nesting females/km) was found in 1996 in the 4.7-km of Caño de Agua south of Puente Nuevo. Most of that the river section (approximately 60%) was lost during the rainy season of 1996 due to river diversion after a severe flooding event, when the river changed its course and diverted into smaller branches toward Caño Camoruco. The fate of the 8 nesting females from that part of the river is not known. Two nests found near Puente Nuevo in 1997, just north of the diverted river section, might have belonged to some of these females.

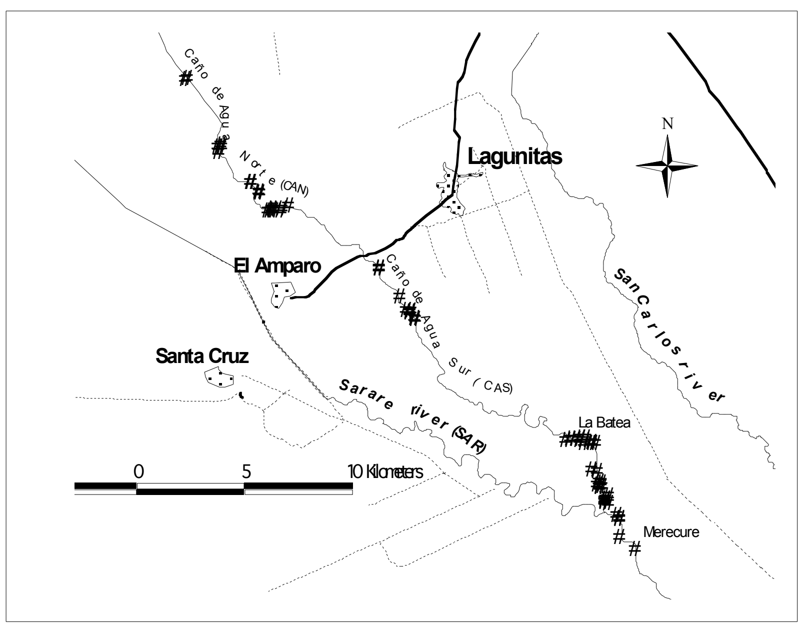

Figure 4. Orinoco crocodile nests found during 1996 and 1997 in the Cojedes river system, Venezuela. Nests tend to occur in clusters, indicating the presence of a dominant male a one or more females.

Four km of CAS, between Camoruco mouth and Puente Lorenzo (Figure 4), were not surveyed for nest or hatchlings. Considering that the characteristics of that river section were very similar to the ones found immediately downstream, in the section Puente Lorenzo-Confluence, six additional nesting females, not listed in Table 2, could be expected in Caño de Agua Sur.

In the Sarare River, only a stretch of 8.4 km (SAR) was surveyed for nest or pods, resulting in a density of 0.83 nest/km. The river section from there down to the confluence with Caño de Agua has never been surveyed.

No hatchling or nest was ever found in Sucre or Caño La Culebra. The size of the crocodiles seen or captured there indicates that they were older than a year, suggesting that crocodiles in these locations may have come from elsewhere, probably upstream.

A detailed examination of crocodile nest distribution revealed a pattern of clustering (Figure 4). Groups of up to four females were found in close proximity, suggesting the presence of a dominant male and a group of females, as has been reported in the Capanaparo River by Thorbjarnarson and Hernández (1993b).

Nest predation by humans did not seem to be an important factor affecting the viability of the Orinoco crocodile in the CRS. One nest seemed to have been taken by people in the section Merecure-Caño Amarillo in 1997, but the evidence was equivocal. People in Retajao took at least 11 hatchlings from a pod in 1996.

Since 1994, reproductive success in the CRS has been monitored repeatedly (but only partially due to logistic problems) along the lower part of Caño de Agua Sur and the Cojedes river from its confluence with the Sarare river and Caño Amarillo, a continous section of about 20 km. The results (Table 3) indicate a high variability in hatching success, probably related to changes in water levels at the end of the incubation period (late April).

Table 3. Number of nests of Orinoco crocodile that produced hatchlings in lower Caño de Agua Sur and Cojedes between Camoruco and Caño Amarillo. Data for 1994 was taken from González-Fernández (1995); data for 1998 and 1999 were taken from Chávez (2000).

Year	Number of successful nests	River length surveyed
1994	21	17.6
1996	5	17.6
1997	7	13.6
1998	16	13.6
1999	16	13.6
2000	13	4.0
2001	9	13.4
2002	0	18.0

Adult Population

Ninety-one reproductively active crocodiles were estimated for the Cojedes River System, most of them (63.2%) in Caño de Agua (Table 4). This figure represents a minimum since (1) some parts of the since river were poorly surveyed and, conservatively, a low density of adults was assigned to them, and (2) not all the adult females nest every year.

Table 4. Reproductive population of Orinoco crocodiles in the Cojedes River System. The number of dominant males was calculated as one per female for relative isolated females, and one male for every three-four females for places with several females.

Place	Length (km)	Nesting Females	Dominant Males	Total
Cojedes Norte (CON)	7	21	1	3
Caño de Agua Norte (CAN)				
Toma Cojedes-La Doncella	25.5	1	1	2
Doncella-Guamita	5.5	4	1	5
Guamita-Puente Nuevo	10.5	12	4	16
Caño de Agua Sur (CAS)				
Puente Nuevo-Carama[2]	4.7	8	3	11

Place	Length (km)	Nesting Females	Dominant Males	Total
Camoruco-Pte. Lorenzo	3.7	61	2	8
Pte Lorenzo-Confluence	7.6	12	4	16
Confluence-Caño Amarillo	9	4	1	5
Caño Amarillo-Sucre	51	11	1	2
Caño Amarillo-La Culebra	33.5	11	1	2
Sarare				
Downstream Amparo bridge	8.4	7	2	9
Lower Sarare	12	81	3	11
Total	**153**	**66**	**25**	**91**

[1] Not surveyed. Figure estimated based on similarity of appearance with surveyed sections.
[2] Most of this river reach disappeared during the flooding season of 1996.

Nesting Chronology

The earliest observation of hatchlings crocodiles was 12 April, during the 1996 hatching season. Morphological characteristics (total length, presence of egg tooth and size of the umbilicus) of the hatchlings found in 72 pods observed from 1991 to 1997, suggest that most of the hatching occurred from mid-April to early-May. In captivity, under ideal conditions, the incubation period lasts some 80-85 days (Ramo *et al.*, 1992; Thorbjarnarson and Hernández, 1993a; Seijas and González, 1994; Lugo, 1995), so construction of nests may start as early as mid January. Most nesting, however, occurs in late January and early February. The earliest nest ever examined by us, on 5 February 1997, and those found by Ayarzagüena (1987) support this conclusion.

Hatchling Pods and Parental Care

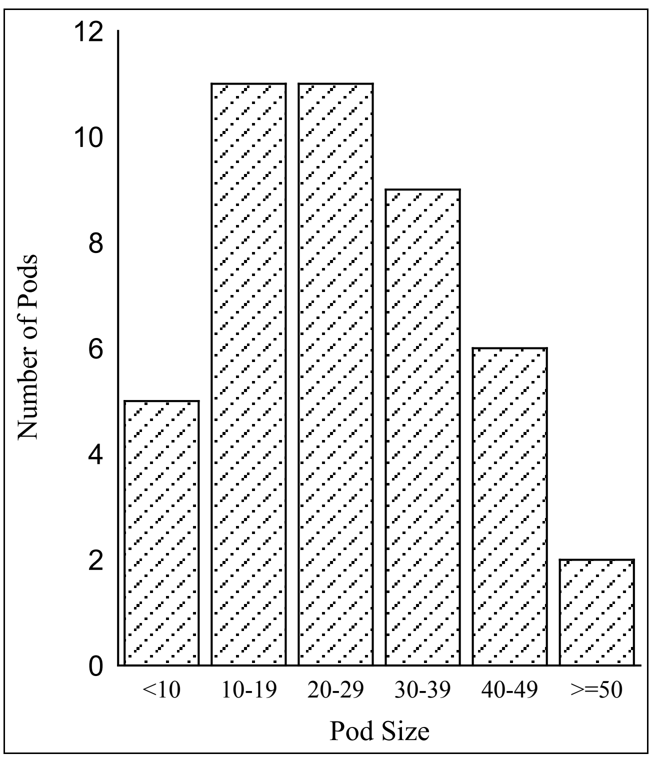

Figure 5. Frequency distribution of pods of Orinoco crocodile hatchlings according to their number of individuals in the Cojedes river system, Venezuela. Large pods may result from the integration of hatchlings from more than one female.

Based on the size 44 pods observed in the first month of the hatching season (Figure 5), the average number of hatchlings per pod was 26.0 "13.9, as compared to 31 "10 reported by González-Fernández (1995). When analyzing for the differences in pod size among localities (CAN, CAS+CAM, and SAR), the statistical result was significant (Kruskal-Wallis Test; X=6.2, P=0.045). This result is a consequence of the higher number of individuals (35.5) in pods from the Sarare River. Pod size in CAN and CAS+ CAM was very similar (24.0 and 22.1 hatchlings/pod, respectively).

According to my own data, and on information reported by Ayarzagüena (1987) and González-Fernández (1995), the average number of eggs per clutch in the CRS is 38.2 "11.0 (n=12), which is below the typical range (40-70) mentioned for the species by Thorbjarnarson (1992). The mean pod size found in this study (26.0) represents 68% of the average clutch size, which could be taken as a preliminary measure of hatching success. A flaw in this method of calculating hatching success is that nests that fail to produce hatchlings could not be detected, and so are not included in the calculations. There is no information on other wild Orinoco crocodile populations to compare these results.

In 47.7% of 44 pods for which the information was recorded, an adult crocodile, presumably the mother of the hatchlings, was seen in close proximity. This figure is surely an underestimation, because the disturbance produced by the noisy approach by boat, powered by an outboard engine, might have caused many females to disappear from sight. Compared to CAN, the river sections of CAS and CAM are less disturbed by human activities (Seijas, 1998, 2001). We expected that human disturbance affect pod attendance. The differences in pod attendance was lower in CAN, supporting that hypothesis (X5=4.48; *P*=0.034).

DISCUSSION

Although depleted in most of its former range, there is high density of Orinoco crocodiles in the CRS. There were at least 48 adult females in the surveyed sections of the river, a number that is most probably an underestimation since a relatively small part of the region was properly surveyed.

Lack or scarcity of good nesting substrate seems to be an important factor determining the current distribution of the species in the CRS. Soil samples taken from active nests indicates that the most frequently selected nesting sites are composed of high proportion of sand (generally more than 70%). The reproductive population is concentrated in the Caño de Agua and in the lower Sarare River, the areas that had the highest quality nesting habitat. There was no evidence that the species reproduces in Cojedes Sur and in Caño Culebra, areas which had lower quality nesting habitat. The abundances of crocodiles and quality of nesting sites of many sections of the CRS have not been evaluated, so this conclusion is preliminary.

Reproductive data from this study, compared to data in the literature (Ayarzagüena, 1987, González-Fernandez, 1995), suggest that the number of nesting females has remained stable over the last 10 years. Globally, the total density of nests was the same as found by González-Fernández (1995) in part of the study area (1.04 nest/km). Ayarzagüena (1987) estimated that there were some 25 nesting females in Caño de Agua Sur, which was roughly the same number found in this study for the same part of the CRS. The nest density of the *C. intermedius* population in the Capanaparo River studied by Thorbjarnarson and Hernández (1993a) ranged from 0.24 to 0.36 nests/km.

Nest density in the CAM (0.44 nest/km) was relatively low when compared with the 1.4 nests/km obtained in 1994 by González-Fernández (1995). The results obtained by González-Fernández may be exceptional, because that year the rainy season started late, with the lowest combined precipitation for April-May (129.7 mm) for the period 1975-1996 (MARNR, 1997). Compared to other years, a lower number of nests (if any) may have been lost in 1994 due to flooding.

Some river sections that have been dredged repeatedly in the last 20 years had relatively high density of nesting. Dredging may have an immediate negative impact because it destroys nesting beaches (González-Fernandez, 1995) but the river seems to recover after several years. One of the lowest nest densities was found in La Doncella-Guamita, a stretch that has been channelized. Channelization may have a greater impact on reproduction and on the population as a whole because it reduces the habitat for the species, eliminates most beaches, and increases the flow speed of the river, which may have a negative impact on pod cohesion and hatchling survival.

The distribution of nests or nesting females along the river indicated that in the Cojedes River the Orinoco crocodile showed the same social structure described for the species in the Capanaparo River, in which dominant males form polygynous groups with two or more adult females (Thorbjarnarson and Hernández, 1993b).

If pollution and other human related factors affect egg viability in the area studied, that may be reflected in the average pod size. Habitat modification and pollution (Seijas, 1998) were higher in CAN than in CAS. Habitat alteration in the surveyed portion of the Sarare River was comparable to that found in CAN, but information on pollution was not available. There was a statistical difference in pod size among localities, due to the relatively higher average pod size in the Sarare River. However, this latter site was insufficiently sampled. Since there are many factors that can affect pod size, including female size and hatching success, it is difficult to interpret the meaning of these differences in pod size. More detailed studies in this regard are necessary, particularly on the effects of contamination on crocodile reproduction.

There was a significant difference in what was interpreted as maternal care or pod attendance between Caño de Agua Norte and Caño de Agua Sur-Caño Amarillo. This may be a consequence of higher human interference in Caño de Agua Norte, as has been reported for *Caiman yacare* in Brazil (Crawshaw, 1987). Another possibility is that females in Caño de Agua Norte were relatively new colonizers of the area and probably younger and less experienced than females in southern locations.

Egg or hatchling collection did not seem to be a factor that affects the survival of the Orinoco crocodile in the CRS, at least where most of the nesting occurs, although anecdotal information indicated that this kind of human intervention occurs sporadically (pers. observ; González-Fernández, 1995) and probably was common practice in the past (Godshalk, 1978) . Human settlements are generally several kilometers away from the river banks, and in the CRS is not inhabited by people exploiting the river resources as is the case in the Capanaparo River (Thorbjarnarson and Hernández, 1992). Gonzalez-Fernandez (1995) reported that 2 of 27 (7.4%) nests analyzed by him were destroyed by a dredge, but no predation by human was reported.

Nesting chronology documented in this study agrees with the general pattern described for the species (Medem, 1981, 1983; Ramo *et al.*, 1992; Thorbjarnarson and Hernández, 1993a): egg-laying starts during the months of lowest precipitation (January-February) and hatching takes place at the onset of the rainy season (late April-early May). Nesting (and consequently hatching) occurs earlier in the captive breeding facilities of the Universidad Nacional Experimental de los Llanos (UNELLEZ), and later in the breeding facilities of Masaguaral ranch, in response to different precipitation regimes in those areas (Ramo *et al.*, 1992, Thorbjarnarson and Hernández, 1993a). Eggs laid late during the nesting season are under a high risk of being lost due to flooding. The high nesting success reported by González-Fernández (1995) for a reach of the Cojedes River (Merecure-Caño Amarillo) in 1994 may be the result of delay of flooding events in that year. The impact that damming, channelizing and water diversion in the CRS may have on nesting and reproductive success of the Orinoco crocodile has not been properly studied. Several kilometers of good nesting habitat have been lost due to flooding and river diversion in the last 10 years. The wise management of the Las Majaguas reservoir and of the future Las Palmas reservoir, to avoid sudden rises of water levels and loses of nests, will be crucial for the survival of the species.

ACKNOWLEDGMENTS

This study was made possible by a grant from the Wildlife Conservation Society (WCS). Jevert González, Eddy Escalona and particularly the late Coromoto Ramírez served as our guides on many occasions. Early version of the manuscript were reviewed by F. W. King, John Thorbjarnarson, Richard Bodmer, Melvin Sunquist, George Tanner and Robert Godshalk.

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Habitat Requirements and Aggregation Patterns of Different Age Groups of Indian Gharial, *Gavialis gangeticus* (Gmelin)

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ABSTRACT: The systematic depletion of crocodile species in their natural habitats has led to the establishment of rehabilitation programmes in India. To assess the natural recruitment rate and breeding potential, population was monitored in the Chambal River (National Chambal Sanctuary) by observing behaviour of different age groups of Gharial (*Gavialis gangeticus*). All gharials of different age groups, starting from hatchlings to adults, are counted during annual surveys. The gharial is a gregarious species. Young gharials are congregated into small groups of 10 to 20 individuals and prefer shallow areas with sand peninsulas. The breeding adults (one male group) are living in deep pools with steep sand banks. The young gharials migrate frequently until they attain maturity. The adults remain in the breeding areas and rarely leave their breeding grounds. The hatchlings have a short period of 15 to 20 days of attachment with their parents, whereas the adults form a breeding group for many years in specific areas. Presence of age specific habitat conditions made the Chambal River an ideal habitat for the Indian Gharial. Although rehabilitation of gharial in other rivers has been carried out, the rehabilitation of gharial in the Chambal River is most successful programme under Indian Crocodile Project.

Extinct Crocodiles Had Specialized Sensory Organs to Detect Water Surface Disruptions

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ABSTRACT: Crocodilians are an ancient monophyletic group. Living crocodilians are divided into alligatorids, crocodiles and gavials. All have an amphibious life-style, spending their time on land, underwater and on the interface of the two media, although some extinct forms were strictly terrestrial or aquatic. Behavioral, anatomical and physiological data shown here demonstrate that these predatory animals have evolved a unique sensory organ that mediates orientation to disruption of the water surface. Pressure waves created by these disruptions stimulate dome pressure receptors (DPR, formally known as integumetary sensory organs) on the crocodilian skin. Removing DPRs abolishes the orienting behavior. The ancient nature of these sensory organs is reflected in the fossil record. Typical patterns of foramina in jawbones associated with DPR innervation appear in extinct specimens in the early Jurassic. These osteological markings are present only in animals believed to have had an amphibious life style and are absent in the extinct fully terrestrial or aquatic forms.

Everglades Alligator Thermoregulation: Unanswered Questions

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ABSTRACT: We instrumented 29 free-ranging, adult Everglades alligators with intra-peritoneal data loggers that recorded time and temperature at 72-min intervals. About 1 year later we recovered functioning data loggers from 13 animals. Alligator temperature data were available from August 1997-June 1998; some environmental temperatures were recorded from October 1997- May 1998. The relationship between alligator- and environment-temperatures suggested thermal conformity during winter and fall, but alligators were warmer than most of their environment in spring. In winter, alligators did not generally seek high temperatures, and T_b's typically conformed to deep-water temperatures—except that alligators warmed episodically to about 30°C. Although T_b's were usually correlated across alligators, these winter spikes occurred on different days for different alligators. When alligators were clustered by thermal histories, statistically significant clusters reflected animal mass.

INTRODUCTION, MATERIAL, AND METHODS

Although ectothermic archosaurs once dominated large-vertebrate niches, crocodilians are the sole surviving members of this vast radiation. And of 23 extant crocodilians species, only American and Chinese alligators are primarily temperate in distribution. Therefore, thermoregulation in these species is particularly interesting.

In May-September, 1997, our veterinary team implanted Tidbit data loggers (Onset Corporation) and radio transmitters (AVM Instruments) into 29 alligators from Everglades National Park (ENP) and Conservation Area Three (CA, to the Park's north). We monitored animals' post-operative recovery and then released them at their capture sites. We also used Tidbit loggers to record environmental temperatures (1) under 20-50 cm of water ("deep H_2O"), (2) under 5 cm of water ("shallow H_2O"), (3) in air, under shade ("shade"), and (4) within 600

cm^3, air-filled copper spheroids painted flat-black ("black-body"). We synchronized all data loggers to record observations simultaneously.

During June-September, 1998, we recaptured alligators, retrieved data loggers, and released animals at their recapture sites. We downloaded loggers using Boxcar software (Onset Corporation) and exported data to SYSTAT 7.0. Then we validated logger-accuracy against mercury thermometers, subsequently excluding data from loggers that had malfunctioned. (We specify data-exclusion procedures in an Appendix.) Table 1 summarizes the data we analyzed.

Table 1. Summary of data.

Inclusive Dates	Alligators Monitored	Environmental Temperatures Monitored	Observation Frequency
01OCT97-31MAY98	13	CA: deep H_2O ENP: shallow H_2O, black body, shade	20/day
31MAY98-31JUL98	13	Loggers considered insufficiently reliable.	20/day

ANALYSES

For initial analyses, we defined 10 variables (see Appendix for definitional details):

1. Average alligator temperature: $\mathbf{G_{ave}}$ is mean temperature calculated across 12 alligators.
2. Environmental temperature index: **E** = [2(deep H_2O) + shallow H_2O + shade]/4.
3. Temperature difference, alligator – environment: $\mathbf{D_{ave}}$ = G_{ave} – E.
4. Daily temperature cycle intensity: **INTENSE** is largest component in Fourier decomposition of a time-series of alligator temperatures. (Note: this was always the daily component.)
5. Circadian response ratio: **RATIO** = INTENSE/largest Fourier component for environment temperatures. (Note: largest Fourier component for environment was also the daily component.)
6. Smoothed temperature difference, alligator - environment: $\mathbf{D_{smooth}}$ is the weekly running median of D_{ave}.

7-8. Alligator maximum and minimum temperatures: $\mathbf{T_{max}}$ is the maximum temperature of an alligator during a specified time period. $\mathbf{T_{min}}$ is the minimum temperature of an alligator during a specified time period.

9-10. Environmental maximum and minimum temperatures: $\mathbf{E_{max}}$ is maximum of (shade, shallow H_2O, deep H_2O); $\mathbf{E_{min}}$ is minimum of (shade, shallow H_2O, deep H_2O).

We plotted D_{smooth} as a function of date. We calculated monthly averages for D and for RATIO variables. We determined correlations, by month, between alligator T_b's and black-body temperatures. Taking January as an example of winter, we compared time-series plots of each alligator's T_b against time-series plots of environmental temperature measures. We also compared pairs of alligator time-series T_b plots, and we listed days on which individual alligator T_b's exceeded 30°C (the value was arbitrarily selected, but see Colbert et al., 1946; Avery, 1982; Coulson and Hernandez, 1983).

For each month and each sequential pair of months we performed a joining-cluster analysis to determine which alligators might exhibit similar thermal patterns. Three clustering variables were defined: (1) mean for month(s) of daily T_{max}, (2) mean for month(s) of daily T_{min}, and (3) INTENSE. See Appendix for technical details. Because our analyses indicated that body mass was important in the thermal clustering of alligators, we investigated this hypothesis, by month, using linear regression.

Finding # 1: Relative to their environment, alligators warm up in spring.

Although our alligators were approximate thermal conformers throughout much of the year, in spring they apparently sought warm temperatures. This contention is supported by 3 analyses.

First, Fig. 1 plots $D_{smootth}$ for all alligators as a function of date for 1 October 1997 – 31 May 1998. Although the graph is noisy, values of D_{smooth} clearly fluctuate near difference = 0 until late February, after which the alligators become substantially warmer than most of their environment.

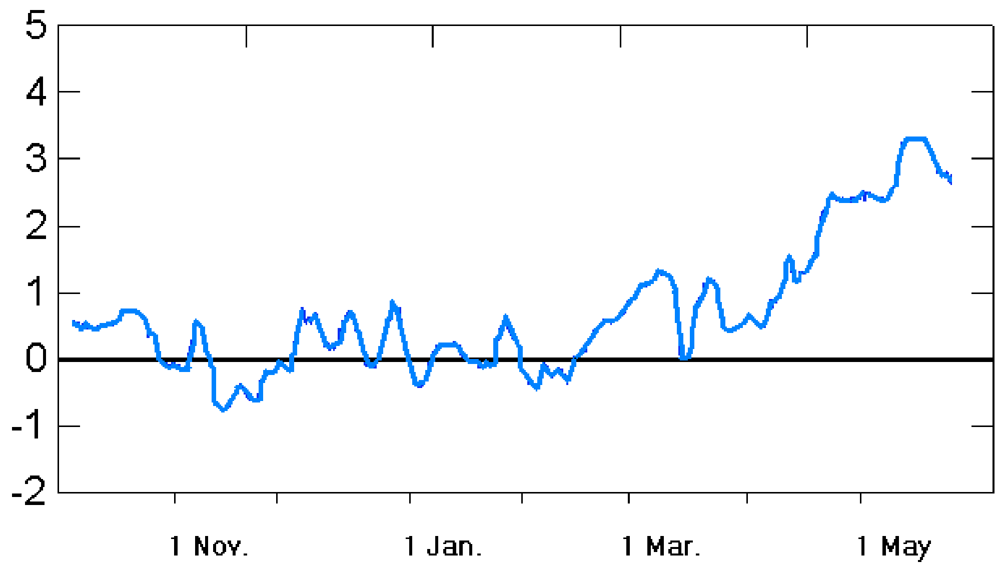

Figure 1. Average alligator temperatures (smoothed) minus environmental temperatures.

Second, Table 2 shows monthly averages of D_{ave}. Note differences are larger in spring (March, April, and May) than at other times.

Table 2. Monthly and seasonal averages of D, the mean difference between average alligator temperature (G_{ave}) and environmental index (E). "Fall-Winter" includes January, February, and October-December, and "Spring" includes March-May.

Month	**D (or, G_{ave} – E)**	**Month**	**D (or, G_{ave} – E)**
January	0.19°C	October	0.34°C
February	0.10°C	November	-0.32°C
March	1.16°C	December	0.39°C
April	1.55°C	Fall-Winter	0.15°C
May	2.57°C	Spring	1.75°C

Third, Table 3 shows values of RATIO by month. These values reflect the intensity of alligator heating and cooling, relative to environmental heating and cooling. Note that ratios are highest in spring, and particularly in March. Indeed, during spring the alligator circadian thermal cycle was more intense than that of their general environment index, E.

Table 3. Magnitudes of largest (daily) Fourier components for G_{ave} ($G_{Fourier}$) and for environmental index ($E_{Fourier}$); ratio of $G_{Fourier}/E_{Fourier}$; ratio of alligator circadian magnitude to circadian magnitude of black-body temperatures ($G_{Fourier}/BB_{Fourier}$); all by month.

Month	**$G_{Fourier}$**	**$E_{Fourier}$**	**Ratio: $G_{Fourier}/E_{Fourier}$**	**Ratio: $G_{Fourier}/BB_{Fourier}$**
January	4.83	3.61	1.34	0.043
February	10.70	6.73	1.59	0.098
March	19.18	6.18	3.11	0.133
April	19.00	10.60	1.79	0.099
May	10.91	25.50	0.43	0.034
October	4.41	5.24	0.84	0.024
November	7.15	6.67	1.07	0.048
December	5.25	5.67	0.93	0.044

Finding # 2: In winter alligators often stay cooler than "necessary."

As indicated by Fig. 1 and Table 2, average alligator temperatures were close to our environment-temperature index except during spring. However, “thermal conformity,” does not entirely describe our alligator temperatures in winter. During January the average temperature of each study-alligator was lower than the average shallow-water temperature. And, as a group, alligators averaged 3.6^{o}C cooler than shallow H_2O in January. Presumably, alligators could have moved toward heat and averaged at least as warm as the shallow water in an Everglades-type environment, but they did not.

Finding # 3: Nevertheless, sometimes winter alligators warm appreciably, perhaps by using solar-radiant energy.

Recall that at any given time, E_{max} is the maximum of shade, shallow H_2O, and deep H_2O temperatures. During January each of 13 study alligators exceeded E_{max} substantially (by more than 6.3^{o}C) at least once. The exploitation of solar-radiant energy is suggested by Fig. 2, which plots black-body temperature and temperature of a representative alligator against date-time. To facilitate visual interpretation, we graphed only 10-20 January. As expected, each spike in alligator T_b inevitably co-occurred with a black-body high.

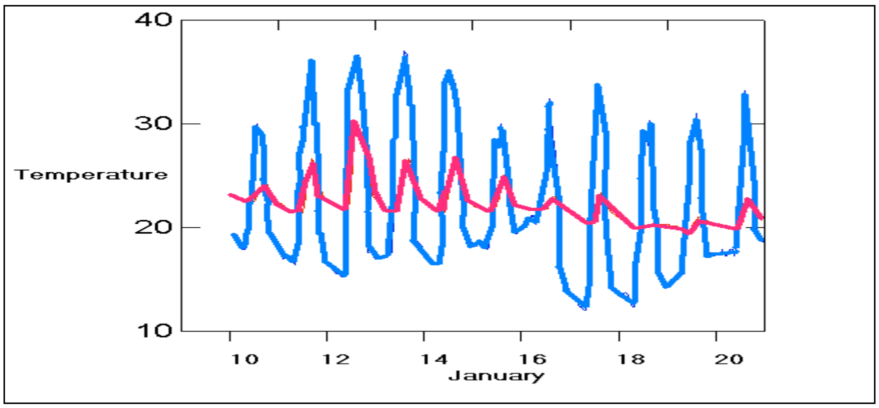

Figure 2. Line with more extreme values shows black-body temperatures; line with less extreme values shows T_b's of a representative alligator.

Finding # 4: Although black-body highs may be a necessary condition for winter alligators' thermal “spikes,” they are not sufficient. Indeed, the high alligator temperatures in January were somewhat eccentric to individual alligators.

Figure 2 (above) shows that not every black-body extreme was accompanied by a proportionally extreme T_b for our example alligator. Nor was such correlation the case for any other study animal. Furthermore, different alligators, even in similar, proximate habitats did not always warm up at the same time. We illustrate this in Figure 3, which overlays January thermal plots for two female animals from ENP.

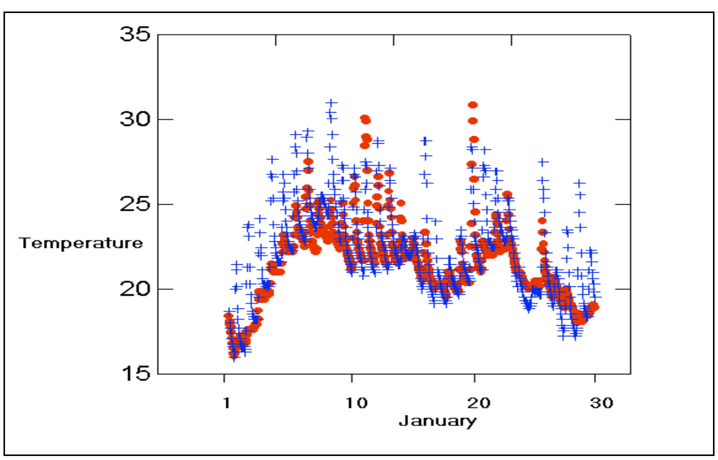

Figure 3. Overlay of January thermal plots for 2 females from ENP.

Similarly, among 9 CA alligators, T_b's of 7 animals (labeled A-G in Table 4) exceeded 30°C at least once during January. One animal warmed 13 times, but for the other 6, there was only one day on which more than one animal achieved ≥ 30°C. In other words, most alligators broke 30°C occasionally during January, but they tended to warm up on different days (Table 4).

Table 4. January dates on which Tb's of 7 CA alligators (labeled A-G) exceeded 30oC.

Date	Animals warming to ≥ 30°C	Date	Animals warming to ≥ 30°C
4 Jan.	A	13 Jan.	A E
5 Jan.	A	17 Jan.	A F
6 Jan.	A	21 Jan.	G
7 Jan.	A	22 Jan.	A
9 Jan.	B C D	24 Jan.	F
10 Jan.	A	28 Jan.	A F
11 Jan.	A	29 Jan.	A
12 Jan.	A E	31 Jan.	A F

Finding # 5: When clustered by thermal variables, alligators group by size.

Cluster patterns and memberships varied in minor detail throughout the year, but typical 2-cluster solutions divided alligators by size. An example is Fig. 4. Only the 2-cluster solution is appropriate (according to the pseudo-F analysis as defined in the Appendix; $\Phi_{1,11} = 61.4$).

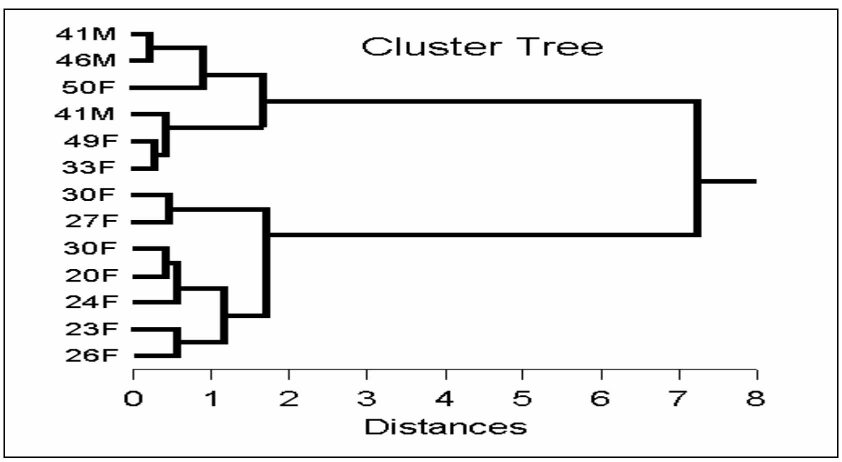

Figure 4. Cluster members are labeled by mass in kg and gender (F or M).

Finding # 6: Alligator size appears to affect T_{min} (not T_{max}) and perhaps INTENSE.

Table 5 shows results of monthly regressions modeling T_{min}, T_{max}, and INTENSE, separately, as functions of alligator size. Models involving T_{max} were never significant. T_{min} was a positive, significant, function of size from November through June. This suggests that during much of the year, large alligators did not get as cold as small ones. During warm months larger alligators had less intense circadian thermal cycles than smaller ones. (That is, INTENSE was a negative, significant function of size in May, June, August, and September.)

DISCUSSION

South-Florida alligators are approximate thermal conformers throughout much of the year (Table 2 and Fig. 1). In spring, however, our animals warmed, relative to their surroundings. This thermoregulation may be associated with breeding and/or increased feeding (McIlhenny, 1935; Neill, 1971). With large samples of known reproductive and non-reproductive females, researchers might sort out the relative importance of those 2 factors. During springtime, alligator daily thermal cycles also increased in intensity, relative to environmental temperature cycles (Table 3). This phenomenon was probably driven by radiant energy—since correlations between black-body and alligator temperatures were highest in spring. In other words our data suggest, as most authorities have believed for years (McIlhenny, 1935; Neill, 1971; Brandt, 1989), that in springtime alligators increase body temperatures by basking. Furthermore, this activity seems less important during other seasons.

Table 5. Linear regressions of thermal variables on alligator size. Mass is in kg; "mean low" is mean, for month indicated, of daily minimum T_b; "mean high" is mean, for month indicated, of daily maximum T_b; "day-cycle intensity" is magnitude of largest (daily) Fourier component; "N/S" indicates P > 0.05; N is all 13 alligators.

Month	Slope / P-value mean low = f(mass)	Slope / P-value mean high = f(mass)	Slope / P-value day-cycle intensity=f(mass)
Nov.	0.07 / P = 0.011	N/S	N/S
Dec.	0.08 / P = 0.001	N/S	N/S
Jan.	0.07 / P = 0.005	N/S	N/S
Feb.	0.06 / P = 0.014	N/S	N/S
Mar.	0.06 / P = 0.024	N/S	N/S
Apr.	0.05 / P = 0.050	N/S	N/S
May	0.08 / P = 0.001	N/S	-0.06 / P = 0.026
Jun.	0.07 / P = 0.003	N/S	-0.08 / P < 0.001
Aug.	N/S	N/S	-0.07 / P = 0.004
Sep.	N/S	N/S	-0.07 / P = 0.007
Oct.	N/S	N/S	N/S

In winter, alligator temperatures were usually at or below water temperatures, but T_b's occasionally spiked to higher levels. These spikes were all associated with black-body highs (Fig. 2), but black-body highs did not inevitably bring T_b spikes with them. Furthermore, different alligators spiked on different days (Fig. 3 and Table 4). These observations suggest that T_b spikes result from alligator thermal "choices." However, if alligators do not eat during winter (McIlhenny, 1935), then the temperature-spiking behavior would be energetically inefficient because raising T_b would increase metabolic costs without apparent benefit (Colson and Hernandez, 1983; Lang, 1987; Lewis and Gatten, 1985; Peterson et al., 1993). Detailed observations of alligator food intake and metabolic activities might have helped explain winter T_b spikes. Coulson and Hernandez (1983) state that alligators stop eating when body temperatures drop below 22°C. The spikes that we observed raised T_b's far above this level, but only for a few hours. This brevity suggests that if food were acquired, it was digested very quickly—or that alligators were warming up for other reasons. The processing of metabolic wastes is one alternative explanation. Because our alligators could not lower winter T_b's to the temperatures of more northern alligators, Everglades metabolic slowdowns may have been less profound. Perhaps, as a result, Everglades alligators must dump metabolic wastes more frequently. Raising T_b to facilitate kidney function may be the most efficient way to deal with ionic and osmotic regulation (Minnich, 1982).

In cluster analyses based on thermal variables, alligators of similar size were grouped together (Figure 4). Also, in most months larger alligators had relatively high daily minimum temperatures and/or less intense circadian thermal cycles (Table 5). Surface/volume considerations suggest such phenomena, and many authors discuss the relationship between crocodilian size and thermoregulation (Spotila et al., 1973; Smith, 1975, 1976; Grigg, 1977; Johnson et al., 1978; Smith and Adams, 1978; Bartholomew, 1982; Grigg et al., 1998; Grigg et al., 1999). However, we were unable to investigate the social dimensions of thermoregulation, and if larger alligators have more choice of thermal microhabitats, then the effect of size on T_b's may be socially mediated (Seebacher and Grigg, 1997). Since our 3 ENP alligators were larger than average, the apparent size effect might be confounded by area. Gender is another potentially confounding variable since our 3 males were also moderately large. (Despite reduced sample size, a significant size effect did persist in some months when we controlled for locality and gender. Gender and location were not in themselves significant.)

The development of implantable temperature recorders has not provided a panacea for research in crocodilian thermoregulation. An alligator's environment presents a mosaic of thermal challenges and opportunities, and within that environment the animal must satisfy its non-thermal needs as well (Lang, 1987). To measure the thermal dimensions of an ENP alligator's habitat would require data loggers (preferably in duplicate, at several depths) in every proximate hole, slough, and sawgrass flat—not to mention air-temperature loggers, in sun and shade (preferably in physical models, with varying orientations to probable winds). The temperatures within an alligator may be almost equally complex (Pough and Gans, 1982), with variations between head, legs, trunk, and tail, perhaps mediated by complex blood shunts or other anatomic and physiological mechanisms (Turner et al., 1979; Bartholomew, 1982; Turner and Tracy, 1985; Lang, 1987). Thus the researcher should implant several loggers in each alligator. And the alligator-sample should be cross-classified by habitat, size, and gender, with sufficient replicates. Obviously the correlation of alligator and environmental temperatures would be more meaningful if the researcher recorded locations and behaviors of each animal (Seebacher and Grigg, 1997), preferably across several years since inter-annual variations in alligator habitat are substantial (Howarter, unpubl. data).

Perhaps such a research project could be funded for less than the cost of a major war, but we would not choose to be involved in it. Indeed, the present study suggests that mountains of data loggers and fleets of airboats are not our most critical research need. Instead, we must define thermoregulation questions more precisely and focus our study design more accurately upon such questions (Peterson et al., 1993). Toward these ends we solicit, and indeed covet, comments and suggestions from the broader crocodilian-research community.

ACKNOWLEDGEMENTS

J. Barnett, P. Cardeilhac, D. Gross, T. Gross, S. Shrestha, and C. Weiser were principally responsible for surgery. M. Anderson, L. Hord, C. Tucker, and A. Woodward assisted with captures. Project technicians were M. Chopp, C. Westall, and J. Wiebe. L. Brandt, F. Mazzotti, P. Ross, and P. Wilkinson were helpful in many aspects of the project. Administrative burdens were borne by B. Fesler and D. Hughes. The project was funded by the Florida Caribbean Science Center, USGS-Biological Resources Division, through the Florida Cooperative Fish and Wildlife Research Unit's Cooperative Agreement No.1434HQ97RU01544, RWO 154c.

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APPENDIX

A. Logger evaluation

At the time of our study, Onset's Tidbit data loggers were available in two models, "narrow range" [-5°C to +37°C] and "wide range" [-20°C to +70°C]. We recovered and tested twenty loggers (Table A1). One had ceased functioning within < 1 day of implantation. All functioning loggers' clocks were within 5 min of actual time at the study's conclusion. Two wide-range loggers differed as much as 5°C from temperatures measured on a mercury thermometer. All data from unsatisfactory loggers were excluded from reported analyses. (Note: Based in part on information obtained during this study, Onset Computer Corporation has addressed problems in "wide-range" data loggers.)

Logger Type	# of Instruments	Deployment	Post-Study Evaluation
Narrow range	13	in alligators	satisfactory
Narrow range	1	in alligator	**unsatisfactory** (quit)
Narrow range	1	in environmental station	Satisfactory
wide range	3	in environmental stations	Satisfactory
wide range	2	in environmental stations	**unsatisfactory** (inaccurate)

Appendix table 1: Logger evaluation.

B. Defining variables

G_{ave} is based on loggers from only 12 alligators. The thirteenth animal was consistently warmer than all others and, as an outlier, was excluded from the calculation of G_{ave}. We found no problems with her data logger. However, she had only three legs, and we feared that this might have affected her thermoregulation in some way. Duplicate analyses with other measures of "average" alligator temperature and other subsets of alligators did not produce qualitatively different results. (Note that we can also talk about the temperature of a given individual, i^{th} alligator as G_i. In the text we usually refer to this variable as the i^{th} alligator's T_b.)

In defining E, we double-weighted deep H_2O because (1) shallow H_2O and shade temperatures were more ephemeral and were highly correlated (in a sense, they measure the same thing) and (2) we wished to give equal weight to environment in both study areas. Because of their extreme daily cycles we excluded black-body temperatures from this environmental measure and analyzed them separately. We duplicated all analyses using additional fragments of environmental data and other indices of environmental temperature; no results were qualitatively different.

D_{ave} is merely the difference between average alligator temperature, G_{ave}, and environmental temperature index, E. Positive values of D_{ave} indicate that, on average, alligators are warmer than their environment. (Note that we can also talk about the temperature of some individual, i^{th} alligator relative to its environment: $D_i = G_i - E$, or $D_i = T_{b,i} - E$.)

INTENSE is the largest component in a Fourier decomposition of alligator temperatures (Wilkinson, 1996). Within an alligator's year, the most intense thermal cycle is daily (this is hardly newsworthy; animals warm by day and cool by night). Therefore the magnitude of INTENSE reflects the intensity of alligators' circadian thermal cycle. (Note that although INTENSE could be calculated on the time series of G_{ave}, we discuss INTENSE only as a variable associated with individual alligators.)

RATIO shows INTENSE divided by the largest Fourier component for environmental temperatures. This is done both for our environmental index, E, and for black body. The textual context makes the current usage clear. (Of course the largest Fourier component for E and for black body is daily; environmental temperatures warm by day and cool by night.)

We calculated the above variables across our entire study period. We also calculated monthly averages for E, G_{ave}, and D_{ave}. And we determined values for INTENSE by months.

D_{smooth} is a running weekly median of D (either D_{ave} or D_i; textual context makes the application clear). Recall that D would be measured 20 times per day, or 140 times per week. Thus, $D_{smooth,1} = \text{Median}(D_1, D_2, \ldots, D_{140})$, and $D_{smooth,2} = \text{Median}(D_2, D_3, \ldots, D_{141})$, etc.

T_{max}, T_{min}, E_{max} and E_{min} require no further definition.

C. Cluster-analysis details

Our distance metric was Euclidean. We considered as interesting only clusters that replicated under both Ward's and median-linkage methods (Milligan, 1980; Milligan and Cooper, 1985; Wilkinson, 1996; Wilkinson et al., 1996). On a cluster diagram of interest we determined the appropriate number of clusters to analyze by the following procedure.

1. Comparing cluster solutions. Begin with 1 cluster (all alligators in one group) and ask whether 2 clusters will explain appreciably more of the variance in clustering variables. (This is done by an analysis of pseudo-F statistics; see 2. and 3. below.) If the answer is "No," then accept the 1-cluster solution. If the answer is "Yes," then ask whether 3 clusters will explain appreciably more of the variance than 2 clusters. If the answer is "No," then accept the 2-cluster solution. If the answer is "Yes," then ask whether 4 clusters will explain more of the variance than 3 clusters….

2. Calculating an appropriate test statistic for comparisons. We call the relevant test statistic a pseudo-F, or Φ, because although the calculations resemble a conventional F-statistic, the data do not fit the underlying probability model of F. The pseudo-F statistic, Φ, is calculated as follows:

$$\Phi = \text{(mean-square-model)}/\text{(mean-square-error)}, \text{ or}$$
$$\Phi = [(SSED_{c-1} - SSED_c)/(c-1)] \,/\, [(SSED_c)/(n-(c-1)-1)],$$

where n is number of observations; c represents the number of clusters under consideration, and $SSED_c$ and $SSED_{c-1}$ represent sums of squared Euclidean distances around cluster centroids.

3. Choosing a cut-off value for Φ. Because Φ is not an actual F-statistic, and because the underlying probability model is in any case unclear, P-values from conventional F-tables are not directly meaningful. Monte Carlo simulations (Beale, 1969) suggest that table "probabilities" ≤ 0.005 προϖιδε αν αππροπριατε χυτ−οφφ φορ αχχεπτινγ αδδιτιοναλ χλυστερσ. Τηε ταβλε προβαβιλ ιτιεσ φορ Φ are read from standard F-tables; "degrees of freedom" are taken as c – 1 and n – c.

Is Bone Surface Texture an Indicator of Skeletal Maturity in *Alligator mississippiensis*?

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ABSTRACT: Recent studies of fossil archosaurs have noted changes in bone surface textures throughout ontogeny. Although the specific textures vary among different taxonomic groups, the general reported pattern is an overall reduction in surface porosity with increasing maturity. The use of predictable texture changes as ontogenetic indicators would provide a valuable tool for determining relative ages of fossil animals. At this time, however, the consistency of reported texture changes in both modern and extinct taxa is largely untested. The current study is part of a broader project evaluating utility of textural aging in the horned dinosaur *Centrosaurus* through analysis of the closest extant relatives of Dinosauria (Crocodylia and Aves). Results obtained to date suggest that although the method may be successfully applied to modern birds, it fails to distinguish relative age classes in *Alligator mississippiensis*. Controlling for additional factors suspected to affect textural variation—sexual dimorphism, seasonally interrupted growth, and wild versus captive lifestyle—provides little resolution. Indeterminate growth is certainly a factor; however, this alone cannot explain all observed variability. Until the factors affecting bone texture changes in modern crocodilians are better understood, it is recommended that this method be applied only with caution to studies of fossil taxa.

INTRODUCTION

A potentially promising method for assessing relative ontogenetic age of vertebrate fossils may be "periosteal aging" (*sensu* Sampson et al., 1997), which relies on the recognition of a fundamental distinction between immature and mature textures on bone surfaces. Such textural variations are considered macroscopic reflections of differences in the degree of ossification of immature versus mature skeletal material. It should be noted that the terms "immature" and "mature", as used here, designate stages in the development and growth of the skeleton, and do not imply any assumptions regarding reproductive status.

Johnson (1977) reported textural differences in the humerus of immature and mature ichthyosaurs, noting a porous texture on immature bones in contrast to a smooth surface on mature elements. Degree of ossification has also been employed in distinguishing juveniles and subadults from adults among small theropod dinosaurs (Callison and Quimby, 1984) and pelycosaurs (Brinkman, 1988). Bennett (1993) examined ontogeny in the long bones of pterosaurs, and described subadult bone as having a porous texture that was absent in adult specimens. Sampson et al. (1997) and Ryan et al. (2001) noted and defined three textural age classes in ceratopsian dinosaurs: a juvenile texture characterized by fine parallel striations generally oriented in the direction of growth, an adult texture characterized by the absence of the juvenile type, and an intermediate subadult texture comprising a mosaic of striated and non-striated regions. Carr (1999) applied the textural classes of Bennett (1993) and Sampson et al. (1997) to tyrannosaurid theropods.

Rapid bone growth has been hypothesized as the cause of the juvenile textures; adult bone texture is thus attributed to a cessation or at least dramatic slowing of growth (Bennett 1993; Sampson et al., 1997; Ryan et al., 2001). The presence of fine porosity and striations on actively growing immature bone may relate to ossification patterns and incorporation of vasculature into the matrix of growing bone (Enlow and Brown, 1958; Cormack, 1987). A reduction in these textures may therefore be presumed to occur during the aging process as growth rates decrease.

Generalized textural differences similar to those described in fossil vertebrates have been noted occasionally for modern species. Callison and Quimby (1984) examined long bones of immature and mature individuals from six extant bird genera. They noted lineations and surface exposure of spongy bone in immature elements; these became progressively fainter and disappeared as the birds matured. Sanz et al. (1997) noted the presence of clusters of tiny foramina on the bones of a Cretaceous bird nestling, and compared these to similar patterns of grooves and pores caused by incomplete ossification of periosteal bone in modern birds. Johnson (1977) postulated that removal of the periosteum from the actively growing bone of young crocodilians would reveal a pitted surface texture, whereas a smooth surface would be revealed in older animals in which appositional growth had slowed.

The potential for using periosteal aging to provide reliable relative age estimates in fossil taxa seems theoretically reasonable, provided there is sufficient preservation of original bone surface (Tumarkin and Dodson, 1999). A detailed examination of the relationship between texture and skeletal maturity in modern taxa is necessary, however, before the periosteal aging method can be comfortably applied to fossils. This study aims to investigate the relationship between surface texture and bone growth in the American alligator *Alligator mississippiensis*. It forms part of a larger project considering the validity of the periosteal aging method for dinosaurs through examination of modern crocodilians and birds, the nearest living relatives of Dinosauria.

MATERIALS AND METHODS

Osteological collections were surveyed at the Royal Ontario Museum (ROM), Museum of the Rockies (MOR) and Florida Museum of Natural History (UF). The UF collection was further supplemented with a sample of postcranial bones obtained in cooperation with the Florida Game and Freshwater Fish Commission (GFC) during salvage of carcasses on Lake Griffin during spring and summer 2000. The total sample is a diverse collection of individuals of both sexes from multiple populations in Florida, Louisiana, and South Carolina. Effort was made to include only those animals for which sex, lifestyle, and season of death were known. Lifestyle is here classified as wild, captive, or farm. Animals coded as captive were raised under ambient light and temperature conditions in large enclosures allowing for normal mobility. Farm-raised animals were those confined in tanks under controlled temperature and light conditions. Wild crocodilians living in environments with seasonal temperature fluctuations undergo periods of slowed or arrested growth during the winter season of lower temperatures and lower food availability (Peabody, 1961; Enlow, 1969; Neill, 1971; Chabreck and Joanen, 1979; Andrews, 1982; Castanet et al., 1993). For American *Alligator*, this period may vary somewhat throughout the species' range but generally lasts from October or November through March (Neill, 1971; Chabreck and Joanen, 1979; Wilkinson and Rhodes, 1997; J.P. Ross; Pers. Comm. 2000). For purposes of this study, animals were classified as having died during one of three seasons: an inactive season of November through March, an active season of May through September, and a transitional season of April and October. The transitional class was created as an attempt to account for geographical and possible yearly variation in duration of the inactive season.

All captive and farm-raised animals died within the active season. Accordingly, no adjustment was needed to reflect the fact that these individuals may have experienced more constant growing conditions than their wild counterparts.

Bone surface textures on femora, tibiae and humeri were documented through a combination of detailed description, sketches and photography. Preference was given to right side elements; left elements were used in cases where the right was missing, damaged *post mortem*, or pathologic. A texture scale, ordered based on decreasing surface porosity and independent of specimen age and size, was developed for each limb element. Within this spectrum, a texture code was then assigned to each individual bone.

Two independent methods were used to estimate relative age and skeletal maturity of individuals. The first used femur length (measured from the most proximal point on the femoral head to the distalmost point on the lateral condyle) as a proxy for overall size of the individual, following studies by Dodson (1975) and Farlow (unpublished data, Pers. Comm., 2002). Relative body size was then employed as an estimate of relative age and skeletal maturity. Estimates of relative ages based on total body length may be unreliable for *Alligator*, however, due to potential variation in size and/or growth rates between sexes and among habitats and geographical regions (McIllheny, 1935; Peabody, 1961; Bellairs, 1970; Neill, 1971; Andrews, 1982; Jacobsen and Kushlan, 1989; Magnussen et al., 1989; Castanet et al., 1993; Woodward et al., 1995; Dalrymple, 1996; Wilkinson and Rhodes, 1997). Sex and geographical region were known for the majority of the study sample; variation due to other factors could not be controlled for in the collections examined. A second, size-independent, method for relative age estimation was therefore attempted.

The method used here is a modified version of that designed by Brochu (1996) to determine ontogenetic transformation series for *Alligator* appendicular bones. Character matrices were constructed based on presence/absence data for muscle scars and other bony landmarks present in the largest and presumably oldest animals. The characters employed here are identical to those outlined by Brochu (1996). These ontogenetic matrices were treated in an analogous fashion to phylogenetic matrices and were subjected to a parsimony analysis using the branch and bound algorithm of PAUP, version 4.0b10 (Swofford, 1999). The outgroup was a hypothetical embryonic stage coded as a form lacking all bony landmarks considered. In cases where more than one most parsimonious tree was obtained, a strict consensus tree was generated to identify those nodes present in all trees. Only the character changes associated with the consistent nodes were treated as representing discrete ontogenetic stages. Characters undergoing reversals and homoplastic characters with variable occurrences were discarded as unreliable indicators. The remaining characters are those that consistently appeared in a predictable order during ontogeny. Based on this transformation series, the ontogenetic status of any given element from a particular skeleton could be expressed as a percentage of the total number of stages through which that element must pass before attaining full maturity. This value, here termed "percent maturity", corresponds to the "transformed stage" of Brochu (1996).

Bone texture codes were then correlated with both femur lengths and percent maturity values to assess whether a recognizable pattern of textural changes occurs during *Alligator* ontogeny.

RESULTS AND DISCUSSION

Although identical analyses were performed for the femur, tibia, and humerus, only results for the femur are reported here. Preliminary examination of data for the tibia and humerus suggests similar results.

Texture Codes

Twelve distinct combinations of surface textures were recorded from the femora examined. These may be grouped into seven major types. It should be noted that in all individuals, certain regions consistently retained a coarser texture than surrounding surfaces. The fourth trochanter and surrounding attachments of *m. coccygeofemoralis longus* and *brevis* are rugose (Romer, 1923; Dodson, 1975; Brochu, 1996), marked by large open pits and pores. The proximal dorsal surface bears an area of strong fibrous texture and parallel ridges and furrows (proximal dorsal tuberosity of Brochu, 1996). Similar rugose ridges are found on the medial and lateral sides of the distal condyle. The proximal ventral surface also tends to have a radiating fibrous and porous texture. These sites are hereafter collectively referred to as regions of persistent coarse texture. Additionally, the longitudinal ridges for attachment of the adductor musculature and *m. iliofemoralis* (Romer, 1923; Brochu, 1996) often preserve distinct porosity when surrounding regions are smoother.

Textural patterns for Alligator femora are described below. Roman numerals denote the seven major texture types. Numbers in parentheses indicate numerical values assigned to each major type and its subtypes for purposes of graphing the textural spectrum.

Type I. This type is characterized by the presence of a "fuzzy fibrous" texture covering nearly the entire bone. The surface lacks distinct pores, but is markedly grainy and generally rough to the touch. (1)

Type II. This type is characterized by the presence of "etched porosity", a condition in which visible pores penetrate the bone surface at variable angles and are often connected via shallow surface grooves. This results in a disorganized, etched appearance midshaft. As the proximal and distal ends are approached, porosity may become more organized, with pores piercing the surface on an angle to form fibrous or striated regions radiating toward the bone ends. Type II bones are divided into two subtypes: one in which the porous texture extends over the entire shaft (2), and one in which porosity fades out to smooth areas proximally and distally (2.5).

Type III. This type is characterized by the co-occurrence of etched porosity and "dotted porosity", a more organized porous condition in which pores penetrate the bone surface at roughly right angles to the shaft. With no discernable pattern, the two types of porosity either occur independently on distinct areas of the bone, or overprint each other in the same region. As with Type II bones, the angle of the pores may change along the shaft to create radiating fibrous or striated regions proximally and distally. Type III bones are divided into three subtypes: one in which porosity covered the entire shaft (3), one in which porosity fades out into smooth areas proximally and distally (3.33), and one in which porous texture shares the midshaft region with seemingly randomly placed large smooth areas (3.67).

Type IV. This type is characterized by the presence of dotted porosity in the absence of etched porosity. As with Types II and III, radiating fibrous and/or striated areas may occur proximally and distally. Three subtypes occur (4, 4.33, 4.67); these are defined by the same relative distributions of porous and smooth areas as the subtypes for Type III.

Type V. This type is characterized by a grossly smooth surface texture, except in the regions of persistent coarse texture described above. Faint shallow dimples may be visible in some areas, but these are not associated with pores that penetrate the bone surface (5).

Type VI. This type is shows a "muting" of coarse textures in the persistently coarse areas. Ridges and furrows are still present in these areas, but are not as well defined as in previous textural types, and are generally not associated with penetrating pores. The rest of the shaft shows a dotted porous texture, but with the pores more widely scattered than in the dotted textures of types III and IV (6).

Type VII. This type occupies the least porous point on the texture spectrum, combining the smoothest features of types V and VI. This type is characterized by co-occurrence of a grossly smooth or faintly dimpled shaft with muting of textures and loss of porosity in the persistently coarse regions.

Estimates of Skeletal Maturity

Use of Brochu's (1996) method and characters to determine percent skeletal maturity yields a transformation series of five stages (Table 1). Stage 1 is equivalent to a hypothetical embryonic or moment-of-hatching stage lacking all scored characters and is therefore assigned a percent maturity value of zero. Thus stages two through five equate to percentages 25, 50, 75, and 100, respectively.

Table 1. Transformation series of ontogenetic stages resulting from parsimony-based character analysis after Brochu (1996).

Stage	Defining Characteristics	Percent Maturity
1	Absence of defining characteristics of Stages 2-5	0
2	Appearance of medial scar for *m. puboischiofemoralis internus, pars dorsalis* Absence of defining characteristics of Stages 3-5	25
3	Appearance of lateral scar for *m. puboischiofemoralis internus, pars dorsalis* Absence of defining characteristics of Stages 4-5	50
4	Appearance of proximal condylar fold Appearance of rugosity on medial and lateral sides of distal condyle Appearance of longitudinal scars for *m. iliofemoralis* Absence of defining characteristics of Stage 5	75
5	Appearance of lipping of finished condylar bone over shaft	100

Unfortunately, the method shows itself to be not particularly useful for analysis of this sample, as only six of thirteen scored characters are informative, and these are all acquired very early in ontogeny. With two exceptions, all femora with a length greater than 33 mm are scored at stage five, or 100 percent mature (Fig. 1). The presence in Fig. 1 of two larger femora scored at stage 4 is misleading. The ends of these bones were eroded *post mortem* such that the presence or absence of the character diagnostic of stage five (lipping of finished condylar bone over shaft) could not be evaluated. They were therefore scored at stage 4 as the last stage to which they could be definitively assigned. Distribution of the rest of the sample, however, suggests that these individuals should more rightly be scored as Stage 5. Although it is of some interest that a repeatable sequence of character acquisition is confined to early ontogeny, it is not helpful for ontogenetic interpretation of surface textures, since 94.5 percent of the sample, comprising animals of a large range of body size and textural variation, falls within the "100 percent maturity" range.

Correlation of Texture and Size / Skeletal Maturity

The size-based analysis of the total sample (Fig. 2a) reveals several notable points. Texture types I and II appear restricted to small animals of femur length less than 70 mm. Animals of the largest size classes (femur length greater than 240 mm) appear restricted to texture types IV through VII; this corresponds to a complete absence of the fuzzy fibrous and etched porous textures. Types III and IV may represent successive stages, with the co-occurrence of etched and dotted porosity (Type III) eventually giving way to dotted porosity alone (Type IV), but the amount of overlap between the two fields is considerable. The wide range of sizes over which Types III through VII occur makes them of extremely limited utility for estimating ages of isolated bones. This assumes, of course, a good correlation between size and chronological age, which may not be the case (see below). Unfortunately, the size-independent analysis (Fig. 2b) does little to clarify this picture. As stated above, 94.5 percent of the entire sample falls into maturity code five, masking most of the variations visible in the size-based analysis.

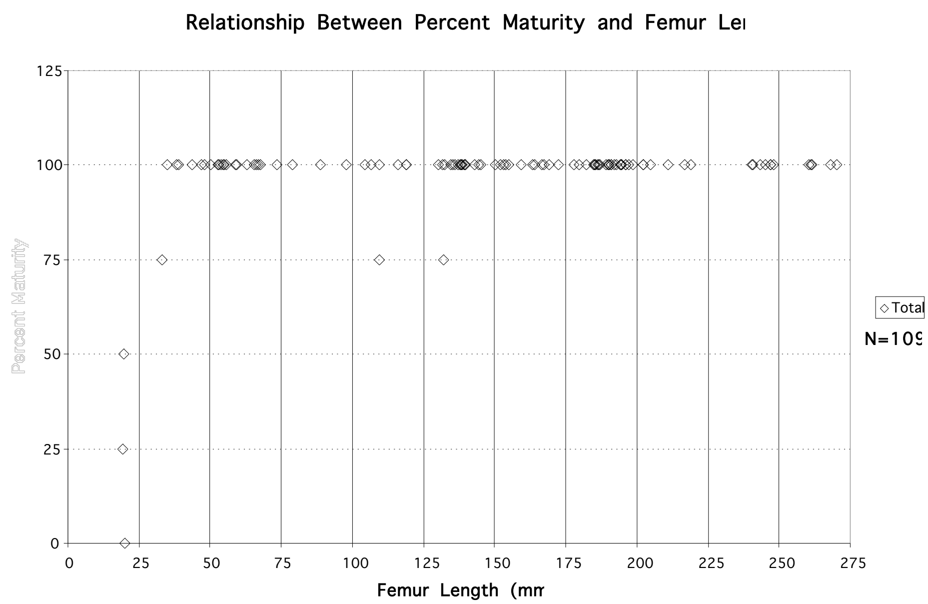

Figure 1. Relationship between femur length and percent skeletal maturity of femur as determined by parsimony-based methods.

As stated above, a number of factors may contribute to growth variation in *Alligator*, and thus the decoupling of size and chronological age. These may include sexual dimorphism; seasonally interrupted growth; environmental conditions of habitat, diet, and temperature; and indeterminate growth (McIllheny, 1935; Peabody, 1961; Bellairs, 1970; Neill, 1971; Andrews, 1982; Jacobsen and Kushlan, 1989; Magnussen et al., 1989; Castanet et al., 1993; Woodward et al., 1995; Dalrymple, 1996; Wilkinson and Rhodes, 1997; Elsey et al., 2000; Lance et al., 2000). To the extent possible, effort was made to control for these variables within size-based analyses of the study sample.

Sexual Dimorphism

Previous studies of American Alligator have reported larger adult sizes for males relative to females, as well as sexual dimorphism in growth rates (e.g. McIllheny, 1935; Bellairs, 1970; Neill, 1971; Chabreck and Joanen, 1979; Magnussen et al., 1989; Woodward et al., 1995; Wilkinson and Rhodes, 1997), such that average growth rate in females decreases relative to that of males after a certain point in ontogeny. Chabreck and Joanen (1979) report that in wild individuals from Louisiana, growth rates in both sexes are similar until roughly three years of age. Although growth in both sexes gradually begins to decrease after the first year post-hatching, after age three this decline is more pronounced in females. Sexually dimorphic growth rates may confound a size-based analysis of textural trends, due to the potential for lumping younger faster growing males with older more slowly growing females in the same size range.

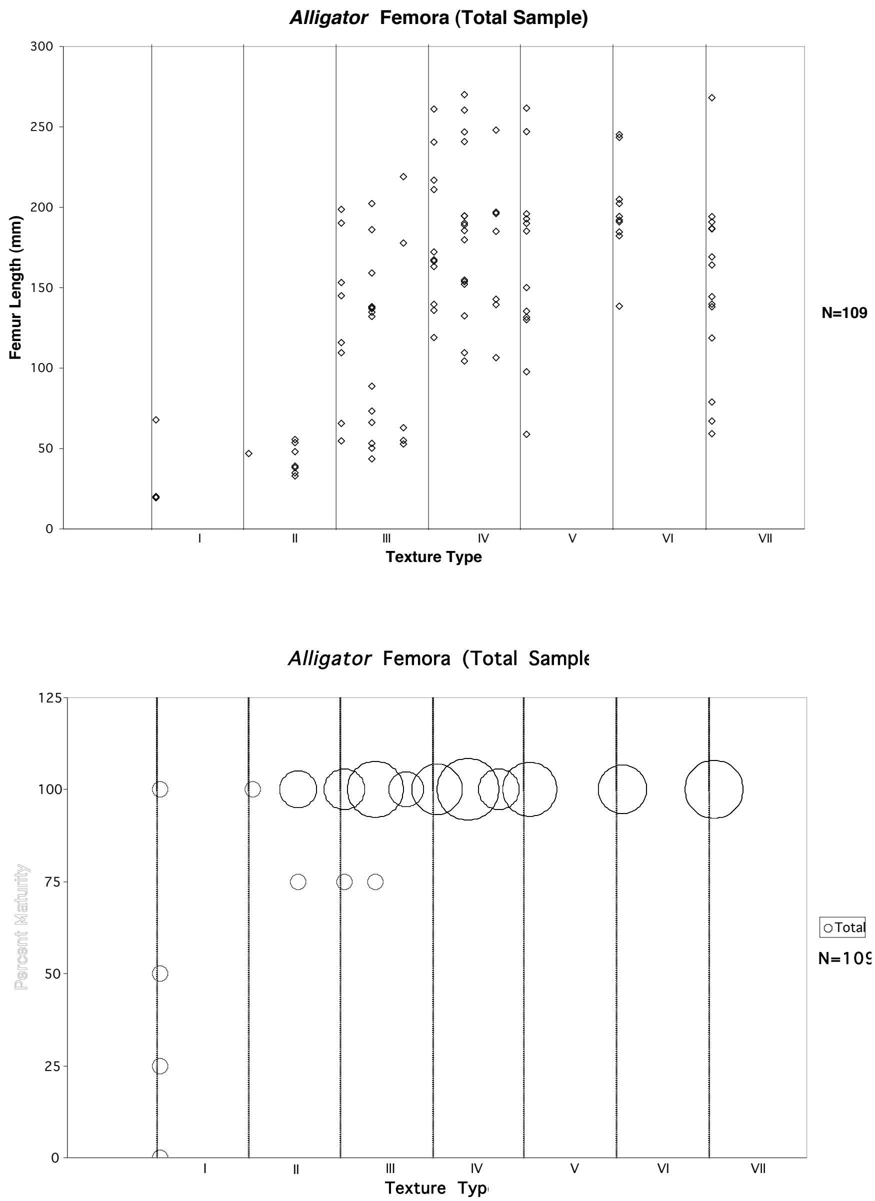

Figure 2. Relationship between textural types and femur length (A) and parsimony-based percent femoral maturity (B). Areas of circles in graph B represent the number of individuals plotting at each location.

Restricting the size-based analysis to individuals of known sex (Fig. 3), however, does little to reduce the high variability of texture type distributions. Examination of Figure 3 does little more than confirm that males of *Alligator* reach a larger adult size than females. Texture types III through VII still occupy wide overlapping size ranges in both sexes. The distinction between types III and IV may be more clearly defined when only males are considered; this however may also purely reflect sample composition.

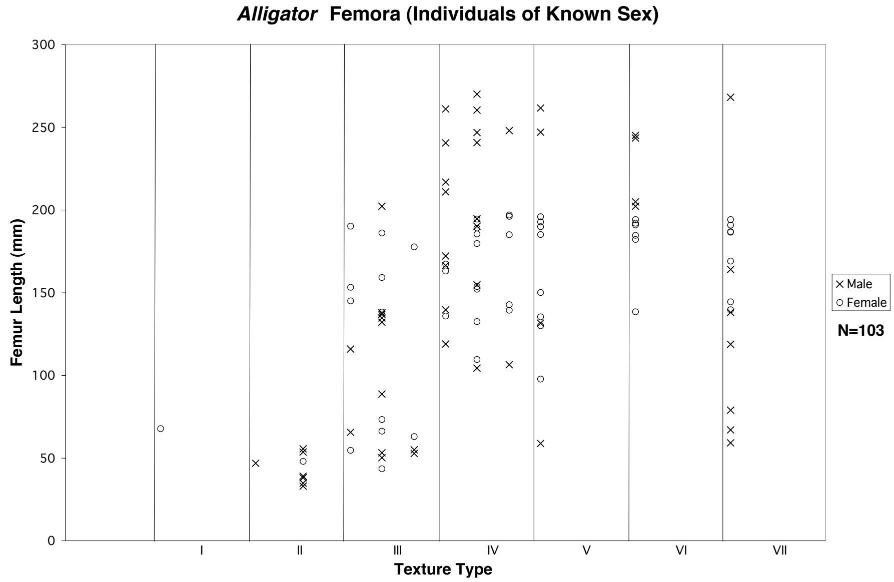

Figure 3. Effect of sexual dimorphism on relationship between textural types and femur length.

Interrupted Growth

In the bone of wild crocodilians, seasonal variations in growth rate are visible histologically as zones and annuli and/or lines of arrested growth (LAGs). Zones are vascularized regions deposited during seasons of active growth. Annuli comprise thinner sparsely vascularized or avascular lamellae deposited during periods when growth has slowed. LAGs, as their name implies, are rest lines formed during a hiatus in growth (Enlow and Brown, 1957; Peabody, 1961; Enlow, 1969; Ricqlès, 1974, 1976; Buffrenil, 1980; Castanet et al., 1993; Castanet, 1994). These histological features have also been documented in captive crocodilians living under more-or-less constant conditions, although they may not be as pronounced as in wild individuals (e.g. Buffrenil, 1980). Since the immature textural types described in previous studies are associated with active osteological growth processes, it might be surmised that an individual dying during a period of slowed or arrested growth would not exhibit these textural features, regardless of overall skeletal maturity (Tumarkin and Dodson, 2000, 2001).

Surprisingly, factoring season of death into the analysis (Fig. 4) lends no additional resolution to the data set. One might argue that this reflects the fact that individuals dying during the transitional and inactive seasons comprise a limited portion of the total sample (4.6 and 5.5 percent, respectively). It is notable, however, that the 89.9 percent of individuals dying during the active season occupy the full range of textural variation seen in the total sample.

Lifestyle and Geographical Range

Individuals of *Alligator* raised in captivity under optimum conditions of temperature, nutrition, etc. have shown the potential for higher sustained growth rates than wild individuals (e.g. Buffrenil, 1980; Elsey et al., 2000). It is also possible for captive animals to experience retarded growth rates relative to their wild counterparts if nutritional and temperature requirements are not met, or as a result of other stresses such as crowding (e.g. Lance et al., 2000). It is therefore a reasonable hypothesis that captive or farm-raised animals may show a different distribution of texture types than wild individuals.

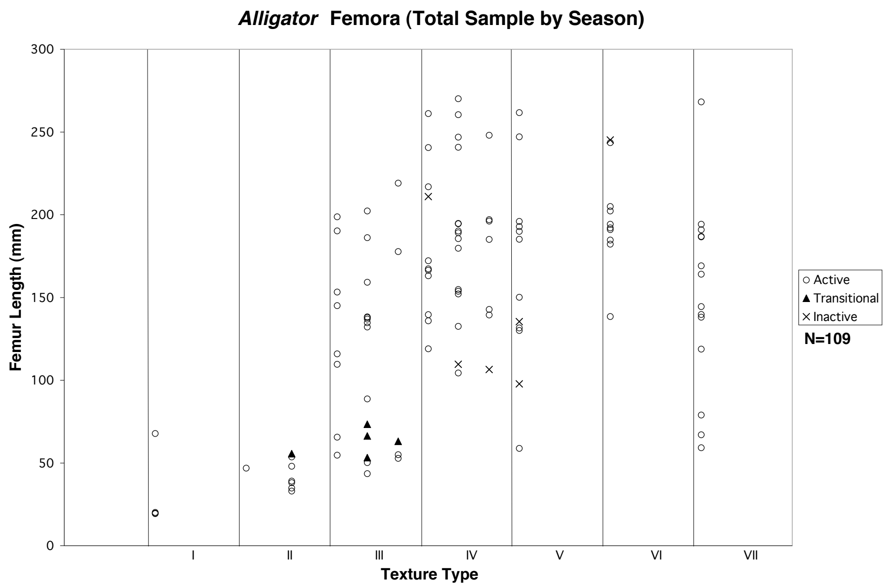

Figure 4. Effect of season of death on relationship between textural types and femur length. Active=May through September; Transitional=April and October; Inactive=March though November.

As with the considerations of sexual dimorphism and season of death, however, this hypothesis is not supported by the data (Fig. 5). Although captive individuals account for the largest individuals of both sexes in the study sample (compare Figs. 3 and 5), the distribution of texture types is similar to that in the smaller wild individuals. Thus, removal of the captive animals from the sample would do little to reduce variability of texture with respect to size. Farm-raised individuals all exhibit texture Types III and IV; however, this distribution is consistent with that of wild and captive individuals of similar size.

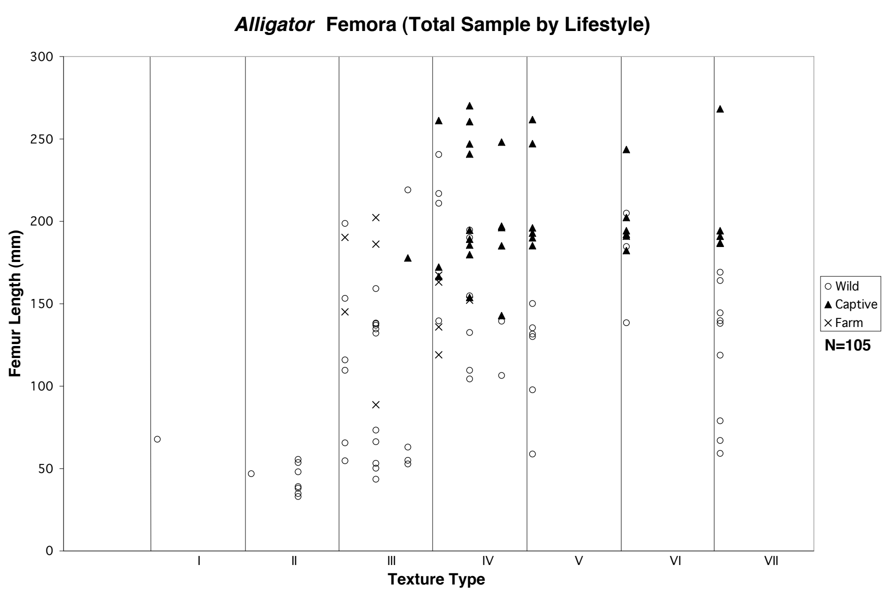

Figure 5. Effect of lifestyle on relationship between textural types and femur length. See text for distinction between captive and farm-raised individuals.

Previous studies of *Alligator* growth have concluded that growth rates vary throughout the species' geographical range due to local environmental conditions and resource availability (Jacobsen and Kushlan, 1989; Dalrymple, 1996; Wilkenson and Rhodes, 1997). It may therefore be fruitless to employ size as an age proxy for a sample drawn from diverse geographical areas. Geographical variation in growth rates, combined with sexual dimorphism, may account for some of the variability observed in the femur length versus texture plots. The study sample examined here included individuals from Florida, Louisiana, and South Carolina. The South Carolina sub-sample included only three individuals, all hatchlings, and was excluded from the geographical analysis. Separate analysis of wild Louisiana individuals (N=21) yields a distribution comparable to that obtained in the total sample analyses. The plot of wild individuals from Florida, however, yields a potentially interesting result (Fig. 6). Although distribution of textural types among males remains variable, there does appear to be a trend among females for a decrease in surface porosity with an increase in body size. It may be that an earlier and greater slowing of growth in female individuals is responsible for the presence of a pattern in this sex which is absent among the males, although with such a small female sample size (N=13) the pattern may also be sampling artifact.

Indeterminate Growth

Although growth in *Alligator* is often described as indeterminate, this does not mean that an individual alligator continues growing at a constant rate throughout life. As noted above, growth rates in females decrease relative to those in males. Growth rates also appear to eventually decrease further in both sexes, becoming nearly asymptotic after total lengths of 2.5 to 3.5 meters are attained in females and males, respectively (Woodward et al., 1995; Wilkinson and Rhodes, 1997). One might expect that a prolonged period of growth may cause so-called immature porous textures to be highly persistent throughout ontogeny (Tumarkin and Dodson, 2000). Although this may explain the occurrence of relatively porous texture types such as Type III in larger individuals, it does little to account for the reverse phenomenon, that is, the persistent occurrence of low porosity texture types such as Types V through VII in smaller individuals.

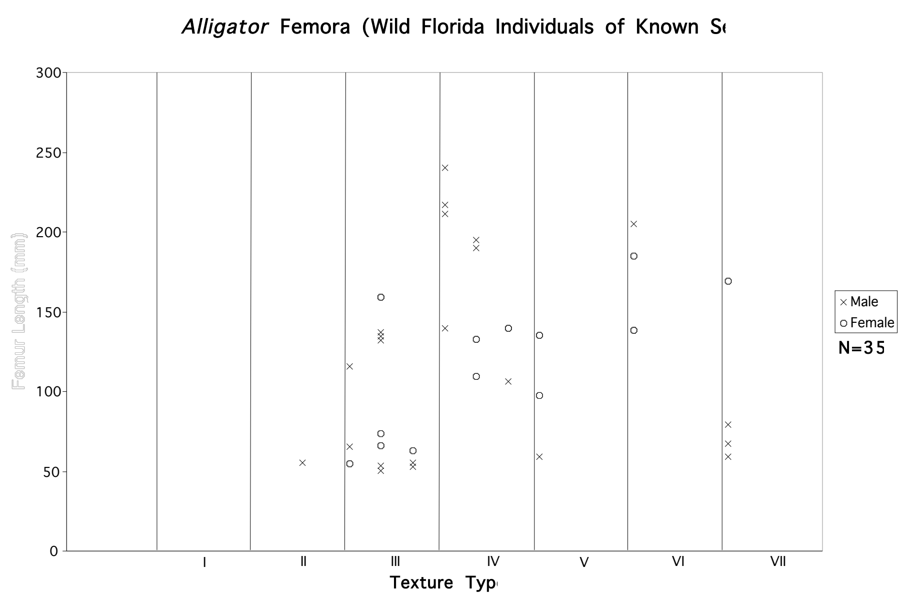

Figure 6. Effect of sexual dimorphism on relationship between textural types and femur length for wild individuals from the Florida subset of the total sample.

SUMMARY AND CONCLUSIONS

The data presented here suggest that the association between bone texture and skeletal maturity in *Alligator* is highly variable, even when sex, season of death, and habitat conditions are taken into account. It should here be noted that a companion study on the Canada goose *Branta canadensis* using identical methodology revealed an excellent correlation between textural types and age based on element size and date of death. In *Branta*, juveniles, subadults, and adults were clearly identifiable by distinct suites of textures with little to no overlap between groups. The growth regime of *Branta* individuals, which experience determinate growth and reach full adult size within one growing season, is, of course, in strong contrast to that of *Alligator*. The success of the

Branta analysis, the results of which will be reported elsewhere, strongly suggests that growth regime may be an important controlling factor in determining the reliability of the periosteal aging method.

Controlling for several sources of growth variation in *Alligator* (i.e. sexual dimorphism, season of death, lifestyle, and geographical range) does little to resolve the extreme variability in the *Alligator* sample. Indeterminate growth alone fails to account for all observed variation, particularly the repeated occurrence of low porosity textures in individuals of smaller size classes. It may be that a high sensitivity to local and regional environmental conditions, coupled with long periods of time to reach full adult size, renders growth in Alligator too variable to successfully apply the periosteal aging method at the species level.

Regardless of the specific controlling factors, the high degree of variation suggests that bone surface textures should not be relied upon as universal indicators of skeletal maturity, at least not in taxa with growth regimes resembling that of the American alligator. Until such time as the controlling factors are better understood, the application of the periosteal aging method for the aging of fossil specimens, especially those for which growth regime is unknown, is not recommended.

ACKNOWLEDGEMENTS

The following individuals and institutions generously granted access to study osteological material under their care: F. Wayne King, J. Perran Ross, and Kenneth Krysko (UF); Hans-Dieter Sues and Kevin Seymour (ROM); Cynthia Marshall (MOR). J. Perran Ross supervised salvage of Lake Griffin animals under the auspices of FWC and Special Use permit WXO1261; Allan Woodward granted use of GFC facilities for initial processing of salvaged material. James Farlow initially invited access to the MOR sample and provided access to unpublished body-size data for those animals. Ruth Elsey, Grant Hurlburt, and Diane Borden-Billiot provided locality and habitat data for many individuals from the MOR and UF samples. Chris Brochu provided access to unpublished supplemental data for the parsimony analysis. Chris Brochu, Tom Carr, Peter Dodson, Barbara Grandstaff, and Matthew Lamanna provided much stimulating and informative discussion. Portions of this research were supported by The Jurassic Foundation, The Paleontological Society, Sigma Xi, University of Pennsylvania Paleobiology Stipends, a National Science Foundation Graduate Research Fellowship, and National Science Foundation Grant EAR 95-06694 to Peter Dodson.

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Shunting in Alligators – Does it Make a Difference?

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ABSTRACT: Unlike other reptiles, crocodilians have a completely divided heart but have retained the ability to shunt right ventricular blood to the body via the left aorta (LAo). The LAo continues posteriorly and supplies the digestive system with right ventricular blood during shunting. This study focuses on the functional significance of shunting right ventricular blood to the digestive system in *Alligator mississippiensis*. Two groups of alligators were used in this study. One group had their left aorta surgically tied off and cut (LAo cut; unable to shunt) and the second group had sham surgeries performed on them (LAo intact). During fasting, serum glucose levels, blood pH and PCO_2 values and metabolic rates were similar in the two groups of alligators, as were the rates of mass loss. During feeding, growth rates were similar. Respiratory exchange ratios were significantly higher in alligators with their LAo cut. Differences were also seen in blood pH and blood PCO_2 measurements as well as in digestion rates. In conclusion, the ability to shunt right ventricular blood to the gut affects acid-base regulation as well as the digestive state in alligators.

Sexual Maturity in Male American Alligators: What Can Plasma Testosterone Tell Us?

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ABSTRACT: Male American alligators are generally considered to reach sexual maturity at a total body length of about 180 cm. This estimate is based on examination of the reproductive tracts or by checking for the presence of sperm in the penile groove during the breeding season. We initiated this study to see if circulating testosterone levels correlated with presumed size of sexual maturity in male alligators. Blood samples were collected from wild caught alligators at Rockefeller Wildlife Refuge over a two-year period in every month of the year. Following sampling the alligators were marked and released. A total of over 1,300 blood samples was collected from male alligators as small as 60 cm and as large as 380 cm during the study period. The data were arranged, by month and by size classes. To our surprise, all samples had measurable testosterone and all showed a seasonal cycle similar to the cycle of large breeding males. However, there was an enormous difference in peak testosterone values in April and May. Peak values in the smallest size class reached only 0.7 ng/ml, whereas peak values in the largest size class were over 70ng/ml. There was a clear positive association between total length and plasma testosterone and no clear indication of when an animal was capable of breeding.

Reproductive Cycle of the American Crocodile and its Environmental Influences. Preliminary Results

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ABSTRACT: The main objective of this project is to understand how environmental factors affect breeding cycle, analyzing sexual hormones and plasma variables in adult American crocodiles to compare between the wild and captive for the management and conservations of the species. Here we present preliminary results of hormonal levels.

Captures and recaptures from 123 wild and captive American crocodiles of both sexes (1.8 – 4.44 m) were made since January to June of 2002 to bleed every month. Manzanilla" estuary in the coast of Jalisco, and in captivity at Crocodile Reproductive Center at San Blas (CRSB), Nayarit, Mexico. The project covers the reproductive cycle of the species.

Also environmental parameters were recorded. Sexual hormones of both sex were analyzed at the Center for Reproduction of Endangered Species (CRES) in San Diego, CA.

Key words: *C. acutus*, environment, hormones, reproductive cycle, México.

INTRODUCTION

Several attempts still development to understand more about the reproductions of the order crocodilia, in order to apply such information to management and conservation in several species. No studies of hormones exist in the American crocodiles to study breeding cycle, neither studies to understand the influences of the environmental factors in the reproduction of crocodilians concerning with hormones.

The American alligator have been study for many years to understand the breeding cycle analyzing hormones (Lance, 1987). Also some environmental factors of the environment have been correlated with the reproduction of some species but, at global level as *C. intermedius* (Thorbjarnarson and Hernández, 1993b) and one or few factors of the environment have been correlated with the breeding cycle of *C. intermedius* (Thorbjarnarson and Hernández, 1993a).

This time we present preliminary results of plasma steroids hormones in males (testosterone) and females (estradiol) in the American crocodiles during six months (January to June of 2002). More studies will be developed in the short future for stress hormone (testosterone) to correlate with sexual steroids and plasma chemistry will developed, as well, with the goal of understanding how and which of the environmental factors influences reproduction of the species by the hormone analysis and its implications for management and conservation of the species, in captive and in the wild to apply this information for the conservation and management of the species, supported by the information available for the species in our area (Ponce and Huerta, 1997; Huerta et al., in preparation).

MATERIALS AND METHODS

In order to study the relations of the breeding cycle of the American crocodile with the environmental factors during six months (January to June of 2002), covering the breeding cycle of the species, 123 individual were captured and recaptured in the wild and in captive. The sizes, total length (LT) ranges from 1.98 to 4.44 m in the wild and 2.20 to 3.40 m.in captive. Also snout vent length (SVL) were recorded as follows: since the tip of the snout to the rear of the tight, when the tight was at 90 degrees in angle from the body. Every measurement (TL, SVL) was taken always on the dorsal side of each animal, for this reason the measurements would be lightly skewed. This (SVL) measurement coincides with anterior vent measurement, standard in cocodrilians. The sampling site in the wild was La Manzanilla estuary in the municipality of La Huerta, south western in the coast of Jalisco. This crocodile population is considered the second best population of the species in the state (Ponce and Huerta unpublished data). Captive sampling site was at Crocodile Reproductive Center at San Blas (CRSB), in San Blas, municipality of Nayarit.

During every capture stress time was recorded - since acute stress begun to the end of blood extraction - this data were tanked into account since the reports that concentrations of stress hormone (corticosterone) increase during acute stress and also is known that an increase of corticosterone produces a decrease in the secretion of gonadal steroids in reptiles (Elsey *et. al.*, 1991; Lance and Elsey, 1986).

The analysis of the testosterone in males and estradiol in females were made at the endocrinology division laboratory of Center for Reproduction o Endangered Species in San Diego, CA. Using radioimmuno assay technique. 50 microliters of testosterone and 100 microliters of plasma for estradiol were utilized during every assay following the technique of Schramm et al. (1999).

Environmental factors and vent temperature were taken as well, in order to correlate this factors with concentrations of steroids during every month. Using data loggers, light intensity, water and air temperature and humidity were recorded on every sampling locality. Water level and salinity were recorded in the wild every month.

Anova analysis were made to analyze hormonal concentration with computer software Stat Graphics in order to understand if there are some differences in the reproductive cycle between captive and in the wild American crocodiles.

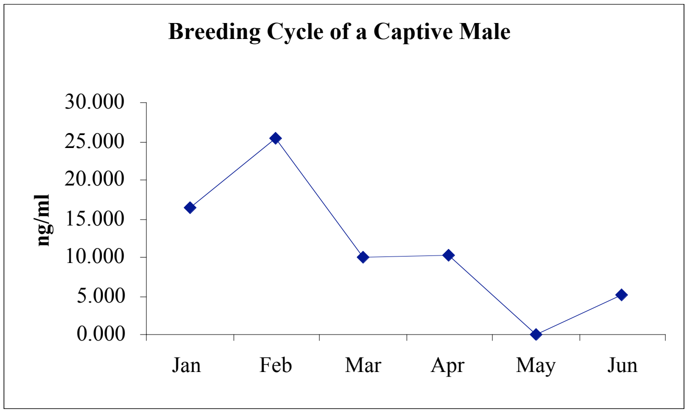
n123 Captures and recaptures
n63 Wild 1.98-4.44m
nMean 3.07m
n61 Captive) Jan-Jun 2002 (1st two weeks)
Mean 2.63; Min 2.20, Max 3.40
nTime of stress
11:36 min W
7:42 min C

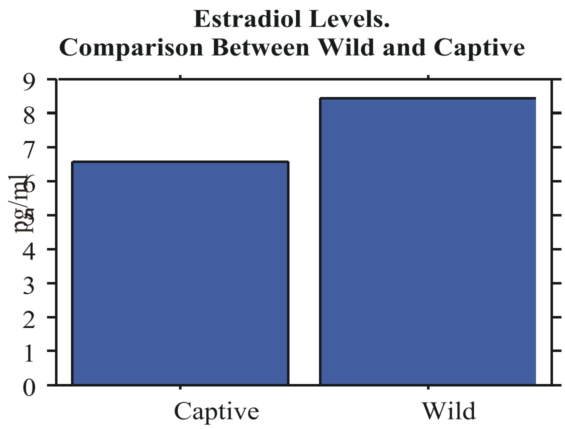
Results and discussion

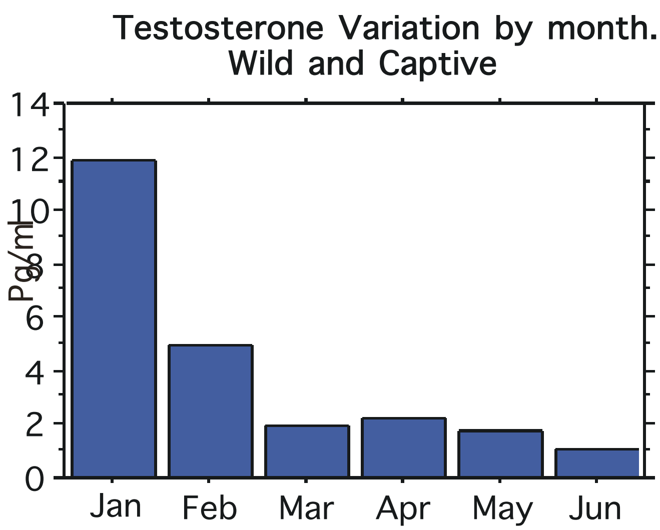
Testosterone levels in wild crocodiles were significant different from those from captive ($P< 0.05$; $F= 5.96$) (Fig. 1), but not differences was recorded in estradiol concentrations (Fig. 2). Estradiol levels were quite low compared with American alligator. Highest testosterone mean value (January) for American crocodiles is 11.82 ng/ml (Fig. 3), lower than reported for American alligator, which mean highest testosterone value rise on April with almost 50 ng/ml. Highest mean value of Estradiol during in January (9.5 pg/ml) in Ameican crocodile (Fig. 4) is quite lower than highest value reported for American alligator, near 600 pg/ml (Lance, 1989).

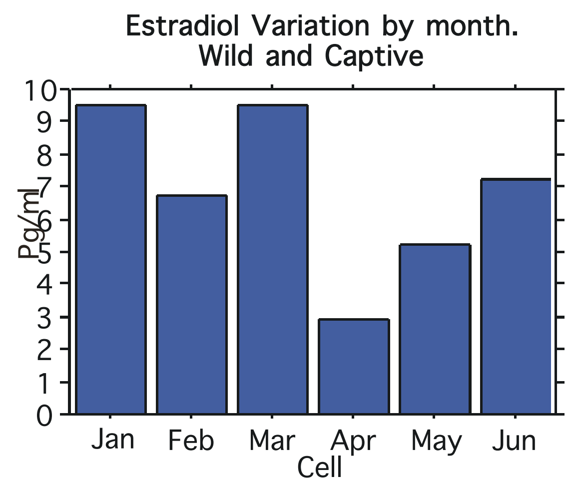
As unexpected higher testosterone level in American crocodiles was in January decreasing in February and falling since March to June with low hormonal levels. Females shows higher estradiol levels from January to March falling on April, showing the beginning of nesting season. Estradiol values begun to rise every month with levels similar to February. Testosterone concentrations suggest breeding at February but estradiol suggest in March. Last coincides with the observations of Lance (1989) who suggest that mating time is two or three weeks before nesting in American alligator. There is some differences observed in the nesting season. In captive, nesting season begun during early April and in the wild late April. Mating time in captive is observed, with monthly hormonal values in one male during six months (Fig,.5) but , monthly hormonal levels in captive females is not representative (data not shown). This information suggest that mating season in captive is during late February to March and nesting time since early/until late April. With the observed nesting in the wild and captive and mating time in the wild, peak matting time in the wild is during March.

Testosterone differences between captive and wild crocodiles, could be due to stress, because dominant males push to the submitted animals out of the pen most of the time and during breeding season aggression are common from alpha males to submitted animals. Something similar was observed in nesting females.









ACKNOWLEDGMENTS

Thanks to SEMARNAT Nayarit to MVZ. Jesús Romero Villaruel, Carlos Villar, Razo e Ivanisack. INIFAB El Verdineño, Nayarit; Lab. De Sanidad Animal Nayarit, Centro Reproductor de Cocodrilos “La Palma” San Blas, Nayarit. In Jalisco to Dr. Manuel García Ulloa Labortatorio de Ciencias Marinas at Barra de Navidad, Universidad Autónoma de Guadalajara; Dr. Mario Valencia, MVZ Ernesto Ron and Luis Meléndezat Unión Ganadera Regional de Jalisco; in La Manzanilla, Ivan García y Familia, Eugenio Chaurand, Carmen Gallo, Francisco Pérez Méndoza, Prof. Rubén Figueroa and all local friends in La Manzanilla. To Huerta-Ortega, Ponce-Campos and Lance family, all CRES staff. Special thanks to Dr. John Thorbjarnarson and Dr. Perran Ross. **Project supported by**: Idea Wild, Conservation and Research Foundation, CRES, San Diego, CA, Huerta y Cia and Bosque Tropical.

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Stress Responses to Noosing and Restraint versus Capture by Electrical Stunning in Captive *Crocodylus porosus*

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ABSTRACT: The aim of this study was to compare and evaluate the stress responses and welfare of captive estuarine crocodiles, *Crocodylus porosus* to electrical stunning, as opposed to the traditional capture and restraint methods of noosing and roping animals. Electrical stunning equipment recently developed and built by the Department of Primary Industries in Australia was used to stun 2-2.4 m crocodiles. A 110 V charge was delivered for 4-6 seconds via a set of metal forks applied to the back of the animal's neck. Crocodiles were rapidly immobilized during stunning, which was followed by 5-10s of rigor and tail twitching after which the animals were completely relaxed with legs splayed backwards, parallel to the body. Crocodiles remained incapacitated for 5-10 minutes, allowing animals to be handled and measured. Blood samples were taken from stunned and noosed animals immediately upon immobilization or capture and after 30 min, 1, 4, 12, 24 and 48 hours of recovery. Blood was taken from the cervical sinus in heparinised syringes, and haematocrit and haemoglobin concentrations measured. Plasma samples were analysed for corticosterone, glucose and lactate levels. The stress response of stunned animals was significantly reduced compared to manually captured crocodiles. Time course of changes in the various blood parameters will be presented.

Ultrasonography of Reproductive Structures and Hormonal Correlates in the American Alligator, *Alligator mississippiensis*: Application to Population Studies

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ABSTRACT: Ultrasonography has been used effectively to study reproduction in a variety of reptile species however its application to crocodilians has been relatively limited. In this study we present results from a pilot study testing the efficacy of using ultrasonography to monitor reproduction in the American Alligator, *Alligator mississippiensis*. Ultrasound results were then compared with hormone results. A total of 65 females were examined by ultrasonography during April, May and June. Ultrasound results were validated on a series of reproductive females (n=14) necropsied for other studies. Vitellogenic follicles, recently ovulated eggs, fully developed well calcified eggs and atretic follicles were readily discernible with ultrasound in reproductively active females. Reproductive structures were observed in 27 females of which 20 were actively reproductive while 7 were non-reproductive containing large atretic follicles. Oviducts were discernible in females with eggs. Ovarian state was also correlated with hormone levels. Ultrasonography can be used to acurately assess reproduction in wild populations and provide data to estimate the number of reproducing females in a given year.

Bite-Force Performance in Crocodilians: A Feasibility Study on the American Alligator, *Alligator mississippiensis*

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ABSTRACT: Ecomorphology is an integrative discipline that focuses on understanding the relationships among the morphology, ecology, and behavior of organisms. Its primary precept is the incorporation of whole-animal performance measures (e.g., bite force, sprint speed) into studies that attempt to relate morphology to ecology and behavior (Arnold, 1983). All crocodilians undergo considerable growth coupled with complex ontogenetic morphological changes of the trophic apparatus. At the same time major dietary shifts occur. How morphological changes are related to dietary shifts requires an understanding of the biomechanics of the system (e.g., bite-force performance, mechanical relationships, dental material properties). We conducted a feasibility study to measure bite-force performance in a large crocodilian throughout ontogeny. Using a series of precision force transducers, we made measurements of bite force on 41 captive *Alligator mississippiensis* individuals ranging from hatchlings to large adults. This shows that quantification of bite-force performance in these large reptiles is feasible. How bite-force performance scales with respect to measurements of body size was determined for these individuals. Also, bite force throughout development was examined in light of ontogenetic changes in trophic ecology. The results show a 800-fold range (12–9452 N) in bite force. Bite force through ontogeny showed positive allometry with respect to body size. The overall pattern of allometric bite force increase throughout ontogeny did not correlate discreetly with major dietary shifts.

INTRODUCTION

Ecomorphology is an integrative discipline that has emerged from the desire to understand how morphological variation causes, shapes, influences, or affects variation in the ecology and behavior of organisms. Its principal tenet, delineated by Arnold (1983), is the incorporation of whole-animal performance measures (e.g., bite force, sprint speed) into studies that attempt to relate morphology to ecology and behavior. A measure of whole-animal performance should be chosen based on its promise to provide clues as to how morphological variation of the focal system may impose constraints onto an ecological or behavioral parameter. Alternatively, there should be an indication that the selected whole-animal performance measure provides a means to broaden the scope of opportunities in an ecological or behavioral sense. In addition, the performance measure should be tractable. It must be readily measurable, repeatable, and amenable to comparison among species.

Bite-force performance is a whole-animal performance measure that can potentially provide insight into the feeding biology of a variety of taxa. Bite force contributes to limiting or expanding the potential to include certain prey items in the diet. Among crocodilians, the American alligator, *Alligator mississippiensis*, provides an excellent system for an intraspecific ecomorphological investigation of the ontogeny of feeding biology for several reasons. First, *A. mississippiensis* spans a considerable size range from hatchlings to adults. At birth alligators weigh about 0.065 kg but can reach 275+ kg late in adulthood (Woodward *et al*., 1995). Second, during this remarkable 4000-fold increase in mass, the trophic apparatus exhibits notable changes in shape. For example, the short and broad snouts of hatchlings elongate and become relatively more slender (Dodson, 1975). Also, the caniniform teeth of hatchlings progress from a delicate and sharp morphology to a blunt and robust form in adulthood. Similarly, the distal teeth (i.e., those toward the back of the jaws), which are initially sharp-edged and blade-like, become bulbous and molariform (Edmund, 1962). Third, the diet of the *A. mississippiensis* undergoes substantial change during ontogeny (Dodson, 1975). The dietary ontogeny of *A. mississippiensis* shows that, as alligators grow, they include prey in their diet with increasingly hard and rigid elements (e.g., integument, bones). Finally, as we demonstrate in the present study, measurement of bite-force performance in *A. mississippiensis* is feasible and can be used to make ties to the feeding biology of this species.

Although many studies have documented the diets and functional morphology of crocodilians, virtually no empirical data have been garnered on the actual biomechanical performance of the jaws and associated musculature (e.g., bite force) and teeth (e.g., sharpness, pressure generation). These measures provide the essential ties between these data sets and are critical to gaining a comprehensive understanding of how the phenotype of these animals relates to their realized ecological niche. Despite the inherent difficulties of working with large carnivorous reptiles, a few pioneering attempts to assess bite force in crocodilians have occurred. Sinclair and Alexander (1987) included a sub-adult (1 m TL) caiman (*Caiman crocodilus*) in their analysis of reptilian bite force. Following their lead, Vliet (cited as a personal communication in Erickson *et al*., 1996) tested a prototype mechanical bite bar on a large adult *A. mississippiensis*. Although a potential design flaw precluded ultimate implementation of the device, the test showed that powerful snapping bites could be elicited from adults of the species.

Building upon the results of these efforts, we recorded bite-force performance throughout ontogeny in a complete growth series of *A. mississippiensis* using a series of precision electronic bite-force transducers. Post-testing measurements of snout-vent length and body mass then were made on each specimen to examine the relationship between bite-force performance and growth.

MATERIALS AND METHODS

Specimens

To quantify the ontogeny of bite-force performance in *A. mississippiensis* and explore its relationships to growth and dietary ontogeny, we procured 53 animals ranging from hatchlings (0.30 m TL) to large adults (3.7 m TL). Of these, 41 produced useable performance measures (see below). Alligators were made available for testing in large numbers through the St. Augustine Alligator Farm and Zoological Park in St. Augustine, Florida, U.S.A. The majority of the animals in this facility were hatched from wild-collected eggs, although there are a few large long-term captive nuisance animals that were collected as adults from the wild.

Force Transducers

Quantifying the ontogeny of bite-force performance in *A. mississippiensis* required the ability to measure animals ranging from small hatchlings to very large adults. In making comparisons among animals differing so greatly in size, it was necessary to insure that all animals produced kinematically comparable bites that could be measured with precision. To meet these requirements, we used three different bite-force transducers (small, medium, large). A small transducer was employed in the testing of specimens < 90 cm TL (< 2 kg). The medium and large transducers were used to measure the bite forces of alligators ranging from 90-200 cm TL (2-50 kg) and > 200 cm TL (> 50 kg), respectively. Bite forces were tested at a homologous location in the jaws among all specimens and to within a few degrees of complete jaw closure.

The basic design of the small transducer is a double-cantilever beam made of stainless steel plates to superficially resemble a tuning fork (see Dechow and Carlson, 1983). Uniaxial foil strain gauges were mounted on the top and bottom surface of each beam (TML Tokyo Sokki Kendyujo Co., Ltd., Tokyo, Japan, FLA-3-11-3L) and wired in a full-bridge configuration such that the voltage output was proportional to the compressive force applied to the beams during biting (Fig. 1). Analog signals from the small transducer were amplified (National Instruments Inc., Austin, TX, SCXI Strain Isolation Amplifier), converted to a digital form (National Instruments Inc., PCMCIA-card), and acquired on a laptop computer (Apple Computer, Cupertino, CA; Macintosh G3 Powerbook) at a sampling rate of 1000 Hz using a customized virtual instrument run in LabVIEW 5.1 (National Instruments Inc.).

The small transducer was calibrated by hanging a series of weights from the end of each beam. The mass of each weight and the voltage output for it was recorded and plotted. The transducer produced a nearly perfect linear relationship, and the slope of this line was calculated for each beam. The slope coefficients were used to calculate the calibration factor ([coefficient beam 1][coefficient beam 2] / [coefficient beam 1 + coefficient beam 2]) to convert raw bite-force data into Newtons. The transducer was calibrated before and after a series of bite-force trials and proved to be highly stable. Noise was < 1% of forces generated during actual bites. No data filtering was performed for either the calibrations or bite-force measurements.

The design of the medium and large transducers incorporated piezoelectric load washers sandwiched between 17-4PH stainless steel plates (Fig. 1). The size of animals for which the medium transducer was intended required a thin and narrow design to ensure standardized testing in which only the teeth of interest were engaged. This model had one load washer with a 0-4450 N (1000 lb) range (Kistler Instrument Corp., Amherst, NY, Type 9000M057, ≤ 1% error, pure DC analog signal with a frequency of display of 10 KHz). The large transducer was designed for use on large alligators with much broader tooth spacing. As such we were afforded the luxury of using a sensor array of four larger load washers (Kistler Instrument Corp., Type 9000M056, ≤ 1% error, pure DC analog signal with frequency of display of 10 KHz) configured so that a bite anywhere on the steel plates would give a precise force measurement within a range of 0-22250 N (5000 lbs). The piezoelectric transducers were factory assembled, pre-loaded, and calibrated (Kistler Instrument Corp.). Charge output from the transducers was input into a DC-powered charge amplifier (Kistler Instrument Corp., Type 5995) equipped with an LCD display and peak-detect and peak-hold functions, so that maximal bite force could be read at the time of each trial.

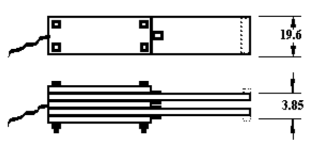
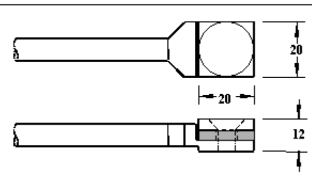
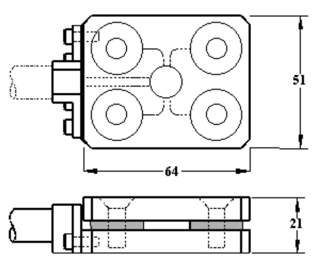
Transducer Schematic	Mechanism	Range	Specimens
	voltage / 4 strain gauges	0-200 N	TL < 90 cm mass < 2 kg
	piezoelectric / 1 load washer	0-4450 N	TL = 90 - 200 cm mass = 2-50 kg
	piezoelectric / 4 load washers	0-22250 N	TL > 200 cm mass > 50 kg

Figure 1. Designs of the three transducers used to measure bite-force performance in *Alligator*. The general mechanism, measurement range, and size range of animals tested are given for each transducer. Dimensions provided on the transducer schematics are in mm.

Testing Protocol

Prior to conducting a bite-force trial, leather pieces were affixed to the working surfaces of a given transducer with the following thicknesses (small transducer: 2.5 mm; medium transducer: 6 mm; large transducer: 6 or 12 mm, depending on size of specimen). The leather pieces served as points of contact for the teeth of the alligators to ensure that the potential for dental trauma from impacting the steel plates was minimized. Leather pieces were removed following each trial to provide a record of the dental contacts made during each bite-force measurement.

For testing, animals were secured by strapping them onto a wooden plank to ensure that axial rolling did not occur, a potential source of signal not related to bite force. If necessary, the animals were encouraged to gape with taps to the top of the snout. The appropriate transducer then was placed unilaterally between the jaws and centered both mesially and distally at the apex of the 11th the maxillary tooth, the most prominent tooth at the back of the jaws. The sensing of the device upon the teeth typically elicited extremely aggressive, snapping bites. Kinematically, these bites were similar to those used by these animals during prey seizure and during intraspecific aggression in which lateral thrusting of the head leads to unilateral seizure of the quarry (Pooley, 1989; Grenard, 1991; Erickson, 1996b). The shattering of teeth often occurs during such bites in the wild and/or captivity as bones (Erickson, 1996a), wooden handling sticks (personal observations of KAV and GME), metal objects (McIlhenny, 1935), or occasionally force transducers with insufficient leather cushioning (present study), are encountered. Obviously, an animal's dentition is only functional within the range of stresses it can sustain, and thus it is very likely the forces we recorded approach the maximum possible for these animals.

During each trial, peak bite force was recorded from the computer (small transducer) or charge amplifier display (medium and large transducers). All trials were digitally videotaped at 30 fps with a Hi-8 digital camcorder (Sony Inc., Tokyo Japan, DCR-TRV520). At least one aggressive, snapping bite was elicited and recorded for each specimen. Post-testing analysis of bite marks on the leather contacts and the videos were used to verify that recorded bites had occurred on the active surface of each transducer, parallel with the jaw line, and directly centered about the 11th maxillary tooth. Trials for which these criteria were not met, for which the bites were not aggressive, or which were discontinuous from start to finish were not utilized in the analyses.

Morphometrics

Three measurements of body size were taken after each bite-force trial. Using a tape measure, snout-vent length was measured to the nearest 0.5 cm. Mass was determined to the nearest gram using a spring scale for individuals <10 kg and to the nearest 0.1 kg for larger animals using a platform scale. Total length also was measured to the nearest 0.5 cm. This last measure would be used to relate our results to those of other published research on dietary ecology that used total length as a body size indicator (e.g., Dodson, 1975).

Statistical Analysis

Raw bite force data were plotted against snout-vent length and mass. The data then were log-transformed for further analysis. Simple linear regression was done with snout-vent length and mass as the independent variables and bite force as the dependent variable. For each regression, 95% confidence intervals were calculated and plotted using StatVIEW v5 (SAS Institute Inc., Cary, NC) for Windows.

RESULTS

Aggressive bite-force readings were obtained from 41 specimens spanning a 12-fold range in snout-vent length and a 3800+-fold range in body mass (Table 1). Peak bite force performance spanned nearly a 800-fold range (12-9452 N; Table 1).

Bite-force performance was significantly and highly correlated with both snout-vent length and mass (Table 2). Bite-force regressions scaled to snout-vent length and body mass gave coefficients departing significantly from the scaling coefficients of 2.0 and 0.66, as predicted by isometric growth, respectively (Fig. 2A, 2B).

Table 1. Ranges for raw morphological and bite-force data.

Variable	Minimum	Maximum
SVL (cm)	15.5	189.0
Mass (kg)	0.077	296.7
Bite Force (N)	12	9452

Table 2. Summary of simple regression analysis. BF = bite force.

Variables	R^2	Intercept	Slope	F-value	P-value
SVL vs. BF	0.972	-1.90	2.59	1337	<0.0001
Mass vs. BF	0.975	-0.31	0.79	1491	<0.0001

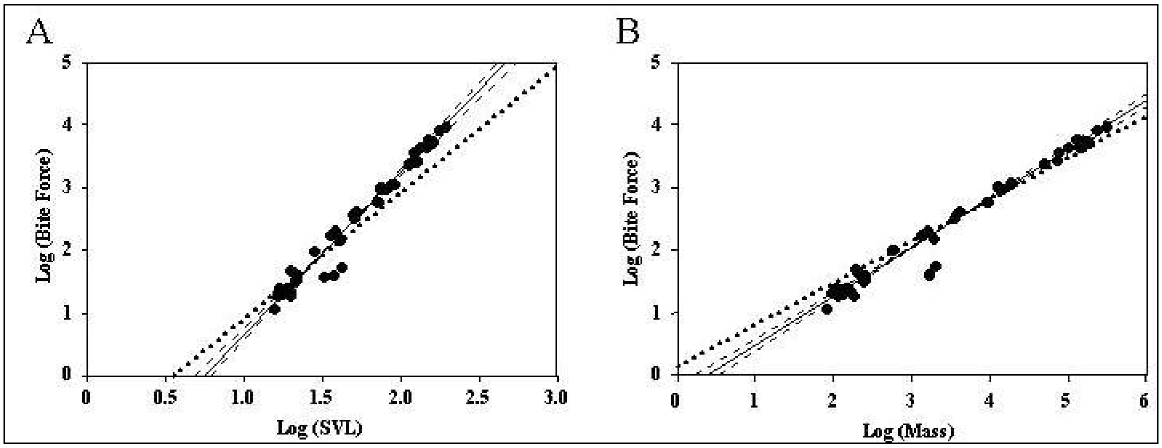


Figure 2. Log-log plots of peak bite-force performance on snout-vent length and mass. Solid lines are the regressions for the data, light dashed lines are 95% confidence bands, and heavy stippled lines show scaling predictions based on isometric growth. (A) Bite force as a function of SVL with predicted scaling coefficient of 2.0. (B) Bite force as a function of body mass with predicted scaling coefficient of 0.66.

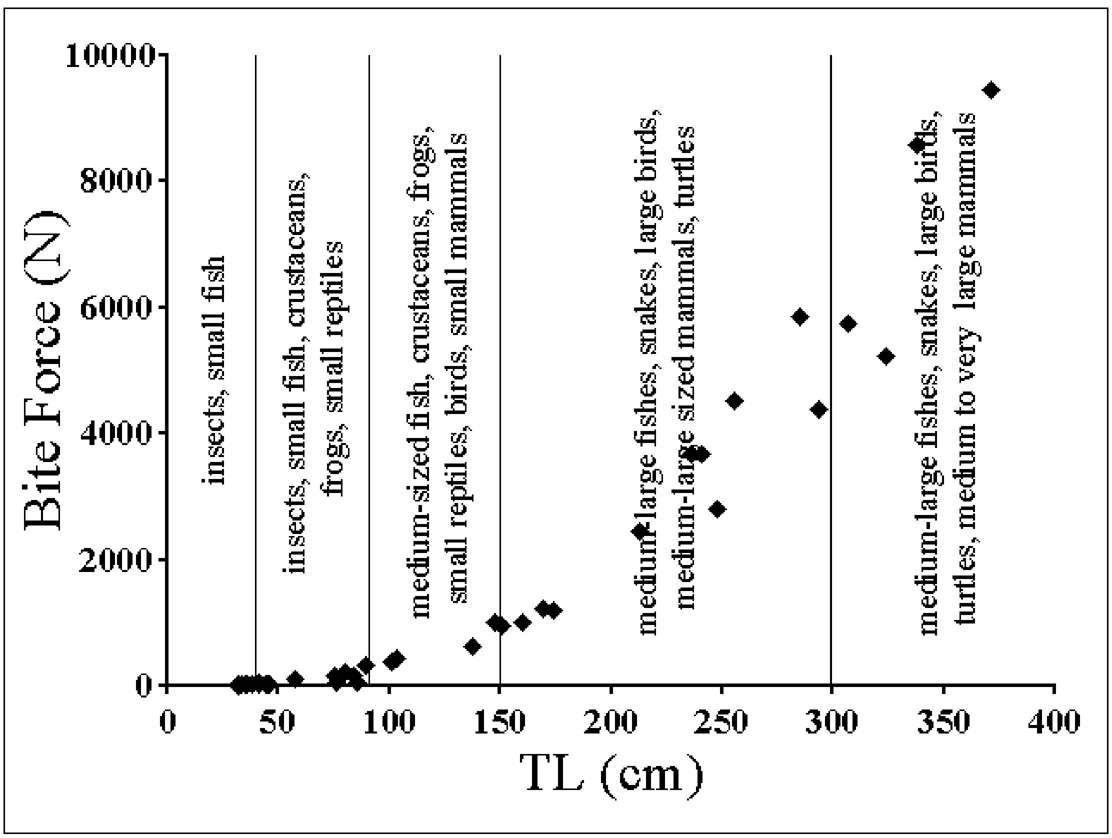


Figure 3. Plot of TL vs. peak bite-force performance. Vertical lines are placed at the TLs at which major ontogenetic dietary shifts are known to occur, based Dodson's (1975) review. Note the considerable increase in bite-force performance just beyond 200 cm TL, within the size range reported to include large mammals and turtles as prey. Bite force continues to increase at even larger body size (> 300 cm TL), at which time even larger mammals become part of the diet of *Alligator*.

DISCUSSION

This study is the first to accurately and precisely measure bite-force performance throughout ontogeny in a large crocodilian species and demonstrates that such analyses are feasible on all crocodilian taxa. *Alligator* *mississippiensis* is one of the largest crocodilian species, and, as such, there is no reason that all crocodilians, including the largest taxon, *Crocodylus porosus*, could not be tested using the protocol described herein.

Significant changes in the types and physical attributes of prey consumed by *A. mississippiensis* occur during ontogeny (Kellogg, 1929; McIlhenny, 1935; Giles and Childs, 1949; Fogarty and Albury, 1968; Chabreck, 1971; Valentine *et al*., 1972; Dodson, 1975). Our preliminary research shows that these dietary shifts are achieved without modification to the continuous allometric trajectory seen throughout life (Fig. 3). In other words, each shift in trophic ecology was not achieved with a discreet increase in bite force compared to the previous growth stage. Instead, an overall disproportionate increase in bite-force performance with size appears to broaden the scope of predatory opportunities for *A. mississippiensis* so that adult alligators include large prey characterized by rigid integumentary or skeletal elements (e.g., turtles, large mammals).

The incorporation of measures of muscle force generation and lever mechanics with direct measures of bite force and system compliance to create musculo-skeletal models of jaw adduction in *A. mississippiensis* will be required to evaluate the influence of each of the myriad of factors potentially responsible for the allometric patterns of bite-force performance.

This research illustrates the potential for measuring bite-force performance throughout ontogeny in crocodilian taxa. These data form a vital bridge between morphological variation and realized ecological niches. A comprehensive understanding of the form, function, performance, ecology, and even evolution of crocodilian feeding will be gained from further future investigations of whole-animal performance. Such standardized investigations on crocodilians and other taxa are encouraged.

ACKNOWLEDGEMENTS

We than Francisco Valero Quevas (Sibley School of Mechanical and Aerospace Engineering, Cornell University), Scott Yerby, Gary Beapré (Department of Biomechanical Engineering, Stanford University and PAVAHCS, Stanford, California), and Lou Phohl (Kistler Instruments) for helping design and implement the various force transducers used in this research. We also thank David Drysdale, owner of the St. Augustine Alligator Farm and Zoological Park in St. Augustine, Florida, and his staff (John Brueggen, David Kledzik, Amanda Whitaker, Shelley Triplet, Jim Darlington, Thomas Rexroad, Gennifer Schrobo) for scientific access to their crocodilian specimens and assistance in taking measurements. We also thank: FSU students Tiffani Dunn, Trevor Parker, Eric Roman, Victor Gonzales, Kyle Gustaffsen, Jill Holliday, and Erin Creech and UF students Greg Pryor, Tamatha Barbeau, Teresa Bryan, and Thea Edwards for their dedication to this project. James Usherwood and John Bertram provided technical assistance, and Kiisa Nishikawa helped with data interpretation. Special thanks is extended to Simon Boyce and Dana Kemp (National Geographic Television) who were instrumental in getting this research off the ground. This study was generously funded by a grant to GME (#7026-01) from the Committee for Research and Exploration of the National Geographic Society and by research funds from the College of Arts and Sciences of Florida State University, Tallahassee, Florida.

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Body Condition Factor Analysis for the American Alligator (*Alligator mississippiensis*)

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ABSTRACT: Condition indices have been used to analyze the fitness of animal populations for the last 50 years. However, the indices are complex and can be used inappropriately if unfamiliar with the constraints. For example, condition for crocodilians has been calculated numerous times using Relative K, developed for fisheries in 1952. Relative K is useful for comparing the condition of a population over time, but not appropriate for comparisons among populations.

We analyzed morphometric measurements of the American alligator (*Alligator mississippiensis*) to determine which are measured most accurately and are appropriate for condition analyses. Condition indices are functions of a body length indicator and a volumetric measurement and are only as accurate as the measurement used. Head length, snout-vent length and total length are suitable for body length indicators and tail girth, neck girth, chest girth, and mass can all be used as volumetric measurements. We then compared four condition indices and two models of volume/length relationships for their ability to distinguish between populations with known qualitative condition differences. Condition indices were Fulton's K, Relative K, a simple length/volume ratio, and relative mass. We also modeled volume/length with a residual index and ANCOVA.

Capturing and Marking American Alligators

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We evaluated passive integrated transponder (PIT), monel web, and cranial mounted reflector tags for marking and identifying American alligators (Alligator mississippiensis). We also tested the use of harmonic radar for relocating marked alligators. A total of 368 adult and 2,674 hatchling alligators were captured between May 1997 and October 1999 using innovative techniques. PIT tags were estimated as 84% reliable on adult and 97% reliable on hatchling alligators during the 3-year study. Placement location and possibly construction characteristics of the tag affected retention of PIT tags. Web tags were estimated to be 92% reliable at 60 days.

Cranial reflectors were unreliable and poorly retained (39% retained) during the 3-year study. PIT tags showed good retention and allowed identification of alligators without visually seeing or handling the animal. Harmonic radar proved of little use in relocating alligators due to short detection ranges (less than 15 m) when tags were at or just below water level.

With increasing attention on alligators and crocodiles, published information on techniques is essential. Additionally, as research needs demand more long-term studies, the needs for tags being of long-life and high reliability increase. Significant variation reported between species, years, and studies preclude reliable extrapolation from studies reporting tag retention rates to alligators (Bjorndal et al. 1996).

Methods of tagging alligators include toe clipping, tail-scute notching, and placement of monel tags. Studies marking American alligators as part of life history research have used the methods of toe clipping and tail-scute notching as originally described by Chabreck (1963). The combination of these 2 marks can provide identification of over 3,000 individuals. Researchers, however, are increasingly marking alligators using individually numbered monel tags placed on webbing located between the toes (Goodwin and Marion 1978, Jacobson and Kushlan 1989, Rootes et al. 1991, Rootes and Chabreck 1993), allowing for an unlimited number of alligators to be marked and later identified.

Our objective was to describe handling techniques and provide an initial evaluation of the use of 3 individual identification tag types (cranial mounted reflectors, monel web tags, and passive integrated transponders) and a harmonic radar relocation system on American alligators.

STUDY AREA

Sabine National Wildlife Refuge is located in southwestern coastal Louisiana. The study area encompassed two impoundments on the refuge and contained vegetative types consistent with fresh (8 km^2) and intermediate (21 km^2) marsh (Chabreck and Linscombe 1988). The main source of water for the impoundments was rainfall. Dense marshhay cordgrass (*Spatina patens*) dominated the habitat. Canals bordered the impoundments. The border levees of the impoundments were vegetated with Chinese tallow-tree (*Sapium sebiferum*), sea-myrtle (*Baccharis halimifolia*), and clumps of roseau cane (*Phragmites communis*). The marsh was interspersed with shallow, open water pools many of which were being colonized by bullwhip (*Scirpus californicus*) and cattail (*Typha* spp.). Each unit had at least one public access point used by recreationists and alligator hunters.

METHODS

Alligators of all sizes were targeted for capture. Larger alligators were captured throughout the two impoundments starting during the courtship period (April and May) and continuing through the nesting season (June through September). Hatchling alligators were initially captured near natal nest sites following their hatch in September. Alligators of, or under, 1.5 m total length were hand-grabbed at the neck. Alligators over 1.5 m were noosed using a cable snare.

A 0.95 cm diameter snare cable noose was attached to a 2.54 cm diameter pole of 3 m length using of a flexible PVC hose of compatible diameter. The noose was attached by swivel to a rope. The rope was passed through the hose and anchored to the boat. The noose was slipped over the head of the alligator and tension applied by the alligator allowed the snare cable to separate from the pole. Alligators were allowed to spin freely until they tired and rotation slowed. As described by McIlhenny (1935), noosed alligators were pulled onto the side of the boat and while applying a forward pulling force on the noose cable, the top jaw was pressed downward against the floor of the boat using a pole or foot. Once closed the mouth was kept shut with approximately 10 size-64 rubber bands. Alligators were pulled to stable locations (i.e., the deck of the boat or flat ground) for processing. Alligators were kept restrained by applying downward pressure to the top of the head and when necessary to the area over the pelvis; eyes were covered with a cloth during processing. Alligators over 3 m total length were restrained on land due to the weight of the animal. During processing tags were applied, body measurements taken, sex identified and notes made of condition and physical abnormalities. The larger alligators were categorized within 4 size classes based on total lengths: Small (1.52-1.82 m), Medium (1.83-2.12 m), Large (2.13-2.42 m), and Very Large (> 2.42 m). Alligators were released at the site of capture and rubber bands removed by pulling an attached cord. Hatchling alligators were placed in a bucket with 8 cm water while awaiting marking. They were restrained with one hand and released on site.

A two person team captured, handled, and marked all alligators. Only animals marked with cranial reflectors were anesthetized.

Alligator dens were checked for the presence of alligators using a 1.27 cm diameter iron pole of 3 m length. The pole was pushed down through the roof systematically until the entire den was searched. The approximate dimensions of each den were recorded. When alligators were found, the pole was used to agitate the alligator with the purpose of causing increased activity (i.e., oxygen consumption); alligators were easily made active by a simple touch. Alligators were noosed when they surfaced to breathe at the den entrance.

In addition to free noosing alligators within marsh pools or out of dens, alligators were captured using baited lines. The baited lines were similar in appearance to that used in Louisiana's harvest of alligators, but a wooden dowel was used in place of a barbed hook. Approximately 20 cm of nylon seine twine (size 30) was attached to the two ends of a 1.27-cm diameter wooden dowel of 10 cm length. A domestic chicken's leg was attached with rubber bands to the dowel. The 20-cm piece of twine was attached to enough twine of the same size to reach from an anchor to deepwater habitat (i.e., the middle of a canal or deep pool). Objects not easily uprooted, such as bushes or artificial stakes, were used to anchor the twine. The baited dowel was hung approximately 61 cm above water level using a clothes pin attached to a 3-m pole of 2.54 cm diameter pushed into the ground at a 30-degree angle. Alligators that swallowed a baited dowel were carefully raised toward the water's surface by pulling the twine up through the noose. Alligators were noosed prior to surfacing with a large diameter snare loop. Once the alligator was noosed, the twine was cut and the alligator restrained as usual.

All alligators were marked with a non-unique tail notch and an uniquely coded Passive Integrated Transponder (PIT) tag. Alligators captured during the 1999 field season and of at least 1.52 m total length, additionally received a web tag. For alligators marked previous to and handled during 1999, a second PIT tag was placed within the left ear flap along with the web tag on the foot. Web tags consisted of an individually numbered self-piercing monel tag (Style 1005-4, National Band and Tag Company, Newport, Kentucky). The tag was placed between the third and fourth toes on the left front foot of alligators. Cranial mounted reflectors were applied to alligators during 1997 only.

The tail notch was created by removing the third single tail scute. The removal of this scute created a distinct gap within the symmetry of the tail and was spotted easily on recapture. This mark ("C" notch) was used as a general identifier of study animals.

Adults were injected with 12 mm x 2 mm (American Veterinary Identification Devices [AVID], Norco, CA) or 11 mm x 2 mm (Destron-Fearing Corp, St. Paul, MN) PIT tags subcutaneously within the right earflap. Hatchling were injected with 11 mm x 2 mm PIT tags with BioBond (Destron-Fearing Corp, St. Paul, MN) into the right neck with the tag resting subcutaneously above the sternomandibularis muscle. BioBond provided true anti-migration characteristics to the PIT tag. A Standard Reader and water resistant probe (American Veterinary Identification Devices [AVID], Norco, CA) were used to identify PIT tags.

Only 18 adult alligators received cranial mounted reflectors. The mounting of the cranial reflector was based on descriptions provided by Smith (1972) and Yerbury (1977). This mark was used to identify individual alligators. Anesthetic (tiletamin-zolazepam) was administered previous to tag application (Clyde et al. 1994). A 5 cm by 3.5 cm by 3.5 cm reflector plate was used and consisted of clear epoxy poured around a flat aluminum plate of 0.6 cm thickness with mounted reflector flags. The aluminum extended out of the epoxy resin and served as a point of connection to the skull. The tag was attached to the skull using #8 stainless steel screws. Holes measuring 2.38 mm were drilled through the plate and 5 mm deep into the posterior end of each squamosal bone. A 6 mm space was left under the plate and pre-filled with all-purpose acrylic to prevent necrosis of the skin. The acrylic pad hardened after the attachment was made.

Commercially produced harmonic radar tags (Recco AB, Lidingo, Sweden) measuring 6.5 cm by 2.2 cm by 0.8 cm were placed subdermally under the bony neck scutes of all adult females. This tag was used to locate alligators and numbers etched within the tag's surface served as a backup identifier of individuals. A 3-cm incision was made posterior to the rear-most neck scute and the tag was inserted through the incision. The tag was pressed forward into place under the leading bony neck scutes. The skin was sealed using tissue glue. The tags were relocated using a hand-held sending/receiving unit (Model R5P1) produced by the same company.

The retention rates of the 3 tags and tail notch were estimated using a binomial distribution and a 0.05 probability level in association with the number retained and functional out of tagged animals reexamined. Percentages used to calculate the mean and 95% Confidence Intervals (95% CI) were transformed to achieve uniform variance using the arcsin of the square root of the estimate. Linear regression was used to describe the detection range for 60 artificially placed harmonic radar tags. Twenty tags were manually placed at each of the following heights compared to water level: -2.54 cm, 2.54 cm, and 91.44 cm. Half of the tags at each of the heights were oriented so to be parallel to the sending/receiver unit; remaining tags were oriented to be perpendicular. The predictor variables included within the model were height of tag compared to water level and orientation of the tag. The response variable was the maximum distance at which the tag was detected.

RESULTS

Individual alligators (2,674 hatchlings and 368 alligators over 1.52 m) were captured between May, 1997 and October, 1999. Alligators over 1.52 m were assumed to be adults. The adult sex ratio for captures was 1 male to 5.24 females. Small, Medium, Large, and Very Large alligators made up 8.5%, 27.1%, 8.5%, and 55.9% of male captures, respectively. Small, Medium, Large, and Very Large alligators made up 5.8%, 22.3%, 43.1%, and 28.8% of female captures, respectively. Average workup time for non-hatchling alligators not receiving a cranial reflector was 14.02 minutes (SE = 0.83). Workup time was significantly longer when cranial reflectors were being applied ($F_{1,312}$ = 15.50, P = 0.001) and averaged 31.36 minutes (SE = 2.84), excluding time for recovery from anesthesia.

Approximately 31% of males and 54% of females were captured out of dens, and 9% of alligators were captured using baited lines. Most alligators captured at dens (89%) were not seen prior to investigation of the den. Alligators left the den after an average of 36 minutes of agitation (range: 1 - 186 minutes). All agitation times over 60 minutes were at dens where alligators were seen prior to searching the den. Additionally, alligators appeared less likely to leave dens a second time after a failed noose attempt. For 4 alligators agitated within the den, missed, and then re-harassed and captured, the first attempt took an average 15 minutes of harassment and the second attempt took an average 80 additional minutes of agitation. The average dimensions of the 75 dens measured were the same size regardless of the adult's sex or size class. The average den had a 2.4 m (SD = 1.0) long tunnel that ended in a 0.9 m (SD = 0.2) diameter rear chamber. The longest den tunnel measured was 7 m and the largest diameter chamber recorded was 1.5 m. Tunnels were generally straight and chambers slightly offset to one side of the tunnel. Dens were at least 60 cm underground. All dens examined (n = 232) had only 1 entrance.

No instances of tail-notches being lost were recorded for hatchlings (n = 204) or adults (n = 117). Fifteen (4%) and 101 (27%) adult alligators were naturally missing parts of, or entire, feet and various lengths of tail, respectively. Hatchlings handled had the following abnormalities: missing parts of tail (0.26%), damaged eyes (0.07%), and missing feet (0.03%).

PIT tags used on alligators $\geq$ 1.52 m total length had a mean yearly retention rate of 0.836 (95% CI: 0.683, 0.946) (Table 1). Gun shots to the head of the alligators during harvest caused 45% of the losses. The remaining missing tags had apparently backed out of the injection hole soon after application. Monel web and PIT tags were placed simultaneously on 100 alligators of which 37 were recaptured within 60 days. No alligators were missing web tags. Using a binomial distribution and a 0.05 probability level in association with 0 cases of missing tags and 37 cases of retained tags, the retention rate up to 60 days was estimated to be no less than 0.922. Three of these same alligators were missing PIT tags. PIT tag retention averaged 0.919 (95% CI: 0.831, 1.000). Forty-nine of 77 adults were relocated under natural conditions and identified using the PIT tag only. Of these adults, 15 alligators were identified without handling using the water resistant probe and 3 of these were identified while still underground within the den.

A total of 204 previously marked hatchlings were reexamined over the 3-year study and yearly PIT tag retention was estimated at 0.972 (95% CI: 0.781, 1.00) (Table 1). All of these losses were for hatchlings handled within the first year of the study. Hatchlings marked and recaptured during 1999 (n = 23) also retained 100% of PIT tags, however, there were only a few weeks between recaptures.

One alligator with a cranial reflector was observed and re-identified using the reflective tag; this occurred 3 days after the original capture. Of the 18 alligators fitted with this tag type, 6 were rehandled at least 90 days after application and no scar or evidence of the tag or its placement remained. Using a binomial distribution and a 0.05 probability level in association with the 6 cases of missing tags and no cases of retained tags, the estimated retention rate after 90 days was no more than 39.3%.

The detection distance for harmonic radar tags used to relocate alligators was under 15 m when the tag was less than 2.54 cm from or below water level, and tag orientation effected signal strength. Overall, the tags detection range (m) was equal to 0.2717 times the height (cm) of the tag above water level (n = 60) but was reduced by 8.6 m when parallel to the receiver ($F_{2,57} = 239.42$, $P < 0.001$, $R^2 = 0.89$).

Table 1. Probability of an alligator retaining a passive integrated transponder (PIT) tag between recaptures from 1997 through 1999, Sabine National Wildlife Refuge, Louisiana. Size is the total length of alligators; Year is the year in which the alligator was originally tagged; year 1999_a includes alligators tagged with both web and PIT tags and were excluded from the 1999 sample; r_{ni} is the number of alligators reexamined within interval ∞; l_{ni} is the number of alligators missing a PIT tag at interval ∞; K_i is the probability of tag retention during the recapture interval ∞.

		$\infty \leq$ 1 Yr			**1 Yr $< \infty \leq$ 2 Yrs**			**2 Yrs $< \infty \leq$ 3 Yrs**		
Size	**Year**	**r_{ni}**	**l_{ni}**	**K_i**	**r_{ni}**	**l_{ni}**	**K_i**	**r_{ni}**	**l_{ni}**	**K_i**
$\geq$1.52 m	1997	21	3	0.857	22	5	0.773	22	6	0.727
	1998	12	1	0.917	13	2	0.846			
	1999	23	3	0.870						
	1999_a	21	4	0.810						
	All	77	11	0.857	35	7	0.800	22	6	0.727
< 1 m	1997	97	10	0.897	32	1	0.969			
	1998	52	0	1.000						
	All	149	10	0.933	32	1	0.969			

DISCUSSION

This manuscript describing the capture, handling and marking of alligators from southwestern Louisiana was written as a reference during the initial stages of starting a research project. Little literature exists that describes safe and effective methods to handling alligators.

We successfully captured a large number of hatchling and adult alligators using knowledge learned primarily through the process of trying. Our estimates of tag retention rates are preliminary and may not reflect those rates realized after many years, but to our knowledge these rates are some of the only ones available.

We found that safe and effective capture and handling of adult alligators was possible with an experienced 2 person crew from a boat. We learned several important lessons when handling alligators. Alligator should be allowed to spin freely prior to being restrained. Alligators mouths can be closed easily while pulling forward on the noose rope and stomping downward on the snout while the alligator is pulling backwards. And, heavy downward pressure over the chest and abdomen or lifting the alligator so it is air born only increases the amount of struggling.

Harassment of alligators out of dens, although time consuming, proved to be highly successful and allowed the capture of animals that would otherwise have been excluded. Care should be taken to agitate the alligator only to induce increased activity through the den roof and not to harass through the den entrance. Alligators appear to become more obstinate as they become aware of the consequence of leaving the den. Baited lines allowed capture of alligators in deepwater habitats that would have otherwise escaped capture. Alligators in deepwater habitat easily out maneuver the noose. The baited line allowed some control prior to noosing. Care should be taken to use a weak enough twine to prevent drowning, due to the line becoming entangled underwater, but strong enough to provide a noosing opportunity while the alligator is still underwater.

When marking alligators for later identification we found no perfect tag available. Within this study only web and hatchling PIT tags had retention rates approaching 100%. Our web tag retention rates, however, were based on only 60 days. Monel tags used on sea turtles also have demonstrated excellent short-term retention, and 100% of tags are suspected lost after a 10-year period (Limpus 1992). Alligators may possibly live well over 50 years (Hutton 1991), and farm-raised alligators are routinely harvested without web tags (Sabine National Wildlife Refuge, unpublished data). Additionally, monel tags that are appropriate for adults are not suitable for use on newly hatched alligators that are only 5% of adult size. Conversely, if an animal retains a PIT tag after the injection wound is healed, the probability it retains the PIT tag is expected to be relatively high and stable over time (Schooley et al. 1993).

Adult alligators have been marked routinely using what are considered permanent body marks consisting of toe clipping and notched tail scutes. Alligators, however, naturally lose various body parts including parts of feet and segments of tails. Our cranial reflectors, even when mechanically attached to the skulls of alligators, demonstrated very low retention rates; these tags were apparently sheared off leaving no scars or other indication of their presence. We found cranial mounted reflectors and radar tags were ineffective for alligators in this habitat.

PIT tags are a viable alternative to other tags for identifying individuals of all size classes. PIT tags allow for unlimited numbers of individuals to be marked and a potential for remote identification of individuals. Retention of 100% may be possible if care is taken where the PIT is applied. The placement in the earflap of adults made the tags susceptible to loss by migration and gunshot damage. The style of tag (i.e., true anti-migration characteristics) may also protect against tag loss. Alligators have a less sophisticated inflammatory response to foreign bodies than mammals and little swelling occurs following injection; the earflap and its restricted size allowed movement toward the injection site. Most preventable losses of PIT tags appear to occur prior to the healing of the injection wound, after this time minimal natural loss should occur. Sealing the injection wound prior to release may additionally help reduce PIT tag loss. We recommend that a different application site with more soft tissue, possibly the neck or cheek, be used in the future. The site should remain close to the head to augment remote reading unrestrained alligators.

Planning a large scale nesting ecology study was difficult due to a lack of information referencing alligator capture and handling techniques and tag retention rates. The goal of monitoring large numbers of individual female alligators and their young over successive years meant dependency on untried methodologies. The unexpected amount of time alligators spent in a subterranean environment (dens) had additional effects on the ease of identifying individuals. Web tags proved to be an excellent tag for adults, however, required alligators to be handled to read tags and identify individuals. Every handling involves risks of injury to researchers and alligators. PIT tags were the only tags tested that provided for the individual identification of all size classes of alligators under various field conditions. PIT tags allowed the identification of individuals without handling or even seeing the animal, even with the limited range (< 7.5 cm) of the water resistant probe.

ACKNOWLEDGMENTS

We thank the staffs at Sabine and Cameron Prairie National Wildlife Refuges (NWR) for support and help provided during all stages of this project. We would especially like to recognize Sabine NWR Biologist Diane Borden-Billiot for her cooperation, and Cameron Prairie NWR Manager Paul Yakupzack for support. Ray Aycock, U.S. Fish and Wildlife Service, provided additional field support. Louisiana State University Agricultural Center and U.S. Fish and Wildlife Service provided funding for this work.

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Stress in Farmed and Captive Crocodiles: Stressors and Effects

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ABSTRACT: The stressors of farmed and captive crocodiles consist of any limitations imposed on the expression of the natural behaviour of crocodiles: fear and the inability to escape a frightening event (capture, restraint, transport), the inability to thermoregulate (lack of environmental thermogradient) and the inability to establish or leave a territory (overcrowding). The effects depend on the severity and duration of the action of the stressor, on the age of the animal and on environmental conditions (immunosuppression by cold, malnutrition). Consequently, they may be expressed in different degrees of severity and they can be behavioural or somatic. The behavioural changes caused by stress are anorexia and hydrophobia or in less severe cases reduced appetite and growth rate. The somatic changes are immune suppression and septicaemia, gastric ulcers and chronic dermatitis, as well as metabolic disorders, particularly lowered calcium levels with resulting poor dental mineralization and osteoporosis.

INTRODUCTION

Stress is one of the natural defense mechanisms common to all vertebrates and it is designed to function in a natural environment. However, captive and farmed crocodiles are frequently subjected to conditions that may be severely stressful. Consequently stress, its mechanisms and its impact have been discussed repeatedly at previous meetings (Lance, 1994; Smith and Marais, 1994; Huchzermeyer, 2000a; Lance *et al*., 2000). The purpose of this paper is to identify important stressors commonly challenging captive and farmed crocodiles and to describe the clinical manifestations of stress in these animals.

STRESSORS

In the context of this paper stressors can broadly be defined as any limitations imposed by captive or farming conditions on the expression of the natural behaviour of crocodiles. These limitations can be seen as inabilities. The stressors can act acutely or over extended periods, chronically.

Fear

The inability to escape a frightening event whether expected or actually happening is commonly present in the following situations:

Hatchlings are afraid of being left in the open. Any disturbance induces them to hide under a cover or to escape into deep water. Even when kept indoors they do not perceive the ceiling or roof as protection. They need cover close to the ground (Fig. 1). The water usually is kept shallow because of the necessity of daily water changes and therefore cannot play a role as refuge either.

Figure 1. Nile crocodile hatchlings seeking refuge under a hide board

All crocodiles are frightened of being caught, restrained and handled, as this also leads them into an inescapable situation. Also affected are the crocodiles witnessing the capture of their pen mate, being unable themselves to escape. The transport of a caught and restrained crocodile is just another extension and prolongation of the inescapable situation.

Thermoregulation

Thermoregulatory behaviour is essential to the well-being of crocodiles. In the natural environment there always is a thermogradient along which the crocodile can choose and adjust its internal temperature. In farming and captive situations such a thermogradient usually is greatly reduced or entirely absent. Suboptimal as well as excessive temperatures occur quite commonly. The inability to thermoregulate under such circumstances is a very common and severe chronic stressor.

Territoriality

In hatchlings and juveniles territoriality is more a function of competition for food while in sexually mature animals the establishment of a breeding territory becomes important, probably with large species-specific differences. In older subadult juveniles there may also be the inborn need to disperse and migrate (Hutton, 1989). In captive and farming situations there is an inability to escape from the other pen mates, to disperse or to establish an own territory when chased away by a stronger or more dominant individual. Consequently overcrowding has long been identified as a major source of stress (Elsey *et al*., 1990; Morpurgo *et al*., 1992).

CLINICAL EFFECTS

The combined effects of several stressors are additive and their effects depend not only on their individual or combined severity and duration but also on the physiological and nutritional state of the animal subjected to the stressor(s). In addition environmental factors can also play a role, viz. the immune suppression by cold. The effects can be behavioural and/or somatic.

Behavioural

In crocodiles, the range of behavioural responses to stress is relatively restricted. Most commonly seen are hydrophobia, the refusal to go into the water, and anorexia, the refusal to feed. Usually the two are combined. In a less severe form the anorexia leads to a lowered feed intake and thereby to a reduced growth rate. It is suspected that the swallowing of large quantities of stones and other foreign bodies could also be a form of stress behaviour.

Somatic

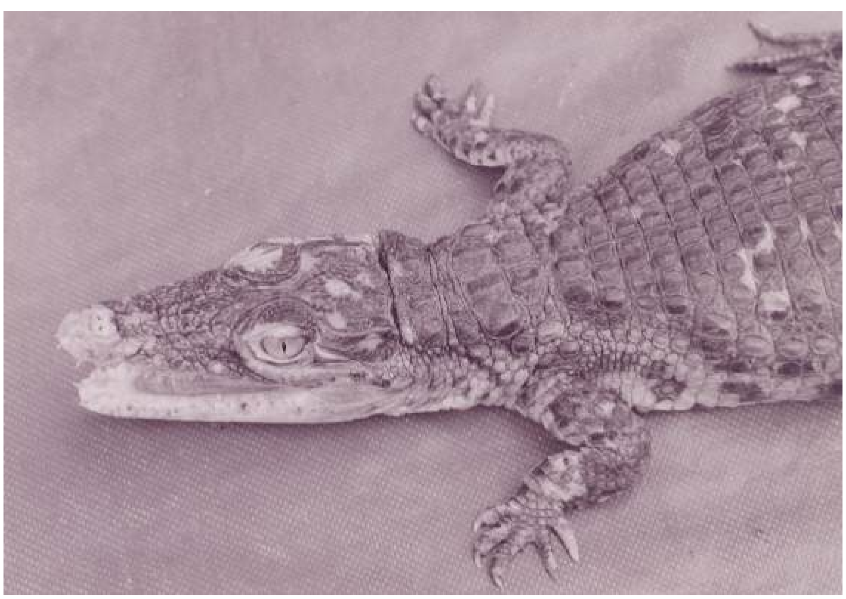

Figure 2. Chronic stress dermatitis characterized by white patches of desquamation, particuarly around nostrils and eyes

There is clinical evidence at least in ostriches and crocodiles that under severe stress intestinal bacteria can become translocated through the mucosal barrier into the blood circulation and cause septicaemia, similar to the shock septicaemia in human trauma and burn patients (Deitch *et al*., 1996). This septicaemia is aggravated by the immune suppresion caused by high corticosteroid levels in the circulation, particularly under prolonged or chronic stress or under conditions of cold and frequently it develops into a polyarthritis (Huchzermeyer, 2000b). Gastric ulcers found in severely stressed crocodiles may partially be a sequel of anorexia. They are commonly associated with a chronic dermatitis characterized by the formation of white patches of desquamation (Fig. 2) and sometimes also by an extremely severe polyarteriitis (Huchzermeyer and Penrith, 1992). The "chronic stress dermatitis" mentioned above may occur also on its own without stomach ulcers.

A stress-induced metabolic disorder is the reduction of circulating calcium levels (Morpurgo *et al*., 1992). Clinically this becomes visible as poorly calcified teeth (Fig. 3) and pathologically as osteoporosis. Initially this osteoporosis had been mistakenly diagnosed by myself as exostoses possibly caused by an overdose of vitamin D (Huchzermeyer, 1999). It real nature became clear when I stared to see many more cases. Decalcification of teeth was an outstanding sign in adult breeding Nile crocodiles which had been translocated during winter and were subsequently dying from stress septicaemia (own unpublished case). However, lowered calcium levels with similar effects could also be due to the difficulty of digesting small particles of bone (bone meal or minced whole chicken) because of their rapid passage through the stomach, before the bone is dissolved by the gastric acid. Glassy teeth are also seen in cases of osteomalacia caused by lack of nutritional calcium (Huchzermeyer, 1986).

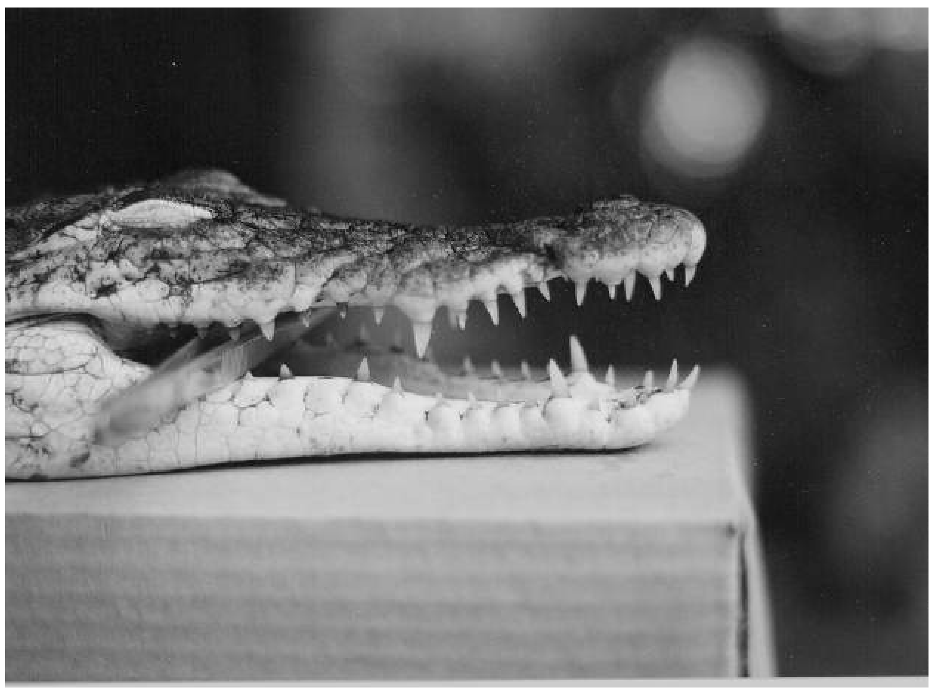

Figure 3. Decalified teeth in a chronically stressed slaughtered Nile crocodile

CONCLUSION

Very few contagious diseases cause high mortality rates on crocodile farms. Instead, most outbreaks are either caused or aggravated by severe and chronic stress. Being able to diagnose the effects of stress and to identify the stressors is the first step towards the prevention of stress-induced disease and mortality.

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Tissue Lead Levels in Captive-Reared Alligators

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ABSTRACT: Alligators from artificially incubated eggs were reared in captivity since hatch in 1972 and 1973 at the Rockefeller Wildlife Refuge. This group of alligators has been the subject of intense study on captive reproduction: they were first observed to reproduce at 6 yr, but egg quality, hatchability and fertility declined over the years. By 1998 successful reproduction in this captive group had essentially ceased, but many of the females continued attempts at nesting. In 1999 they were euthanized and complete necropsies were performed. All females had extensive reproductive tract pathology. The males appeared normal. However, upon examination of stomach contents lead pellets were discovered in both males and females. It was determined that the lead pellets came from the ground nutria (*Myocastor coypus*) meat that the alligators had been fed over the years. Liver, kidney, muscle, bone, and yolk from large preovulatory follicles were collected for analysis. For comparison, tissue samples from wild alligators were used. The tissue samples were digested in concentrated nitric acid and analyzed on a graphite oven atomic absorption spectrophotometer for lead, chromium and selenium. Tissue chromium levels were very low in both wild and captive samples and were not significantly different from one another. Liver lead concentrations in the captive group, however, were extraordinarily high, higher than any previously recorded values in reptiles. Lead in the liver of the wild alligators was very low. Lead was also very high in the yolking follicles of the captive alligators

Antimicrobial Activity in the Blood of the Saltwater Crocodile, *Crocodylus porosus*

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ABSTRACT: The saltwater crocodile shows a low incidence of infection from serious injuries sustained during intraspecific aggression, in spite of the microbe-laden environment in which it lives. This suggests a well-developed innate immune system, which provides a rapid, non-specific first line of host defense. In other aquatic species such as amphibians and fish, this defense is found in the mucous skin secretions as antimicrobial peptides. Due to the anatomy of the crocodile, we reasoned that a homologous defense would be found in the circulatory system, either as soluble factors or as agents expressed in phagocytic cells. To address the first hypothesis, we extracted serum from wild saltwater crocodiles to isolate naturally occurring antibiotics. The serum was maintained at -80C until fractionation. Serum was fractionated by Reverse-phase HPLC on a C-18 column with a 0-60% acetonitrile gradient, and fractions were assayed for antibiotic activity against *E. coli* in a modified radial diffusion assay. Preliminary results indicated strong antibiotic activity in several fractions. We have taken a single fraction, eluting at 13% acetonitrile, for further characterization. Based on our initial observations, we predict that the crocodile exhibits both peptide and non-peptide based antimicrobial activity in its blood.

Antibacterial Properties and Complement Activity of Serum in the American Alligator (*Alligator mississippiensis*)

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ABSTRACT: Treatment of alligator or human serum samples with E. coli resulted in a 10-fold lower bacterial survival rates in the alligator serum after 1 hour. When inoculated with E. coli, alligator serum exhibited a time- and concentration-dependent inhibition of bacterial proliferation. In addition, the antibacterial spectrum of alligator serum was shown to be much broader than that of human serum, with growth inhibition occurring in 100% of bacterial strains tested (compared to only 35% for human serum). Additional results showed that the antimicrobial activities of alligator serum could be completely inhibited by preincubation with proteases, indicating the proteinaceous nature of the antimicrobial activities. Furthermore, incubation of serum at 56^{o}C for 30 min. (classical human complement inactivation conditions) obliterated all antimicrobial properties of the alligator serum. Immunofixation of electrophoretically-resolved alligator serum proteins with antihuman C3 polyclonal antibodies resulted in recognition of alligator C3 protein. Incubation of alligator serum with sheep red blood cells in the presence of antihuman C3 antibodies reduced complement activity by 60%. These data suggest that the antibiotic properties of alligator serum are likely due to the presence of a complement-facilitated humoral immune response analogous to that described in mammalian systems. The complement activity in alligator serum is shown to be much more potent and has a broader spectrum of activity than human serum. This study represents the first detailed characterization of reptilian complement protein system and may provide a partial explanation for disease resistance in the American alligator.

INTRODUCTION

Eukaryotic organisms must continuously defend themselves against infiltration and colonization by microorgamisms. The humoral immune response comprises a significant portion of the immune system and acts as an initial defense mechanism against microbial growth shortly after infection occurs. The serum complement system, an important component of the humoral immune response, is composed of 25-30 proteins that can be activated to initiate the inflammatory response, recruit leukocytes to the site of infection, mediate opsinization of particulate foreign materials and to kill microorganisms directly by the assembly of a multiprotein membrane attack complex in the outer membrane of microbes (Muller-Eberhard, 1986, Dalmasso et al., 1989). Because of the immunological importance of the serum complement system, a deficiency or mutation in any complement protein is almost always associated with multiple recurring infections (Morgan and Walport, 1991, Pascual and French, 1995).

Complement proteins are expressed and circulated as inactive precursor proteins that can be activated in a very precise and highly coordinated fashion (Campbell et al., 1988). The complement cascade can be initiated by two distinct mechanisms, an antibody-dependent classical pathway and an antibody-independent alternative pathway, that result in the modulation of immune function. The serum complement system has been well-characterized in humans as all of the proteins have been purified to homogeneity, their functions in each pathway identified, and their genes isolated (Campbell et al., 1988). Although several studies have reported the presence of complement components in a variety of reptiles (Koppenheffer, 1987), the serum complement system is not well-characterized in reptilian systems. The results from this study provide evidence for a potent and broad-acting complement system in the serum of the American alligator (*Alligator mississippiensis*).

MATERIALS AND METHODS

Chemicals and biochemicals. Nutrient broth and nutrient agar were purchased from ISC Bioexpress (Kaysville, Utah). Lyophilized ATCC bacterial strains were purchased from Chrisope Technologies (Lake Charles, LA). The following ATCC-registered strains were used: Klebsiella oxytoca (49131), Providencia stuartii (33672), Escherichia coliform (25922), Proteus mirabilis (43607), Enterobacter aerogenes (49469), Salmonella typhimurium (14028), Pseudomonas aeruginosa (27853), Citrobacter freundii (C109820), Shigella sonnei (25931), Shigella dysenterae (13313), Salmonella poona (4840), Yersenia enterocolitica (9610), Staphylococcus pyrogenes (19615), Streptococcus epidermitis (19615), Staphylococcus aureus (6538), and Enterococcus faecalis (29212). Protease derived from Streptomyces griseus was purchased from Sigma Chemical Company (St. Louis, MS). Goat antihuman C3 polyclonal antibodies were obtained from Rockland Immunologicals (Gilbertsville, PA).

Treatment of animals. Alligators were captured and housed at the Rockefeller State Wildlife Refuge in Grand Chenier, Louisiana. Numerous juvenile alligators, which were hatched in captivity from eggs collected in the wild, were maintained at Rockefeller Refuge in fiberglass-lined concrete tanks approximately 12' long x 6' wide. Several small alligators (up to 3' in length) are housed in a single tank. Adult alligators were typically captured at night with use of a wire snare.

The environment in the tanks consisted of 50% dry bottom and 50% water of approximate 6" depth. The temperature is maintained at a constant 87-88ºF. The alligators are fed formulated dry pellets four times per week and the cages are cleaned five times per week. Blood samples were drawn from the supravertebral branch of the internal jugular vein using a heparinized 1_" 18 gauge needle and a 10 ml syringe (Olsen et al., 1977) and transferred to either serum or plasma (50 mM EDTA) vacutainer tubes.

Bacterial cultures. Bacteria were maintained on nutrient agar slants at 4^{o}C. The day before an experiment, a 4 ml nutrient broth liquid culture was inoculated from the slant with a sterile cotton swab. The bacteria were allowed to incubate at 37^{o}C overnight to obtain log-phase culture. Serial dilutions of the log-phase cultures were plated on nutrient broth agar in 100 mm Petri dishes to determine the colony-forming units (CFUs) in each culture.

Determination of CFU. Fifty µL of a dilution of each sample was spread onto the surface of nutrient broth agar plates to determine the CFUs for each sample. Samples were typically plated at three different dilutions to obtain plates with a quantity of colonies such to provide a reasonable estimate of bacterial density (50-400 CFUs/plate).

Concentration-dependent antibacterial properties of human and alligator sera. Two ml samples containing various concentrations of human or alligator sera in 12 x 75 mm culture tubes were inoculated with approximately 1×10^5 E. coli bacteria from a log phase culture and incubated for 12 hr at 37^{o}C. The optical density of each sample was measured at 0, 3, 6, and 12 hrs using the Varian Cary 50 spectrophotometer at 430 nm.

Antibacterial capacity determination. E. coli cultures in log growth phase were used to make 10-fold serial dilutions in sterile saline. Fresh alligator or human sera samples (450 µl) were treated with 50 µl of bacterial culture or a dilution containing different amounts of bacteria. The samples were incubated at 37^{o}C for 1 hr and the CFUs for each culture was determined by the solid medium bacterial growth assay as described above.

Effects of serum on the growth of different strains of bacteria. Nutrient agar was dissolved in boiling water and 30 ml aliquots were transferred to 70 ml culture tubes, autoclaved, and held in liquid phase in a 45^{o}C water bath. The aliquots of sterile nutrient broth agar were inoculated with 100 µL of a log phase culture of one of various bacterial strains and then dispensed into 145 x 20 mm Petri dishes. After the agarose set, wells were cut with the large end of sterile, cotton-plugged Pasteur pipettes attached to a vacuum line. Twenty-five µL of serum was pipetted into each well and allowed to incubate at room temperature for 3 hrs. Another 30 ml aliquot of sterile nutrient broth agar (45^{o}C) was poured onto the top of the original agar layer and allowed to set. The plates were incubated in an inverted position overnight at 37^{o}C and the zones of bacterial growth inhibition were measured. For slower growing species of bacteria, plates were incubated for 48 hrs to observe the results.

Immunofixation Assay. Detection of C3 complement protein in human and alligator serum was achieved by immunofixation using a SPIFE Combo protein analyzer (Helena Laboratories, Beaumont, Texas). The analysis was performed according to the manufacturer's instructions, with the exception that goat polyclonal antihuman C3 antibodies were used for immunofixation. The human serum was analyzed at a 1:3 dilution while the alligator serum was analyzed undiluted.

Sheep Red Blood Cell (SRBC) Hemolytic Assay. The functionality of the alligator serum complement system of proteins was investigated by a SRBC lysis assay modified from the method of Mayer (1967). Six hundred µL of 1% SRBCs were mixed with 700 µL of undiluted alligator serum. The incubate was increased to a total volume of 1500 µL using saline, or a C3 antibody solution. The optical density of the samples was measured at 525 nm using a Varian Cary 50 UV/Vis spectrophotometer.

Statistics and controls. All experiments were performed in quadruplicate to obtain valid statistical evaluation of the results. CFUs/ml for each sample were calculated by multiplying the number of colonies counted by the dilution factor and then by ten (due to the fact that only 50 µL were plated on each dish). Zones of growth inhibition were measured and the width of the well subtracted prior to statistical calculations. All results represent the means ± standard errors.

RESULTS

Table 1 exhibits the effects of heat-treatment and preincubation of alligator and human sera with proteases on the antibacterial effects. Treatment of human or alligator sera for 30 min. at 56^{o}C completely obliterated antimicrobial activities, as determined by a solid phase growth inhibition assay as described in the Materials and Methods. In addition, pretreatment of a 100 µL sample of human or alligator serum with 20 uL of a mixed protease cocktail eliminated antimicrobial activities.

Table 1 Effects of Protease- and Heat-treatment on the Antibacterial Activity of Human and Alligator Serum. Twenty µL of each serum sample were transferred to 6 mm wells cut into nutrient agar that had been inoculated with E coli. The samples were allowed to incubate in the wells for 3 hr, nutrient top agar was poured over the surface, and the plates were incubated overnight at 37^{o}C. The results are expressed as the means ± standard errors for four determinations.

	ZONE OF GROWTH INHIBITION (mm)
Human Serum	
Untreated	***2.3 ± 0.4***
Heat-treated	***ND***
Protease-treated	ND
Alligator Serum	
Untreated	6.5 ± 1.0
Heat-treated	***ND***
Protease-treated	***ND***

Inoculation of nutrient broth with approximately 10^{6} CFUs of E. coli resulted in a time-dependent increase in bacterial proliferation as measured by spectrophotometry at 430 nm (Fig. 1). Inclusion of different concentrations of human or alligator serum in the broth produced a concentration-dependent decrease in bacterial growth. 10% alligator serum reduced bacterial growth by 84% at 3 hours, compared to only a 47% reduction by human serum (Figures 1A and 1B). The addition of 10%, 25%, 50%, 75%, and 100% alligator serum resulted in statistically significant ($p<0.001$) decreases in bacterial growth at all time points after zero. Inoculation of 100% alligator serum that had been thermally inactivated (56^{o}C, 30 min) produced only a 16% decrease in growth as compared to 97% growth inhibition by serum which had not been heat-treated (data not shown). Likewise, the growth of bacteria in 100% human serum that had been heat-treated showed only a 18% reduction in growth, relative to nutrient broth cultures (data not shown). The ability of thermally-inactivated alligator serum to inhibit bacterial proliferation demonstrates that the antibacterial effect is due to the presence of a heat-labile factor(s) and not to the dilution of nutrient in the growth medium.

Figure 1A

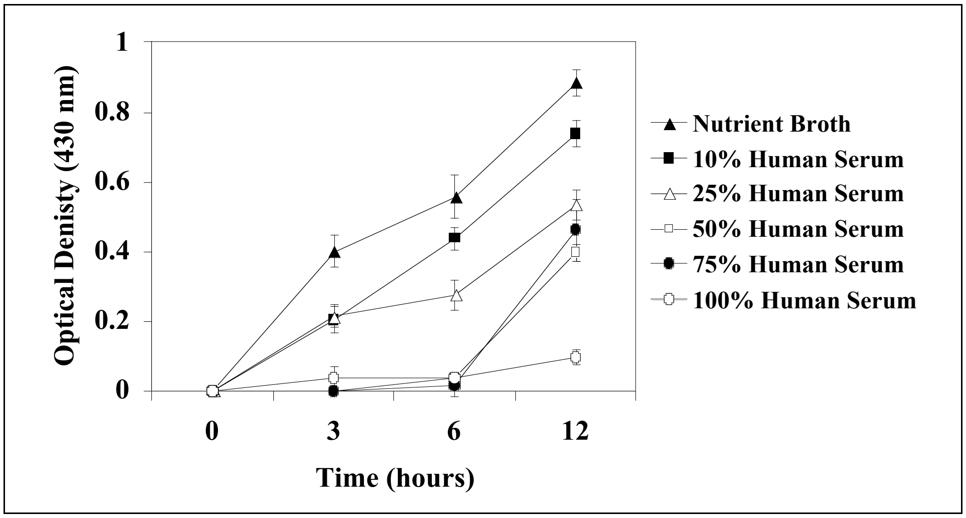

Figure 1B

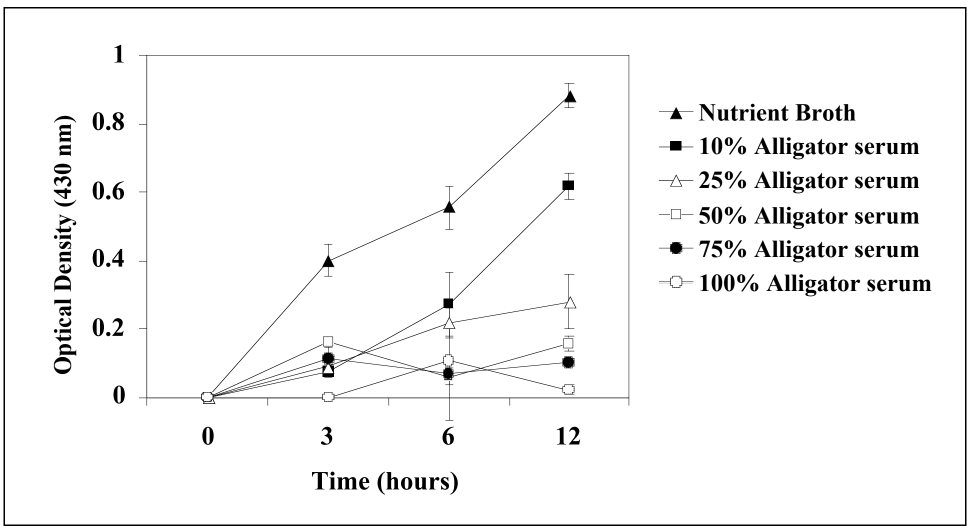

Figure 1. Concentration-Dependent Inhibition of Bacterial Growth by Human and Alligator Serum. Culture tubes containing 2 ml of 0, 10, 25, 50, 75, or 100% human (1A) or alligator serum (1B) in nutrient broth were inoculated with 10^5 E. coli. The cultures were incubated at 37^{o}C and their optical densities were measured (430 nm) at 0, 3, 6, and 12 hr post-inoculation.

Measurement of the antibacterial capacity of human and alligator serum (Fig. 2) revealed that alligator serum killed approximately 11- or 9-fold more bacteria when serum samples were challenged with 104 or 103 CFUs/ml, respectively. Inoculation of alligator serum with 105, 104, or 103 CFUs/ml of E. coli resulted in a stepwise decrease in bacterial survival of 54, 3, and 5%, respectively. In contrast, treatment of human serum resulted in 66, 44, and 44% survival for the same inoculations. Inoculation of cultures with 106-108 CFUs of E. coli overloaded the capacity of the serum complement to kill the bacteria, resulting in 100% bacterial survival in all three sample groups for both human and alligator serum. However, inoculation of serum with 105 CFUs/ml resulted in a 46% and 34% decrease in bacterial survival for alligator and human serum, respectively.

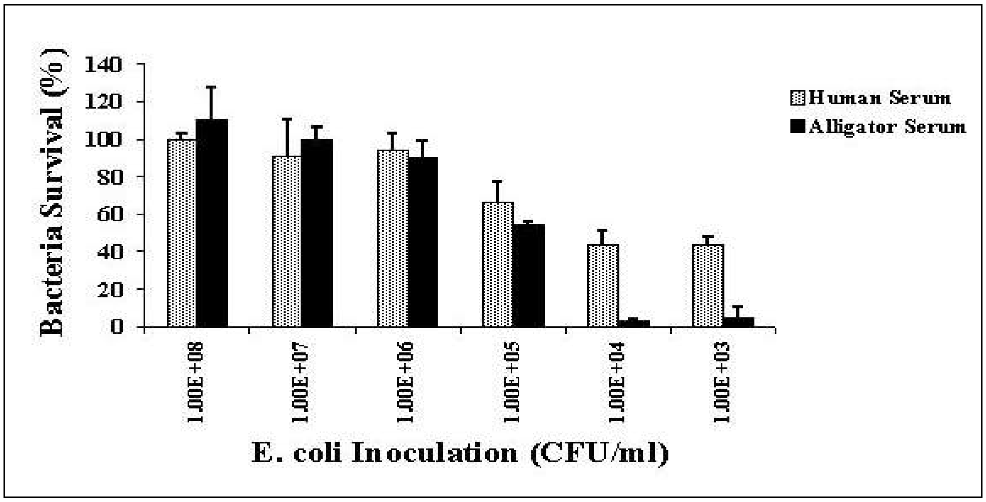

Figure 2. Bactericidal Properties of Human and Alligator Serum. Serial dilutions of a log phase E. coli culture were added to 0.5 ml serum samples and incubated for 20 min. Dilutions of each sample were plated to determine CFUs. Results are expressed as bacterial survival ([CFUs after incubation/CFU added to sample] x 100.

Treatment of 17 different strains of bacteria (representing 13 different genera) with alligator serum resulted in 100% effectiveness of growth inhibition (Fig. 3). In comparison, human serum was only effective on 35% of bacterial strains. Human serum exhibited antibacterial activities toward only 6 of 13 gram negative strains and was completely ineffective against gram positive strains. Furthermore, the degree of antimicrobial activity was significantly lower for all bacterial strains tested in human serum than that of the alligator.

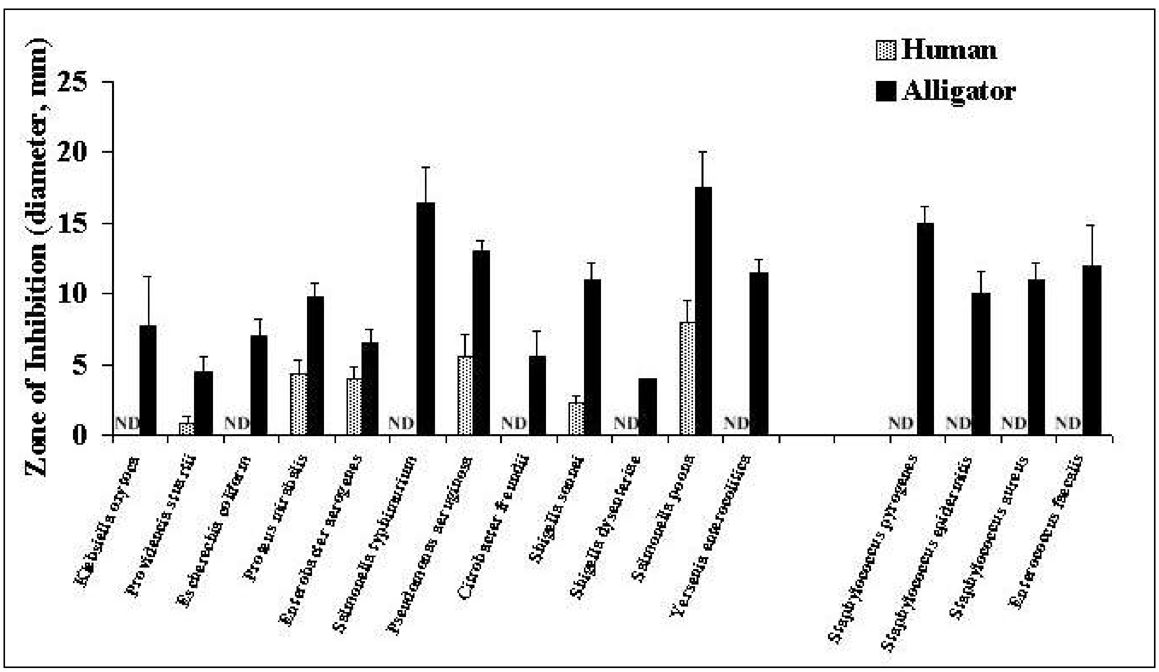

Figure 3. **Antibiotic Spectrum of Human and Alligator Serum**. Aliquots of nutrient agar in liquid phase (45oC) were inoculated with one of various strains of bacteria and poured into 125 mm Petri dishes. Samples of alligator or human sera were transferred into aseptically formed wells. After a 3 hr incubation at room temperature, top agar was poured over the plates and the samples were incubated overnight at 37oC. ND = not detected.

The native agarose gel electrophoretic analysis of human and alligator serum revealed remarkably similar protein patterns (Fig. 4). The albumin band in the alligator serum constituted only 25% of the total serum protein, as determined by densitometry, compared to approximately 50-60% for human serum. The albumin band migrated slightly more anodal than that of the human serum. Immunofixation of the human C3 protein showed a single band just cathodal to the application point on the gel (Fig. 4, lane 2). The same antibodies (goat antihuman polyclonal C3) detected a single band in alligator serum (Fig. 4, lane 4) that migrated slightly more anodal than the human C3. The appearance of only one band indicates the specificity of human C3 antibodies for the alligator C3 protein. The interaction of the alligator protein with the human C3 antibodies and the similar migration of the protein band lead us to believe that this protein represents a crocodilian complement component analogous to the mammalian C3 protein.

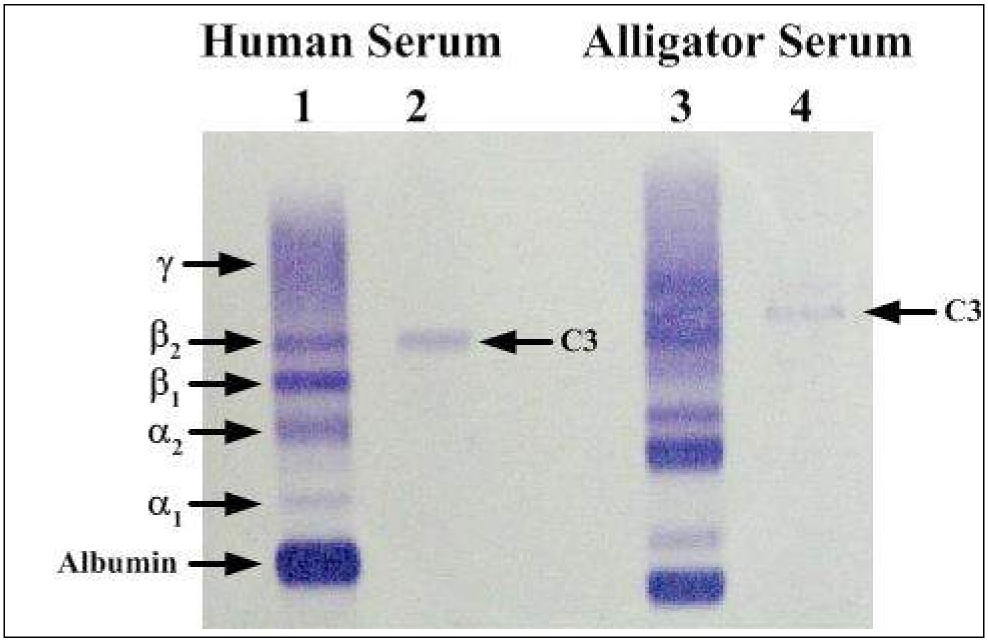

Figure 4. Detection of Serum Complement C3 Protein in Human and Alligator Serum. Serum samples were resolved on a 1.2% native agarose gel and the total protein was precipitated using 5% acetic acid (lanes 1 and 3). Protein was visualized using Acid Violet Coomassie-type stain. The cathodic C3 protein band was detected by immunofixation (lanes 2 and 4) using goat antihuman C3 antibodies.

The data in listed in Table 2 illustrate the ability of alligator serum to disrupt SRBCs in vitro. Incubation of 50% alligator serum with 1% SRBCs (v/v) resulted in a 60% increase in the optical density at 525 nm. The serum-mediated hemolysis of SRBCs was decrease 40% by the addition of antihuman C3 polyclonal antibodies.

Table 2. Effects of C3 Antibodies on Alligator Serum Complement . Alligator serum was incubated with sheep red blood cells in the presence or absence of antihuman C3 antibodies. The resulting hemolytic activity was measured spectrophotometrically at 525 nm.

Sample	Abs (525 nm)
Alligator Serum	0.347 ± 0.010
Heat-treated Serum	0.092 ± 0.003
Serum + antiC3 antibodies	0.140 ± 0.009

DISCUSSION

The immune systems of crocodilians have not been well-characterized. However, several descriptive reports have described the presence of cellular components of the immune system in the American alligator. Cuchens and Clem (1979) have reported the presence of B-like and T-like lymphocytes in the alligator. In addition, Mateo and coworkers (1984) described the morphological and cytochemical characteristics, and relative abundance of various types of alligator peripheral blood cells. However, no description of a humoral immune response has been reported in alligators.

Several investigators have reported the presence of an active serum complement system in a variety of reptilian species (Koppenheffer 1987, Sunyer and Lambris 1998, Sunyer et al. 1998). For instance, Kuo and coworkers (2000) described the complement-mediated killing of the Lyme disease spirochete (Borrelia burgdorferi) in the western fence lizard. Koppenheffer (1986) has demonstrated the presence of both classical and alternative pathways in turtle serum. Other studies have focused on the complement activities in snake serum (Kawaguchi et al., 1978, Dias et al., 1984). The most extensive characterizations of reptilian complement have been in the cobra (Vogel and Muller-Eberhand, 1985a, Vogel and Muller-Eberhand, 1985b, Fritzinger et al., 1992). Sharbanay et al. (1999) described the antibacterial activity of crocodile serum. However, to our knowledge, a detailed functional description of crocodilian complement has not been published to date.

Alligators seldom exhibit detrimental health conditions due to infection. Alligators often sustain serious injuries and, despite the septic conditions under which they live, heal very rapidly and almost always without infection. Crocodilians have been known to live with opportunistic pathogenic bacterial infections but exhibit no physiological effects (Manolis et al., 1991, Madsen, 1993, Madsen et al., 1998). While crocodilians are not completely immune to microbial infections (Gorden et al, 1979, Novak and Siegel, 1986, Brown et al., 2001), these species do exhibit remarkable resistance to microbial colonization. The results from this study provide the first evidence that the American alligator has an active serum complement system.

Human complement contains heat-labile proteins that are thermally inactivated when incubated at 56°C for 30 minutes. The fact that the antibacterial activity of alligator serum can be obliterated under these conditions (Table 1) provides circumstantial evidence that these activities are due to the presence of a crocodilian complement immune system component. The concentration-dependent increase in antibacterial activity by alligator serum (Figure 1) also suggests the presence of complement activity. The inclusion of a thermally-inactivated 100% alligator and human serum controls show that the bacterial growth inhibition is due to the effect of a heat-labile serum factor(s) and not dilution of the nutritive value of the liquid growth medium by the addition of increasing amounts of serum.

The data listed in Table 1 provides evidence that the antimicrobial activities observed in alligator blood are due to the serum complement system of protein present in higher eukaryotes but not yet characterized in reptilian systems. Incubation of alligator serum at 56°C for 30 min. (classical conditions for the inactivation of human complement) completely depletes the serum of antibacterial activities. In addition, pretreatment of serum with proteases also diminishes the antimicrobial character indicating that these activities are dependent on the action of protein(s).

Results from the investigation of the range of antibacterial activity demonstrated that alligator serum has a much broader spectrum of antibacterial activity than that of human serum (Fig. 3). Human serum complement proteins are typically ineffective against gram positive bacterial strains. However, the alligator complement was highly effective as an antibacterial agent against all four gram positive strains tested (Fig. 3).

Complement protein C3 plays a pivotal role in the activation of the serum complement activation by both the classical and alternative pathways. C3 is a 195 kDa protein present at 1.3 mg/ml in human serum, making this protein the most abundant of the complement factors. The data depicted in Fig. 4 reveal the presence of C3 complement protein in alligator serum. The densitometric analysis of the C3 bands (data not shown) show a 2.3-fold decrease in intensity of the C3 band in alligator serum despite a three-fold increase in sample load on the gel. Although the interactions are relatively weak, the fact that antibodies directed toward human C3 protein bind to alligator C3 complement shows the similar surface antigenic character of human and alligator proteins. These findings contrast those reported by Eggersten et al. that showed no cross-reactivity of human C3 antisera to cobra C3 complement protein. In addition, the same approximate cathodal migration on the native agarose gel reveals a similar charge/mass ratio for the alligator and human C3 proteins. The presence of the C3 protein in both humans and alligators exhibits the immunological importance of this protein in host defense.

The use of sheep red blood cell (SRBC) hemolytic assays has been used for years to assess the functionality of serum complement in the clinical laboratory. The data shown in Table 2 exhibits the ability of human and alligator serum to disrupt SRBCs. The ability of alligator serum to hemolyse SRBCs is another similarity of the complement-like activities of alligator and human sera. The incubation of sera at classical complement inactivation conditions (56oC, 30 min.) disabled the hemolytic capacity of the samples. The addition of C3 antibodies neutralized the ability of the serum complement system from both species to hemolyze the cells.

The study describes potent and broad-spectrum antibacterial activities in the serum of the American alligator. The results also represent the first report of serum complement activity in a crocodilian species. The complement system is shown to exhibit similar functional and molecular properties of mammalian complement. We believe that the complement system may be responsible for the antibacterial properties of alligator serum.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of Dr. William Taylor of the Department of Biological and Environmental Sciences at McNeese State University and Phillip "Scooter" Trosclair with the Louisiana Department of Wildlife and Fisheries. This research project was supported by the Shearman Research Initiative Fund, Pfizer Global Research, and McNeese State University TASC.

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Pix Skin Disease in the American Alligator (*Alligator mississippiensis*)

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ABSTRACT: "PIX" is the trivial name for a type of scar found on alligator hides. PIX scars are small pits about 1mm in diameter, located primarily in the ventral neck, abdomen and tail region, and designated as PIX by the tannery because they appear to be small pits in the hide made with an ice pick. The incidence of PIX in alligator hides from farms has dramatically increased since November of 1999. The potential seriousness of an increased incidence of PIX becomes apparent when the hides are presented for grading, where damaged hides may be downgraded by as much as 50% and more recently, some hides were branded as total rejects (no value). Hides from alligators greater than four feet in length have the highest incidence of PIX, which indicated that an increase in the incidence of PIX was associated with increases in age of the alligator and suggests prolonged exposure of the animals to an infectious agent. Histological studies showed that the PIX pit results from eruption of an epidermal granuloma. Therefore, epidermal granulomas are considered to be pre-PIX lesions. *Hortaea werneckii*, a primary pathogenic fungus found in the skin of animals has been isolated from a granuloma found in a severe case of PIX. Studies on the occurrence of PIX scars on hides from farms with a high incidence of PIX showed that more than 40% of the hides from a single lot may be severely affected and that 100 or more scars can be present on a single hide. This finding suggested that an increased incidence of PIX may follow a systemic mycosis caused by a primary pathogenic fungus such as *Hortaea werneckii*. Milder PIX infections may be caused by a systemic mycosis of opportunistic fungi that are of lower pathogenicity but can infect a host with a weakened immune system. Our studies indicate that good sanitation and the treatment of pen water with an antifungal agent such as chlorine should reduce the severity of PIX infections. Preliminary results indicate that these preventative measures are effective.

ACKNOWLEDGEMENTS

The authors wish to thank Mr. E. L. Froehlich, Mr. Noel Kinler, Dr Ruth Elsey, and Mr. Ted Joanen for providing their information and assistance. Mr. Wayne T. McClellan and Mr. Joseph P. Cardeilhac provided technical assistance. This research was supported by a grant from the Louisiana Department of Wildlife and Fisheries Fur and Alligator Council.

Environmental Contaminants, Gonadal Development and Alligators: From Genes to Populations

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ABSTRACT: Many chemicals introduced into the environment by humans adversely affect embryonic development and the functioning of the vertebrate reproductive system. It has been hypothesized that many developmental alterations are due to the endocrine disruptive effects of various ubiquitous environmental contaminants. The endocrine system exhibits an organizational effect on the developing embryo, altering gene expression and dosing. Thus, a disruption of the normal hormonal signals can permanently modify the organization and future functioning of the reproductive system. We have worked extensively with contaminant-exposed and reference populations of the American alligator (*Alligator mississippiensi*s) as well as performed a number of experimental studies exposing developing embryos to various persistent and non-persistent pesticides. Using this specie*s*, we have described altered steroidogenesis and follicular morphology in the ovary of females living in polluted environments. A number of these alterations mimic those reported in DES-exposed rodents. Egg dosing studies, with total egg pesticide exposures of 100 picomolar or greater have produced alterations in gonadal steroidogenesis, secondary sex characteristics and gonadal anatomy that are similar to those reported in wild populations. Further, studies of males have documented differences in testicular release of inhibin B and gene expression of $P450_{arom}$ and SF-1, using homologous probes and quantitative rtPCR. Following our the recent cloning of alligator estrogen receptor alpha and beta ($ER_{\alpha,\beta}$), as well as the progesterone (PR), thyroid (TR_{β}) and androgen (AR) receptors, studies have begun to examine ontogenic and environmental influences on ovarianand testicular expression and function[1]. In summary, these descriptive and experimental studies have begun to provide an understanding of the causal relationships between embryonic pesticide exposure and reproductive abnormalities that have been lacking in previous field studies of wildlife populations. An understanding of the developmental consequences of endocrine disruption in wildlife can lead to new indicators of exposure and a better understanding of the most sensitive life stages and the consequences of exposure during these periods for other crocodilians. Research funded in part by grants from the US EPA (#R824760-01-0; CR826357-01-1) and the NIEHS (#PR471470).

[1] Work performed in collaboration with the laboratories of Prof. Taisen Iguchi, National Institutes of Basic Biology, Okazaki Japan, Dr. Caren Helbing, Dept. Biochemistry and Molecular Biology, Victoria University, Canada and Dr. Teresa Woodruff, Biochemistry and Molecular Biology, Northwestern University

Developmental Alterations as a Result of Embryonic Exposure to the Pesticide Metabolite p,p'-DDE in *Alligator mississippiensis*

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ABSTRACT: Altered circulating hormone concentrations and *in vitro* steroidogenesis, and reduced phallus size have been reported in several juvenile alligator populations Florida. It has been hypothesized that these abnormalities are the result of contaminant exposure during embryonic development. Organochlorine pesticides such as DDT and its metabolites DDE and DDD have been implicated as being hormonally active—possibly acting as environmental estrogens or anti-androgens in developing embryos. The purpose of this study was to determine the effects of *in ovo* exposure to DDE on neonatal alligator development and endocrine function. Eggs were obtained from Lake Woodruff National Wildlife Refuge and treated topically with either p,p'-DDE or estradiol-17β (E_2) in 50 μl of ethanol at doses of 100, 0.1, or 0.0001 μg/kg just prior to the temperature sensitive period of sex determination. Following incubation at 32^o C, untreated and ethanol treated (vehicle control) eggs resulted in 60 % females, whereas 33.5^o C produced 97 % males. DDE altered sex determination at 32^o C only at the highest concentration used (87.5 % females) and did not affect sex determination at 33.5^o C, whereas E_2 produced a greater percentage of females at both temperatures. There were no detectable differences in plasma testosterone (T) or *in vitro* E_2 production among any of the groups. Thyroid to body mass and spleen to body mass ratios were greater in DDE treated animals than controls at 32^o and 33.5^o C respectively, whereas E_2 increased spleen and liver mass respective of body mass at 33.5^o C. These results indicate that DDE has weak estrogenic or anti-androgenic effects on sexual differentiation and development, but does not explain some of the alterations in endocrine function reported in contaminant exposed populations.

Thiamine Status and Mortality of Adult American Alligators (*Alligator mississippiensis)* in Lakes Griffin and Woodruff in Central Florida during 2000 and 2001.

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ABSTRACT: Abnormal behavior and mortality of adult American alligators (*Alligator mississippiensis)* and reduced alligator hatch rates have been observed in Lake Griffin in central Florida. Schoeb et al., 2002 and our own continuing work has found no association between mortality and environmental contaminants, toxins, viruses, or cyano-bacteria. However, results of brain tissue histology and lethargic behavior in these animals suggested a similarity with early mortality syndrome (EMS) in salmonids (Schoeb et al. 2002). The present study was conducted to evaluate thiamin status in eggs, liver and muscle of Florida alligators collected in 2000 and 2001. Total egg thiamine in 2000 was lower in eggs from Lake Griffin (0.4 nmol/g) and Lake Apoka, (0.6 nmol/g) than from reference lake (Orange Lake 3.1 nmol/g). Muscle total thiamine values were lower than in liver which is similar to data from salmonids. Samples from farmed alligators were found to have the highest total thiamine (liver, 3.58 nmol/g, muscle 0.49 nmol/g). Thiamine content of alligator muscle is more similar to walleye than salmonid muscle. Significant differences in total thiamine were noted in adult alligator muscle and liver in 2000 between sick alligatorsand alligators classified as healthy but absolute thiamine values may

have been affected by freeze-thaw before analysis. In 2001, correctly handled liver and muscle again showed differences in thiamine. We propose that large populations of Gizzard Shad (*Dorosoma cepedianum*)in Lake Griffin may be a source of thiaminase. These results provide supportive evidence that thiamine deficiency is involved in alligator mortality of adults and developing embryos. Alligator mortality has declined markedly in spring 2002. One possible explanation is that over one million pounds of gizzard shad were removed from the lake by commercial fishing thus reducing the source of thiaminase. Preliminary data indicate that alligators ate fewer shad in this period than in earlier years.

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Ecotoxicology of Morelet's Crocodile in Belize

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ABSTRACT: Reproductive impairment and population declines have been reported for American alligators (*Alligator mississippiensis*) inhabiting contaminated lakes in Florida, USA. The principle objective of this study is to examine exposure and response of another crocodilian, Morelet's crocodile (*Crocodylus moreletii*), to environmental contaminants in Belize and assess the effect of these chemicals at the individual and population levels. In 1995, we found contaminants including mercury and multiple organochlorine (OC) pesticides in Morelet's crocodile eggs from three lagoons in northern Belize. We now hypothesize that crocodiles inhabiting contaminated lagoons contain higher contaminant concentrations in their tissues than individuals in non-contaminated areas, and that differences in crocodile morphology, blood hormone levels, serum chemistry, reproductive success, population density, and survival exist between contaminated and non-contaminated sites. From 1997-2000, approximately 650 crocodiles were captured, sampled, and released from areas in north-central Belize for examination of exposure and response to environmental contaminants. In addition, various endpoints of reproductive success, population density, and survival were measured. In this paper, we present and discuss results obtained to date.

Crocs in the Pews: Interfacing Crocodilian Conservation with Church Mission Activities

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ABSTRACT: Although the major religious denominations of the world have always been at the forefront of concerns for moral and ethical issues, environmental concerns, particularly those related to the conservation of wildlife resources, have only recently been addressed by the church. Church mission work, in many under-developed parts of the world, takes place in many regions that are important for the survival of endangered wildlife. In such regions, church infrastructures offer a vast but as yet untapped potential resource for the development and support of programs for the sustainable use and conservation of wildlife. As an example, we describe the potential for the inclusion of crocodilian conservation concerns in the overseas mission work of the Presbyterian Church (USA) in Sudan, Niger and Nigeria. Specifically, we suggest ways in which church support could prove helpful in providing: (1) travel and logistical support for researchers and conservation workers in remote regions, (2) information/data on the status, distribution and potential for the utilization of crocodilian populations, (3) expanded opportunities for contacts to gain the support of local government officials, and (4) promotion of the local acceptance of the principles of sustained-use, particularly as they apply to the management of wild crocodilian populations. In return, development of crocodilian resources on a sustained-use basis can provide local economic development and support for church social programs in the region.

INTRODUCTION

Throughout the course of human history, a number of important causes have come on the scene only to sputter, stumble and stall until they became the focus of national or global organized religious denominations. Although such causes often enjoyed significant grass-roots support in their early stages, it really wasn't until the organized religious establishment of the time became active in support of the cause that national thinking began to transform generational thinking and genuine change and progress began to take place. A good example of this process has been the issue of racial relations and civil rights in areas such as the southern United States. Here, churches eventually became a seat of activism and coordination in pursuit of what had previously been a more disorganized and certainly less effective effort to transform national attitudes. The result has been the replacement of a widespread attitude of racial hatred and suspicion with more rational thinking, sympathy and support at both the national and individual level.

The so-called "Green Revolution" of environmental concern began to sweep the more developed countries of the world with the initial Earth Day in the early 1970's. However, in many of the underdeveloped parts of the world where critical natural resources may still remain available for management or exploitation, environmental thinking and concerns have only recently begun to become parts of national programs and priorities. The church itself, with the exception of certain eastern religions such as Hinduism and Buddhism, has similarly only recently begun to accept the fact that it has a responsibility to not only support but become active in the conservation and wise/sustainable use of environmental resources, including wildlife populations. Generally considered as "creation restoration", this thinking is based on the premise that God is the creator of the earth and all of its environmental resources. It is therefore man's responsibility to provide wise stewardship for this creation upon which all life on this planet depends (Stivers, 1989; Andrews, 1990).

We present here as an example of this process, a brief history of the development of environmental awareness, leading to activism and finally institutionalized programs in the area of environmental concerns and conservation within a major North American Church denomination, the Presbyterian Church (USA) (PCUSA). We will then show how some of these institutionalized programs have now begun to interface with the issue of the conservation of wild crocodilian populations through the concept of sustainable use based on sound scientifically-based management programs. We will show how this interface has particularly developed within the Africa Office of the Worldwide Ministries Division of the PCUSA's General Assembly Office in Louisville, Kentucky, USA, with support from the church's Office of Social/Environmental Concerns. Finally we will suggest specific ways in which this newly developing interface may soon bear fruit in terms of concerns for the assessment of the status and conservation/sustainable use of wild populations of crocodilians in Nigeria, Niger and Sudan.

ENVIRONMENTAL CONCERNS AND THE PRESBYTERIAN CHURCH: A BRIEF HISTORY

The first concrete recognition of the importance of environmental stewardship by the PCUSA came in the form of a 1990 report (Andrews, 1990) that identified these concerns as a legitimate and scripturally-justified part of the church's mission in the world today. This position statement was written as a response to an earlier grass-roots report (Stivers, 1989) which had been submitted to the national administrative body of the PCUSA a year earlier. The resulting church position statement was then distributed throughout the church body with a recommendation that it be used within congregations as a study document. The aim was to encourage further dialogue, thinking and commitment concerning the restoration and conservation of all forms of environmental resources - particularly those that had been in the past or are now being degraded, threatened or endangered by man's activities. One of the most important and tangible results of the dissemination of this report was to commission and train a nationwide network of "Restoration Creation Enablers" (RCE's). The RCE program was administered by the PCUSA Office of Environmental Justice which had been established at the church's national General Assembly headquarters. RCE's serve as grass roots volunteers, with one being appointed within each of the church's 173 geographic administrative units (presbyteries) within the United States. It then became the responsibility of each commissioned RCE to stimulate and coordinate environmental initiatives within their local area, although broader thinking on national and even global scales was also strongly encouraged.

An often-unappreciated aspect of the church's efforts to establish appropriate environmental programs has been the importance of including within such programs, a sound foundation of basic principles of environmental science (ecology). These scientific principles have been developed from programs of research and are based on a familiarity with the published scientific literature. They are needed (although the need is often not appreciated within many church circles) to determine which positions are appropriate for the church to support and/or which actions are proper for it to take. Appropriately, there is now, within the PCUSA, a movement to better understand and reconcile the interface between science and religion. This movement is being undertaken by the Presbyterian Association for Science, Technology and Christian Faith (PASTCF). However, most of the membership in this organization and much of the focus of its activities has been in the areas of the philosophy of science, cosmology and physics; until recently there has been relatively little interaction between this group and the environmental activities of the church. In the summer of 1998 however, an opportunity arose to combine the environmental concerns of the PCUSA with the interests of the PASTCF in bringing environmental science into an active role in the life of the church. Furthermore, as will be explained below, the focus of both of these areas was then brought to bear on an issue of particular importance to the work of the IUCN Crocodile Specialist Group (CSG). This issue is the way in which science has now demonstrated that economic benefits can be associated with sound conservation policy through the application of sustainable-use (Balmford et al., 2002; Leshner, 2002).

THE CHURCH MEETS SCIENCE: SUSTAINABLE - USE

As indicated above, many elements of the major religious denominations have adopted a strongly pro-environmental stance whether or not they have actively put it into practice. In the case of some denominations such as the PCUSA, this stance has been embodied in strong statements supporting the maintenance of world biodiversity and the protection of endangered species. The biblical story tells of the first endangered species project - Noah and his ark. The teaching is clear, that God wills for each species on earth to continue (Andrews, 1990).

Supporting this position, many well-meaning elements of the church joined the call from the "Green Revolution" in deploring the utilization of products from endangered species. Andrews (1990) for example, in establishing a template for environmental action of the Presbyterian Church (USA), called for the implementation of a policy to, "Prohibit trade in endangered wild animals and endangered plants, or products derived from them".

Unfortunately, this well-intentioned policy became yet one more element of a general societal attitude of prejudice against the use of legitimately marketed wildlife products such as crocodilian leather goods, which may be similar in appearance to those of closely related endangered forms. As described by Ross (1998), misunderstanding by the public in this regard has been exacerbated by misguided information promoted by some conservation groups discouraging the use of all such wildlife products. Information of this kind, when disseminated to the public, invariably fails to make a distinction between those products produced by legitimate sustained-use programs of harvest or ranching vs. those obtained illegally from endangered species. Moreover, as also pointed-out by Ross (1998) and Webb (2000), any resulting decrease in the worldwide demand for luxury crocodilian leather goods depresses market prices for raw crocodilian hides. This in turn reduces the profits that may accrue to local people who own or at least have harvest/management rights to legitimately usable non-endangered crocodilian resources. This in turn then reduces the incentives of such people for managing these resources on a sustained-use basis. Thus, in an ironic way, well-meaning programs initially intended to save and protect endangered crocodilian species may, in some instances, actually now be working to hinder their recovery. This hindrance is now coming in the form of threats to those very programs of sustained-use harvest which have repeatedly proved their importance in the recovery of crocodilian populations in many parts of the world (Webb, 2000). All of this stems from a basic lack of understanding on the part of the church and other elements of today's society of the basic principles of sustained-use science, particularly as they pertain to crocodilians.

As explained in detail by Webb (2000) and Messel (1991), the science of sustained-use management of crocodilian populations is based on the fact that wild nests of these species invariably produce many more young than ever reach maturity and enter the breeding population of subsequent generations. Management programs, generally in a form known as "ranching", begin with removing all or nearly all of the eggs from wild nests. These eggs are hatched in captivity and the young are raised to a size at which they can be considered to be safe from the myriad of predators and other sources of mortality that frequently befall small hatchlings in the wild. A percentage of these partly-grown "head started" immature animals are then be returned to the wild population while the remainder are marketed as meat and leather to produce (often substantial) income for local peoples. The keys to the success of this approach are important advances in nutrition and other aspects of the husbandry of captive crocodilians (e.g. Brisbin et al., 1990). These advances can now, under appropriate conditions, allow enough hatchlings to be marketed to realize financial profits while still returning more animals to the wild than would ever have resulted from the wild nests in the first place. Careful monitoring programs are required however, to ensure that levels of egg removal are not having detrimental effects on the numbers or population dynamics of the wild populations from which they are being taken.

As illustrated by Temsiripong et al. (2000), such monitoring programs must be based on sound scientific principles of population biology and must consider a number of factors such as hatch rates of wild vs. harvested clutches of eggs, growth and survival rates of repatriated vs. wild immatures, etc. Any of these factors moreover can interact in compensatory or contradictory ways, again requiring a thorough understanding of the basic population biology of the species under consideration in the particular region where harvest/ranching programs have been proposed.

Because of the long-term experience of many of its members in studies of these very scientific principles, the CSG has become an important player in the monitoring and evaluation of the effects that any proposed program of sustained-use harvest and/or ranching may be having on wild crocodilian populations. In this capacity, the CSG can bring together the interests of governments who want to establish harvest programs within their national boundaries, with those interests of conservation groups, (and/or churches), which want to ensure that such programs do not harm the very populations upon which they are based.

CHURCH MISSION AND CROCODILE CONSERVATION

The initial interfacing of the interests of the PCUSA in the areas of science and environmental concern with the work of the CSG came about during the meeting of the latter's Steering Committee in Singapore in July, 1998. At this meeting there was discussion of a request from the Wild Life Conservation Administration of the Ministry of Interior of the Republic of Sudan seeking assistance in initiating a program to collect data on the status and distribution of crocodile (*Crocodylus niloticus)* populations in that country. The eventual aim was to use this information to justify a program of sustained-use harvest and/or ranching of crocodiles, resulting in the production of products for export into the world trade. There was great interest within the Steering Committee in seeing crocodile surveys initiated in that nation. The Sudan has variously been claimed to have the largest crocodile population of any nation in Africa with total numbers estimated as high as one million animals (Elobeid, 1990). However logistic constraints quickly came to light, related to a long on-going state of civil war which has prevented safe access to many areas of important crocodile habitat, particularly in the southern part of that country.

The PCUSA however has had a long-standing program of humanitarian missionary concern in parts of the southern Sudan (Welch and Ryan, 2000). It was therefore hoped that the considerable infrastructure and familiarity of those involved with "on the ground" PCUSA missionary activities in that region could somehow help to facilitate plans for the collection of the needed crocodile survey data. Then, when military conflicts are finally resolved, the required information database could be more expeditiously collected and sustained-use programs of crocodile harvest/ranching could begin to provide badly needed economic benefits to all of the people of that nation. Unfortunately, the continuation of military conflicts in Sudan has so far prevented any such survey activities from taking place. However, the thinking outlined above has at least had the benefit of now bringing-together the program interests of the Africa Office of the Worldwide Ministries Division of the PCUSA and the work of the CSG. It was this contact that eventually resulted in the extension of thinking similar to that outlined above, for the nations of Niger and Nigeria where there have been more opportunities to develop cooperative program interests between the PCUSA and the CSG.

THE PRESBYTERIAN CHURCH (USA) IN AFRICA AND CROCODILES: WHERE CAN WE GO FROM HERE?

As indicated above, on-the ground Sudan crocodile surveys, even those taking advantage of church missionary infrastructure in that region, can not begin until a stable peace has been established allowing open contact and cooperation in this effort between the government in the north and rebel forces in the south. However humanitarian relief efforts in the south of Sudan, such as the United Nations' Operation Lifeline Sudan, have operated relief flights into the south from a base camp in Lokichokio, Kenya (Spinney, 1996). These flights have provided valuable information in the past on the status and distribution of other wildlife resources, particularly large grazing herbivores, in this region. It may therefore be possible for church/humanitarian groups to work through such programs to begin to obtain at least some of the preliminary information needed by the Sudan government, concerning crocodile status and distribution in this region.

In the meantime however, the interests of the church (PCUSA) in developing the concept of sustained-use crocodile harvest/ranching in Sudan has attracted the interests of Presbyterian church elements in at least two other African nations, Niger and Nigeria. Of the two, by far the greater potential for the development of crocodile resources is in Nigeria where the extensive mangroves and marsh habitats of the Niger River Delta in the southeastern part of that country, offer the possibility of extensive suitable crocodile habitat (Luiselli and Akani, 2002). However as pointed-out by those authors and by references cited therein, Nile crocodiles are generally rare in this region which is under heavy pressure of habitat disturbance and destruction from oil-exploration activities. Thorbjarnarson (1992) reports declines of crocodiles in Nigeria attributed to hide hunting, and Luiselli et al. (2000) report that juvenile *C. niloticus* occasionally appear in the bush-meat trade. Crocodiles can still be found however in the less accessible areas of mangrove creeks and marshes that also seem to serve as refuge habitat for African rock pythons (*Python sebae*; Luiselli and Akani, 2002). These pythons are also hunted intensively by local peoples for meat and leather, so there does seem to be a potential for a formalized commercialization of trade in reptilian meat and leather goods in this area. However, exploited populations have apparently yet to be harvested on a sustained-use basis since Luiselli and Akani (2002) report that like crocodiles, pythons are widespread but also in general decline throughout this region. Competing oil interests almost guarantee that any efforts to establish crocodile harvest/ranching programs in this area will have to present an economically competitive alternative use of habitat resources - particularly with regard to economic returns to local people. It is precisely in this latter respect however, that CSG-fostered programs of sustained use (sensu Webb, 2000) can make an important contribution, particularly if they can be introduced and promoted by a church-mediated program establishing grass-roots support and education through local church congregations.

In the case of Niger, crocodile populations are almost certainly less abundant than in either Sudan or Nigeria, due mostly to lesser amounts of suitable habitat. Moreover there is relatively little known about crocodile populations in that country and no recent information exists for numbers or distribution. On the ground inquiries however, conducted in the spring of 2002 in the course of other activities of the Africa Office of the Worldwide Ministries Division of the PCUSA (DMW), suggest that crocodiles are rarely hunted in Niger. Thus their population numbers are probably relatively stable in that country. Nevertheless, crocodiles are officially protected by law 98-07 which was enacted in April 1998 to regulate hunting and the protection of wildlife. Crocodile meat is consumed to some extent by local peoples in Niger and local church contacts suggest that there is interest in pursuing the idea of crocodile farming/ranching. However technical guidance would need to be provided by outside groups (e.g. the CSG) which are experienced in this area of in situ local economic development.

As in the case of Niger described above, our initial inquiries suggest that the potential is high for church connections to assist in the development of viable and economically profitable crocodilian farming/ranching programs in a number of African countries. The only exceptions are those cases where current conditions would make on-the-scene visits either dangerous or impractical, as is currently the case with Sudan. Even there however, experience gained from the use of church connections to initiate such programs in other countries (e.g. Niger and Nigeria) could help convince governmental officials and local peoples alike of the value of such an approach to combining conservation concerns with local economic development once national peace has been achieved. If nothing else, our initial experiences as outlined above, suggest that the time is now right to begin to "spread the word" to other church denominations in Africa as well as other parts of the world, that sound conservation of crocodilian resources can go hand-in-hand with badly needed local economic development in these same regions.

A FINAL THOUGHT: THE CHURCH, CROCS AND BUSH-MEAT

Like so many other topics of environmental concern, the conservation and management of world populations of wild crocodilians through sustained-use is not an isolated issue. Rather it is part of the larger issue of the science of sustained-use for a wide variety of environmental resources. This issue has recently come to the fore of global environmental thinking and action (Balmford et al., 2002; Leshner, 2002). Both of these citations however show that there must be a firm understanding of the basic science involved in order to have reasonable expectations of a successful outcome for such programs.

Nowhere is thinking on conservation through sustainable-use more ripe for application than in the developing countries of the African continent. Yet nowhere is there now a clearer need for the input and assistance of those experienced in all aspects of the science of sustainable-use. In the case of crocodilians, this role can and should, we maintain, be played by the CSG. Furthermore, we believe that the church may be just the vehicle needed in some instances to introduce CSG thinking in such a way as to maximize the probability of its acceptance by local peoples. When so "preached from the pulpits" of local congregations, the sustained-use of crocodile products such as meat and leather would almost certainly have a greater probability of acceptance. In addition, a church-CSG collaboration may also prove more effective than either would be alone in avoiding some of the common pitfalls that often plague small-scale business/production start-up activities in under-developed parts of the world. In return, the substantial economic benefits that could be provided to local peoples by such programs would help fulfill many aspects of the church's mission of humanitarian outreach in such regions.

When introduced in this way, the sustained-use of crocodilian leather and particularly meat could also offer an alternative to the meat of great apes and other wildlife species that currently form part of the bush-meat trade, but not on a sustained-use basis (Pearce, 1996; Ammann, 1999). Juvenile crocodiles and other reptilian species are already traded and are apparently accepted as part of the bush-meat trade (Akani et al., 1998; Luiselli et al., 2000). We believe that meat from crocodiles that have been carefully ranched under conditions guided by the best principles of the science of sustained use (Webb, 2000); (Messel, 1991), have the potential to provide an even cheaper source of higher-quality protein than bush-meat from other wild species. Moreover, its use in this way could also serve the purposes of the conservation value system that should be espoused by church mission activities in these areas.

Realizing such a win-win situation will almost certainly demand considerable mutual cross-education and a redirection of thinking on the part of both the church and the world conservation community. We believe that the CSG is in a position to now begin to make just such cross-education and redirected thinking a reality for model programs for the conservation and sustainable-use of African crocodiles in countries such as those discussed above. Furthermore, we feel that such efforts may yield dividends of a broader conservation significance than to just crocodilians alone - if for no other reason than for the simple importance of initiating a dialogue between church mission activities and conservation interests in this and other parts of the developing world.

ACKNOWLEDGMENTS

We are grateful for the support of those particular individuals and groups who encouraged us to think outside of the box with regard to our exploration of this unique interface between two diverse areas of societal concern. Deserving of special mention are the encouragement of Perran Ross, Executive Officer, and Richard Fergusson, Vice Chairman for Africa, both of the IUCN/SSC Crocodile Specialist Group, and the members of the Division of Mission and Sudan Task Force Subcommittee of the Presbyterian Church (USA)'s Trinity Presbytery, South Carolina, USA. Manuscript preparation was supported in part through Financial Assistance Award DE-FC09-96SR1845 from the U.S. Department of Energy to the University of Georgia Research Foundation.

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Human-Crocodile Conflict in Belize: A Summary

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Two species of crocodiles are indigenous to Belize, Morelet's crocodile (*Crocodylus moreletii*) and the American crocodile (*Crocodylus acutus*) (Groombridge, 1987). While Morelet's crocodile is typically found in interior freshwater habitats and the American crocodile in offshore saltwater habitats, the two species are also known to live sympatrically in areas of brackish water along the coast (Platt and Thorbjarnarson, 1997; Rainwater et al. 1998). While anecdotal testimony suggests crocodile attacks on humans in Belize have historically involved American crocodiles, the majority of the documented cases appear to involve only Morelet's crocodiles.

Previous accounts of crocodile aggression and attacks on humans in Belize persist in the literature (Morelet, 1871; Sanderson, 1941; Abercrombie et al. 1982; Marlin et al. 1995; and Rainwater et al. 2000). Attacks have also been documented in Guatemala and Mexico (Neill, 1971 and Alvarez del Toro, 1974). Additional anecdotal accounts exist in Belize as oral testimony, but the accuracy of these accounts is questionable. In each of the cases listed, causal factors responsible for attacks on humans appeared to vary.

On the afternoon of 12 August 2001, while swimming in a canal in the Belama area of Belize City, a 13 year-old male named Jamaal Swift drowned as a result of attack by a large crocodile. Following the attack, Mr. Swift's body was recovered and inspected by the Belize City coroner who confirmed the cause of death to be drowning. Only limited puncture wounds were observed about the legs (M. Windsor pers. comm.).

On 14 August 2001, at approximately 2200 hours, a group comprised of personnel from Belize Forestry, Texas Tech University, and Lamanai Outpost Lodge captured an adult male Morelet's crocodile in a canal adjacent to (and approximately 500 meters away from) the location of the attack. The specimen captured measured 284.5 cm (total length), weighed 97.5 kg, and upon necropsy stomach content analysis revealed chicken remains, a nail, and multiple rocks (M. Windsor pers. comm.).

Following the death of Mr. Swift, media and concerned citizens stressed the need for a nationwide crocodile management strategy in Belize. As a result, the Belize government contacted the Florida Association of Volunteer Agencies for Caribbean Action who in turn contacted Dr. Frank Mazzotti to make assessments and recommendations for the mitigation of human-crocodile conflict.

Morelet's crocodile is currently recognized as endangered under the United States Endangered Species Act (ESA), listed on Appendix I of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) and is protected domestically under the Belize Wildlife Protection Act of 1981. Following near-extirpation in the late 1970's, Morelet's crocodile populations experienced substantial recovery as a result of its protection status. In addition to an increasing crocodile population, Belize has also experienced rapid growth in its human population over the last few decades (Figure 1).

Increases in both human and crocodile populations potentially increase contact between the two groups and thus increase the possibility of conflict. Exacerbating this problem is the development of Morelet's crocodile habitat around Belize City. A similar problem exists offshore with the construction of resorts and the development of crucial nesting habitat for the American crocodile.

Development of a crocodile management plan is needed in Belize to effectively address nuisance crocodiles, development and encroachment of crocodile habitat, and most importantly public education regarding crocodiles.

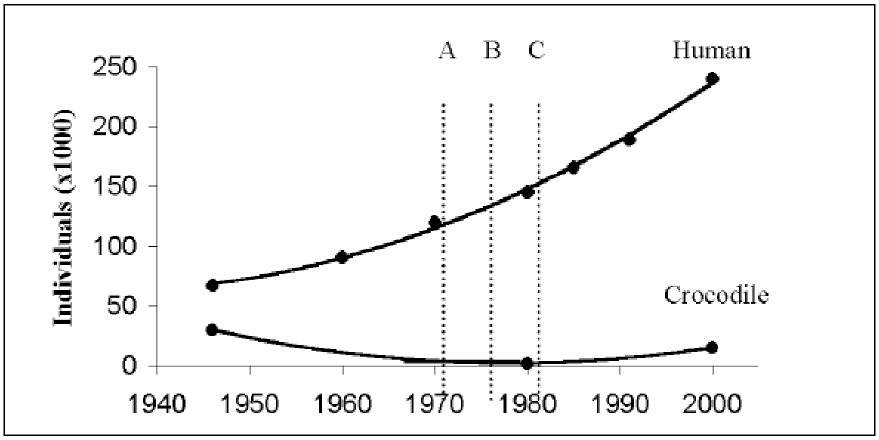

Figure 1. Estimated Human-Morelet's crocodile population size changes in relation to conservation legislation (A. ESA listed in 1970, B. CITES listed in 1975, and C. Belize Wildlife Protection Act of 1981). Human population data provided by the Belize Central Statistical Office.

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Interacción Hombre-Cocodrilo en la Costa de Jalisco, México.

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ABSTRACT: The coast of Jalisco has 52 water bodies and 35 have crocodile populations. The principal problem of the conservation of the species in this State is because the accidents happened with crocodiles. That is why it is important to study the problem to determine solutions for the extinction of these animals. To carry out this project we visited most of the water bodies where we made interviews to the local people trying to find people who had been attacked by a crocodile. We are registered 16 accidents since 1958, most of them with local people, adult crocodiles and related with fishing activities. Some of this accidents occurred during reproductive season. We found since 1993, the accidents are increasing because the raise the human activity near the estuaries as well as the growth of crocodile population. Therefore it is necessary to begin environmental education with focus in the crocodile and the importance of its habitat in addition to inform them about the risks and how to avoid them.

Keywords: Accidents, *Crocodylus acutus*, Coast of Jalisco, Mexico.

RESUMEN

La costa de Jalisco cuenta con 52 cuerpos de agua costeros, de los cuales, en 35 existen cocodrilos. El principal problema para la conservación de la especie en el Estado se debe a los accidentes ocurridos con cocodrilos; por esta razón es importante estudiar este problema para determinar y dar solución para evitar la extinción de estos animales. Para llevar a cabo este proyecto se visitaron la mayoría de los cuerpos de agua donde se hicieron entrevistas a la gente local, para encontrar gente que hubiera sufrido un accidente con cocodrilos. Se registraron 16 accidentes desde 1958, la mayoría ocurridos durante la temporada reproductiva, además, desde 1993, los accidentes se han incrementado debido al crecimiento de las actividades humanas cerca de los esteros así como el crecimiento de las poblaciones de cocodrilos. Sin embargo, es necesario comenzar un programa de educación ambiental con foco en los cocodrilos y la importancia de su hábitat, además de informar a la gente sobre los riesgos que existen y como evitarlos.

Palabras Clave: Accidentes, Crocodylus acutus, Costa de Jalisco, México.

INTRODUCCIÓN

Cuando el hombre apareció en la Tierra, los cocodrilos ya se encontraban establecidos en ella y nuestros ancestros vivían en armonía con los cocodrilos. Sin embargo, como sucede en el mundo entero donde habita el cocodrilo, el incremento de la población humana cambia el ambiente provocando día a día su fragmentación y la invasión de su territorio. Ya que se trata de un depredador, que además representa un valor económico en su piel, ha sido cazado durante décadas produciendo la declinación de las poblaciones. Además, éstos son destruidos indirectamente con la destrucción de su hábitat (Butler, 1987).

En México, durante los años 40 y posteriormente en los 60´s se presentó la explotación irracional de la piel de cocodrilo, junto con la de tortuga marina. Con esto se vino una disminución de la especie que la llevó casi a la extinción. A partir de 1970 se decretó la protección de las tres especies de cocodrilianos mexicanos. A partir de ahí y a pesar de existir la cacería furtiva, las poblaciones se han ido incrementando, gracias también a la creación de reservas en donde el cocodrilo es protegido. Por otro lado, el crecimiento de la población humana ha ido invadiendo terreno que una vez perteneció a los cocodrilos, por esta razón los habitantes de la costa creen que el cocodrilo es el que ha invadido las lagunas costeras.

Desde principios de los 90 se ha llevado a cabo un monitoreo sobre los accidentes y sus causas para analizar los problemas y buscar soluciones adecuadas a estos, que se incrementa día a día. Este proyecto forma parte del Plan de Conservación del "caimán" (*Crocodylus acutus)* que se realizó para el estado de Jalisco (Ponce y Huerta, 1997).

Durante las diferentes investigaciones que se han realizado en torno al cocodrilo en Jalisco para su conservación, al igual que otros lugares como Costa Rica (Jiménez, 1998), se encontró que uno de los principales problemas se debe a los accidentes ocurridos generalmente con la gente local.

Debido a esto es importante estudiar la problemática hombre-cocodrilos (accidentes) ya que cada vez que ocurren accidentes se pretende eliminar a la especie, de tal forma que es necesario encontrar nuevas perspectivas para que la gente comprenda su importancia. Esto se puede lograr con programas productivos en donde los cocodrilianos aporten recursos para las comunidades.

METODOLOGÍA

Para llevar a cabo las investigaciones sobre los accidentes se aprovecharon las visitas hechas a la mayoría de los cuerpos de agua costeros monitoreados, y se entrevistaron pescadores en las principales cooperativas de la costa, gente local en poblaciones cercanas a bocas de ríos, esteros, lagunas y áreas inundables. Los datos principales que se analizaron fueron, fuente o informante, si la información de este fue por terceras personas, por testigos de los accidentes o los mismos accidentados. Además se tomaron datos del lugar donde ocurrió el accidente, datos sobre el animal involucrado, información general del accidentado como edad, sexo, actividad que realizaba, si tenía conocimientos de la presencia de cocodrilos en el lugar, nivel de agua en la persona, si nadaba o buceaba durante el accidente, entre otros. Algunos de los casos se les dio seguimiento durante varios años, en diferentes visitas y con diferentes entrevistados. En ocasiones se habló con el accidentado o con testigos, para verificar la validez de la información y de ésta forma evitar reportar la información no confiable.

RESULTADOS

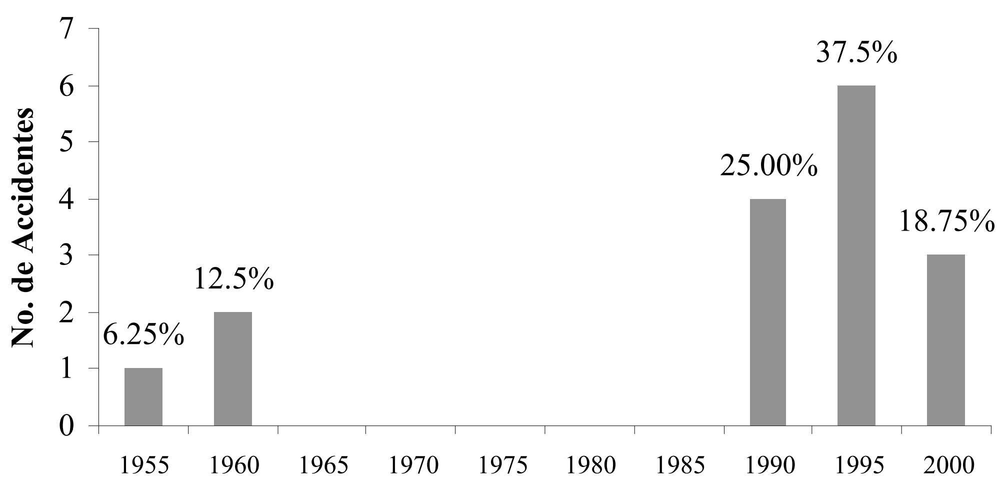

Figura 1. Gráfica donde se muestra el número de accidentes por cada 5 años

El accidente más antiguo registrado data de 1958, y para los años 60 se reportan 2 más. Sin embargo a partir de ahí no se reporta otro accidente hasta el año de 1991. Esto se debe a que a finales de los 60 habían exterminado casi por completo las poblaciones de cocodrilos en la costa, y para los 90 hubo una recuperación de estas, las cuales se fueron extendiendo por todos los cuerpos de agua costeros. Sin embargo, para finales de los 90 y principios del 2000, se reportan más de la mitad (56.15%) de los accidentes registrados.

El 37.5% de las personas accidentadas dijeron haber tenido el agua arriba de la cintura, mientras que el 31.25% debajo de la misma. El 18.75 % se encontraba nadando o buceando y el 12.5% no se determinó. De acuerdo a las edades de estas personas, el 62% eran adultos mayores a los 25 años, el 19% jóvenes entre los 15 y 20 años de edad y el otro 19% niños entre los 3 y los 10 años. Solo en 2 de los accidentes resultó con pérdidas humanas, un niño de 3 años aproximadamente en los años 60 y un buzo de Tecomán que se metió a pescar en el Río Marabasco. En estos dos casos no se vio al animal que los atacó, solamente desaparecieron.

El 62.5% de las personas accidentadas fueron gente local, el 12% turistas y el 25% de ellos eran residentes de la costa que fueron a pescar a otra localidad. En total fueron 15 hombres y una mujer. El 87.5% de los encuentros fueron con animales adultos de más de 2 m, de los cuales, el 28.6% fueron animales arriba de los 3 m de longitud total y el 14.3% animales de más de 2m.

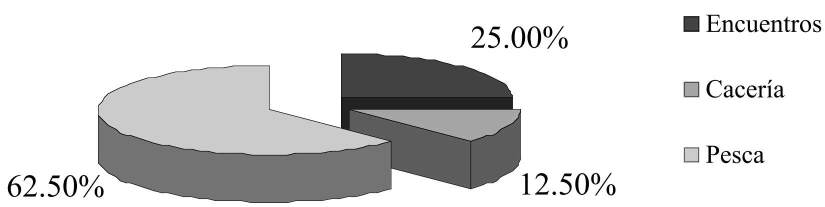

Figura 2. Porcentajes de accidentes debida a encuentros accidentales con cocodrilos, cacería de cocodrilos o pesca en los esteros.

DISCUSIÓN Y CONCLUSIONES

Dos de los accidentes registrados coinciden con la temporada reproductiva, cuando la especie es más activa y agresiva (Lazcano-Barrero, 1996). Nueve accidentes coinciden con la temporada de nacimientos. Seis accidentes se relacionan con actividades de pesca con el agua a la cintura o más arriba, 3 de estos por traer pescado colgando, al igual que 4 de los 7 accidentes reportados por Lazcano-Barrero (1996) en Quintana Roo.

A diferencia de otras partes del mundo, en Jalisco solo se ha reportado dos muertes causada por cocodrilos. En Madagascar, Behra (1996) reporta 140 ataques de los cuales, 57 causaron la muerte de la víctima y Jiménez (1998) reporta 3 muertes desde 1995 en Costa Rica. Según la información obtenida en todos los casos donde se han reportado accidentes, las personas sabían de la presencia de cocodrilos al igual que los accidentes ocurridos en Jalisco con excepción del niño turista y de la persona que falleció a principios de los años sesenta.

A partir de 1993 se han incrementado los accidentes, pero la frecuencia no ha sido tan alta como la reportada por Lazcano-Barrero (1996) quien reporta siete accidentes en un periodo de seis meses. Este incremento se asocia con el aumento de la actividad humana en los esteros, principalmente la pesca. De 1995 a la fecha han ocurrido nueve accidentes. El accidente más grave ocurrido después de la pérdida humana, es el del río Cuitzmala.

Por medio de las investigaciones que se han llevado a cabo a través del plan de conservación del cocodrilo en Jalisco, se están determinando categorías para los diferentes cuerpos de agua costeros y áreas inundables con el fin de establecer prioridades y estrategias de conservación con base en la problemática.

Algunas de las acciones urgentes que se pretenden realizar en la costa de Jalisco, es la creación de centros de investigación y conservación del "caimán". En primer plano, estos lugares servirán para introducir animales problema, además de exhibirlos, hacer investigación, implementar programas de educación ambiental, evitar la captura y el tráfico ilegal de la especie, entre otros. Esto se puede apoyar con lo ocurrido en Quintana Roo, Jalisco y otros estados, donde los animales problema son llevados a un zoológico o a otros lugares que generalmente no tiene la capacidad suficiente para todos estos animales.

Otra acción importante es informar a la gente local, pescadores y turistas para que conozcan los riesgos y como evitarlos por medio de trípticos, letreros y pláticas a diferentes niveles. Esto se está comenzando en el estero de La Manzanilla con la participación de profesores locales, profesores de la Universidad Pedagógica Nacional y David Collins.

AGRADECIMIENTOS

Agradecemos las atenciones y la información que proporcionaron los accidentados y la gente local que nos apoyó como Gilberto Hernández y Juan Cervantes, Sr. Andrés Aceves Franco, Don José en la Cruz de Loreto. También queremos agradecer al Biól. Marciano Valtierra de Cuxmala, A. C. y al Biól. Julian Gamboa voluntario de Bosque Tropical, A. C

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Crocodilians: Fact vs. Fiction

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ABSTRACT: This is a discussion of crocodilian behaviors witnessed at the St. Augustine Alligator Farm. There are four specific topics discussed:

Crocodilians have the ability to swallow prey under water: We have witnessed *Crocodylus johnsoni, Crocodylus porosus,* and *Tomistoma schlegelii* swallowing their food without coming to the surface.

Crocodilians eating their vegetables: Is it possible that biologists have been assuming too much when doing stomach content surveys on crocodilians? We have compelling evidence that alligators in captivity, at least, may seek out vegetation in their diet.

Siamese Crocodiles as parents: A two-year account of a pair of *Crocodylus siamensis* raising young on exhibit at the St. Augustine Alligator Farm.

Crocodilians feeding their young?: Observations of a female *Crocodylus siamensis* allowing her young to feed from a piece of meat in her mouth.

INTRODUCTION

The St. Augustine Alligator Farm has been in existence for almost 110 years. Its name is a little misleading. It is not a true alligator farm. There is no production of skins or meat at the facility, and there never has been. It is a zoological park, accredited with the American Zoo and Aquarium Association (AZA). The facility started in 1893 by displaying only American Alligators, *Alligator mississippiensis*. It has now grown to include other reptiles, birds, small primates, and the world's only complete collection of all 23 species of crocodilians. The following are four accounts of observations of crocodilian behavior that tend to go against the current literature or common thought.

Crocodilians have the ability to swallow prey under water: The palatal valve, in the back of a crocodilian's mouth, is a unique adaptation that seals the throat off from both air and water. With the palatal valve shut a crocodilian can grasp food underwater and not have the water flood past into the esophagus or glottis. Essentially the inside of a crocodilian's mouth is outside its body. Crocodilians obviously prefer to keep this palatal valve closed while submerged, and come to the surface to swallow their food, thus avoiding water rushing past the palatal valve. It is often assumed that crocodilians are unable to swallow food underwater. However, we have witnessed three crocodilian species swallowing their food underwater. The first is a female Freshwater crocodile, *Crocodylus johnsoni,* housed alone. On several occasions she has picked up pieces of meat from the bottom of the pool and proceeded to eat them without surfacing. Once this behavior was noticed, it became a regular observation.

The second observation is of a female saltwater crocodile, *Crocodylus porosus*, housed with its mate. This female swallows both above the water and below, seeming to not have any preference for one over the other. When she surfaces, after swallowing underwater, she has been observed purging excess water at the surface. This appears to be done by contracting muscles in the throat. Water can be seen spraying out of the mouth from the palatal valve.

The third species we have observed swallowing underwater is a female false gavial, *Tomistoma schlegelii*. She is currently housed in a large exhibit with another female and a male. This exhibit affords visitors a complete underwater view of the entire pool though four large glass panels. Soon after moving the female to this exhibit, I witnessed her taking a piece of meat to the bottom of the pool and holding it. After about five minutes, she very deliberately partially opened her mouth, then opened her palatal valve, and quickly moved her head forward and swallowed the meat. She remained in a resting position on the bottom of the pool for another ten minutes. Because she had recently come to us from Audubon zoo, I called the reptile staff there and asked if they had witnessed this behavior. They said that they had. Apparently the male *Tomistoma* at this facility was in the habit of stealing the female's food if she surfaced with it. I have witnessed her swallowing underwater on only one other occasion. I believe the behavior is being extinguished by our training efforts, as our male does not have an opportunity to steal meat from the females.

Figure 1: Male Siamese Crocodile, *Crocodylus siamensis* showing palatal valve.

Crocodilians eating their vegetables: Scientific literature is filled with research regarding the stomach contents of crocodilians. Almost all of them refer to the plant material found in the animals' stomachs as either an accident (i.e., the crocodilian got leaves in its mouth while trying to swallow a prey item), or secondary (i.e., the crocodilian swallowed a prey item that had grass or leaves in its stomach). One such article lists plants as a "nonfood item", but notes that the plants were found in ninety percent of the animals sampled. In the summer of 2000, some of our keepers said that they had been seeing American alligators eating fruit from the elderberry plants in the Swamp exhibit. Of course I wanted to blame this on the fact that the alligator must have seen an anole or some other animal in the plants and lunged for it. The keepers were fairly persistent, saying that the alligator had gotten a mouth full of elderberry, swallowed, and then gone back for more. Reports of the alligators eating elderberry, as well as wild grape, from plants in the Swamp exhibit happened several more times that year and have continued over the following years.

In May of 2001, we began a mixed species exhibit which includes: American alligators, Chinese alligators (*Alligator sinensis*), brown caiman (*Caiman crocodilus*), dwarf caiman (*Paleosuchus palpebrosus*), dwarf crocodiles (*Osteolaemus tetraspis*), mugger crocodiles (*Crocodylus palustris*), *and* red-foot tortoises, (*Geochelone carbonaria*). The keepers reported observing American and Chinese alligators eating out of the tortoises' dishes. Again, I was inclined to explain this away by saying that the alligators must have been attracted to the food dishes by the movement of the tortoises, and just accidentally eaten some lettuce. However, it is now a common sight to see the alligators at the tortoise bowls eating romaine lettuce and yellow squash. Sometimes the alligators even beat the tortoises to the dishes. We have had plenty of opportunity to record this behavior on videotape.

There are several citrus trees in this mixed species exhibit. Occasionally, we have witnessed alligators running around with an orange or lemon in their mouth, trying to keep it away from the other animals. It eventually gets chewed up or torn by other animals and swallowed. In March of this year, we watched as an American alligator raised itself into the lower parts of a small kumquat tree and grabbed fruit directly from the tree. In the course of a few minutes, we observed this same individual swallowing the fruit and going back for several more kumquats.

In August 2002, some of our park visitors reported seeing an American alligator "sit-up" and remove a lime from one of the trees and proceed to chew it up and swallow it.

We are not exactly sure why alligators in our park are eating their vegetables. It is possible that our animals, in captivity, are lacking something in their diet that makes them seek out vegetation. Or, is it possible that crocodilians deliberately consume vegetation as part of their normal diet?

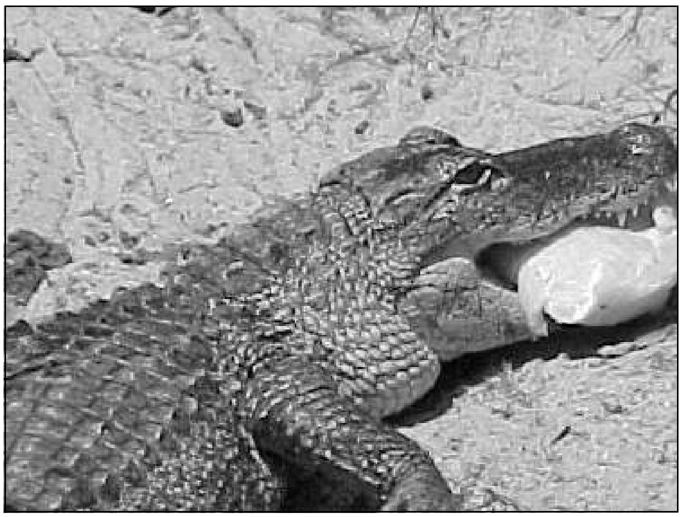

Figure 2: American Alligator, *Alligator mississippiensis* eating a lemon from a tree in its exhibit.

Siamese Crocodiles as parents: In May of 2000 the St. Augustine Alligator Farm decided to do things a little differently. Typically, when the alligators or crocodiles lay eggs the keepers collect the eggs and put them in an incubator. There are several reasons for this. The success rate of artificially incubated eggs is usually higher, the sex of the animals can be controlled by the temperature at which they are incubated, and it keeps the larger animals in the enclosure from eating the hatchlings. Though mother alligators are usually very good parents, some literature implies that male American Alligators tend to be unconcerned with their offspring, or worse yet, have been known to eat the hatchlings. Because of multiple paternity, it is possible the males don't even know which hatchlings are theirs. It is also possible, that observations have been misinterpreted. Neill points out, in his 1971 book, that except in very controlled circumstances, it is difficult to say with any accuracy whether an alligator is male or female just by looking at it, much less know if it was, in fact, the parent of the alligator being eaten.

While Neill is not willing to authenticate observations of adult alligators cannibalizing their own young, he is quick to disregard any possibility of crocodilians playing a significant role as attentive parents. However, the following two accounts might have changed even Neill's mind.

On May 21, 2000 our female Siamese crocodile built a beautiful nest right in the front of her exhibit. We decided to leave the nest alone for all of the visitors to see. We had no idea what would happen. There were any number of things that could have gone wrong. The nest could have been too dry, fire ants could have claimed the eggs, or the male could have eaten all of the young as they came out of the nest. We just had to wait patiently. It turns out the nest was built over a sprinkler head which kept the inside of the nest quite moist. Ants were seen several times at the nest, but were controlled. And when it came time to prove the male's intentions, he performed admirably.

We are unsure exactly when the female actually laid the eggs in the nest mound. One week after the mound was built, we gently opened the top of the nest and removed the top three eggs. They were nicely banded and we put them in our incubator, just to make sure some of the clutch would survive.

At 7:30 am, on August 13, 2000, about seven weeks later, the female was seen lying on the nest mound with her head cocked sideways appearing as though she were listening to the nest. By 8:30 am eight hatchlings were out of the nest and eggshells were noticed floating, or laying on the bottom of the pool. As we watched, the female slowly used her front legs to pull dirt away from the top of the nest. When she uncovered a hatchling, she gently picked it up in her mouth and carried it to the water. If she uncovered an egg that was not yet hatched, she gently broke the egg with her mouth, scooped up the baby and again carried it to the water. Sometimes the hatchlings were still attached to the egg by their yolk and both baby and egg would be carried to the water. One little guy had quite a struggle as the egg he was attached to started to fill up with water and began to drag him under. He was pulled partially under water before he managed to wiggle his way free.

By 12:30pm the female got out of the pool and started to bask. There were seventeen hatchlings all huddled together at the edge of the pool, and it was assumed that this would be all that would hatch. But, at 2:45 the female returned to the nest and removed four more hatchlings.

The adult male stayed in the water during this entire process, and was quite curious as the female brought the babies to the pool. He swam over to almost every new release and watched as things went on. He never made an aggressive move toward any of the hatchlings.

On several occasions the female brought whole, unopened eggs to the water and released them. The eggs floated, and she left them, with no apparent interest in their future. The adult male bumped into one of these eggs as he was patrolling the pool. He gently picked it up in his mouth. At first, it looked as though he swallowed it, but he rolled it around on his tongue for almost a minute, and then gently broke it open. He then rinsed the shell out of his mouth, but the egg was empty. There is no way of knowing for sure, but it appeared that he was trying to open the egg and release a baby, just as the female had done. After opening the first egg, he seemed to patrol the pool more diligently, even diving to the bottom of the pool and gently breaking open what was left of hatched eggs. The male never went to the nest to retrieve eggs or young, but did open several of these infertile eggs. His basking site is near the nest mound, and twice during the day he crawled out and basked near the nest.

One week after hatching, the baby crocodiles started chasing and eating crickets and mealworms that were tossed into the exhibit. They are fed worms, crickets, and gator chow every two or three days. On August 25, 2000, twelve days after hatching, many of the babies were seen basking on the back of the parent crocodiles. This has been a common sight on warm afternoons ever since. When in the water, babies tend to congregate around the parents' heads, some even resting on the adults' heads as if they were a floating island.

The goal of leaving the nest alone was to allow our visitors be able to see the nest, the hatching, and now a family unit of crocodilians on display. It has been a great success. Visitors who take the time to look carefully can see many of the baby crocodiles usually, lined up at the edge of the pool. This is not the first time that the St. Augustine Alligator Farm has hatched Siamese Crocodiles, but it is the first time that we have allowed the parents to do all of the work. The three eggs that we put in the incubator from the nest hatched three days after the eggs in the exhibit hatched. We have since introduced these three babies back to the exhibit and they have been accepted into the family unit.

As long as we had this unique setup, we decided to try a couple of experiments. First, three yearling crocodiles were added to the exhibit to see how the parents reacted. These yearling crocodiles were offspring from the adults, but had never seen their parents, as they were artificially incubated and raised separate from the adults. The adults accepted these juveniles in the exhibit as well, and all are living comfortably together.

Secondly, we introduced a couple of hatchling American alligators. This introduction was very interesting as well. The alligators did not seem to mind being with the crocodiles their own size, but were intimidated by the adults. While the juvenile Siamese crocodiles would congregate around the adults (even the yearlings), the juvenile alligators would swim away from them. Early on, there were several occasions that the alligators were seen around the adult crocodiles, but the alligators seemed shocked when the adults moved, and they swam away quickly. This test was performed to see if the parent crocodiles could distinguish between hatchling species. It is generally accepted that some crocodilian species will guard their offspring in nurseries. In other words, one female may guard offspring from several females in the area. One of the hatchling alligators did not survive in the exhibit. It appeared to have been accidentally crushed by a basking adult. However, one American alligator now seems to be just as comfortable as the young crocodiles and can still be seen, more than two years later, swimming, feeding, and basking with its surrogate family.

Figure 3: Male Siamese Crocodile, *Crocodylus siamensis* allowing the young to bask with him.

Crocodilians feeding their young?: More and more we are realizing how closely birds and crocodilians are related. They have many similar adaptations and behaviors. However, one distinct difference is that crocodilians are not known to feed their young. Unlike most birds, hatchling crocodiles are ready to feed on their own soon after hatching. In spite of this, there have been occasional observations that may suggest that some parent crocodilians provide a little extra help to their offspring.

McIlhenny, in his 1935 book, claimed to have seen American Alligators feeding their young on eight different occasions. A private individual in Florida claims to have seen his broad-snouted caiman, *Caiman latirostris* tearing pieces of meat from a large feeder rat and feeding the smaller pieces to their hatchlings. Blohm, in 1982, said that he witnessed an adult Orinoco crocodile, *Crocodylus intermedius* offering food to hatchling animals.

On two occasions, we have witnessed our adult female Siamese crocodile allowing her hatchlings to eat meat from her mouth. This has only happened twice in almost two years, and did not occur until the hatchlings were more than a year old. The adult Siamese crocodiles are shifted off exhibit when they are fed. This gives the keepers a chance to count the hatchlings, clean the exhibit, and trim the plants. Both adults usually swallow their food almost immediately. However, on these two occasions the female still had a large piece of nutria in her mouth when she was released from the shift cage. The female sat for more than an hour with the meat protruding out of her mouth, allowing the hatchlings to tear off small pieces of meat. The adult male attempted to take the meat away from the female, but she just got up and walked away. Once, she even got in the pool to avoid the male's attempts, but she crawled right back on the bank and held the meat in her jaws until the hatchlings began feeding again.

Many people have read my account of this event, and there are many skeptics that think I might be exaggerating what I saw. However, once they see the event captured on video, there is no doubt that the female allowed the hatchlings to feed from the meat in her mouth. I do not pretend to know what this means. I am not assuming that all crocodilians feed their young, or even that this particular female intended to feed her young. I can only say that she did not mind the hatchlings eating her meal. It is entirely possible that she was just not hungry, and decided to hold the meat for later.

The adult male in this exhibit has been a great father to the hatchlings; he is protective and cautious around them. He is also very food motivated and has never been seen attempting to share his meals with the hatchlings. In addition to attempting to steal meals from the female, I have even seen him try to take the occasional large piece of meat from the hatchlings. He is very gentle about it; trying to only get a hold of the meat without touching a hatchling, even to the point of quickly pulling his head back if a hatchling was accidentally in the way. To prove his good intentions, I have seen him basking with his mouth open just after eating. Hatchlings have crawled in his mouth looking for the meat that they can still smell. One even tried to bite his tongue. The male is very patient, but really does not like the young crocodiles in his mouth, and he gently turns his head and shakes them out.

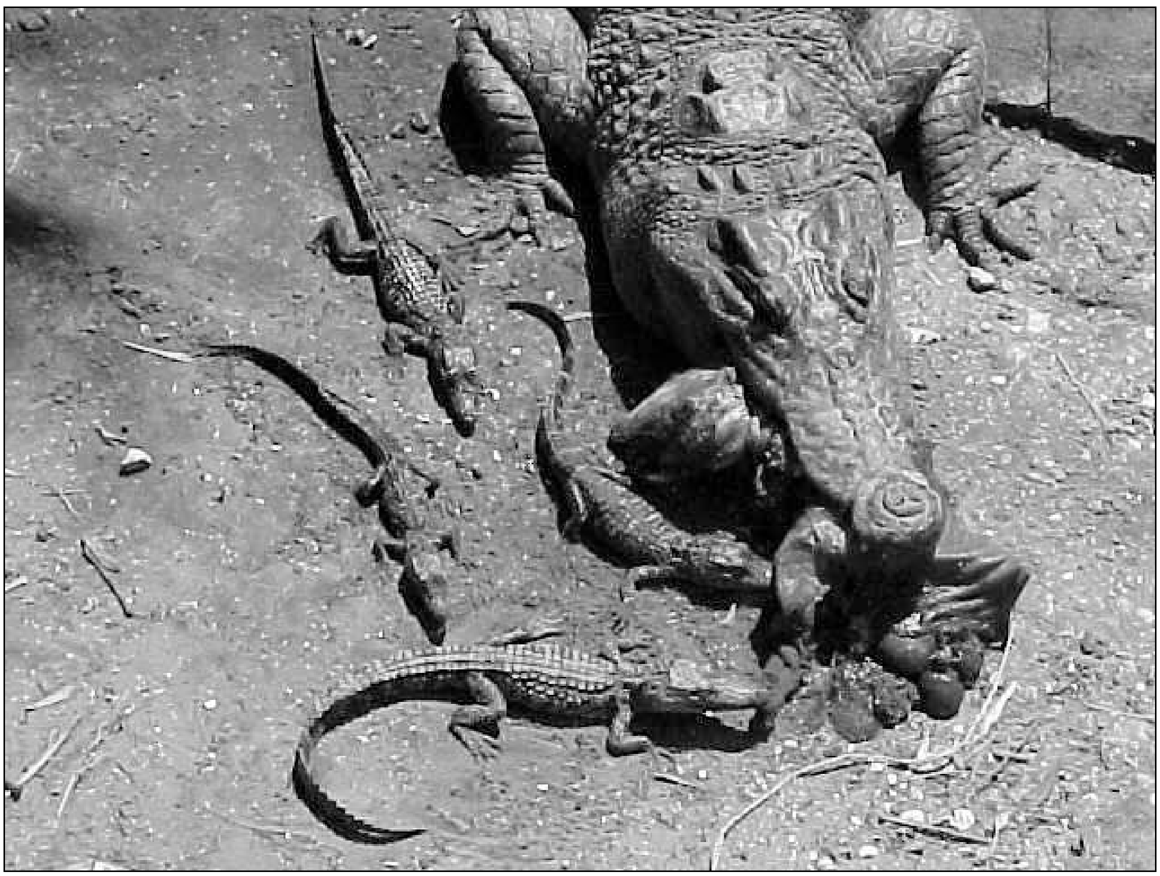

Figure 4: Female Siamese Crocodile, *Crocodylus siamensis* allowing her young and one adopted American Alligator, *Alligator mississippiensis* (closest to the adult) to eat some of her meal.

CONCLUSION

Crocodilian behavior is often overlooked because we tend to think of them as prehistoric, and therefore too primitive to have complicated behavior. We have also been quick to dismiss all of a particular author's writings, because they were not completely accurate in everything they wrote. I am not the first to suggest that crocodilians swallow under water or that they may feed their young, but other authors have often been ignored because of errors elsewhere in their observations or because so few others have witnessed these behaviors for themselves. It is my assertion that crocodilian behavior deserves a more in depth look, as I am confident they have much more to teach us.

ACKNOWLEDGMENTS

I am very grateful to the animal staff at the St. Augustine Alligator Farm for being so observant. This paper is made up of observations that could have very easily been overlooked if it were not for their diligence and dedication. Thanks to the Reptile department: Shannon Chapman, Jim Darlington, David Kledzik, Thomas Rexroad, and Shelly Triplett. I would also like to thank David Drysdale for his continued support of our efforts. Lastly, I would like to thank my mentor, Dr. Kent Vliet for his knowledge, insight, and encouragement.

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DNA Tools and Resources for Crocodilian Research

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ABSTRACT: Many new tools for the analysis of DNA from crocodilians have been developed. These tools can be used for the study and identification of individuals, family groups, populations, and species. The biological and genetic basis for 2 types of markers now available for most crocodilians – mitochondrial DNA and microsatellite DNA loci – will be explained. Examples from our previous research will be used to illustrate the potential utility of these DNA tools. Specific information about the DNA tools now available, PowerPoint slides used for this presentation, abstracts of research presented at the 2nd International Crocodilian DNA Workshop, as well as a variety of additional resources are available from the Crocodilian DNA Information Repository (follow links from http://BadDNA.srel.edu).

Nuclear RAG-1 and Mitochondrial Control Region Sequences of the Order Crocodylia: Phylogenetics Implications with Emphasis on the Family Crocodylidae

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ABSTRACT: Crocodilians comprise an ancient and ecologically diverse group and the phylogeny of the Order Crocodylia has been the subject of numerous molecular and morphological studies. While several recent studies have focused on the so-called "gharial problem" – a conflict between morphological and molecular data sets on the relationships between the true and false gharials and their position relative to the rest of the order -, the intrafamilial relationships of the Crocodylidae have been largely ignored. Here, we address both aspects of Crocodylian phylogenetics using the nuclear RAG-1 gene for higher-level relationships and the more variable mitochondrial control region sequences for relationships within *Crocodylus*. Results of nuclear sequence analyses conform to other molecular studies by placing the alligators and caiman as ancient sister lineages, uniting the two gharials as sister taxa of a possibly recent origin, and confirming the recent radiation within family Crocodylidae. Mitochondrial control region sequence analyses agree with morphological studies by uniting the New World forms with the Nile crocodile and by placing *Crocodylus cataphractus* and *Osteolaemus tetraspis* as basal within the family.

Genetics on *Caiman latirostris*

Luciano M. Verdade, Rodrigo B. Zucoloto, Priscilla M.S. Vilela and Luiz L. Coutinho

ABSTRACT: *Caiman latirostris* is an endangered mid-sized South America crocodilian. In the state of Sao Paulo there is an increasing interest on its economic use and also on the conservation of its remaining wild populations. In order to provide genetic management for the captive breeding program of the species by farmers and also in order to understand the use of space by the species in the wild we have developed molecular markers from $(ACC\text{-}TGG)_n$ and $(AC\text{-}TG)_n$ enriched microsatellite DNA library. Since 1988 the captive colony of the species managed by the University of Sao Paulo has already furnished more than 500 captive-born animals from F1, F2, and F3 generations to nine farmers. The animals are individually marked and annually reported by the Regional Studbook of the species in Brazil, managed by the University of Sao Paulo in SPARKS software by ISIS. Parentage tests have been applied to the captive colony when necessary in order to establish individual pedigrees by the use of molecular markers. Combined use of morphometric and genetic methods to assess site of origin of wild individuals on a microgeographic scale has been relatively inefficient, but effectiveness might be improved by an increase in sample size and subject variables (i.e., morphological measurements and DNA markers). Preliminary genetic results suggest, however, that the wild groups sampled are composed predominantly by related individuals. A possible combination between high mortality and low natality rates results in a low number of successfully dispersed individuals per generation. Future studies might help us to understand metapopulacional processes that are possibly occurring with the species in São Paulo, Brazil.

Population Genetic Structure of Amazonian Crocodilians: Preliminary Results

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ABSTRACT: We used the mitochondrial cytochrome *b* gene to study the population genetic structure of *Melanosuchus niger* (from Negro, Purus and Amazonas rivers, and French Guiana), and *Caiman crocodilus* (from Purus and Amazonas rivers). We found 11 haplotypes in both species. In both species one common haplotype predominated, while the other haplotypes were rare. Tajima´s D statistic test was not statistically significant in *M. niger*; it showed that the population is at a genetic equilibrium. However, this test was significantly negative in *C. crocodilus* (D=-2.239, p<0.01), i.e. there is a significant excess of the number of segregating sites compared to the average pair-wise sequence divergence. This pattern is frequently observed in populations undergoing a rapid demographic expansion. Gene flow in *C. crocodilus* was also high (Nm = ~16). *Melanosuchus niger* showed significant population structuring and differentiation among all population (F_{ST}=0.31; P<0.05) with lower gene flow (Nm = ~3). These results are compatible with the life-style of the two crocodilians; *C. crocodilus* is a habitat generalist and appears to disperse rapidly to newly available habitats, while *M. niger* is a more sedentary habitat specialist.

INTRODUCTION

The smaller spectacled caiman (*Caiman crocodilus*) and the black caiman (*Melanosuchus niger*), have a long history of overexploitation in the Amazon. Intense commercial skin hunting that started in the 1930's continued into the 1980's (Medem, 1983). The commercial importance of the Amazon crocodiles can be appreciated in the descriptions of Fittkau (1970), Medem (1971; 1983), Magnusson (1979), Smith (1980), and Rebêlo and Magnusson (1983) documenting that millions of Amazonian crocodilians were slaughtered for their skins. The commercial hunting drastically decreased the numbers of these two crocodilians, particularly *M. niger*, throughout the Amazon basin. Despite the Brazilian Federal Laws that prohibit all commercial hunting, and IUCN conservation dependent status of *M. niger*, illegal hunting continues throughout the year, threatening the survival of these species (Da Silveira and Thorbjarnarson, 1999). While historical hunting was primarily for the skin trade, current hunting of crocodilians is primarily for their meat fueled by local demand (Da Silveira and

Thorbjarnarson, 1999). Therefore it is necessary to formulate and implement a realistic conservation policy for both species that takes local socioeconomic needs into account.

Preliminary ecological studies suggest that these two crocodilians from the Amazon are very different in terms of life history and reproductive patterns (Da Silveira et al., 1997; Da Silveira and Magnusson, 1999; Thorbjarnarson and Da Silveira, 2000). However, nothing is known about the genetic structure, or about the population genetic indicators of effective population sizes and gene flow among populations of these species. These data are vital for the conservation management of wild populations, as well as for the management of captive breeding efforts. It is with this motivation that we proceed to investigate the population genetic structure of the Amazon crocodiles.

The analysis of mitochondrial DNA (mtDNA) polymorphisms within and between populations is useful for defining Evolutionary Significant Units (ESUs) and Management Units (MUs) (Moritz, 1994) since the distribution of genetic variability within and among populations is affected by historical events and by recurrent factors (Templeton et al., 1995). The high substitution rate of the mitochondrial DNA has facilitated reconstruction of intraspecific phylogenetic relationships and resolved population structure in a variety of taxa. The mitochondrial cytochrome *b* gene is widely used in systematic studies to resolve divergences at many taxonomic levels from "deep" phylogenies to the population and recent divergence levels (Johns and Avise, 1998), including crocodilians (Glenn et al., 2002). We therefore sequence the cytochrome *b* gene, and use the sequence data to conduct a preliminary study the biogeography and the population genetic structure of *Melanosuchus niger* and *Caiman crocodilus* in Amazônia.

MATERIAL AND METHODS

Tissue samples were collected from the tail scales obtained during the marking of adults and hatchlings. Scales were preserved in 95% ethanol, and once in the laboratory stored in a freezer. Samples of *Melanosuchus niger* were collected from Anavilhanas archipelago (N=17), Lake Janauacá (Solimões-Amazonas River, N=8), and Purus River (N=8), and from Kew Swamps (N=13). Samples of *Caiman crocodilus* were collected from Lake Janauacá (N=11) and Purus river (N=13). Tissue samples were dissolved and digested with a Proteinase K/SDS solution, followed by phenol-chloroform extraction, the addition of 5M NaCl, and a final 70% ethanol precipitation of DNA product (Sambrook et al., 1989).

The complete mitochondrial cytochrome *b* gene was amplified by Polymerase Chain Reaction (PCR) using the primers listed in Table 1. Protocol is as follows: denaturation at 94°C for 35 seconds, annealing at 50°C for 35 seconds, and extension at 72°C for 1:30 minute repeated for 35 cycles. Sequencing reactions were performed according to the manufacturers recommendation using the Terminator Cycle Sequencing Kit (Amersham Pharmacia), and resolved a MegaBACE automated sequencer (Amersham Pharmacia).

Table 1. Sequencing primers used in the present study.

Primer Sequence	Reference
L14254 (5'-ATGACCCACCAACTACGAAAAT-3')	(Glenn et al., 2002)
L14731 (5'-TGTCGTGCCATGAATTTGAG-3')	(Glenn et al., 2002)
H14779 (5'-CGAATGGAAGGAGGAAGTG-3')	(Glenn et al., 2002)
H15454 (5'-GGTTCCGTCCACTTCTGTCTTACAA-3')	(Glenn et al., 2002)
H15982 (5'-TCCTRGCTTTGGTAGCCAGG-3')	This study

DATA ANALYSIS

Homologous protein-coding regions were aligned manually and confirmed by translating the DNA data into putative amino acid sequences in the program BioEdit (Hall, 1999). The present data set is composed of nearly complete cytochrome *b* gene sequences, which did not show any insertions or deletions (indels). A total of 46 individuals of *M. niger* from four locations, and 24 individuals of *C. caiman* from two locations were scored; the cytochrome *b* segment represented of 11 haplotypes defined by 12 segregating sites in *M. niger*, and 11 haplotypes defined by 15 segregating sites in *C. caiman*.

A number of statistical methods have been developed to infer historical processes shaping observed patterns of genetic distribution and diversity. The genetic equilibrium of mtDNA alleles was tested using Tajima's D test (Tajima, 1989). Although this test have been formally designed to test for selection, a significant deviation from genetic equilibrium in mtDNA alleles is most likely a result of recent population expansions or bottlenecks in situations where no selective advantage among haplotypes exists (Hartl and Clark, 1997). The hypothesis of a recent genetic bottleneck was tested for by looking for significant excess of common and of medium frequency alleles at the expense of rare alleles (Watterson, 1978). Population subdivision and structure was examined using an analysis of molecular variance (AMOVA) (Excoffier et al., 1992), and pair-wise population F_{ST} significance test (Cockerham and Weir, 1993) as implemented in the program ARLEQUIN (Schneider et al., 2000).

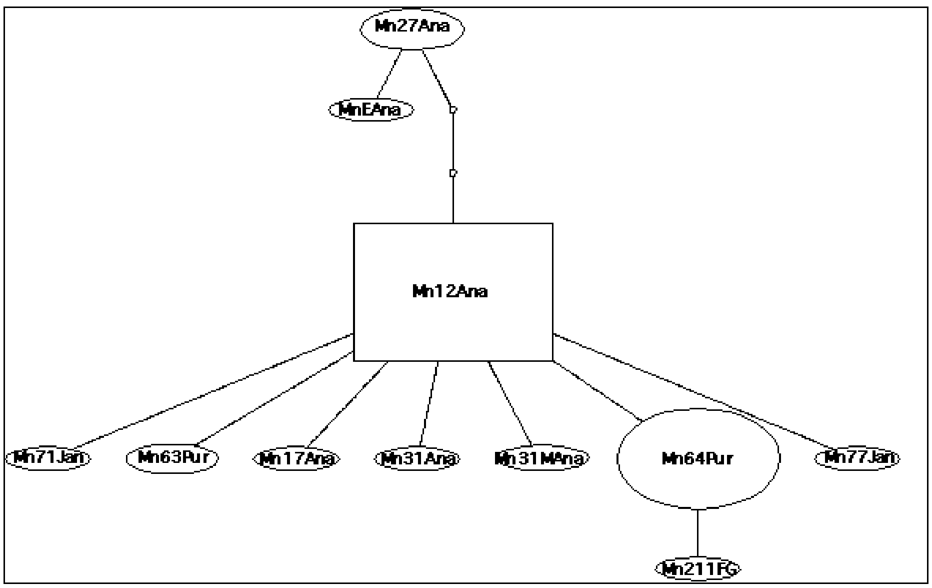

Figure 1. A minimum spanning network of *Melanosuchus niger* haplotypes. Mn12Ana is the most likely ancestral haplotype from which most other haplotypes are derived. Each oval represents a haplotype and the size of the oval is proportional to the number of individuals possessing that particular haplotype.

RESULTS AND DISCUSSIONS

We used the mitochondrial cytochrome *b* gene to study the biogeography and population genetics structure of the two Amazon crocodilians. Here we describe the first population genetic results for *Melanosuchus niger* (black caiman) and for *Caiman crocodilus* (spectacled caiman) from the Amazon basin.

Melanosuchus niger

A total of 46 individuals of *Melanosuchus niger* from four localities were scored. The final alignment comprised 871 positions of partial sequence of cytochrome *b* defining 11 haplotypes separated by 12 segregating sites (Fig. 1). The mean frequency base composition was 28% A, 24% T, 35% C and 13% G confirming a slight under representation of Guanine, as is normally observed in the mitochondrial genome (Zhang and Hewitt, 1996). One common haplotype predominates, while the other haplotypes are composed of rare haplotypes or singletons. Tajima´s D statistic test is not significant (D=-1.44, P>0.05), i.e., it shows that the population is at a genetic equilibrium with respect to mtDNA alleles. The negative result of Tajima´s D is suggestive of a population expansion, however, this result is not statistically significant. Implications for the *M. niger* as a whole is that it appears to be undergoing a recovery and a population expansion after laws have been passed that protect this species from uncontrolled hunting.

Melanosuchus niger shows significant amount of population structuring and differentiation among populations analyzed. Differentiation among population was inferred from Wright's *F* statistics (Wright 1951) that revealed a significant F_{ST} values among all comparison, except between Purus and Janauacá (F_{ST}=-0.02, P=0.78); Purus and Janauacá are also the only two localities to experience any significant between locality gene flow. In order to estimating the extent of subdivision between samples we pooled the four populations into three larger groups according to macrogeographical areas and water type, where Solimões region comprised Purus and Janauacá, rio Negro comprised the Anavilhanas archipelago, and French Guiana comprised Kew Swamps. AMOVA tests indicate that there is significant structuring in the data at all hierarchical levels. The mean source of genetic variation (69.4%) was attributable to variation within populations, –2.79% of the total variance referred to variance among populations within regions, and 33.4% to variance among regions. The F_{ST} value for the combined data from all groups was significantly greater than zero (F_{ST}=0.31; P<0.05). The female variance effective population is on the order of ~ 2.1 x 10^5 individuals.

Melanosuchus niger is restricted to floodplain lakes that are isolated hydrologically to a large degree from main river systems, thus isolation by distance would seem to be likely mechanism responsible for structuring. However, gene flow among localities does exist as seen in the Purus and Janauacá Lake samples that are geographically approximately equidistant to the Anavilhanas archipelago that is significantly isolated. Other factors, such as water type may therefore play a role in the geographic structuring of *M. niger*. Based on these preliminary mtDNA results, the presence of a population structuring suggests that *M. niger* will have to be divided in to different management units and possibly comprises different evolutionary significant units.

Caiman crocodilus

A total of 24 individuals of *Caiman crocodilus* from two localities were scored. The final alignment comprised 1188 positions of nearly complete sequence of cytochrome *b* and a non-coding spacer between cytochrome *b* and $tRNA^{Thr}$ defining 11 haplotypes separated by 15 segregating sites (Fig. 2). The mean frequency base composition was 31% A, 25% T, 33% C and 11% G confirming a slight under representation of Guanine, as is normally observed in the mitochondrial genome (Zhang and Hewitt, 1996). One common haplotype predominates, while the other haplotypes are composed of rare haplotypes or singletons. Tajima´s D statistic test is significantly negative (D= -2.239, p<0.01), i.e. it shows a significant excess of the number of segregating sites compared to the average pair-wise sequence divergence. This pattern is frequently observed in populations undergoing a rapid demographic expansion (Hartl and Clark, 1997) as would be expected in a prolific species released from hunting pressure.

AMOVA tests indicate that there is no significant structuring (F_{ST}=0.04, P=0.04 and that gene flow between the two localities is high (Nm ~ 16). The mean source of genetic variation was attributable to variation within populations (96%) and only 4% of the total variance referred to variance between populations. These results are compatible with the life style of *C. crocodilus*; *C. crocodilus* is a habitat generalist and appears to disperse rapidly to newly available habitats while *M. niger* is a habitat specialist. While census populations sizes of *C. crocodilus* are higher than those of *M. niger*, the female variance effective population is only on the order of ~1.78 x 10^5 individuals.

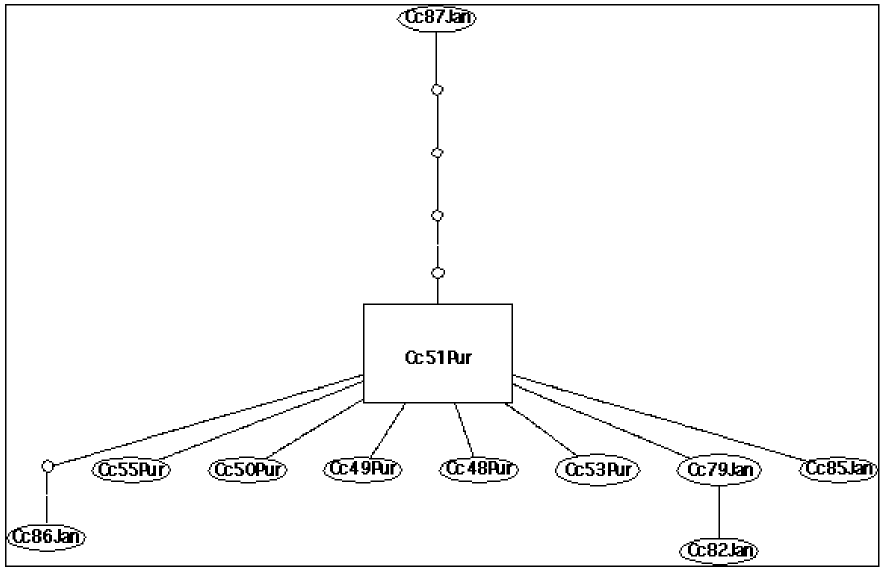

Figure 2. A minimum spanning network of *Caiman crocodilus* haplotypes. Cc51Pur is the most likely ancestral haplotype from which most other haplotypes are derived. Each oval represents a haplotype and the size of the oval is proportional to the number of individuals possessing that particular haplotype.

CONCLUSIONS

The cytochrome *b* gene has shown to be a good molecular maker to study population differentiation in the Amazon crocodiles. The two species analyzed in the present study are very different in terms of habitat use; *Melanosuchus niger* is a species restricted to floodplain lakes that are isolated hydrologically to a large degree from the main river systems while *Caiman crocodilus* is a habitat generalist. Our molecular data suggest that significant amount of genetic differentiation exists among *M. niger* populations, and populations inhabiting black water and white water regions of the Amazon basin may represent different evolutionary significant units, and certainly should be treated as separate management units. Additionally, *M. niger* appears to be undergoing a relatively slow demographic expansion, however, this result is not significant most likely due to its life history. *Caiman crocodilus* on the other hand is much more of a habitat generalist, and while some individuals may nest in floodplain lakes, the vast majority inhabit open lake systems and overflow channels whose water level fluctuates markedly during the year and facilitate dispersal. Molecular data suggest there is very little or no population structuring in this species. *Caiman crocodilus* appears to act as one large population that is currently undergoing a demographic expansion.

Based on this preliminary study, the prospects for the recovery of both species appear to be good. However, both species, and *M. niger* in particular, will need careful management as well as additional molecular studies to define appropriate units of management and conservation.

ACKNOWLEDGMENTS

This research was supported by the University of Amazonas (to I.F.), the Wildlife Conservation Society and Sociedade Civil Mamirauá (to J.T. and R.D.S.), PTU/CNPq 46.9940/00 (to L.M.), Kaw Swamps natural reserve and the French Ministry of Environment (to B.T.) and NSF INT-0002213 (to T.H.). We thank Cláudia Pereira de Deus for assistance in the field. Permission to conduct fieldwork and to collect tissue samples has been granted by IBAMA and the French Ministry of Environment.

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Molecular Approaches for Evaluating Species Boundaries in Crocodilians

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ABSTRACT: We applied molecular sequencing and genotyping approaches to two questions concerning species boundaries in crocodiles. First, we evaluated population structure and validity of subspecies designations for wild populations of Nile crocodile (*Crocodylus niloticus)* from mainland Africa and Madagascar. We examined sequence data for unique molecular characters in both mitochondrial (mtDNA) and nuclear gene regions and then genotyped populations for unique allelic signatures. Results to date indicate substantial regional sub-structuring concordant with previously hypothesized biogeographical events. Second, we evaluated the southern Belize populations of the endangered American Crocodile (*C. acutus*) and Morelet's crocodile (*C. moreletii*) for evidence of hybridization using mtDNA and nuclear markers. These data were used to corroborate hybridization events inferred from behavioral and morphological data. The methods developed by these projects provide the basis for a more integrated approach to crocodile management and conservation.

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Conservation Genetics for *Caiman yacare* in Bolivia: Potential Forensic Applications

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ABSTRACT: *Caiman yacare* is a medium sized crocodilian of the family Alligatoridae. It occurs abundantly in variety of freshwater habitats in Bolivia, Brazil, Paraguay and Argentina. I took a total of 245 blood or tissue samples from caiman in the five principal lowland river drainages of Bolivia. Molecular analysis of the mtDNA cytochrome *b* gene using PCR techniques showed a distinct divergence between the caiman found in the Amazon basin (4 river drainages) and those from the Paraná River basin. Higher resolution was desired so genomic DNA was screened for microsatellites. Primers were developed and initial results showing population partitioning are presented.

All range states have commercial use programs for caiman hide export in various stages of development. Bolivia is in the process of conducting intial harvests of wild caiman populations. One of the main concerns is entry of illegal hides into the system during harvest, either from non-permitted areas or from a neighboring country. Use of molecular techniques with microsatellites has potential use by Wildlife authorities for proof of origin for caiman hides. A new technique, Amplified Fragment Length Polymorphisms (AFLP), is less complicated and less costly. AFLPs might potentially be used for forensic hide control and preliminary data are discussed.

Bioecological Aspects of *Crocodylus acutus* Liberated in the Tacarigua Reservoir (Falcon, Venezuela)

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ABSTRACT: In order to evaluate a program of repopulation of *C. acutus* in the Tacarigua reservoir, we undertook a comparative study of the bio ecological aspects of resident and released crocodiles. Among the results, we detected that the average growth rate of 7.60 mm/month in animals after release was significantly less than their prior growth in captivity of 24.93 mm/month. In resident crocodiles the average and instantaneous growth rates were greater: 10.03 mm/mo estimated from recaptures and 26.15 and 29.19 estimated by the models of von Bertalanffy and Richards. We used the Jolly-Seber method to estimate survival rates of 52.5% of the released crocodiles and 29.6% in residents. Indices of condition in in released male crocodiles were significantly greater than the resident males. Crabs (*Poppiana dentata*) occupy an important position in the released sample and fish (*Caquetaia kraussi, Hoplias* sp. and others) in the residents, in that their frequencies were similar. The released animals preferred positions in the openings with logs and branches, possibly as an instinctive response to caution produced in captivity, but the resdients preferred areas with aquatic vegetation. It can be concluded that released crocodiles have established themselves succesfully in the environmenatl structure of the reservoir, which would lead to sympatry with *Caiman crocodilus*.

Aspectos Bioecólogicos de *Crocodylus acutus* Liberados en el Embalse Tacarigua (Falcón, Venezuela)

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RESUMEN: Para evaluar el programa de repoblamiento de *Crocodylus acutus* en el Embalse Tacarigua, se realizó un estudio comparativo de aspectos bioecológicos de cocodrilos liberados y residentes. Entre los resultados destaca la tasa de crecimiento promedio de 7,60 mm/mes en liberados, significativamente menor a la tasa en cautiverio de 24,93 mm/mes. En residentes las tasas de crecimiento promedio e instantáneas fueron mayores: 10,03 m/mes por recapturas, y 26,15 y 29,19 mm/mes por modelos de von Bertalanffy y Richards. Por el método de Jolly -Seber se estimaron índices de sobrevivencia de 52,50 % en liberados y 29,60 % en residentes. Los índices de condición de cocodrilos machos liberados fueron significativamente mayores al de machos residentes. Los cangrejos (*Poppiana dentata*) ocupan un importante lugar en la dieta de liberados y el renglón peces (*Caquetaia kraussi*, *Hoplias sp* y otros) en residentes, a pesar que sus frecuencias son similares. Los liberados prefieren lugares en las orillas con palos y ramas, posiblemente como respuesta instintiva de cautela producto del cautiverio, mientras que residentes prefieren sitios de vegetación acuática. Se concluye que los cocodrilos liberados se han establecido exitosamente en el ambiente estructuralmente complejo del embalse, que a su vez favorece simpatría con *Caiman crocodilus*.

Ecology and Conservation of the American Crocodile in Florida

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ABSTRACT: The American crocodile (*Crocodylus acutus*) is primarily a coastal crocodilian that is at the northern end of its range in southern Florida. In Florida, habitat loss from human development has been the primary factor in this endangered species decline. Currently, they face new issues--Florida Bay has undergone a number of changes that have caused a great deal of concern for the ecological health of this ecosystem and primary crocodile habitat. Efforts have been, and continue to be, made to improve Florida Bay and Biscayne Bay. In south Florida we have the unique opportunity to integrate endangered species conservation with ecosystem restoration and management. American crocodiles thrive in healthy estuarine environments, and are particularly dependent on freshwater deliveries. Recovery of the American crocodile in Florida will require an integration of habitat enhancement for an endangered species with environmental education. As crocodiles benefit from a restored freshwater flow into estuaries, their numbers will increase. The challenge of integrating a recovering population of the American crocodile with an ever increasing use of coastal areas by humans will require a proactive educational program and will be the final challenge in the successful recovery of this once critically endangered species.

Monitoreo de Poblaciones Silvestres del Cocodrilo de Morelet *Crocodylus moreletii* en Varios Estados de la República Mexicana

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ABSTRACT: Durante 2002 hicimos tres viajes itinerantes en 8 estados de la república mexicana: Yucatán, Quintana Roo, Campeche, Chiapas, Tamaulipas, San Luis Potosí, Veracruz y Oaxaca. Monitoreamos 22 localidades potenciales de *Crocodylus moreletii* para conocer el estado actual que guardan sus poblaciones. Realizaron monitoreos nocturnos bajo las técnicas establecidas. Observaron 378 cocodrilos de Morelet y capturamos 80, En ningún sitio observamos neonatos (NN) ya que los muestreos se hicieron 6 meses posteriores a la eclosión. De las clases I, II, III y IV se observaron 144, 86, 70 y 78 ejemplares respectivamente. Las localidades donde se encontraron las densidades mas altas fueron: Lago El Caracol, Chiapas: 18.5, Hampolol, Campeche: 14.1, Arroyo San Vicente, Chiapas: 14,Lago El Aguacate, Chiapas: 13.3, Estero La Victoria, Veracruz: 10.24, Lago de Nixtamalapan, Veracruz: 10, Laguna de la Mancha, Veracruz: 10, Villa de Casas, Tamaulipas: 8.74 y Río Yalikín, Quintana Roo 8.33 cocodrilos/Km. En esta información se aportan las densidades poblacionales más altas registradas para la especie en México.

Population Size Structure of *Caiman latirostris* in Artificial Impoundments in Northern Uruguay

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ABSTRACT: Populations of *Caiman latirostris* are known from Uruguay but survey data is scarce. This species shows an apparent capability of colonizing a wide variety of habitats. As remaining habitats destruction and modification seems to be of major concern for this caiman conservation, we focused attention on its presence in artificial water bodies. Night-light surveys were performed in impoundments used for agricultural purposes in northern Uruguay. A total of 35 surveys were conducted over 26 sites corresponding to three stream basins of the Uruguay River drainage (Ñaquiñá, Lenguazo and Falso Mandiyú). Surveys were carried out between January and March 2001, and between December 2001 and March 2002. Caiman sizes were estimated from a slow moving boat for 153 individuals. Our results showed that juvenile, sub-adult and adult categories were represented in artificial impoundments. The most frequent sizes observed were included in juvenile categories up to 1 m total length, which comprised more than half of the individuals. The distribution of population size classes in this study is perhaps not atypical for crocodilian populations expected to be healthy. Accumulation of data is needed to assess the viability of populations in artificial habitats and their role in this species management and conservation strategies.

Status of the French Guianan Black Caiman (*Melanosuchus niger*) Population

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ABSTRACT: One of the largest remaining *Melanosuchus niger* population is located in the Kaw swamps Natural Reserve, French Guiana. Until a few years, this population focused a limited interest and remained substantially unknown. The habitat is a large flooded savanna (75 km_), bordered by marsh and gallery forests, and mangroves. The bordering rivers have been harvested during decades, until late eighties; alternatively the main part of the swamp remained inaccessible and rather pristine. Since 2000, monthly surveys are conducted on the 60 km-long river crossing the reserve and in surrounding areas; regular missions are undertaken in permanent ponds in the heart of the swamp. In these inaccessible ponds, *Melanosuchus* densities varied from 25 to 60 animals/km, the species accounting for 80-99% of caimans total sightings. On the river, densities are less than 1 individual/km, and dominant species are spectacled and dwarf caimans, with a strong habitat partionning. Current aditionnal developments are a capture/marking/recapture study on the Kaw River, and the study of 5 microsatellite DNA loci to assess the population efficiency and structuration; the recovery potential will now be followed-up in depleted areas. Our preliminary results confirm the presence of a large and viable black caiman population in French Guiana.

Monitoring wild populations of *Caiman crocodilus* (babas) in Guárico and Llanos Boscosos Ecological Regions, Venezuela

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ABSTRACT: The Cayman (*Caiman crocodilus*) program for commercial use in Venezuela is implemented in 7 ecological regions since 1983 to the present. Each ecological region is surveyed to determine the population status in terms of its abundance and sizes classes. During the year 2002, a total of 114,805 ha were censused in the Guárico Ecological Region and 117,840 ha in Llanos Boscosos. The density obtained in both regions resulted very inferior to the previous censuses, probably due to environmental factors, mainly the strong drought. However, sizes classes did not show differences in relation to previous censuses. It was recommended to suspend the implementation of the program in both ecological regions until carrying out a new census before the beginning of the next drought season, with the aim to determine the population's real situation.

RESUMEN: El programa de aprovechamiento comercial de la baba (*Caiman crocodilus*) en Venezuela se implementa en 7 Regiones Ecológicas desde 1983. Cada región ecológica es censada para determinar el status de las poblaciones en términos de su abundancia y estructura de tamaños. Durante el verano de 2002 se censaron 114.805 ha en la Región Ecológica Guárico y 117.840 ha en Llanos Boscosos. La densidad obtenida en ambas regiones fue muy inferior a los censos anteriores, problablemente debido a factores ambientales, principalmente la fuerte sequía. Sin embargo las estructuras de tamaños no mostraron diferencias en relación a los censos anteriores. Se recomendó suspender la implementación del programa en ambas regiones ecológicas hasta realizar un nuevo censo antes del inicio de la próxima temporada de sequía, a los fines de determinar la situación real de la población.

INTRODUCTION

Velasco and Ayarzagüena (1995) evaluated in 1991-92 the status of wild populations of baba in terms of abundance and sizes classes after 9 continuous years of harvesting. This work was the first one that study the effect caused by a sustainable program on wild populations of this species. Until then, PROFAUNA have not reliable records that allows evaluating the impact of harvesting.

Among the most important results of this work, it was the description and characterization of seven ecological regions, size classes and abundance, with an estimation of the capacity of sustainable crop in each one. A recommendation was proposed to PROFAUNA of suspending during four years the harvest in Guárico Region, due to the small proportion of Class IV individuals (mature males of great size), the hunted portion of the population. Finally, the study recommended continued population surveys in each ecological region.

In 1995, the region Guárico was evaluated, giving as results the characterization of six sub-regions in it and restarts the program in the sub regions Camaguán and Cazorla (Colomine *et. al*., 1996). In 1996, PROFAUNA took the decision to paralyze the program in Venezuela (Quero & Velasco, 1995), in order to execute another recommendation of the 1992 study: the evaluation of the harvest impact on the babas populations. In the 1995 study the ecological regions were ratified and the status of populations subject to annual harvest were qualified as good, as much in their abundance as in their size classes. A main recommendation to PROFAUNA was the continuation of population surveys with a yearly schedule for ecological region, covering a wide surface during each study.

The present work is part of the aforementioned recommendation, with which the third survey of all the ecological regions is completed, coinciding with 20 years of application of the Sustainable Use Program.

OBJECTIVES

The objectives of the present study contemplate to establish the status of the populations in each ecological region, as much in their abundance as their size classes, and the characteristics of the habitats where the babas populations were located.

METHODS

Light-night counts were made accordingly to Chabreck (1966) and Woodward & Marion (1977), in order to determine population abundance and size classes (Ayarzagüena, 1983): Class I (hatchlings), Class II (juveniles), Class III (male adults and females) and Class IV (adults larger than 1.8 m of total longitude), in each one of the observed water bodies.

AREA OF STUDY

The fieldwork was carried out in Guárico and Llanos Boscosos ecological regions (Fig. 1), defining as study area a sample of farms visited previous censuses 1991-1992, 1995 and 1996 (Velasco & Ayarzagüena 1995; Colomine *et. al.* 1996 and Velasco *et. al*. 1997), according to the Ministry of Environment and Natural Resources (MARN) records.

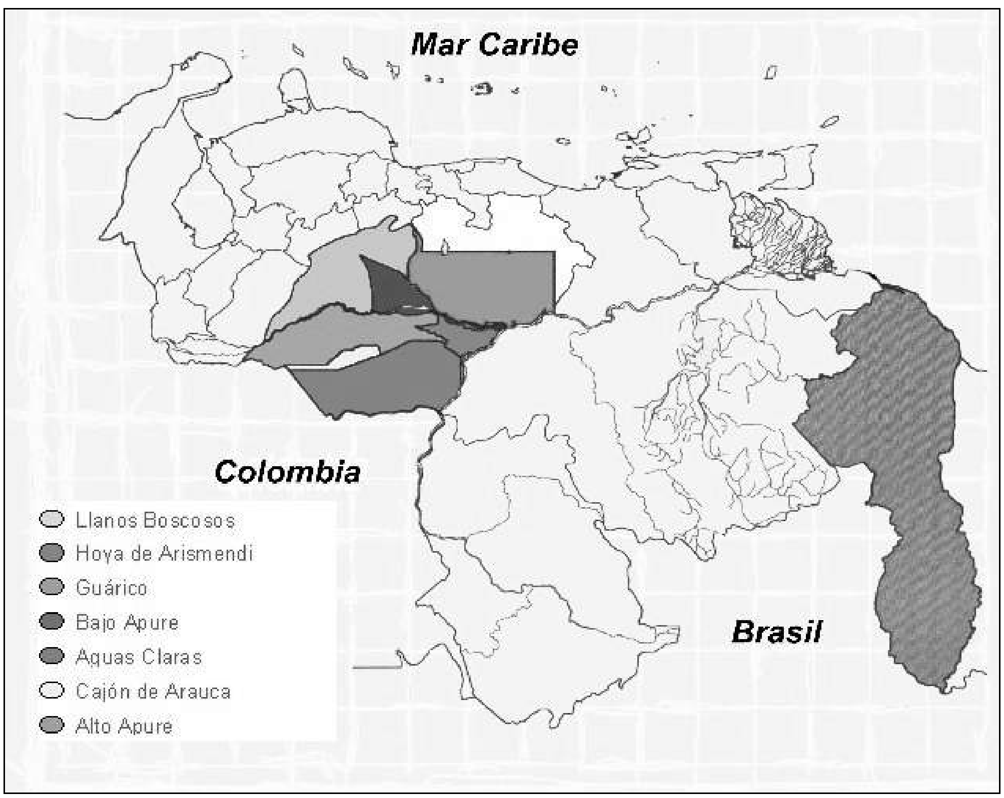


Figure 1. Ecological regions in Venezuela

The present study embraced a total surface of 232,645 ha, representing 4.06% of the total area in both regions, separated in 114,805 ha in Guárico Region and 117,840 ha in Llanos Boscosos Region with 42 farms visited (Table 1).

Compared with previous studies, the surface covered in Guárico Region was smaller than the observed in 1995-96 (Table 1), partly because census was carried on exclusively in those areas where the species was harvested since 1997. The areas of Cabruta, Santa Rita and Parmana, included in the total surface of the region, were not surveyed. In the case of Llanos Boscosos Region, the surveyed surface was similar to those of previous studies.

Table 1. Total and surveyed surfaces in 1991-1992, 1995-1996 and 2002

REGION	Total surface (ha)	Surveyed surface 1992 (ha)	%	Surveyed surface 1995-1996 (ha)	%	Surveyed surface 2002 (ha)	%
Guárico	2,620,800	69,297	2.64	288,420	11.01	114,805	4.38
Llanos Boscosos	3,114,384	193,873	6.23	125,515	4.03	117,840	3.78
TOTAL	**5,735,184**	**263,170**	**4.59**	**413,935**	**7.22**	**232,645**	**4.06**

Table 2 shows the aquatic surface observed in each region and survey. In 1991-1992 it covered 614.19 ha (0.23% of the total observed surface) in both regions. In the present work the observed aquatic surface was much smaller, 264.19 ha (0.11% of the total surface).

Table 2. Total and aquatic observed surfaces and their percentage in 1992, 1995 - 1996 and 2002

REGION	Total surface observed 1992 (ha)	Aquatic surface observed 1992 (ha)	%	Total surface observed 1995-1996 (ha)	Aquatic surface observed 1995-1996 (ha)	%	Total surface observed 2002 (ha)	Aquatic surface observed 2002 (ha)	%
Guárico	69,297	149.19	0.22	288,420			114,805	182.54	0.16
Llanos Boscosos	193,873	465.46	0.24	125,515	270.24	0.22	117,840	81.65	0.07
TOTAL	**263,170**	**614.65**	**0.23**	**413,935**			**232,645**	**264.19**	**0.11**

The aquatic surface reduction in both regions in 2002 indicates a strong drought in the moment of the census. In Guárico Region, the proportion of aquatic surface observed was inferior in comparison with previous censuses (0.22% in 1992 and 0.16% in 2002). The same situation is reported for Llanos Boscosos Region, where the drought effect was even more marked, with a drastic reduction of the observed aquatic surface (from 0.24% and 0.22% in the previous censuses to 0.07%).

GENERAL RESULTS

As a consequence of the described drought effects on both regions, the number of observed water bodies was lower than in previous censuses, surveying only 68 in Guárico and 36 in Llanos Boscosos (Table 3). The mean number of individuals observed in water bodies shown significant differences among both regions (_ =0.05), with Guárico reaching the highest value. Although these results reflected different conditions of the populations in each region, the statistical analysis is not supported by enough data and show high standard deviation.

Table 3. Results of ANOVA of the means of individuals for body of water in each region (_ =0.05).

REGION	CASES	MEANS	STD	Dif.
Guárico	68	90.65	106.04	X
Llanos Boscosos	36	40.50	121.59	X

The shortage of obtained data prevented to analyze statistically the abundance of babas in each type of water body. The sample obtained in Llanos Boscosos was 36 water bodies in total, conformed by 4 "caños" (natural drainage channels), 2 lagoons and 21 "préstamos" (man made excavations for construction of roads) with water, with other 9 water bodies completely dry. In Guárico 6 "caños", 35 lagoons, 22 préstamos and 3 artificial channels were observed, with other 2 water bodies completely dry.

These data confirms the strong influence of drought in both regions, reflected in the low aquatic surfaces observed under the prevalent environmental conditions at the moment of the census.

Most farms visited in Guárico and Llanos Boscosos were previously surveyed or appeared in MARN files of the Program. Many of these were currently abandoned, invaded, broken into fragments or even urbanized. That was a strong limitation for the realization of the census in this period.

GUÁRICO REGION

Density

The registered density was 0.05 babas per hectare, obtained from a total count of 6,266 individuals in 114,805 observed hectares, from which only 0.16% corresponded to aquatic surface. This density is inferior to the registered one in 1992 and 1995 of 0.13 babas/ha and 0.09 babas/ha, respectively (Fig. 3).

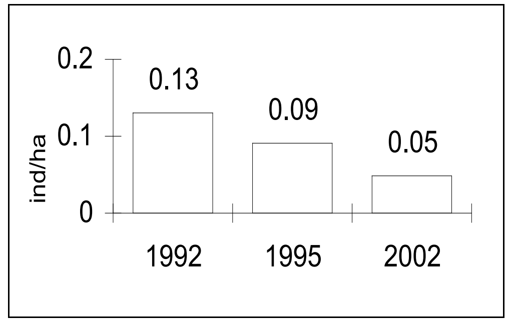


Figure 3. Density in Guárico Región (Baba/ha)

The values of density in the three censuses presented a sustained decline that can be related to the environmental conditions of extreme drought. These conditions caused a reduction of the aquatic surface and the number of observed bodies of water.

Size Classes

The size classes in this region did not show an important variation compared with the obtained in 1995 (Fig. 4), with a slight decrease of Classes IV and II, and an increase in proportion of Class III.

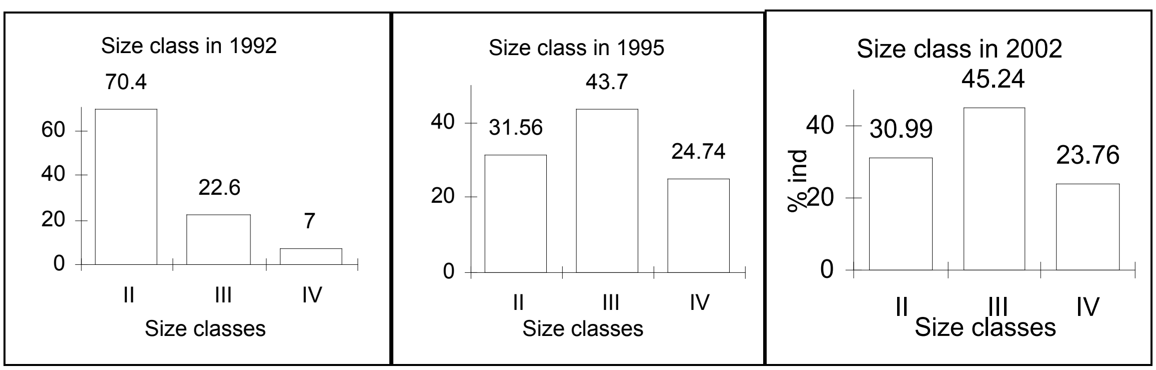


Figure 4. Sizes classes in Guárico

The histogram of size classes does correspond to wild populations subjected to sustained commercial exploitations, with pyramidal form and Class IV value superior to 18% (Velasco & Ayarzagüena 1995). The size structure also indicates the recovery reached by the populations after the suspension of the program between 1992 and 1995. A proportion of 23.76% of Class IV with 2,629 individuals is reported.

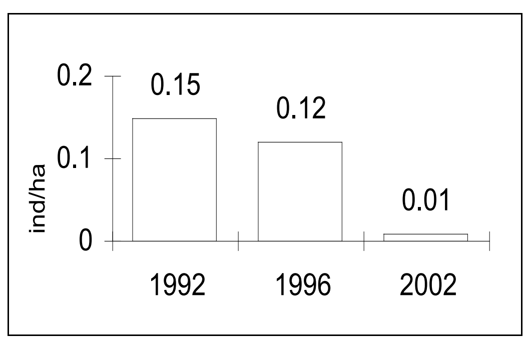


Figure 5. Density in Llanos Boscosos Region (Babas/ha)

LLANOS BOSCOSOS REGION

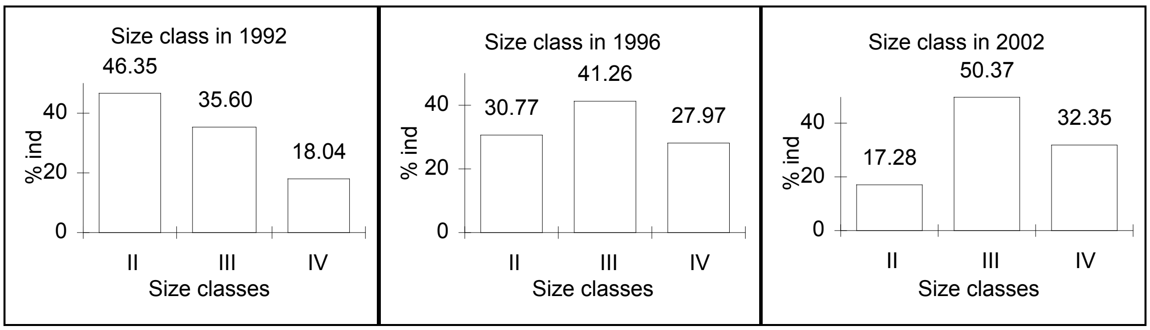
Density

Global density in Llanos Boscosos was 0.01 ind/ha (Fig. 5), much lower that the previous results, resulting from the count of 729 babas in 117,840 ha observed, with only 0.07% of aquatic surface.

As in Guárico, the density show a sustained tendency to decline in the successive censuses, being much more marked the reduction in the density in Llanos Boscosos, reaching the lowest data recorded in all censuses practiced to the present in ecological regions. However, it is necessary to point out that the environmental conditions in the moment of the present census were characterized by an intense drought, with a large amount of water bodies totally dried.

Size Classes

Size classes reflected increases in proportions of Classes III and IV in comparison to 1992 and 1996 (Figs. 6), with a reduction of Class II. The current structure presented a pyramidal type, corresponding to harvested populations coincident with the structure recorded in 1996. It is important to remark that PROFAUNA authorized the hunt of only 2,941 animals in 2001 while in 2000 no hunt was permit.



CONCLUSIONS

1. Both regions presented very low levels of density, showing a tendency to diminish in comparison to previous censuses. Values presently obtained should be related with the prevalent environmental conditions of extreme drought during the period of study. The scarce observed water bodies presented highly concentrated, abundant and stable populations, with size structures corresponding to not over cropped populations. This result indicates that the reduction registered in population density is not probably caused by on-exploitation or illegal hunt, but rather attributable to the drastic reduction of the availability of water bodies. However, extremely low density levels were registered in comparison with previous censuses in these two regions and densities obtained in other ecological regions.
2. Most of the visited water bodies included in MARN database or previously observed, were completely dried. It indicates that during the period of maximum drought the appropriate evaluation of the natural populations is affected, due to the promptness with which these water bodies disappear when the drought is advancing. Even several important rivers of the sector were segmented and their flow detained (i.e. Guariquito, Caballo and Apurito Rivers).
3. Together with the environmental condition of extreme drought, irregular condition of abandonment, invasion, fragmentation, disordered occupation and even urbanization in many properties registered in MARN records hindered the realization of censuses in both regions. Some properties registered in MARN simply did not exist at the present time and peasants irregularly occupy lands. This condition also affected the analyses on mean abundance of babas in each property type classified by the surface occupied by the farm.

RECOMMENDATIONS

1. The obtained values of density did not serve as base to allow sustainable harvest of babas in both regions. It is recommended to suspend the grant of licenses and maintain a strict surveillance of the illegal hunt in both regions, until a repeat of the population study under favorable environmental conditions to establish a confident evaluation of the wild population status.

2. The coincident of the survey with the months of maximum drought in both regions, did not allow a complete evaluation of the wild populations. It should be considered that these regions are located at north of the Apure River fluvial system. These areas keep natural water bodies flooded during a very short period in the dry season, due to their altitude above sea level, soil conditions and drainage capacity. It is advisable to perform population studies toward the end of rainy season and beginning of dry season (December-January), when natural water bodies still maintain enough flood levels and populations are more easy to evaluate.
3. The previous recommendation implies to study possible modifications of the Program calendar in the two regions, particularly the application lapses and grant of licenses, and the lapse of hunt. The situation of extreme drought and disappearance of water bodies in both regions also has a negative effect, because it favors that the granted skins has to be obtained in other ecological regions, due to the difficulty to locate animals in the few remaining water bodies during the lapse of hunt.
4. MARN database and files of farms and water bodies should be updated, evaluating the possibility to request again all the legal documentation to the users of the program in both regions. This can be an answer to the current nonexistence of a considerable number of farms or properties included in this database, and to the frequent situations of abandonment, invasion, fragmentation, deforestation, intervention, illegal and disordered occupation and even urbanization in the lands that were presented as legally registered properties participating in the Program. Equally, MARN should exhort to the competent organisms to achieve the regularization of the property of lands in both regions, as well as to promote the design of a special plan of surveillance and control in both regions, directed to the conservation and recovery of favorable primary and secondary habitats to the species and, in general, to the wild fauna.
5. It is recommended that MARN consider the possibility to restore at its previous levels the taxes collected through the Law of Tax Stamp by consideration of services. It has been proven the minimal influence on the economic activity of the decision took on last year of discharge 80% of the tax payment by users of the Program. There is a continuous rise of prices to the final consumers of the products obtained under this regime, although practically the tributary contribution was eliminated to the producers, middlemen and traders that have increased its earnings substantially thanks to the public consumers expenses. It is remarkable that the funds obtained with this tax were the only source to support population studies of the species subjected to commercial use. On the other hand, funds should be available at the end of each year.
6. The adoption of these recommendations requires the participation and wide consultation to all the involved stakeholders. A first step for this consultation will be the realization of a Workshop foreseen to evaluate the program, where regional and local governments, private sector integrated by producers, middlemen and industrial, ONG's, academic and research sectors, and the agencies involved in surveillance and control should participate. Technical meetings with National Council for Wild Fauna (CONAFASI), National Council for Baba, and Crocodile Specialist Group, should also be implemented in this consultation process.
7. MARN should develop a specific project to evaluate the hydrometeorological cycle rain/drought of the ecological regions, directed to settle down with more precision the flood characteristics and drying of the natural water bodies. This project should include the analysis of precipitation, evapo-transpiration and other climatic variables that can influence this cycle, and also the use of satellite images in environmental and geographical description of the water bodies in the ecological regions.
8. As indicated in previous reports, MARN should develop a specific activity of environmental education on the Program, focusing it as one of the most important practical activities in sustainable development applied to rural environment, working on a natural resource of wild fauna that has received recognition at international level for its quality. The main recommended issues for this educational activity should be the conservation of habitats, control of illegal hunt and participation of the communities in the wild fauna species management.

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Preliminary Results of a Population Study of American Crocodile (*Crocodylus acutus*) in Jalisco, Mexico.

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ABSTRACT: The American crocodile and its habitat in the coast of Jalisco are impacted by the tourist industry and the growing human population. Similar factors have extirpated or diminished *C. acutus* in most of its range. This research presents information about some aspects of population ecology in three populations in Jalisco.

During 1999-2002, three coastal locations in Jalisco (Boca Negra, Majahuas and La Manzanilla) were monitored to understand the population behavior and to provide a basis for making comparisons among the sites. Night surveys were made on two consecutive days in each site four times a year. The size of each crocodile sighted was estimated and classified into the following categories: (only eyes (OE), < 0.60, 0.60-1.5, 1.5-2.5, >2.5 m). The estimated size was calibrated by captures. Conversion of the number of animals sighted to a population estimate was made by a formula suggested by King et al. 1990 and Thorbjarnarson et al. 2000.

The estimation of population in Boca Negra estuary (28 ha) was 92 individuals (3.20 crocs/ha, p=28.56%), Majahuas (195 ha) 49 (0.26 croc/ha, p=46.63%) and La Manzanilla (153ha) 314 (2.05 crocs/ha, p=51.50%). Size structure in Boca Negra consisted of mostly hatchlings (<0.6 m) (38.6 %) and juveniles (0.6-1.5 m) (26.2%), in Majahuas of juveniles between 0.6 and 1.5 m (42%) and in La Manzanilla of adults (> 2.5m) (31%). The differences between these three sites and the effects on conservation of the species in Jalisco are discussed.

Key words: *Crocodylus acutus*, population size, size structure, nest, habitat use, Jalisco, Mexico.

RESUMEN

La industria turística y el incremento de la población humana han causado un impacto negativo en el hábitat y en las poblaciones de cocodrilo en la costa de Jalisco. Factores similares han provocado que la especie haya sido extirpada o reducida en la mayor parte de su distribución. Esta investigación presenta información acerca de algunos aspectos de la ecología de poblaciones en tres poblaciones silvestres en Jalisco.

Se censaron tres lagunas costeras (Boca Negra, Majahuas y La Manzanilla) en Jalisco de 1999 a 2002, para entender y comparar cada una. Se realizaron conteos nocturnos durante dos días consecutivos en cada sitio, cuatro veces al año. Se estimó el tamaño de cada cocodrilo avistado y se clasificó dentro de las siguientes categorías: (solo ojos (OE), < 0.60, 0.60-1.5, 1.5-2.5, >2.5 m). La estimación de las tallas se calibró mediante capturas. La conversión de los números de animales avistados a un estimado de la población se hizo mediante la fórmula sugerida por King et al. 1990 y Thorbjarnarson et al. 2000.

La estimación de la población en Boca Negra (28 ha) fue de 92 individuos (3.20 ind/ha, p=28.56%), Majahuas (195 ha) 49 (0.26 ind/ha, p=46.63%) y La Manzanilla (153ha) 314 (2.05 ind/ha, p=51.50%). La estructura por tallas en Boca Negra consiste, principalmente en animales menores a 0.6 m (38.6 %) y de la categoría 0.6-1.5 m (26.2%). En Majahuas de la categoría 0.6-1.5 m (42%) y en La Manzanilla

de animales mayores a los 2.5m (31%). La diferencia entre los tres sitios así como los efectos en la conservación de la especie en Jalisco es discutida.

Palabras clave: *Crocodylus acutus*, tamaño de la población, estructura por talla, nidos, uso de hábitat, Jalisco, México.

INTRODUCTION

The American crocodile and its habitat in the coast of Jalisco are impacted by the tourist industry and the growing human population. Similar factors have extirpated or diminished *C. acutus* in most of its range. Because of the wide distribution of the American crocodile, population research and protection of this species are difficult.

Interest in conserving the American crocodile began a number of years ago (Kushlan, 1982; Thorbjarnarson, 1989; Sasa y Cháves, 1992). In Mexico, by 1970, the government decreed this species protected and began the research to describe the status and distribution of the species in some localities (Casas y Guzmán, 1970; Casas et al., 1990; Méndez y Casas, 1992; Huerta y Ponce, 1997). In Jalisco, most of the population dynamic research had been done in the Biosphere Reserve "Chamela-Cixmala" (Lazcano-Barrero, 1989; Thorbjarnarson, J. 1998).

Currently, *C. acutus* is cataloged as rare species in the "Norma Oficial Mexicana" (NOM-059ECOL-1994); the Endangered and Threatened Wildlife and Plants (ETWP, 1993) registered it as endangered; in CITES (1992) *C. acutus* is placed in the appendix I and the Red Check List of the IUCN (1996) as cited by Ross et al. (1998) and is reported as vulnerable.

This paper present preliminary results about the population dynamic research in three localities with different conditions, and distributed along of the coastal line of the State of Jalisco. The goal of this project is to know more about the behavior of these populations, to provide a basis for its conservation. One of the most important points in the conservation of those localities is the management and sustainable use of the species as economic alternative for local communities. These studies are creating a picture of the structure of the crocodile population occupying each site and their responses to variables such as season, water level, and level of human disturbance. These studies also provide the major vehicle for our interactions with local human residents and our attempts to recruit their help for crocodile conservation.

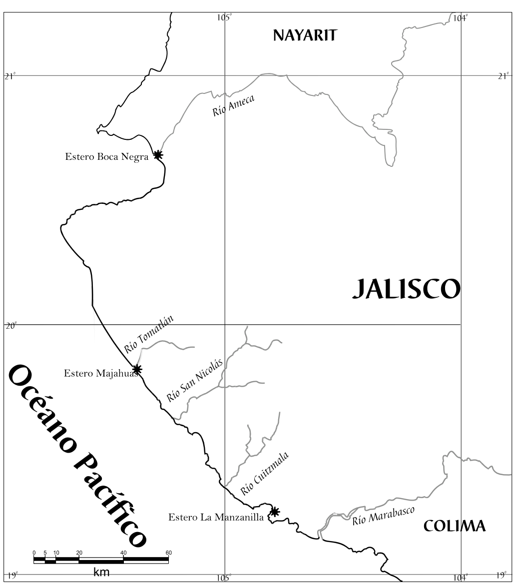

Figure 1. Map of Jalisco State where study localities are indicated.

STUDY AREA AND METHODS

The study area is located on the coast of Jalisco between 19° 13' 05'' and 20° 43' 33'' north latitude and between 104° 39' 03'' and 105° 40' 11'' west longitude. From the suite of localities identified for crocodiles (Ponce and Huerta, 1997), three representative estuaries were chosen for intensive study: 1) Boca Negra in the municipality of Puerto Vallarta, 2) Majahuas in Tomatlán, 3) and La Manzanilla in La Huerta. These localities represent different situations and components of the threats faced by crocodiles.

Boca Negra is a small pond (25 ha) of the larger marsh complex of the Rio Ameca at Puerto Vallarta. The delta covers about 20 sq. km but development, agriculture, an airport, a marine harbor complex and condominiums heavily impact most of this. A central saline mangrove estuary, called El Salado, though impacted for the activities mentioned before, remains in natural condition and is the site of proposed conservation protection promoted by a local conservation society, Grupo Ecologico de Puerto Vallarta. Boca Negra is a short

(850m) channel of El Salado.

Majahuas estuary (388 ha approximately) is part of the delta of the Rio Tomatlán. About 10 km of narrow mangrove creeks and lagoons lie parallel to the beach dunes. The survey area is about 190 ha. Crocodiles of all sizes are present but extremely shy, apparently as a result of recent illegal hunting. Most of this is impacted by agriculture and livestock.

La Manzanilla estuary (153 ha) in the south of Jalisco is a brackish estuary of about 2.2 km that flows to the sea at the small village of Manzanilla, local fishermen attempt to protect the crocodiles, erecting signs and fencing to keep crocodiles and people apart and prohibiting the use of motors on the estuary. Their hope is to develop a small industry based on displaying crocodiles and other wildlife to tourists.

We scheduled trips to the three different localities along the coast of Jalisco (Puerto Vallarta, Majahuas and La Manzanilla). These areas were chosen because of the presence of a representative crocodile population (Ponce et al., 1996), and its priority in the "Plan de Conservación para Jalisco" (Ponce y Huerta, 1997). During each trip, night spotlight counts (King et al., 1994) were used to estimate the population size. These counts were made four times a year when possible for a total of 10 times. Size of animals sighted were estimated to the nearest half m and classified as: eyes-only (EO), < 0.60 m, 0.6-1.5, 1.5-2.5, >2.5 m, the location of each sighting was recorded (King *et. al.* 1994). Crocodilew were captured by hand, and tongs for smaller animals, and by noosing, indirect techniques such as Alligator Trip Snare modified from Wilkinson (1994) and other techniques by Webb *et al.*(1987) and Pérez-Higareda (1991ab) for larger individuals. Crocodiles were sexed by the palpation technique suggested by Chabreck (1963) was used. The captured crocodiles were marked by clipping tail scales as suggested by Ross (com. personal) and with cattle or goat tags in the tail scales, which also were used for a parallel physiology and genetic studies on these crocodile populations. Nests were located by foot and boat trips of suitable nesting areas. Survey and size class data were analyzed using standard methods expressing crocodile densities per ha.

RESULTS AND DISCUSSION

Population size

Since it was not always possible to survey all three sights, we used an index of abundance to calculate density to compare the 3 estuaries. According to the calibration method used by King et al (1990) and Thorbjarnarson et al (2000) we calculate a total population for Boca Negra estuary of 92 organisms (no hatchlings) (3.20 crocs/ha). In Majahuas estuary we calculate a population of 49 individuals (0.26 croc/ha) and in La Manzanilla we calculate a population of 314 organisms (2.05 crocs/ha).

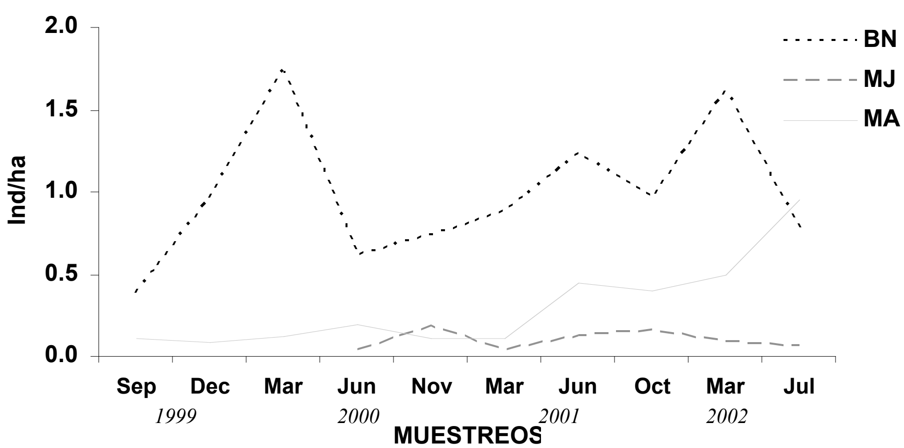

Figure 1. Comparison of the animal sighted during the surveys per hectare in each water body.

The smallest location, Boca Negra, had the highest density, while Majahuas, the biggest, had the lowest density, despite there are not a human population there, or a lot of pressure by fishermen and illegal hunting. On the other hand, Boca Negra is the release location for problem crocodiles of Puerto Vallarta and Bahía de Banderas. The town of La Manzanilla is located next to the estuary. Their community takes care of the estuary and it's crocodiles for a long time. Farming and livestock occur in the vicinity of the mangrove portion of the estuary.

Size Structure

Boca Negra estuary is represented by all size categories; the most dominant size category is hatchlings (>60) with 54.66% and juveniles (0.60-1.5) 28.8%. In Majahuas the most dominant size category is juveniles (48.8%) and in La Manzanilla is a population principally composed of juveniles (0.60-1.5) with 36.5% and adults (>2.5) with 22.5%. Thorbjarnarson (1988) found in Haiti that 15.7 % of the population is composed by adults. He report the lower proportion composed by sub adults, caused by shy behavior or the occupation of marginal habitats. That is true for the La Manzanilla estuary, since during one night survey in dry season we found in a shallow pond (0.6m deep), a great number of animals between 1 and 1.5 m. The presence of juveniles, principally, in Majahuas estuary, could be the result of the human pressure; they could be in areas far away from the human contact.

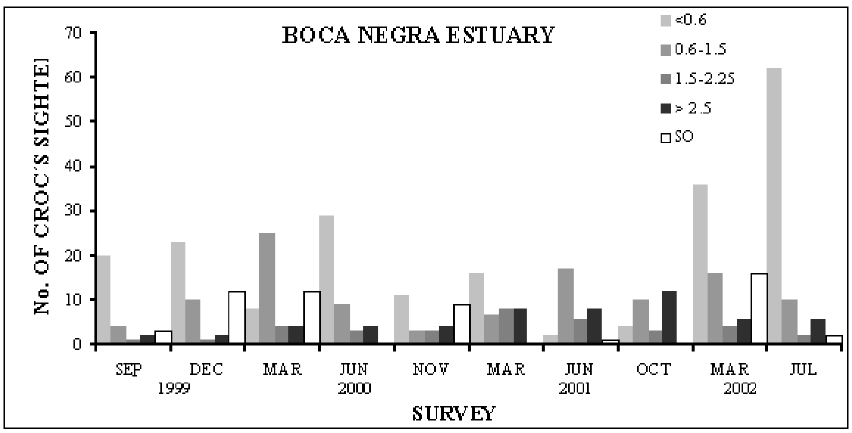

Figure 2. Number of crocodiles sighted during surveys in Boca Negra Estuary from September 1999 to July 2002

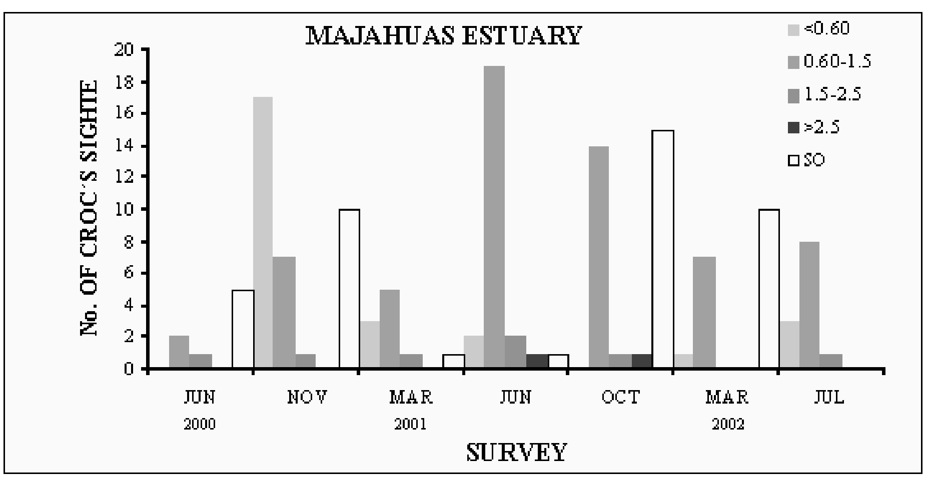

Figure 3. Number of crocodile sighted during surveys in Majahuas Estuary from June 2000 to July 2002.

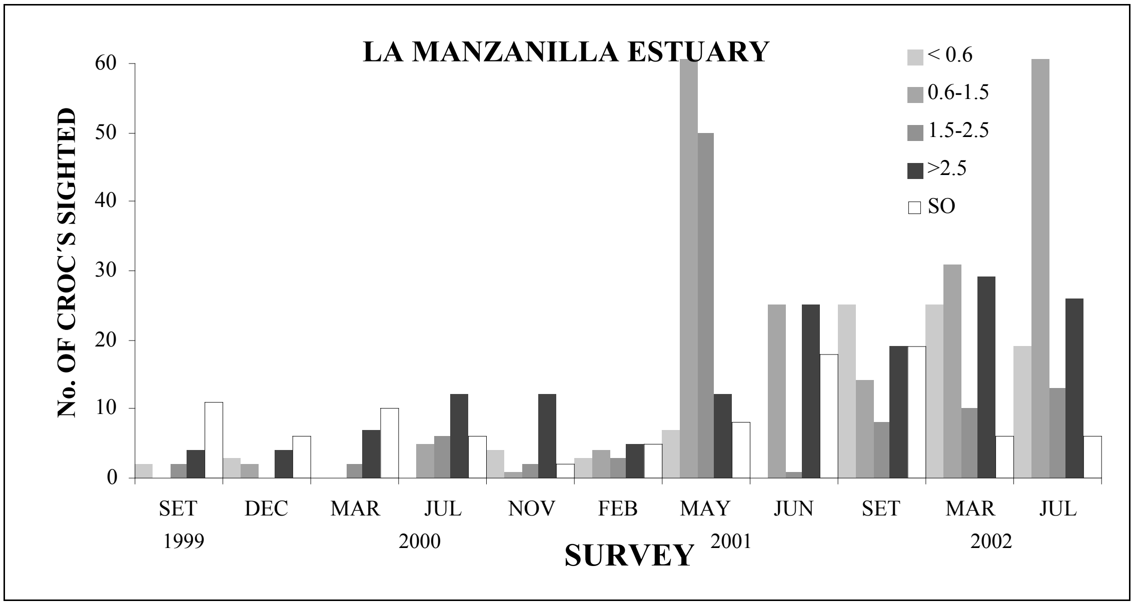

Figure 4. Number of crocodile sighted during surveys in La Manzanilla Estuary from September 1999 to July 2002.

We report for Boca Negra the same pattern as registered by Sasa and Chávez (1992) in Costa Rica, where juveniles are the most abundant, followed by adults and a low proportion of sub adults.

Boca Negra has a population of approximately 12 adults, while in Majahuas has only two individuals of approximately 2.5 m. It was very difficult to adults at Mahahuas because of illegal hunting. In La Manzanilla we calculated a population of 29 adult individuals, although, during reproductive project we captured a total of 49 crocodiles above 2 m.

Nests

Nesting activities are on late April and early May, as reported by Casas and Guzmán (1970) and Valtierra (2000). Nesting areas are diminishing day by day. In Boca Negra we found the nests on a sandy area. Two of them are in areas with human activities and the other four are protected by the boundaries of the airport. In Majahuas nesting areas were very dispersed. All of the nests are in sandy areas, surrounded by vegetation. In La Manzanilla estuary, one important nesting area disappeared because the construction of a concrete walkway for tourists along the sand barrier between the ocean and the estuary. This estuary has two types of nesting areas, the first one is a sandy beach and the other is on crop and livestock land next to the estuary. This place is formed by hills of hard clay soil. Four nests were located nests in that area.

In Boca Negra we found 6 nests this year, in Majahuas 2 nests and in la Manzanilla we discovered at least 10 nests.

Habitat Use

As mentioned by Kushlan and Mazzotti (1986) the 3 estuaries are coastal lagoons of mangrove and are suitable protected areas for crocodiles. They are composed of brackish water with a mean salinity of 2.7 ‰ (range 0-5.5, n=19), in Boca Negra the mean was 5.01 ‰ (range 0-17, n=12) and in La Manzanilla it was 12.2 ‰ (range 1-26.5, n=21). La Manzanilla presents the highest level of salinity but the mean was in the range of 14 ‰ reported by Kushlan and Mazzotti (1986). The three estuaries also contain microhabitats suitable for this species composed by shallow and deep water and suitable areas for basking and nesting (Thorbjarnarson, 1989). Although nesting sites are being lost.

In Boca Negra the dominant vegetation is the white mangrove (*Laguncularia racemosa*). We found the adults in the principal pond, while the juveniles and sub adults prefer to hide in the small creeks where they found protection.

In Majahuas, we found principally two types of vegetation were seaside mahoe and white mangrove. Mahoe is a shrub that grows in the water edge and is very leafy where crocodiles can hide.

In La Manzanilla the dominant vegetation was the white mangrove but the last pond is shallow and was dominated by red mangrove (*Rhizophora mangle*). In this place, we found principally juveniles. The adults prefer the main channel, which is the deepest area of the estuary. Some sub adults (more than 10) were seen in the area preferred by adults.

Conservation

The coast of Jalisco supports a dense and growing human population and is subject to rapid modernization and coastal development pressure. It will not be possible to conserve crocodiles or any other large fauna, solely by declaring protected areas. The majority of the coastal estate is in private landholdings and coastal planning is weak and erratic. One major protected area, the Chamela-Cuixmala Biosphere reserve, provides protection and management for crocodiles as well as six species of felids and other charismatic mega fauna. However, over most of the coastline crocodiles will have to co-exist with people and their activities. Ironically, some of the poorer human inhabitants feel as endangered by current development as crocodiles and this provides a foundation for an unlikely but effective alliance. Coastal fisheries resources in Mexico are under the jurisdiction of local fishery cooperatives that are increasing displaced and alienated by development. Coastal building, increased pollution and emphasis of employment in the service sector are challenging traditional lifestyles and occupations. We initiated contact with fisheries cooperatives and their leaders in several localities where crocodiles are present. Initially this was a practical matter- the old fishermen knew more about crocodiles than we did (having been crocodile hunters in the past) and are a rich source of information. To our surprise we found a considerable sentiment of concern and respect of fishermen for crocodiles. We are now working directly with two fishing cooperative leaders to inform them of the intricacies of crocodile lifestyles and the potential to obtain economic benefit from crocodiles. This will require the protection of core habitat from disruption by development, which incidentally overlaps with fishermen's concerns about retaining access and benefit to estuarine fishing grounds.

The conservation of Boca Negra estuary is the most difficult, because of human pressure, This is part of a central saline mangrove estuary called "El Salado" that remains in natural condition and is the site of proposed conservation protection promoted by a local conservation society, Grupo Ecologico de Puerto Vallarta.

The largest estuary, Majahuas has habitat, including nesting areas, suitable for crocodile population growth. However, both illegal hunting and fishing nets are reducing the population. Our work is sensitizing the community of fishermen about the importance of crocodiles and how they can get economic benefits from them. Currently, tourist agencies from Puerto Vallarta take groups to visit the estuary, but the problem there is that only the boat driver makes money ($50.00 pesos) and no one from the community benefits.

In La Manzanilla estuary, the work is advanced because, as we said before, a group of this community has boat rides into the mangrove. However, they need more tools to increase the benefits. The rest of the community is not included as only a few individual benefit. We have begun an environmental education project with some schoolteachers from the community as well as expatriate (US) volunteers.

The first step in La Manzanilla and Majahuas estuary is the development of limited and low impact ecotourism.

ACKNOWLEDGEMENTS

Support for this project was provided by Disney Foundation, University of Florida, Idea Wild and Huerta y Cia, S.A. We thank the following individuals for their help in various aspects of this study: Frank Mazzotti and John Thorbjarnarson in Florida; Mr. Ron Walker and the "Grupo Ecológico de Vallarta" in Puerto Vallarta; Gilberto Hernández and Rafael in Majahuas; Iván y Fam. García, Francisco Pérez Mendoza, Andrés Aceves y Fam., Eugenio Chaurand and Carmen Gallo in La Manzanilla, Diana

Ponce, Shaun O´Neil, Patricia Ascencio and Taylor Larson as field assistants, and all the people who cooperate in any way to this project. Special Thanks to Fam. Huerta and Fam. Ponce for their appreciable help.

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Stranger in a Lost Paradise: *Caiman crocodilus*, Puerto Rico's Own Aliengator

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ABSTRACT: In the early 1970's *Caiman crocodilus* was successfully introduced in spring-fed Lake Tortuguero, the geographic center of the northern limestone aquifer and wetland belt that supplies at least a quarter of the island's drinking water. This is also the principal metropolitan region, featuring major conglomerates of pharmaceutical, electronic and allied chemical industries. Its water resources have been diagnosed as critically contaminated by toxic wastes. The region boasts high incidences of cancers, ontogenetic abnormalities and endocrine disorders.

The naturalized caiman has extended its range despite ongoing attempts at eradication by the Department of Natural and Environmental Resources (DNER) which persists in invoking an anti-exotics rationale contrived from bioxenophobic premises and dubious ecological theories.

This paper chronicles a collaborative academic and professional effort to promote an alternative policy: scientific study and management of the local caiman as a 'sentinel species' for monitoring insidious forms of water pollution, as has been pioneered in Florida.

Puerto Rico has a lot in common with Florida in terms of environmental history. At the peak of the last Ice Age, both had at least twice their present territory. During the past 16 thousand years rising sea level inundated extensive platform savannas creating, then submerging, vast coastal wetlands until about 6 thousand years ago (Hallam, 1992). That epic wetland period lasting roughly 10 thousand years provided ample habitat for crocodiles and other water-loving fauna, including capybaras (*Hydrochaeris*) in Florida, and a coypu forerunner, the Puerto Rican "beaver", *Elasmodontomys* (Hallam, 1994; Watlington, 1998).

The rise and fall of the great wetlands coincided with the arrival of humans who surely prospered in the times of abundance and attended, likely assisted, the reduction and extinction of some of the larger swamp vertebrates such as the capybara in Florida and the Puerto Rican croc and beaver.

Modern Florida and Puerto Rico started out sharing the same first governor, Ponce de León, who according to tradition, was driven by an obsession with the quality of drinking water. Scores of his island compatriots are moving into central Florida, pursuing essentially the same illusion. Most know little about Orlando's Lake Apopka, although it may remind some of Puerto Rico's Lake Tortuguero a virtual geomorphological and ecological analogue (Veve and Taggart, 1996; Lugo, *et al.* 2001).

Both lakes are fed by limestone aquifers and surrounding surface runoff. Both lakes are on the periphery of sprawling metropolitan regions. And both have substantial populations of resident crocodilians. Apopka is home to the American alligator, *Alligator mississippiensis* (Ross and Garnett, 1990). Tortuguero is home to the naturalized spectacled caiman (*Caiman crocodilus*) introduced from South America via the Florida pet trade (Thomas and Joglar, 1996).

Apopka and Tortuguero share another coincidence. Their waters are insidiously contaminated by industrial chemicals and toxic wastes that have similar deleterious effects on wildlife and humans. However, since Rachel Carson, it has been widely understood that long-lived top of the ecological pyramid carnivores bioaccumulate and biomagnify pollutants present in hard to detect parts per million in the sedimentary basement of the food chain (Carson, 1962). Consequently, alligators have emerged from Florida's Lake Apopka as a model environmental sentinel species (Colborn, Dumanoski and Myers, 1996).

Why just Florida? Why not globalize the model? A most persuasive reason for crocodilian conservation would be their enlistment in programs to monitor water resource quality world-wide. Particulary so where their habitats interface with dense human populations. Crocodilians can become "keystone" species in humanized as well as vanishing "pristine" wetland environments (King, 1988; Williams, 1990). Is there any good reason why the Tortuguero caiman, an ecological equivalent of the Apopka alligator, should not be studied and managed as an environmental sentinel?

Unfortunately, in Puerto Rico the Department of Natural and Environmental Resources (DNER) considers the naturalized caiman an undesirable alien, a dire threat to life and limb and the very survival of a purportedly fragile insular ecosystem. Guilty until proven innocent summarizes the policy of the DNER, which has remained unchanged for over two decades regardless of the fact that no ecological studies of the Tortuguero caiman have ever been forthcoming that would either substantiate or dispel the alleged menace (Ruesink *et al*., 1995; Colón-Negrón and Chabert-Llompart, 1998).

However, the environmental management imperative of having an effective biomonitor species was recognized from very early on. Shortly after the DNER was established in response to aroused public concern with surface and ground water pollution, a visiting consultant lamented the absence in local wetlands of a long-lived top-of-the-food-chain carnivore which might serve as a biological sentinel (Bonnefil, 1974). Even as he spoke, the yet to be discovered caimans were quietly proliferating in the 224 ha lake and adjoining 1,500 ha plus Cibuco-Ciénaga Prieta marshlands (Watlington, 1998).

Discovery of the caiman presence in the early 1980's led the DNER into a theatrical 1985-86 media assisted campaign to get rid of them, interrupted when the agency head and prime instigator was abruptly sacked for his antics. There have been subsequent well-publicized razzia every so often during the 1990s, staged primarily as a promotional stratagem.

What follows is a chronicle of latter-day portends of the future of Tortuguero's caimans. In mid 1985, the crusading Secretary of the DNER urged hunters and restaurants to promote the consumption of caiman meat. When a random test in the DNER lab revealed high concentrations of mercury, the agency was forced to backtrack and issue a caveat. It was already feared but apparently never confirmed, that high levels of lead might be a problem, since Tortuguero had been a National Guard firing range for many years, not to mention the annual barrage laid down by droves of waterfowl hunters.

In 1987 prominent Puerto Rican ecologist Ariel Lugo dared challenge the myth of island ecosystem fragility (Lugo, 1987). Three years later Lugo took on the anti-exotics conservationists in a memorable verbal shootout (Lugo, 1990, 1992, 1994; Watlington, 1995). To be sure, the heroic lone ranger seems hopelessy outnumbered by the legion of taliban-minded invasion biologists such as Daniel Simberloff whose metaphorical depiction of Florida as a paradise threatened by nonnative species (i.e. foreign immigrants) is a travesty (Simberloff *et al.*, 1997; but see Wilson and Porras, 1983; Butterfield, Meshaka and Guyer, 1997). A fellow neo-conservationist begins *his* book with the following disclaimer: "At first glance, invasion biology can look like some sort of xenophobia in disguise" (Bright, 1998: 198).

The role of crocodilians as biomonitors of aquifer and surface waters materialized in the early 1990s. Following the lead of Colborn and Clement's ground breaking report: The Wildlife/Human Connection (1992), University of Florida zoologist, Louis Guillette literally came to grips with the disappearing alligators of Lake Apopka. By 1994 he had wrestled the terrible truth out of them. The shrinking penises of Apopka gators were definitively linked to endocrine disrupting water-borne pollutants that can have similar unthinkable effects on human machos (Guillette *et al*., 1994; Colborn *et al.*, 1996) Popular science media spread the shocking news (cf. Raloff, 1994; Luoma, 1995) and Guillette's career as distinguished researcher and lecturer blossomed.

Long before Guillete, toxicologists had developed a separate line of inquiry, into the bioacummulation of mercury in alligators (Peters, 1983; Hord *et al*., 1990; Heaton-Jones *et al*., 1997). Apparently gators are capable of putting away considerable amounts of mercury without obvious ill effects. In Puerto Rico similar studies have diffusely examined estuarine sediments and associated lesser organisms, but have never been aimed at caimans (Burger *et al.*, 1992; Dumas, 1999). Indeed, there have been few if any ecological or toxicological surveys of the widely introduced *Caiman crocodilus* in Cuba, Florida or Puerto Rico (Espinosa, 1998).

Surprisingly, one of the longest running clinical investigacions of endocrine disruptors in humans has taken place in Puerto Rico, focusing on pesticides and pthalate plasticizers with well known estrogenic and antiandrogenic properties (Colon et al., 2000). The island has the highest known incidence of telarche, premature breast development in very young girls. A satisfactory causal explanation has yet to be found, although the presence of anabolic steroids in poultry and high phytoestrogen content in soy-based formua have been controversially implicated.

A major historical flaw of the research is that the registry of cases has not pinpointed their geographical origin, possibly based on the assumption that diet rather than location is to blame. However, in 1995, geographers Sonia Arbona and John Hunter established a benchmark geographic perspective with their exhaustive review of water pollution in Puerto Rico (Hunter and Arbona, 1995). In it, the north coast limestone region aquifer emerges as the island's most critically important reserve of potable water and its most dangerously contaminated source.

Although current regional ground water withdrawal is roughly 75 millon gallons per day, nearly 16% of total island water use, the north coast limestone has the largest available untapped flow of any water resource region. Although surface water currently provides about 71% of island-wide supply, reservoir sedimentation is expected to reduce that supply dramatically in the near future.

Moreover, the north coast limestone region aggregates over half of Puerto Rico's industrial plants in the categories of primary metals and fabrications (74%), chemicals (55%), plastics and rubber (55%), electronics (49%), and pharmaceuticals (50%). The main concentration is in the west-central portion of the limestone belt, in a strip lining lake Tortuguero's catchment zone. In fact, one of the largest plants in the area, the DuPont complex practically abuts on the lake itself, and owns a sizable portion of its water frontage.

In the early 1980s the USGS conducted surveys of ground water quality in wells and springs of the industrial region surrounding Tortuguero. Very high levels of a variety of "high priority" and diverse other pollutants were found, including: TCE and PCE, benzene, dieldrin, lindane, methylene chloride, PCBs, PCNs, DDD, DDT, Dieldrin, Toxaphene, Furan, Diazinon and Diethyl phthalate. At the time, more was known about the cancerigenous and toxic properties of such chemicals than of their endocrine disrupting attributes. Even so, one had to wait until 1997 when geographers Cruz-Báez and Boswell published their *Atlas of Puerto Rico*.

Maps published in the *Atlas* showed distributions by municipality of the ten main causes of death in 1969-71. The Tortuguero region showed the highest concentration of "diseases of early infancy", and higher than average incidences of cancer and cerebrovascular diseases. A map for 1989-91 added high mortality from pulmonary diseases, but there was no follow-up for infant deaths.

In early 1998, I began to advocate in favor of recognizing the Tortuguero caiman as a naturalized wetland sentinel. My first presentation was on March 13, at the 23rd DNER Symposium on Natural Resources. My suggestion that crocodiles had been part of the native fauna in prehistory drew outraged derision from establishment biologists. Later, in May, the presentation was repeated for a more appreciative audience in Tampa, Florida (Watlington, 1998).

Early in the academic year 1998-1999 the University of Puerto Rico announced the availability of funds for visiting lecturers on interdisciplinary topics. Together with biologist Magda Morales we invited Dr. Guillete, who was briefed on our caiman agenda. He agreed to come to the Río Piedras campus and lecture ad honorem on his work with alligators. His visit to Puerto Rico took place on October 23 to 25, 2000 (Watlington, 2001). The main event was a public lecture for a mixed audience of mainly non-specialist faculty and students. As expected he delivered a great performance.

Later Guillette met separately with biology and chemistry students and faculty, and wildlife professionals who work with caimans. All seemed to go well until he made an off-hand comment to the effect that smaller (i.e. safer), short lived species such as Poecilid fishes could be as effective biomonitors as caimans. It suddenly dawned on me that he had not gone out of his way to endorse our caiman project.

Still, next day at the Bayamón Zoo he demonstrated, for the benefit of the biologists present, the proper technique for extracting a blood sample from the nape of a young caiman. Later that night, we counted caiman eyes on Lake Tortuguero, courtesy of the DNER. Oblivious to the possibility that he may have been trespassing on DuPont property, Guillete managed to grab a baby caiman and later enthusiastically 'counted coup' on capturing his 15th crocodilian species. He promised to return with students for hands-on field work.

That was two years ago, and the caimans are still waiting. To my chagrin, I learned that Guillette has been coming back to the island regularly, mainly to visit the lab of a longtime friend at the U.P.R. who owns patents on sophisticated bioanalytic instruments. It is strictly BYOB. I am told he brought with him almost a dozen live Florida alligators.

As a University of Florida alumnus, on January 8, 2002 I attended a dinner meeting at the Bankers Club convened to promote establishment of a Puerto Rico chapter of the UF alumni association. The guest speaker was International Studies Dean, Dennis Jett. Louis Guillette was also featured, and as usual gave a great lecture on his specialty. The caimans were mentioned in passing, along with the cryptic disclaimer that he was a "zoh-ologist not a zuu-ologist".

The last time I met the now Dean Guillette was at an August 21, 2002 midday presentation for the U.P.R. Biology Department. I always learn something from his alligator road show. The amphitheater was full but the questions raised at the end of his talk incensed me with their triviality and irrelevance. Finally, I asked: What will it take to get Puerto Rican biologists to do the same kind of research you are doing on Florida alligators with Puerto Rican caimans? Taking a swig of bottled (Florida?) water, he answered: "I don't know, you ask them". Somehow, his reply brought to mind Clark Gable's famous one-liner in Gone With the Wind.

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Reproducción del Cocodrilo Americano (*Crocodylus acutus*) en el Lago Enriquillo, República Dominicana

Andreas Schubert

SUMMARY: Nesting data from the American crocodile in Lago Enriquillo, Dominican Republic, was collected and processed during ten consecutive years (1992 – 2002). The nests were located on different beaches of the lake. Egg numbers oscillated between 14 and 51, with an average of 22 eggs per nest. The eggs are incubated by the heat of the sand, incubation time was 83 days average. About 75% of the eggs produced healthy hatchlings.

The total number of hatchlings per year varied between 200 and 800. Usually the mother helps them of leaving the nest and takes them to fresh water. In some cases, she takes care of them during several days. The hatchling survival rate during the first year was between 10 and 20%.

RESUMEN: En 10 años consecutivos se levantaron datos sobre el anidamiento del cocodrilo americano en el Lago Enriquillo. Los nidos estaban ubicados en diferentes playas en la orilla del lago. La cantidad de nidos oscilaba entre 14 y 51, con un promedio de 22 huevos por nido. Los huevos son incubados por el calor de la arena, la incubación duraba 83 días promedio. Un 75% de los huevos llegó a producir neonatos saludables.

El número total de neonatos eclosionados por año oscila entre 200 y 800. La madre les ayuda de salir de su nido y los lleva al agua dulce. En algunos casos los cuida durante varios días y hasta semanas. La taza de supervivencia durante el primer año está entre el 10 y el 20%.

INTRODUCCIÓN

Cocodrilos producen una cantidad elevada de huevos. Embriones, neonatos y juveniles son sujetos a una alta taza de mortalidad (estrategia r). Si esta mortalidad sobrepasa un cierto nivel la población se puede extinguir a largo plazo.

Las siguientes condiciones ambientales pueden afectar la supervivencia de los neonatos:

- Temperatura dentro del nido. Una temperatura por encima de los 34ºC y por debajo de 29ºC puede causar la muerte de todos los embriones.
- Inunandación del nido o sequía prolongada
- La distancia entre la playa de anidamiento y el próximo lugar con agua dulce. Los neonatos son transportados por su madre, cruzando el agua hipersalado del lago. En las islas en el interior del lago no hay hábitat disponible para los neonatos
- Depredación de nidos por otros animales o por el ser humano

  Hubo una fuerte persecución de los cocodrilos en décadas pasadas, incluyendo el saqueo de nidos. El saqueo de nidos ocurría sobre todo en playas de tierra firme y a menor grado en las islas.

Esta investigación busca dar una respuesta a dos preguntas principales:

- ¿Hay diferencias entre las características y el éxito de los nidos en las islas y en tierra firme?
- ¿Hay diferencias con otras poblaciones de Crocodylus acutus dentro del rango de su distribución?

MÉTODOS

El área de estudio incluye todas las playas reconocidas para el anidamiento del cocodrilo americano en el Lago Enriquillo. El tiempo de estudio incluye el periodo entre el 1990 y el 2001, con énfasis en los años 1993-97. Las playas fueron visitadas frecuentemente en la temporada de la puesta de los huevos entre enero y marzo de cada año, accesando en bote, en motocicleta o a pie. Los nidos fueron encontrados al seguir las huellas de las madres dejadas en la arena.

Distancias entre nidos fueron medidas con cinta métrica y con Hip-chain, las temperaturas de los nidos fueron con termómetros computerizados (Hobo-Temps) y la humedad del suelo con un llamado moisture meter.

RESULTADOS

Entre 1990 y 2001 fue localizado un total de 236 nidos para el lago entero, de ellos 50 nidos después de la oviposición y el resto después de la eclosión. Unos 32 km o 30% de la costa del lago son playas de arena, siete km de ellas usan los cocodrilos para anidar. Hay un total de once playas de anidamiento en el lago, seis de ellas están usadas frecuentemente, las otras han sido usadas solamente en una o dos ocasiones. La mitad de los nidos ubicados en una de las tres playas de las islas.

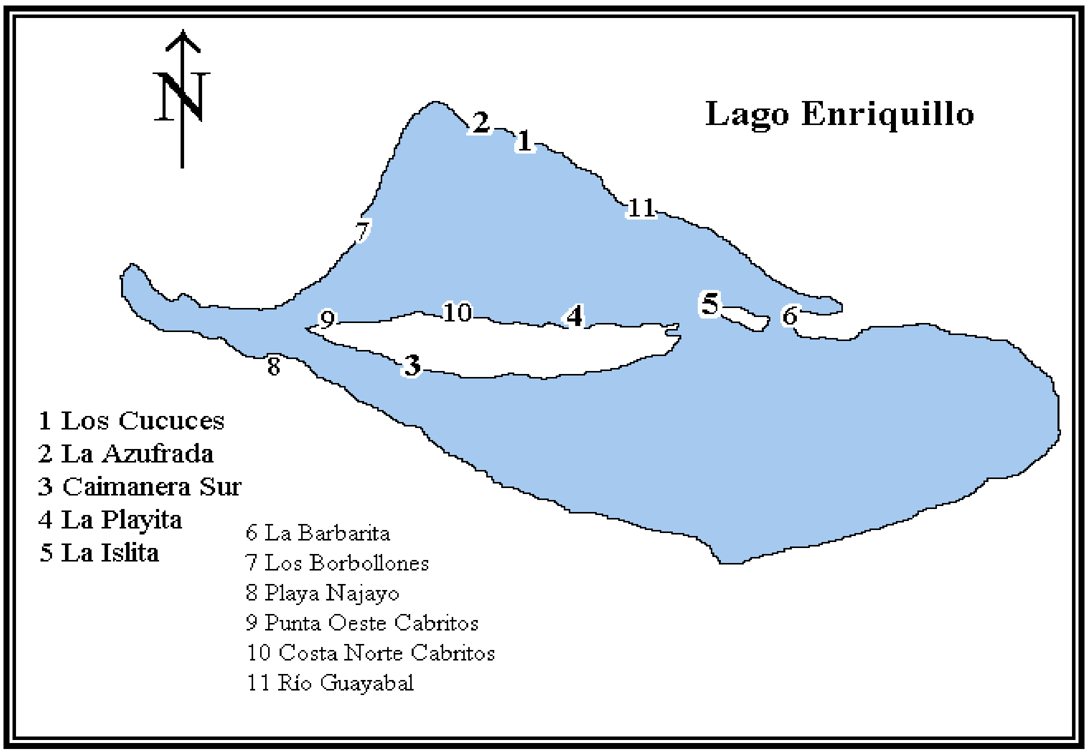


Figura 1. Playas de Anidamiento, las primeras cinco son las más importantes

Características de las playas Las playas de anidamiento tienen una longitud entre 150 y 1200 m, El promedio era de 605 m. La Caimanera Sur y de La Playita son las mas cortas (150 y 200 m) y las de La Azufrada y Los Cucuces las mas largas (1200 m cada una). Durante los 11 años de estudio había fuertes cambios en la anchura de las playas, debido a los cambios en el nivel del lago.

En casi todos los casos el área de los nidos está soleada durante la mayor parte del día, con excepción de Los Borbollones, donde todos los nidos quedan en la sombra.

Las tres playas principales de las islas quedan en sitios, donde se agregan los cocodrilos para solearse y para pernoctar. Las dos playas principales de tierra firme solo son frecuentadas durante la temporada de reproducción.

La distancia de los nidos al agua dulce es muy corta en el caso de las playas de tierra firme, como el de La Azufrada y el de Los Borbollones. Mientras tanto las playas de La

Playita y la Caimanera Sur en la Isla Cabritos quedan muy lejos del agua dulce: hasta mas de ocho km.

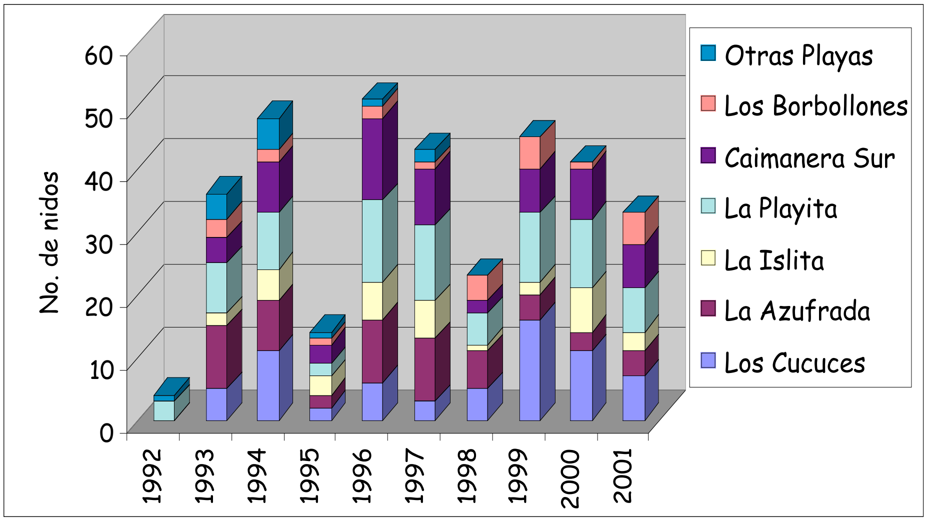


Figura 2. Nidos por playa en los años 1992 a 2001

Características de los nidos Todos nidos eran del tipo hoyo en playas arenosas. La distancia del nido a la orilla del lago era menor a 100 m, con excepción de Los Borbollones, donde quedaba en mas de 200 m, al bajar el nivel del lago en 1997. Generalmente la distancia nido – lago dobló entre los años 1994 y 1997. El mínimo para la altura del nido sobre el nivel del lago quedaba en 0.90 m, el máximo en mas de 4 m. Esta altura también aumentó mucho entre los años 1994 y 97.

La mitad (50 %) de los nidos estaba ubicada en forma conglomerado, con una distancia de menos de 10 m entre nidos. Otros 38% tenían una distancia entre 10 y 100 m y solamente un 12 % estaba ubicada en forma aislada a mas de 100 m de distancia al próximo nido. Hubo un alto porcentaje de reuso de sitios de anidamiento: 35 sitios fueron reusados en una o más ocasiones, 90 de 192 nidos (47%) estaban ubicados en sitios reusados entre 1 y 4 veces. Presumo que es la misma hembra que está reusando los sitios.

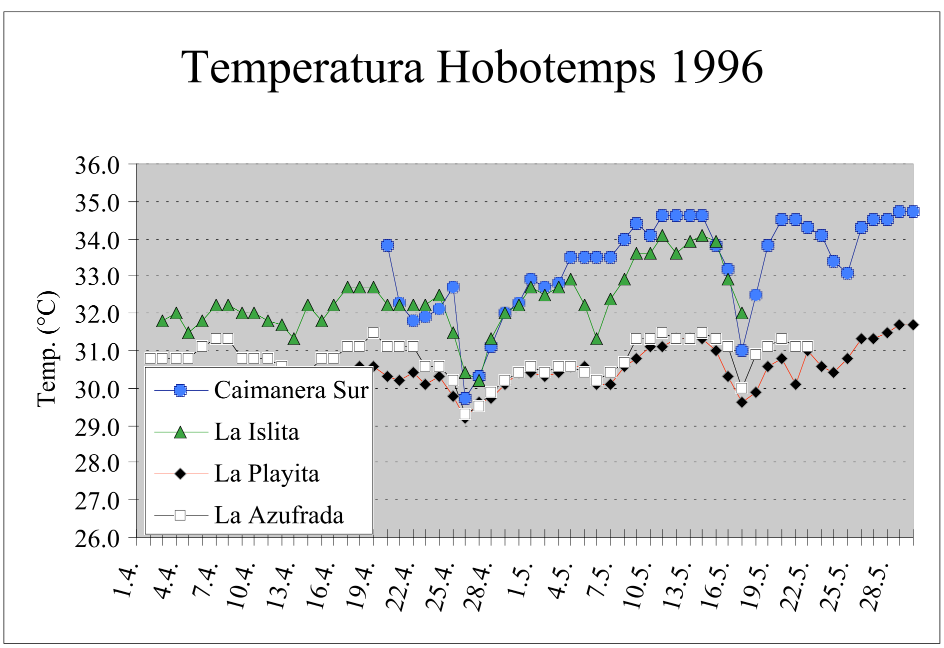


Figura 3. Temperatura en cuatro nidos durante el 1996

La temperatura fue medida en cuatro nidos durante los años, 1996 y dos en 97, usando termómetros computerizados (Hobo-Temps). El mínimo absoluto era 29 ºC, el máximo absoluto 35 ºC.

El gráfico arriba muestra las temperaturas para los cuatro nidos del 1996. Es obvio que los patrones de La Playita y La Azufrada se parecen, igual que los de la Caimanera Sur y La Islita. Este fenómeno no se puede interpretar por los patrones de temperatura del aire, porque La Playita queda prácticamente en el medio entre la Caimanera y La Islita. Las bajadas en la temperatura casi siempre coinciden con unos días de lluvia. La lluvia enfría el suelo. Las precipitaciones pueden ser un fenómeno local que nada más afecta una sola playa.

La distancia entre los dos nidos del 1997 era menor de 50 m. Uno se encontraba en una playa de alta insolación, el otro en completa sombra. Aparentemente el nido de la sombra tenía una temperatura de mas de un grado por encima del nido de la playa soleada. El hobo-temp estaba ubicado a una profundidad de 25 cm en el primer caso y a 30 cm en el segundo. Parece que la influencia del grado de insolación sobre la temperatura del nido es mucho menor que otros factores, como la profundidad del nido y la conductividad del calor dentro de arena. No se pudo probar diferencias en la temperatura entre los nidos de las islas y de tierra firme.

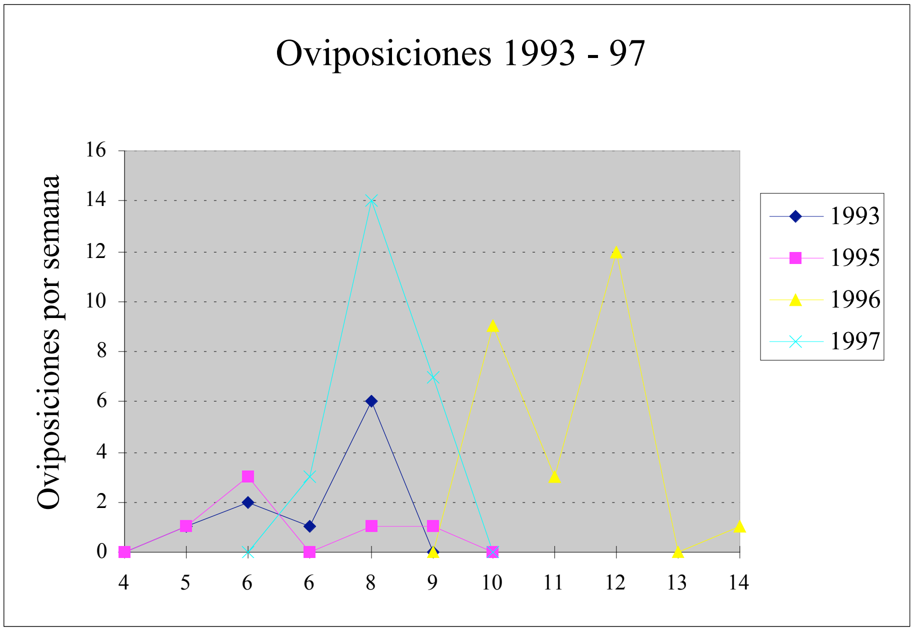
La humedad de la arena fue medida dentro del nido y a _ m hacia dos lados del nido. El punto de saturación de la arena con agua era 25%. La saturación se debe al agua de fondo, proviniendo del lago o de acuíferos de agua dulce. En un 24% de los casos (basado en datos de 86 nidos del 1996 y 97) el punto de saturación estaba por debajo, en un 28% al mismo nivel y en un 7% por encima de los huevos. En un 27% la arena no hubo saturación de agua hasta los 60 cm determinado por la profundidad máxima que puedo medir el aparato usado. En un 14% de los casos hubo placas de caliza precipitada por debajo del nido.

El punto de saturación estaba significativamente (U-test, _ = 0.01) mucho mas profundo en las playas de las islas (promedio de 55 cm) que en tierra firme (35 cm). Sin embargo, en La Caimanera Sur las madres podían elegir entre sitios secos sobre la berma y sitios con el punto de saturación cerca de la superficie. Mas de la mitad eligieron los sitios bajos cerca de la orilla.

La excavación del nido y la oviposición pueden cambiar la textura y así la humedad de la arena. En un 38% de los 86 nidos investigados la cavidad tenía mas del doble de la humedad que en los alrededores inmediatos; esto fue observado en lugares secos. En sitios húmedos con el punto de saturación mas cerca de la superficie, la humedad dentro de la caverna era mucho mas baja que en los alrededores (17% de los casos). En un 45 % de los casos, la humedad del nido era similar al ambiente, sobre todo en lugares con una humedad mediana.

Número de huevos. Para los años 1993-97 hubo un promedio de 21.6 (SD 6.4, n = 159) huevos por nido, con un rango de 9 a 36. No había ninguna diferencia significativa entre los promedios de los años. Sin embargo, el promedio de huevos en La Caimanera Sur quedaba en 18.1, significativamente menor que los promedios de La Playita y de las playas de tierra firme (U-test, _ = 0.05 y 0.01 respectivamente). Este hecho sugiere que la Caimanera es usada por un mayor número de madres jóvenes. La masa total por nido equivale a 1878 g promedio (SD 626 g). Las excavaciones tienen una profundidad promedia de 36 (SD 5) cm, n = 52, la profundidad del primer huevo (él mas cerca de la superficie) queda a 24 (SD 5) cm. El diámetro promedio del nido es 27 cm (SD 5 cm). No hubo diferencias significativas entre los nidos en las diferentes playas.

El tiempo de incubación era de 82.5 días promedio (SD 6.8), con un mínimo de 72 días y un máximo



de 104 días.

Figura 4. Oviposiciones por semana, 1993 – 97

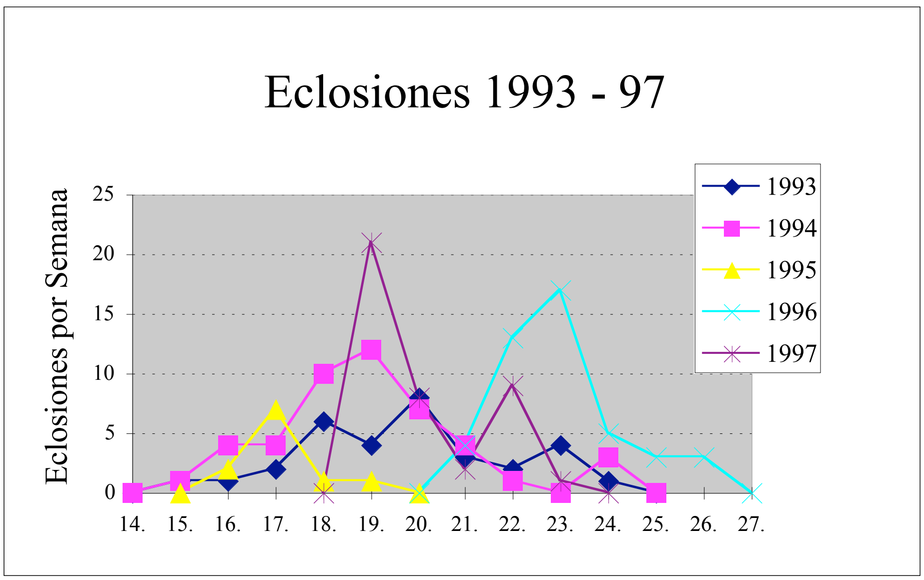


Figura 5. Eclosiones por semana, 1993 – 97

Características de los huevos El promedio para la longitud era 73.4 (SD 2.0) mm, rango 66.0 a 77.1 mm, para la anchura era 43.5 (SD 0.7) mm, rango 40.3 a 46.5 mm, para la masa era 85.5 (SD 3.3) g, rango 67 – 102.2 g, n = 1404 huevos de 62 nidos en los años 1993-97.

La fertilidad de los huevos fue determinada en 49 nidos en 1996 y 43 nidos en 1997. En un tercio de los nidos no había huevos infértiles. En 1996 11 nidos tenían números elevados de huevos infértiles, en 4 casos todos o casi todos los huevos eran infértiles.

Mortalidad de embriones. De 188 nidos encontrados durante los 5 años de estudios intensivos, cuatro fueron robados. Calculamos un total de 3987 huevos para los 188 nidos. De estos 513 (13 %) fueron inviables, es decir fueron infértiles o el embrión murió poco después de la oviposición. Otros 95 (2.4 %) fueron encontrados con el embrión desarrollado y muerto. En 64 casos (1.6 %) los neonatos fueron encontrados muertos, fuera del cascarón pero en cercanía al nido. En síntesis: la mortalidad embrional alcanzaba un 17% durante los cinco años.

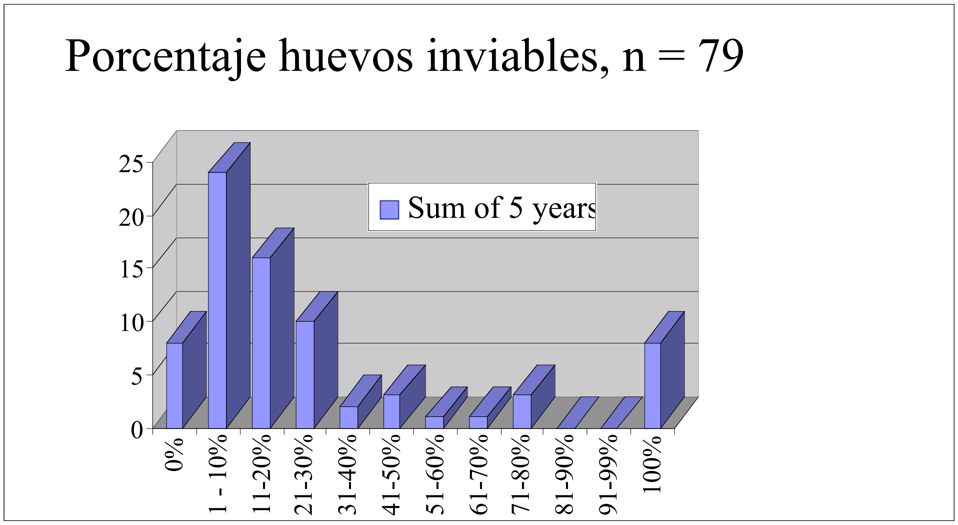


Figura 6. Porcentaje de huevos inviables al total de huevos en 79 nidos durante cinco años

Las razones para la mortalidad embrional fueron: en el 1993 la alta humedad en el fondo de muchos nidos causó su fallo parcial o completo. En los demás años esto no fue un problema importante. Existe solamente una depredación por el ser humano (cuatro nidos robados en los cinco años). No hubo evidencia de depredaciones por animales. La falta de atención al nido por parte de la madre fue registrada solamente en dos ocasiones y puede ser considerada como un fenómeno poco común.

Los Neonatos

El proceso de la eclosión es iniciado por la madre que se acerca al nido para escuchar si hay sonidos por parte de los embriones. En caso positivo la madre abre el nido y saca los neonatos con su hocico para llevarlos a un hábitat favorable fuera de la zona de nidificación. En pocas ocasiones los lleva a todos en la misma noche, mientras en la mayoría de los casos lleva la mitad en una noche, y la otra mitad en la próxima noche.

Los neonatos son llevados a áreas donde crece la enea, a caños y a charcas de agua dulce. En muchos casos la madre los lleva primero a áreas intermediarias donde pueden sobrevivir dos o tres días para luego ser llevados a un destino final. Estas áreas intermediarias quedan generalmente a menos de 100 m del nido. La madre esconde los neonatos debajo de arbustos, raíces, halófitas o placas de caliza en o cerca de la orilla. También los deja en charcas que se forman en la orilla del lago. Algunas de estas charcas superan los niveles de salinidad del agua del lago con hasta mas de 100 g/l.

De 41 nidos observados durante el periodo 1994 a 97 quedaron nueve (22%) sin atención de la madre después de la eclosión. En las islas (Islita y Cabritos) hubo una atención de 1 a 3 días por parte de la madre, incluyendo su transporte a los sitios con hábitat favorable. En las playas de tierra firme la atención duró hasta 80 días, como es el caso de piscina sucia en La Azufrada. De 17 madres, 8 estaban en charca con neonatos, 9 en la orilla cerca de la charca

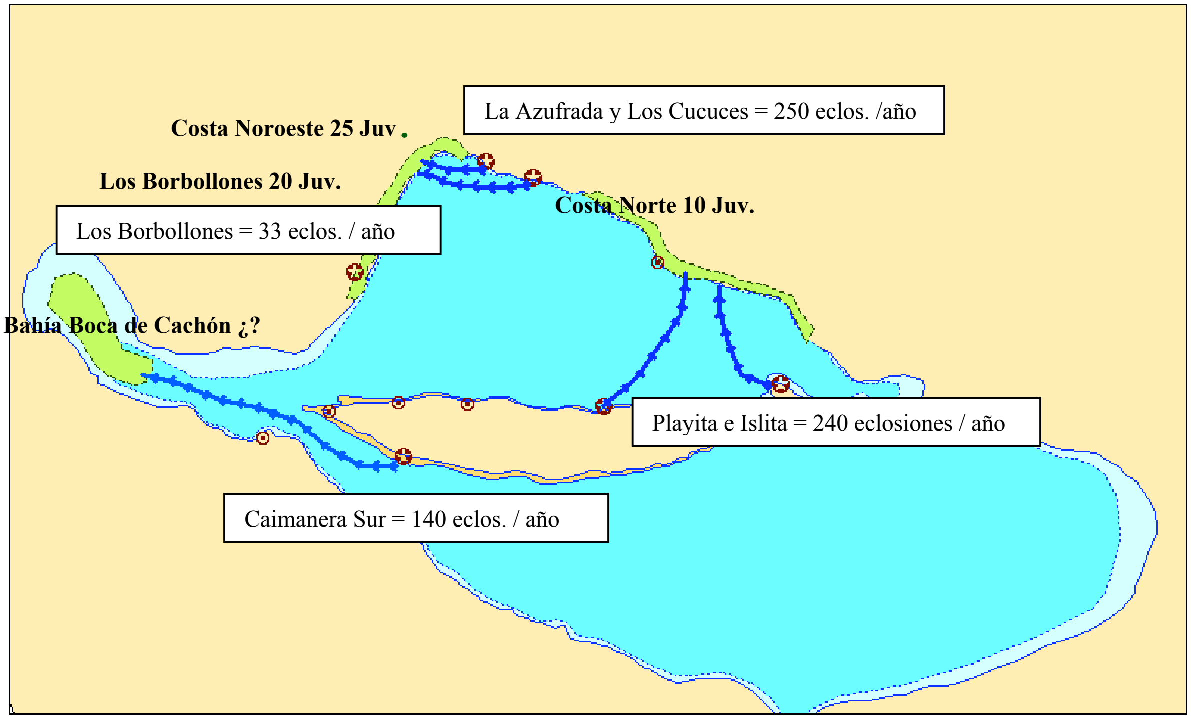


Figura 7. Rutas de las playas a los hábitats de crianza

El mapa arriba (Fig. 7) muestra las playas de eclosión con la cifra del promedio de eclosiones por año en cada playa o conjunto de playas. El mapa muestra también las supuestas rutas y las áreas de crianza de neonatos con la cifra del promedio de juveniles vistos en estos sitios durante los cinco años de estudio. Los neonatos de La Playita y La Islita se crían en la costa norte del lago, los de La Azufrada y Los Cucuces en la costa noroeste (El Platón y Los Borbollones). Mientras tanto los que eclosionan en la Caimanera Sur llegan presumiblemente a la Bahía de Boca de Cachón. No era posible levantar datos sobre la abundancia de juveniles en esta zona debido a problemas de acceso a esta zona.

DISCUSIÓN

¿Por qué los cocodrilos anidan en las islas?

Aparentemente la supervivencia de neonatos es mayor en las playas de tierra firme como La Azufrada – Los Cucuces y Los Borbollones que en las islas como en las playas de La Playita y La Islita. Queda la pregunta: ¿Por qué los cocodrilos anidan en las islas? Aparentemente no hay mucha diferencia en condiciones biofísicas entre las playas de tierra firme y de las islas.

Nuestra hipótesis: La persecución y el saqueo de nidos por el ser humano han sido muy alto antes del 1992, cuando se estableció una vigilancia efectiva en el Lago Enriquillo. En estos años los cocodrilos se acostumbraron a anidar en las islas, donde el impacto humano es mucho menor, pero la supervivencia también es menor, debido a las largas travesías por aguas hipersaladas.

Comparación de la población del Lago Enriquillo con otras poblaciones de *Crocodylus acutus*

Tamaño del nido. El número promedio de huevos por nido (21.6) es similar a él de Monte Cabaniguán en Cuba, donde Rodríguez et.al. reportan 24.8 para los años 1992-96. Para Etang Saumatre en Haití Thorbjarnason (1988) reporta 22.5 en los años 1983/84. Para los cayos (atolones) de Belice Platt and Thorbjarnarson (1997) indican 22.3 huevos por nido.

Sin embargo, los nidos de diferentes poblaciones en Centroamérica, México y Florida tienen considerablemente mas huevos por nido. Valtierra-Azotla (2000) reporta un promedio de 33.4 huevos por nido para la reserva de biosfera Chamela Cuixmala en Jalisco, México. Este número ha subido bastante desde el 1989 cuando reportaron solamente 18 huevos. Para los nidos de Florida Bay Kushlan y Mazotti (1989) calcularon un promedio de 38 huevos. Alvarez del Toro (1974) habla de 30 – 60 huevos por nido para diferentes sitios en México.

Cantidad de nidos. Durante los años 1976 – 84 contaron entre 70 y 112 nidos en el lago, estimando entre 100 y 150 (Incháustegui en SEA/DVS 1993). El presente estudio revela un promedio de 37.1 nidos por año, rango 14 – 51 para los años 1993 – 2001. En otras palabras, el anidamiento había bajado a menos de un tercio debido a fuertes persecuciones (SEA/DVS 1993, Schubert & Santana, 1996). En los años 1991 – 92 la producción era muy reducida. Sin embargo, en 1993 y 94 la reproducción y supervivencia era muy buena. En la actualidad los juveniles que fueron marcados en aquel entonces ya tienen la edad y el tamaño para poder reproducirse. Aún los datos actuales todavía no demuestran un aumento en la cantidad de nidos.

Generalmente la cantidad de huevos por nido y la masa total del nido dependen del tamaño de la madre (Thorbjarnarson, 1988). Hace 20 años los cocodrilos del Lago Enriquillo eran mucho mas grandes (Thorbjarnarson, com. pers.). Probablemente la poca cantidad de huevos por nido, masa por huevo y masa por nido se debe al menor tamaño de las madres.

La taza de **supervivencia embrional** es muy alta en el Lago Enriquillo (83%). En Monte Cabaniguán en Cuba eclosionó un 62.5 % de los huevos (Rodríguez et.al 1998), sin embargo un _ de ellos con ayuda de los investigadores. Moler (1991) reporta un 52% de nidos exitosos Key Largo en Florida y Platt & Thorbjarnarson (1998) un 80% para Belice. Nota: los últimos dos reportes están basados en los nidos, mientras en el ejemplo del Lago Enriquillo y de Cuba se trata de huevos individuales.

La atención maternal es común en el Lago Enriquillo. Las madres ayudan a los embriones de salir del nido. Después llevan los neonatos a lugares de agua dulce. En Monte Cabaniguán un cuarto de los nidos carecía de atención parental. En este estudio hubo muy poca evidencia de no atención al nido (solo dos casos durante los cinco años).

Otros estudios demuestran poca evidencia de atención a los neonatos de C. acutus (Platt & Thorbjarnarson, 1997, Thorbjarnarson 1988, Moler 1991, Kushlan & Mazotti, 1989). En este estudio si encontramos una atención prolongada de una a dos semanas y en el caso de la "piscina sucia" en La Azufrada la madre cuida sus crías hasta 80 días cada año.

CONCLUSIONES

- No hay diferencias marcadas entre las playas de tierra firme y de las islas que puedan influir la supervivencia de los embriones
- La anidación en las islas se debe presumiblemente a las fuertes persecuciones que sufrían los cocodrilos en tiempos pasados
- Las Playas de Anidamiento del Lago Enriquillo son de buena calidad y la supervivencia embrional es alta.
- La supervivencia de los neonatos es relativamente baja, debido a la necesidad de cruzar las aguas hipersaladas
- Existe una atención maternal muy marcada a los nidos y a los neonatos después de la eclosión. Creando más cuerpos de agua dulce, tipo "piscina sucia" se aumentará significativamente la supervivencia porque se crean mas oportunidades de atención prolongada

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Sub-nosed Crocodile *(Crocodylus palustris)* Study in Iran

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ABSTRACT: A small population of 200 to 300 Mugger crocodiles occupies vast range or water bodies in south eastern Iran, near the Pakistan border. Their habitats are represented by the natural ponds along 3 main rivers, Kaju, Sarbaz and Bahukalat. Egg laying takes place in mid May with number of 20-30 and they hatch in late July. Crocodiles use any available resources as food like fish, birds, insects, dogs and even villager's goats. One of the most specific behaviors of Mugger is burrowing which are mostly used as refuge to avoid heat and may be other purpose. Migration between water bodies is another considerable activity of Muggers in the area. They are legally listed as "protected wildlife", there is a fine for any killed crocodile, and more over, the distribution area has been designated as a "protected area" due to its importance as crocodile habitats.

DISTRIBUTION AREA

A small population of Mugger crocodile (*Crocodylus palustris*) inhabits the southeastern most part of Iran in the Baluchestan province. Their habitats are along three main rivers of the area: Sarbaz, Kaju and Bahukalat and their related headwaters and ponds. Due to its importance as crocodile habitat, part of this area (3,800 sq km) was designated "protected area" in 1971. It was then named Bahukalat and in 1982 was renamed "Gandou" protected area. Gandou is the local name for crocodiles.

In the area, they occupy vast range of fresh water bodies such as lakes, ponds, reservoir and artificial ponds named Hootak which are constructed nearby villages to hold rain water for people's daily use and in most of them 1-2 crocodiles can bee seen. However, the main habitats are some natural ponds along the rivers with specific conditions such as depth, living organisms and vegetation. These ponds are considered as permanent habitats for crocodiles all year long depending on water quantity so that in drought seasons even 20-30 crocodile live together in one pond.

The reservoir of the Pishin dam since its construction plays an essential role. It is one of the most important habitats for the crocodiles although in recent years due to the lack of rain, the water reserve is getting down and down. The area has international importance. It is considered the 19th Ramsar site (international wetland) of Iran. There, crocodile habitats extend from Pishin Dam to Hure-Bahu (Bahu Estuary) along Sarbaz and Bahukalat River. Mugger is one of the noteworthy species of this wetland. The main distribution area of Mugger in Iran starts from Sarbaz and southeastern part of NIkshahr along Kaju River which joins to Sarbaz River in its way to the sea. Sarbaz River renames to Bahukalat after the village with same name. Although Kollany village and its ponds are near Govater Bay which is considered the end of crocodile range in Iran, there is no evidence that Iranian crocodile enter saltwater.

REPRODUCTION

Although observations on courtship and mating weren't made, probably it starts late winter and egg laying takes place at mid-may and the eggs are laid in typical hole nest with a depth of about 30cm in the sandy beach of the nearby water resource usually under shadow of trees. The eggs with number of 20 -30 are approximately 8 cm long, 4.7 cm wide and weigh 80-90 g. They hatch after 50-60 days incubation period in late July. Noteworthy threats for the eggs and hatchlings with length of about 25cm are natural predators like mongooses, foxes, monitors (*Varanus* sp.) and birds. But the main threat in previous years have been inundation which caused nest destruction and death of hatchlings and in recent years, vice versa, extreme drought causes mortality of the hatchlings.

FEEDING

Depending on water bodies, it seems that crocodiles use any available resources as food. Studying their feeding habits, we collected some fecal samples composed of beetle elytra and legs, fish remains and kingfisher or other bird feathers. Other observations and local people reports indicate that Muggers catch and feed on villager's herds (mostly goat) and wandering dogs too and also there are some evidences on eating dead animals.

There are just occasional and not serious attacks of crocodiles on humans in its range in Iran. These creatures aren't dangerous under normal circumstances at villages so that children swim in the river and ponds and women do washings without fear of Gandou (local name for Mugger crocodile). All evidences indicate that Mugger use vast range of resources as food and even they have seen wandering in the villages seeking for something to eat. However nowadays in most parts due to drought and drying out of water bodies they've lost their food resources and are dying out of hunger and some of them are too thin and weak .

Main Behaviors

Similar to other crocodiles daily activities are basking, swimming and under water staying. However, the most specific behavior of Mugger is burrowing. The burrows are used as refuge to avoid heat during hot hours of the day and may be other purposes and come out at night in search of food.

In my activities, I couldn't find any evidences indicating nesting and egg laying in the burrows. The behavior is observed in many different conditions and situations which seem to be related to habitat. In natural or artificial ponds burrow entrance is commonly observed within 0.5 m of the water edge and level and muggers living along rivers are observed to dig their burrows further than water edge possibly because of periodic flooding and sometimes the burrows are under the root system of trees far from water. Most of the time, the burrows are dug directly into the river or pond bank. Sometimes burrow entrance is behind emergent vegetation such as *Typha* and *Phragmtes*. The holes are about 1.5 to 5 m deep and any hole is used by one crocodile. Once I could find two holes nearby each other may be a horse shaped or both of them used by one or two crocodiles.

Migration of Muggers is another activity which in last years due to specific condition in the area caused by drought was recorded. Scanty rainfall and high temperature cause water bodies to dry out one after another which in turn causes loss of crocodile habitats and food resources. Therefore, they have to find and move to new ponds which some times are far from each other. This migration causes aggregation of crocodiles in ponds which aren't too large for crocodiles. We have recorded 10 -30 crocodiles in one pond in which in normal condition one to three crocodile can be found. Now, the main art of the population is aggregated in Pishin Dam reservoir with a number of about 60-70 crocodiles. Prolonged drought is causing mortality of weak crocodiles which their pond is drying out and they are too weak to find another suitable water body and food.

MUGGER POPULATION STATUS AND CONSERVATION IN IRAN

The main part of the distribution area of Mugger due to its importance as "crocodile habitat" have been established as "protected area" since 1971 named Bahukalat with an area of 3,800 sq km which was renamed "Gandou" since 1982. Some specific areas along Sarbaz and Bahukalat rivers have recently been designated as 19^{th} International wetland (Ramsar site), so legally specific regulations are carrying out in the area and wildlife guards control it. Fortunately because of specific social and religious believes, there is no hunting on crocodiles and local people don't harm them, although crocodiles catch their goats. More overdue to conservation regulations crocodiles are listed as protected wildlife and any killed one has fine of 16 million Rials which is about $ 2,000.

Based on available information and my last visits, the Mugger population counts between 200-300 individuals which are distributed in the area and are very scattered, especially during the rainy seasons. Visiting the rivers near the Iran-Pakistan border, in my opinion, the crocodiles of the countries in border area are related and move between Iran and Pakistan specially in the rainy seasons that water bodies are closed to each other and seasonal common rivers are following.

The present condition of Mugger population is very bad due to drought that has dried out most of the water resources. There has been just occasional raining for 4 years, even the Pishin Dam reservoir is reduced to a big pond and has no useable reserve and in some areas, crocodiles are faced to death. I hope that they could survive this condition.

CONCLUSION

It was a brief report about Mugger population status and biology in Iran which I hope to be useful in providing any needed information about crocodiles in Iran. Considering no hunting and utilization in Iran and their protection, we could have a positive role in improving Mugger population and its conservation. But we are in need for more attention and especially technical support and experiences to help us carrying on conservation and research activities like habitat protection and breeding. More contact between Mugger range countries would be especially useful for providing needed data about their population and planning for more and future programs, which in this relation Madras Crocodile Bank, as a data base, could have essential role.

It would be my great pleasure and I'd be grateful if researchers and scientists interested in Mugger in Iran contact me for needed information and be kind enough and help me in my works and providing needed information.

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The Photographs

Natural ponds along rivers with food resources are the main crocodile habitats

A Mugger nest with eggs

Monitors are abundant in the area

Fish is one of the main food resources

Burrowing is one of the most specific Mugger behavior

Some crocodiles due to lack of food caused by drought are too thin and dying

Community-driven Conservation of Crocodile Habitat in the Middle Sepik Region, Papua New Guinea

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Abstract: The crocodile management programme in Papua New Guinea is recognized as one of the most successful in developing countries. A multi-faceted approach, including generation of substantial benefits to local communities from sustainable wild harvests of skins, young and eggs, is an important factor in that success. Even so, habitat degradation in the middle Sepik River region, where >40 % of PNG's crocodile exports are produced, is of increasing concern. Regular widespread burning of floating mat vegetation, which harbors prime nesting sites of the Indo-Pacific crocodile *Crocodylus porosus*, establishes disclimax associations that are inferior or unsuitable for nesting.

A current GEF Small Grant project seeks to strengthen conservation of remaining strongholds of nesting habitat, and to restore degraded sites of importance. A local Interest Group (IG) is using Participatory Rural Appraisal (PRA) techniques to discern the root causes of wetlands degradation, and to motivate local land users to devise and implement site-specific conservation strategies. Expansion and enhancement of commercial egg harvests is seen as a key activity to increase mutually interactive benefits to local communities, nesting habitat and the crocodile industry.

This paper describes the PRA-derived methodology, results of initial fieldwork, and prospects to achieve community-driven conservation of critical wetlands.

INTRODUCTION

The Indo-Pacific (=saltwater) crocodile, and to a lesser degree, the New Guinea freshwater crocodile *C. novaeguineae*, are major income generating resources for some 15,000 people in the middle Sepik region. Both species were extensively exploited for skins and meat in the 1950s and 1960s. Hunting controls (maximum bellywidth limits) were imposed in the 1970s to ensure that harvests were sustainable. In the 1980s ranching and farming schemes based on collection of juveniles were developed to capture additional economic value of the crocodile resource, promote production efficiency, and further establish conservation of wild populations. This mutually beneficial approach was substantially strengthened in the mid-1980s by introduction of egg harvests (see Cox and Solmu 1996 for a review of this component).

Crocodile populations in the middle Sepik have been primarily monitored by aerial nest counts, conducted in most years from 1981 to 1998. Surveys are flown during the annual peak nesting season of each species over a large sample of sites representing various nesting habitats. Counts are particularly indicative for *C. porosus*, which prefers to nest in more open (and more easily scanned) floating vegetation, and largely restricted to lagoons and lakes in close proximity of the Sepik River (Cox 1985).

Monitoring studies suggest that saltwater and freshwater crocodiles in the Sepik are sustainably utilized, and until 1998 (following an extraordinary drought in 1997), indicated an overall increase in *C. porosus* nesting in the middle Sepik (Cox and Genolagani 1992; Manolis 1995; Cox 1998; Kula and Meru 1998). Nevertheless, aerial surveys of most sites reveal a long-term trend of moderate to severe degradation in the critically important expanses of floating mats that constitute primary nesting habitat for *C. porosus*. (Hollands 1984, Cox *et al*. 1988, Genolagani *et al*. 1989, Genolagani *et al*. 1991, Cox 1995, Cox and Solmu 1996, Cox 1998, Kula and Meru 1998).

The Middle Sepik was recently identified as a Very High Priority area for conservation of wetland biodiversity in Papua New Guinea (Olivieri and Hutchinson, 1993; Swartzendruber 1993). Area habitat is therefore not only a crucial testing ground for rural development based on sustainable utilization of wildlife, but of major importance for conservation of biodiversity.

To address and reverse the root causes of habitat degradation, the Sepik Wetlands Management Initiative (SWMI), a local IG, has received a Global Environment Facility (GEF) Small Grant for an 18-month project. Fieldwork began in September 2000 with conduct of an initial Participatory Rural Appraisal (PRA), co-led by SWMI members and the authors. This paper is based on the results and findings of the PRAs as presented in reports by Cox (2002) and Solmu (2002) and follow-up activities of the Initiative. Results of the PRA equip SWMI with the necessary technical skills and impetus to advance community-based implementation of the project and to evaluate its effectiveness.

The ultimate value of PRA exercises will be the ability of SWMI members, key individuals and local focus groups, using information and insight gained, to devise site-specific conservation strategies. At remaining areas of primary crocodile nesting habitat, especially where *C. porosus* is abundant, ongoing conservation success can be enhanced, while at selected sites of degraded habitat, restoration efforts can be initiated.

METHODS

The strategy to achieve project objectives relies heavily on selected tools associated with the PRA approach. SWMI is a facilitator and catalyst that enables a community-oriented effort to determine the fundamental causes of habitat degradation, and to encourage local communities themselves to identify, develop and implement rehabilitative measures. In village domains where nesting habitat and crocodiles have been effectively conserved, PRA can be similarly employed to ascertain the underpinnings of success, and in turn, stimulate management actions (often based on increasing economic benefits to local stakeholders) that will strengthen conservation. In these contexts "appraisal" is actually participatory learning and doing.

PRA was developed in the late 1980s and early 1990s mainly for use in agriculture and agroforestry initiatives (Chambers 1992). Only in recent years have aspects of the methodology been incorporated into community-driven conservation. There remains much scope, particularly in non-protected areas of developing countries, for conservation planning to fully embrace PRA.

The technique appears eminently suitable for use in Papua New Guinea, where a traditional system of land tenure based on local ownership is widespread and strong, and the government has very limited resources for wildlife management or biodiversity conservation. The PRA approach is particularly appropriate for the socio-cultural and political situation in the middle Sepik. All crocodile nesting habitat is traditionally owned, and legal aspects of ownership are strengthened by PNG organic law. Most areas of interest to SWMI feature nesting habitat managed by one or more clans of a single village. Some larger sites are shared with clans from neighboring villages. Ownership or land use rights at other sites are in dispute, sometimes continual.

The PRA works considered most relevant for tailored applicability in the Middle Sepik are Chambers (1992) and Grant (1996). The principals of PRA described by these authors are:

- **They teach us**. In a reversal of roles, outsiders learn from and with rural people; elicit and use their criteria; discover understanding and appreciate indigenous technical knowledge. Outsiders listen and learn instead of lecturing. Interactions are scheduled for times that are convenient for the community or informants, and happen at a relaxed and informal pace. Note taking is kept to a minimum. Questionnaires are usually avoided. Open-ended questions are asked. Information is probed for, and cross-checked to verify accuracy and reliability.
- **We facilitate**. Local people are empowered and enabled to lead PRA exercises (*e. g.*, mapping, ranking, scoring, planning), and are encouraged to analyze and interpret the results. They own the results and share them with outsiders. *Locally determined* assistance, whether advisory or material, is the desired output.

- **Critical self-awareness about our attitudes and behavior**. How to deal with doubt; learn by doing; embrace and learn from error. (We often learn more from our mistakes than successes). Build learning and improvement into each activity. Seek diversity and difference. Make rapport more important than methodology; empathy; humor; respect; trust; encouragement; confidence that they can succeed.
- **Outside investigator's direct contact**. Staying in the village. Engaging in face to face contacts. Asking to be taught. Working in small groups. Finding the right questions to ask (We assume we know what to ask; the beginning of wisdom is to realize how often we do not know, and to recognize that we need their help [Chambers, 1992]). Direct observation. Identifying key informants. Seeking a variety of contributors in meetings. Involving women at each and every stage.
- **The power of the open against the closed, the visual against the verbal; group versus individual analysis, and comparing versus measuring**. We are trained to make absolute measurements, although trends, scores or ranking are often all that is required (Chambers 1992). PRA methods are fundamentally qualitative rather than quantitative.

PRA tools assessed as most appropriate for SWMI, and subsequently used in discussions with local communities were:

Group meetings. Scheduled at the convenience of the community and usually held in either the *haus boi* (men's house) or the school. Usually a focus group of residents with knowledge of crocodile nesting areas, and typically composed of men. PRA team members introduced themselves and the objectives of the project, then asked landowners and others to teach the team about wetlands resource use in general, and crocodile nesting habitat in particular. Included probing for specific information and views, and questioning to cross-check the information received. Ideas were sought on how nesting habitat could be conserved in ways that generate benefits for local communities.

Interviews. Usually conducted with a single informant or resource person, and often to discern the oral history of a nesting site or a trend in a local crocodile population. This tool is also useful to obtain information from individuals who feel it is too sensitive to be discussed in meetings, or to communicate reservations about information provided in group meetings.

Informal discussions. Often spontaneous, with individual discussions comprised by a variety of persons: renowned hunters, influential members of the local community, concerned residents, local guides and persons met on field excursions.

Mapping. Villagers drew maps in the ground, tracing outlines and borders with sharp objects and using locally available symbols (*e. g.*, flowers, leaves, twigs, betel nuts, small stones) to represent important features. Alternatively, school chalkboards were preferred by some groups, at times with assorted colors of chalk to represent various features. Questions raised during map making were a principal means to obtain detailed knowledge of specific nesting areas, habitat characteristics (*e. g.*, vegetation, succession, effects of fire, crocodile species) and other issues related to crocodile resource use. The lengthy time required to construct maps allowed probing for information to be done in a relaxed manner.

Resource Importance Matrices (RIMs). Used to gauge the relative importance of the local resources. A PRA team member asked group members to name the most important resources *utilized* in the local economy. The group was then invited to gather symbolic objects (often the same as in map making) to represent important (usually 6-8) resources. A grid was drawn in the ground. Each symbol was placed in a row and column, and pairwise ranked by group consensus (*e. g.*, which is more important, fish or crocodiles?). An additional item of the symbol representing the more important resource was then placed in the intersecting column/row grid cell. After each resource was compared with all others, "winners" in the matrix were totaled in the far right column to obtain a relative importance index. Reasons for overall rankings were then sought from participating villagers. At some villages, a chalkboard version of the RIM chart was preferred by local participants.

RESULTS

PRA exercises.

The initial PRAs produced a wealth of detailed information on crocodile nesting habitat, patterns of use, and conservation issues. In addition, many views and ideas were expressed that could lead to development of mutually beneficial initiatives.

The reasons for the occurrence of fires in nesting habitat were better understood as a result of the PRAs. Burning of nesting areas was often described as unintentional, resulting from the creep of fires set to clear and enrich adjacent lands for gardening (slash-and-burn agriculture). In seasonal wetlands fire was used to create more fishing habitat during highwater periods and to facilitate travel by canoe. Some informants confided that fires were also (occasionally?) set simply because dense vegetation was ripe for burning, and to create pathways, possibly including ones across nesting habitat.

The effects of fire on nesting habitat were also better discerned. As observed from aerial nest counts (Cox 1998; Kula and Meru 1998) primary *C. porosus* nesting habitat was susceptible to fire only in the driest years, usually coincident with El Niño-Southern Oscillation events. Dense floating mats of sago *Metraxylon sagu*, pandans *Pandanus* spp., hanguana *Hanguana malayana*, reeds *Phragmites karka* and sedges could be incinerated if anchored and dry for months. Gradually these associations would return through successional stages of herbaceous association if not burned again, but regeneration to sturdy dense mats of tall vegetation with non-herbaceous elements favored by *C. porosus* was estimated to take 5-10 years or longer.

RIM exercises showed that crocodiles were a major economic resource in middle Sepik communities. Crocodiles were ranked first or second in 63% (n= 11) of the RIMs. Fish followed next in importance and was more commonly cited as a sustenance rather than economic resource. *Gaharu* placed first or second twice. This aromatic bacterial extract of forest trees is mostly restricted in the study area to the largely montane communities of Wagu and Yigei. Current prices remain high, but unsustainable local exploitation is causing gatherers to search more distant areas where effort (cost) is resulting in lower economic returns. Other economic resources such as carvings, gold and coffee were locally valuable, but none approached the regional importance of crocodiles and fish.

Crocodylus porosus egg harvests were endorsed by most nest owners as an important source of income with key conservation spinoffs that could be substantially enhanced by higher payments for eggs. Highest concentrations of nests (and crocodiles) were reported from sites where regular and more intense egg harvesting has been conducted (*e. g*., Nebgyoibag, Ningyum, Kamiemu).

Widespread opinion was expressed that egg harvests should resume and be conducted more intensively and expansively. The reasons cited for this were the pressing need for cash income, attractiveness of substantially higher prices, and the nearly ubiquitous view that crocodiles were currently plentiful. Intensified egg harvests were generally viewed as flexible and benign. If perchance post-harvest inspections of habitat revealed substantially fewer hatchlings, subsequent egg harvests could be suspended for a year to allow replacement of this cohort.

A gamut of nesting habitat and utilization patterns were encountered on the PRAs. Biimba, a large lake intensively used by all Yerekai village clans, has lost nearly all of its nesting habitat by fires over the past 20 years, and its crocodile resource is now virtually defunct. At the other extreme, crocodiles, overgrown channels and scrolls of Nebgyiobag under the domain of a single landowner from Kubkain village, have been well-protected and feature some of the densest *C. porosus* nesting in the Middle Sepik (pers. obs.).

An intriguing and innovative idea was expressed by Wilson Baka of Senapian village. Mr. Baka proposed converting a small area of dense herbaceous vegetation, composed mainly of hacksaw sedge (= *wail karakwa*) *Thoracostachyum sumatranum*, which is considered by local people as virtually useless to them and crocodiles alike. The sedge was said to grow in dense uniform swaths that crocodiles could not penetrate for nesting, food or cover. (Large areas matching this description are routinely encountered on aerial nest counts in the Middle Sepik, and are usually devoid of nests; pers. obs.).

Modification would involve cutting and removal of a section of the sedge mat to expose open water. The proponent expects this will create general (and possibly nesting) habitat for *C. porosus* and fish resources, and enable access for villagers to utilize these resources. Furthermore, the relatively species-poor sedge mat would evolve and be maintained as a more biologically diverse wetland. The only assistance requested from SWMI for a trial effort was provision of outboard motor fuel to facilitate the cutting of vegetation into chunks, which would be swept away by receding highwater.

PRA exercises were also successful in identifying issues associated with the introduction of exotic fish species (*e. g.*, paku or "bolkata" *Colossoma bidens*; Java Carp *Puntius gonionotus*) and the impending invasion of water hyacinth *Eichhornia crassipes*. Concern was regularly expressed at PRA locations that recently introduced fish species were displacing traditional species (*e. g.*, makau *Tilapia rendalli*) that local communities prefer for diet and sale. Bolkata was observed to feed on the edges of floating mats and considered by local residents as a threat to dense mat formation and persistence.

At most villages few women took part in the PRA exercises, and those that did usually stood quietly in the background. At Bagu village, however, a vocal contingent of women joined the discussion and contributed their intricate knowledge of nesting habitats gained from daily activities related to fishing and gardening.

The perceived need and potential to develop economic incentives for habitat conservation was regularly voiced during village meetings and interviews. The results at Swagap village were particularly instructive. Swagap domain is one of the main success stories in 20 years of crocodile management efforts in the Sepik. Indiscriminant, suspicious hunters of a secluded and feared community have gradually become enthusiastic supporters and beneficiaries of the crocodile management program. Income earned from sustainable use of crocodiles has helped establish local business ventures such as a fuel depot and purchase of outboard motors (Cox 2002).

Following two days of intense PRA discussions that emphasized detailed mapping of main nesting areas, one of the village elders, Yamkrawau, was asked why landowners had devoted so much time, enthusiasm and openness to the exercises. Mr. Yamkrawau explained that (translated and paraphrased from Pidgen to English) "this all comes down to money. You see, we only have the resources around us, and we need ways to make more money from them to develop our village and give our children a better future".

Resumption of egg harvests

The March 2002 egg harvest was the most comprehensive conducted since the activity began in 1985 (Table 1). Seventy-eight nests were harvested from 12 village domains, almost all of which are located upriver from Ambunti. In order to bring additional communities into the programme, particularly the remote and impoverished villages in the Upper Sepik, first-time harvests were carried out at Mowi, Iniok and Paru.

Table 1. *Crocodylus porosus* egg harvest data from the Middle Sepik region, P. N. G. a = one nest excluded because only a partial clutch of 20 eggs delivered; b = data from Cox 1998; c = unpubl. data provided by D. Wilken; d = sample of 48 clutches where viable + non-viable eggs = stated clutch size. 1985-1996 data from Cox and Solmu 1996.

Year	no. of nests harvested	% of nests surveyed	no. of eggs harvested	number of viable eggs	% of viable eggs	clutch size
1985	14	19.4	795	661	83.1	56.8
1986	17	23.9	1061	859	81.0	62.4
1988	13	16.1	793	647	81.6	61.0
1989	20	20.6	1329	1198	90.1	66.5
1990	29	29.6	1613	1324	82.1	57.6[a]
1992	35	24.6	2066	1656	80.2	59.0
1994	29	25.4	1726	1545	89.5	59.4

Year	no. of nests harvested	% of nests surveyed	no. of eggs harvested	number of viable eggs	% of viable eggs	clutch size
1996	47	33.3	2722	2145	78.8	57.9
1998[b]	36	40.7	1983	1591	80.2	55.1
2002[c]	78	n/a	4428[(?)]	3465	78.8[d]	57.6[d]

For the fourth consecutive year, concurrent aerial counts of *C. porosus* nests (as part of DEC's population monitoring programme) were not conducted. Therefore, all eggs had to be harvested by canoe and on foot. This limitation did, however, afford the fortuitous opportunity to examine the relative costs of aerial vs. non-aerial harvesting. For areas along the Sepik within a half day's river travel from Ambunti, surface harvests were found to be more time-consuming but less expensive than aerial harvests, even when a helicopter was pre-placed in conjunction with aerial nest counts.

Surface travel also provided an important, although difficult to quantify, advantage to all harvest stakeholders, in that local communities actively participated in the harvest. Landowners or their designated representatives could verify the number of viable eggs. Most importantly, travel to and from nest sites enabled time for wide-ranging discussions on harvest related topics and issues.

In the absence of aerial nest count data, counts by landowners were used to ensure that approximately half or more active nests were left to hatch in each harvest/survey area. Apart from the 78 nests harvested, another 119 active or recently hatched nests were reported to harvest team members. Therefore, only 40 % of reported (= known) nests were harvested. How many more nests in harvest areas were unknown to local people? Although local residents are evidently adept at locating *C. porosus* nests (Cox 1985), aerial counts suggest that at least some go undetected.

The price of a viable egg was increased to PNG Kina 6.00 (= USD 1.67), nearly double that (K 3.20) of the harvest in 1998. Although the increase is offset by a 49 % decline in the value of the kina since March 1998, and the export value of *C. porosus* skins has changed little since then, the higher egg price elicited widespread support by communities where the harvest was conducted.

A near average nest of 50 eggs yielded K 300, which for cash-strapped owners of nesting habitat is a substantial amount of money. Returns from two nests are sufficient to pay annual fees for a student to attend the area's lone high school at Ambunti. Villagers in the Middle Sepik often cite priority need of cash income to pay school fees, which are due shortly after the *C. porosus* egg harvest (Kula and Meru 1998).

The potential value and benefits of egg harvests were illustrated by John Nilitakwas of Kubkain village. Mr. Nilitakwas has staunchly protected habitat, nests and breeding crocodiles under his ownership during much of the past 20 years, and has participated in most prior egg harvests. In March 2002 he reported 24 active *C. porosus* nests. Due to logistical constraints only six of these were harvested, yielding a return of K 1,926.

Mr. Nilitakwas's domain includes prime nesting habitat for *C. porosus*, but in terms of available nesting sites or numbers of nests, does not seem much better than similar areas in the Middle Sepik. Moreover, there is obvious potential for more intensive harvests in the future. Had half of Mr. Nilitakwas's nests been harvested in 2002, he would have earned K 3,500 - 4,000 – a very substantial amount of money in Kubkain. Other nest owners would note the benefits accruing from harvests of this scale, and would be more apt to join or hone their existing participation.

DISCUSSION

The PRAs demonstrated the appropriateness and promise of a locally based effort to manage renewable natural resources for the mutual benefit of rural development and conservation.

Encouraging and facilitating development of local strategies to control the use of fire near nesting habitat will be a major heuristic challenge for SWMI, one in which the economic benefits of nesting habitat can likely play a key role in creating effective initiatives.

Locally proposed trials to 'improve' habitat in the Senapian and Brugnauwi village domains merit support and encouragement by SMWI. Even if the results are not as successful as envisaged, they will provide an excellent learning experience for all concerned. And most importantly, local communities themselves devise and implement a possibly innovative initiative with minimal outside assistance.

In collaboration with local communities, SWMI is ideally positioned to monitor the impact of introduced fish species and water hyacinth, and to liaise with national and provincial agencies in the formation of management initiatives. Water hyacinth in particular directly threatens the food security and income earning ability of local communities.

Results of the initial PRAs and the March 2002 egg harvest indicate that the benefits already accruing to crocodiles and local people from egg harvests are sufficient to achieve increases in local populations of crocodiles while improving local livelihoods.

A substantially larger egg harvest is considered feasible by incorporating the lessons learned from the March 2002 and prior harvests. The anticipated harvest in March 2003 should elicit greater support, simply because nest owners are now more likely to believe that a scheduled and independent (*i. e.*, land-based) harvest will take place. This situation contrasts with that of recent years when increasing uncertainty surrounded the resumption of aerial counts and harvests. As a result, few landowners prepared for harvests by protecting and checking nests.

Future annual harvests can probably yield 6,000 – 8,000 or more viable eggs by:

- advance confirmation to local communities by the participating crocodile enterprise of plans to conduct a land-based harvest;
- involvement of nesting habitat owners (or their representatives) in every stage of planning and implementation;
- more intensive harvesting at middle Sepik sites where supported by landowners, and especially where relatively few nests were harvested in 2002;
- expansion of harvests to other communities in the middle and upper Sepik regions, and as recommended by Solmu (2002), to villages downriver from Ambunti in the Chambri Lakes area. Crocodile population monitoring and egg harvests were previously conducted there, and pressing need exists to rehabilitate and conserve *C. porosus* nesting habitat for rural development;
- substantially higher prices for viable eggs, made possible by 1) the greater scale of economy and more efficient logistics from doubling the March 2002 harvest, 2) increased production efficiency at the participating commercial enterprise, and 3) *pro rata* investment in commercial returns from future harvests, generated by enhanced conservation of crocodile nests and nesting habitat; and
- dependent upon resumption of aerial nest counts, co-conduct of egg harvests with counts in particularly remote areas where land-based harvesting is impractical or expensive, and to deliver economic benefits to the most impoverished and isolated communities in the region.

Successful management programmes in the Northern Territory (Australia), and Florida and Louisiana in the USA have demonstrated the resilience of crocodilian populations to egg harvests at higher to much higher intensities than previously conducted in the middle Sepik , including March 2002 (Webb 2000, Rice *et al*. 1999; R. Elsey, pers. comm.). Egg harvest components of these programmes are providing a strong economic incentive to conserve crocodile populations and habitat. An overview of Sepik egg harvests and habitat since introduction in 1985 shows that survey sites with highest increases in nesting and least incidence of habitat degradation correspond to the same sites where egg harvests have been most intensively conducted (*i. e.*, Nebgyoibag [Kubkain village], Ningyum [Swagap village], Kamiemu [Bagu]; DEC, unpubl. data).

Such incentives to conserve nesting habitat dovetail with the overarching aim of habitat conservation. Achievement in the socio-cultural and political setting of the Middle Sepik may well rest with ability of crocodiles and other wetland resources to outcompete alternative forms of land use (see

Webb 1991). Although Sepik wetlands are not yet envisaged for conversion schemes, the area is threatened by the downstream effects from proposed logging of watershed forests and large-scale mining ventures.

Sustainable use incentives in the Sepik could be complemented (if not synergized) by including the sympatric *C. novaeguineae* population. Unfortunately, as long as skin prices of this species remain depressed, harvests of hatchlings or eggs are currently considered uneconomical in P. N. G. (D. Wilken, pers. comm.).

This demonstrates how production from successful management programs and the static global market for crocodile products are important factors influencing the prospect of habitat conservation and rural development in the middle Sepik. There is probably little that stakeholders in P. N. G. can do to ameliorate this situation other than appeal for greater efforts by the Crocodile Specialist Group, conservation and development agencies, and the crocodile industry (in particular finished product manufacturers and marketers) to more effectively promote the fact that a crocodile product purchased from a recognized management program indirectly supports crocodiles, habitat and local people.

The experience and determination of SWMI members augurs well for the successful conduct of additional PRA exercises and follow-on initiatives. Intricate knowledge of local nesting and habitat change has been acquired in a >20 year association with many crocodile-using communities in the Middle Sepik. Despite publicizing and promoting crocodile harvest restrictions (including one member responsible for wildlife law enforcement in his capacity as DEC Wildlife Ranger), SWMI has developed good rapport and a welcome, help-oriented reputation with key resource users.

Project success may hinge, however, on the ability of SWMI members to refrain from roles of reiterating conservation messages, especially those related to restrictions, which are often viewed by local communities as imposed. Instead, there is pressing need to catalyze a process that will elicit, develop and implement *villager ideas* (with greater input from women) to conserve and restore habitat. These innovative schemes will require testing at select locations, and a long-term view for widespread implementation.

Results of the initial PRAs demonstrate that high potential exists for communities in the Middle Sepik to self-manage enhanced sustainable use of their crocodile resource and associated habitat. The development and implementation of initiatives will, in turn and in time, also foster enduring conservation of local biodiversity assets.

ACKNOWLEDGEMENTS

The authors are grateful to the many people who have helped make the Sepik Wetlands Management Initiative a reality, and the initial PRA exercises a success. Harumi Sakaguchi, Merawe Degemba, Thomas Paka and Dorothy Luana of the United Nations Development Programme, Papua New Guinea have been instrumental in helping to obtain and administer the GEF Small Grant.

Appreciation is extended to DEC, in particular Dr. Iamo Wari, John Genolagani, Barnabas Wilmot, Veari Kula and Barbara Roy, for endorsing and supporting the project.

David Wilken generously contributed egg harvest data and related information and impressions to greatly improve the section of this paper on the March 2002 egg harvest. Eric Langelet kindly provided information on exotic fish species in PNG.

The PRA was successful in no small part because of the enthusiastic teamwork provided by SWMI members. Chairman Alfonse Mapa co-led with villagers many of the PRAs and smoothed travel logistics. Benny Gowep and Wilson Lambi facilitated various exercises. The team was fortunate to be joined by Michael Nianfop, District Officer-in-Charge, Department of Primary Industry. Mr. Nianfop contributed to initial PRA meetings with his inspiring interpersonal communication skills, insight into land use issues, and expertise in agricultural and economic development. Sharon ________, Conservation Officer with WWF Sepik Hills LandCare Programme, accompanied excursions in the Upper Sepik, provided valuable socio-cultural insight, and assisted the technical conduct of PRA exercises.

Finally and foremost, the authors are indebted to the many local residents for their hospitality, profound knowledge of wetlands resources, and willingness to share their experience, ideas and stories. Intensive and exhaustive PRA sessions were at times almost overwhelming, but always gratifying and unforgettable.

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Report on the Workshop on Latin American Issues Gainesville, October 9th, 2002

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The Workshop on Latin American Issues it was held at the Sheraton Gainesville Hotel during the 16th Working Meeting of the Crocodile Specialist Group with the aim to summarize the activities on different topics at a regional level.

Caiman yacare

The issue was opened by Alejandro Larriera with a report on the results of the previous Workshop on the specie (Gainesville 3-5 October 2002), with the most relevant recommendations as follows:

At a regional and international level, the most important agreement was the recommendation to create an *ad hoc* commission, with representatives of every range country, the CSG (represented at a regional level), and TRAFFIC. The commission functions will be:

i. Unification of standards and norms between countries.
ii. To act as a mechanism for solving discrepancies.
iii. To act as a verification mechanism of the implementation of the recommended actions.
iv. Become in a focal point for interchange of information with other interested countries and the CITES Secretariat.
v. To share information and take action (confidentially) in relation to the information obtained on illegal trade.

After this, Robert Godshalk did a presentation of his paper on the Bolivian population studies carried out in 1995/96.

The issue was closed with country reports on the current situation of the species in every range state: Alfonso Llobet (Bolivia); Nora Neris (Paraguay) and Marcos Coutinho (Brasil).

HIGH PRIORITY SPECIES

The first presentation on this issue it was made it by Andreas Shubert with regard to the population of *Crocodylus acutus* in Lago Enrriquillo (Dominican Republic).

Andrés Seijas did a presentation on the situation of *Crocodylus intermedius* in Venezuela.

Luis Sigler from Mexico, did a presentation on the situation of *Crocodylus moreletii* in the country.

Finally, Roberto “Toby” Ramos from Cuba, did a presentation on the situation of *Crocodylus rhombifer* and its hybridization with *C. acutus* in the Cienaga the Zapata region.-

RANCHING ON LATIN AMERICAN SPECIES

The issue starts with presentations from Alejandro Larriera, regarding the ranching program of *Caiman latirostris* in Santa Fe Province, Argentina, followed by a presentation on the projected ranching in Formosa Province, also in Argentina.

Following, Tommy Hines did a presentation on the finally unsuccessful ranching program on *Melanosuchus niger* in Ecuador.

Some comments were also made on this topic, by Marcos Coutinho, with respect to the ranching program of *Caiman yacare* in Brazil.

Caiman crocodilus

MANAGEMENT PROGRAMS

The first presentation on the issue, it was carried out by Alvaro Velasco with respect to the use of wild population of "babas" (*Caiman crocodilus crocodilus*) in Venezuela, followed by a report of Hernando Zambrano on the farming of "babillas" (*Caiman crocodilus fuscus*) in Colombia.

CROCODILIANS RESEARCH RESOURCES IN LATIN AMERICA

Carlos Piña did a presentation on the work he did previous to this meeting, with Luciano Verdade and Pablo Siroski, investigating at a regional level, the situation of the research on crocodilians by country and by species. The work becomes a first step for the construction of a database on the topic for the region and also useful at a world level.

CONCLUSIONS

All the presentations were followed by a constructive interchange of opinions and ideas, showing that the Latin American region it is highly improving the contacts in between in a positive way.

Status of *Caiman yacare* in Bolivia: Results of 1995 and 1996 Cites Surveys

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ABSTRACT: *Caiman yacare* is a very abundant crocodilian occurring in Bolivia, Brazil, Paraguay and Argentina. Population surveys, funded by CITES, were undertaken in the five principal lowland river drainages of Bolivia in 1995 and 1996. These surveys were conducted to form a basis for establishing a national program for sustainable use of the resource. During the 2 field seasons, over 23,500 caiman were observed during nocturnal counts. Due to observed size-class structures and the overall densities of caiman, we recommended that the Bolivian Government proceed with development of a sustainable harvest program.

Subsequent surveys have taken place since, usually citing results from our CITES project mentioned above. Many counts were repeated at numerous sites from our unpublished report. We present our survey results, condensed and re-analyzed, in an effort to make the information readily available and more useful to researchers. A national quota of 40,000 hides was established in 2001 which emphasizes the need for monitoring populations with annual surveys. The pre-harvest data presented here can serve as an index against which to gage future change.

INTRODUCTION

The first CITES effort aimed at developing a conservation strategy for the crocodilians in South America was initiated in 1986 when surveys were carried out in several regions of Bolivia, Brazil, and Paraguay to document the distribution of the crocodilian species (see King and Videz Roca 1989; Scott, Aquino, and Fitzgerald 1990; Brazaitis, Yamashita, and Rebelo 1990).

The second phase of the caiman project that was initiated in Bolivia in 1995 included programs to monitor the wild populations of lagarto, *Caiman yacare*, primarily in the Departments of Santa Cruz and the Beni; to establish an experimental, rigorously controlled, sustainable harvest of lagarto in full compliance with CITES regulations on international shipments; and to train university students in long-term studies of the ecology and management of the commercially valuable *Caiman yacare*.

Funding for the first year of this project was provided by the Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Professor F. Wayne King, consultant to the CITES Secretariat, was selected to serve as project director, and Robert Godshalk was selected to act as project coordinator. In Bolivia, Dante Videz Roca, a former official in the wildlife office of the Santa Cruz Centro de Desarrollo Forestal (CDF) and a participant in the 1986-87 CITES surveys in Bolivia, was selected to serve as the Bolivian counterpart and assistant project coordinator.

PROJECT GOALS:

1) In consultation with Bolivian wildlife officials, ranchers, indigenous leaders, and interested citizen groups, draft and begin a pilot plan for sustainable use of the caiman resource.

2) Establish annual programs to monitor the wild populations' status and harvest impacts.

3) Initiate pilot projects for the management and sustainable utilization of the caiman resource at selected cattle ranches, Indigenous Territories and other sites. This included the establishment of an experimental harvest at these sites and the implementation of a skin tagging system in compliance with CITES, and tracking those tagged skins from the hunter and site, through the tanning process and export to the international market.

4) Initiate long-term studies on the ecology and population dynamics of *Caiman yacare* at a minimum of six (6) sites in Bolivia.

5) Begin building the administrative and institutional infrastructure needed to initiate a pilot program in sustainable utilization of *Caiman yacare*.

6) Train university students and Bolivian wildlife staff in techniques for the study and monitoring of crocodilian populations.

7) Lectures to local groups, wildlife officials, and university students and faculty on the benefits of professional wildlife management for conservation and sustainable use.

8) Provide the Bolivian Dirección Nacional de Conservación de la Biodiversidad (DNCB), Ministerio de Desarrollo Sostenible y Medio Ambiente, and the CITES Secretariat, with a report on the progress being made in the Bolivia caiman program.

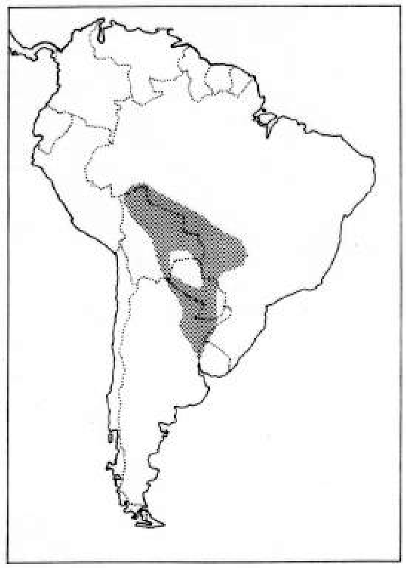
Details on the realization of the Project Goals can be found in the Final Report (King and Godshalk 1997). The present document details only the results of our caiman surveys undertaken during 1995 and 1996. Field work was scheduled during the dry season, which generally occurs between May and November depending on the locality, in order to take advantage of the concentration of caimans at that time. The project started later than planned in 1995. The early arrival of seasonal rains in November both dispersed the caimans and made overland travel impossible in many areas, which delayed implementation of the experimental harvest of lagarto, *Caiman yacare*. Prior to 1996, the Government of Bolivia also did not promulgate new decrees or laws necessary for an experimental hunt and the export of skins under CITES control.

Some CITES funds remained after the end of the 1995 field season was completed and were dedicated for continuing with a 1996 field season. In December of 1995, we met with Lic. Arturo Moscoso, Director of Environmental Programs of the Netherlands Embassy, and discussed our objectives and financial needs. The project was awarded US$ 10,000.

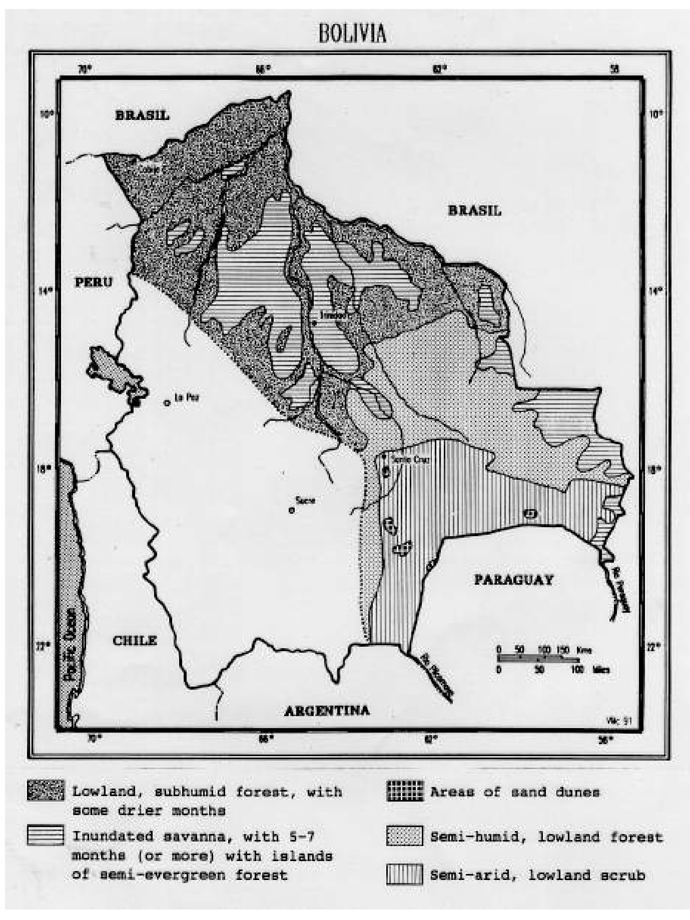
The 1996 field season was conducted during the originally scheduled months of May to September. While the 1995 season may have been conducted too late in the dry season, we also had the added effect of a severely dry year. The 1996 field season appears to have been scheduled a little too early even though some months were drier than normal. Certain sites could not be reached for re-surveys due to flooding in intervening areas, and other sites had to be planned near the end of the field season in order to gain entrance. The sequence of surveys in 1995 began with Santa Cruz and ended in the Beni. Due to long water retention in the Pantanal region of eastern Santa Cruz, we were obliged to visit this area at the end (September) of the 1996 field season. The sequence of survey sites is reported below from east to west, first Santa Cruz then Beni (see Maps 3 - 5). They are also grouped according to major river basins marked in the headers.

Since completion of this project, new regulations have been enacted which affect future surveys in Bolivia. Loosely following the current Venezuelan model, lowland Bolivia was divided into ecoregions. The available habitat is not uniform across the broad landscape and carrying capacity, population densities, hunting pressure, and other factors differ according to locality. Division of the area should make management more efficient. However, the ecoregionalization was conducted from satellite imagery with little ground truthing or regard to caiman biology. The lowlands were subdivided into too many units, a total of 30, each requiring surveys for developing an individual harvest quota.

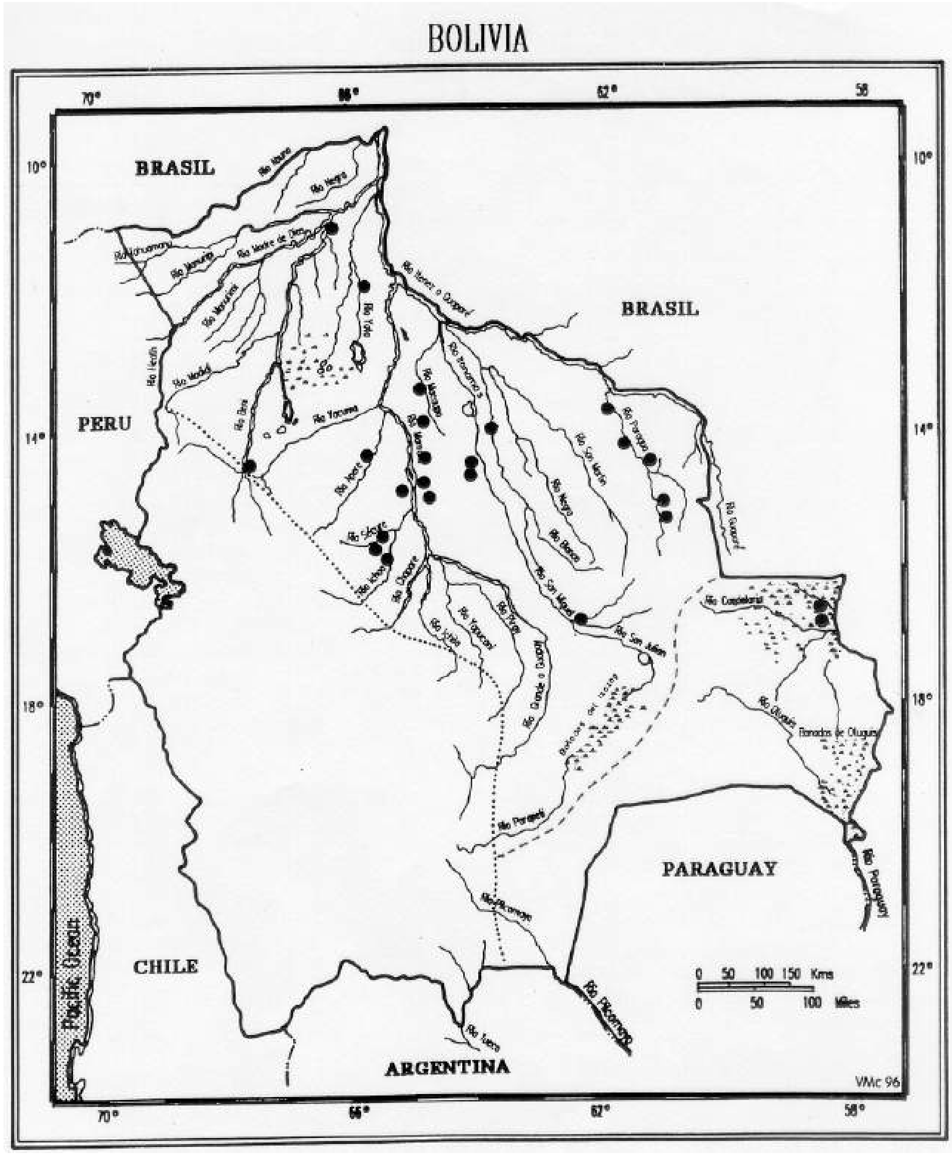
The survey results are presented below. Each survey site is described and a summary table of the numerical results is presented at the end of the respective geographic region. The tables are also referenced to the current ecoregion system. An analysis of individuals per linear distance and per unit area is also given at the end of the Santa Cruz and Beni Department sections for comparison with other survey data.



Map 1. Distribution of the yacare caiman, *Caiman yacare*, in South America. Void in the center of the range represents the driest areas of the xeric Chaco environment in Bolivia and Paraguay. (From Godshalk 1994).



Map 2. Ecological regions of lowland Bolivia (from Godshalk 1994)



Map 3. The hydrology and survey sites in lowland Bolivia. Dotted line represents 500 m altitude contour. Dashed line represents division of Amazon (west) and Paraguay (east) River drainages. Circles represent sites visited in the CITES/Bolivia Caiman Project during 1995 and 1996. (Multiple survey locations occur for each site shown (after Godshalk 1994).

SURVEY RESULTS. The field team in 1995 consisted of F. Wayne King (FWK), Robert Godshalk (RG), and Dante Videz Roca (DVR). Ingrid Fernandez S. (IFS), Herpetology section of the Museum of Natural History 'Noel Kempff Mercado,' participated in the Santa Cruz surveys. The core field team in 1996 remained the same (FWK, RG, and DVR). Dr. Victor Hugo Inchausty from the DNCB Wildlife Unit in La Paz traveled with us in the Beni. Thesis student Daysi Molina Rejas conducted fieldwork in the Beni. Lic. Alfonso Llobet and UMSA undergraduate student Eddy Perez assisted in 1996 in Santa Cruz.

A few Spanish terms are used throughout this report as they appear prominently on maps and in other publications and/or because they are used widely in lowland Bolivia. These few terms are not uniquely Bolivian, but their use varies among the Latin American nations.

atajado (*atajao*)—man-made water hole
bajío—a shallow depression in the landscape, generally inundated most of the year
bañados—swamp, partially or completely intermittent
caimán—black caiman, *Melanosuchus niger*

campos—fenced pastures, usually sections of a ranch
caño—stream, usually intermittent
cañada—small stream, always intermittent
cañuela—various species of emergent vegetation (e.g., *Hymenachne, Luziola, Arcocerus*)
cocodrilo—dwarf caiman, *Paleosuchus palpebrosus* or *Paleosuchus trigonatus*
cunetas—roadside borrow pits
curiche—swamp with little or no flow
estancia—ranch, usually a cattle ranch
isla—forested 'island' in savannas, usually on elevated ground
lagarto—yacare caiman, *Caiman yacare*
lago—lake, subjectively larger than laguna
laguna—lagoon, shallow lake
overo—broad-snouted caiman, *Caiman latirostris*
palmares—pure stands of palms, often flooded intermittently
pampa—savanna, with or without tree islands
pozo—pool, pond, artificial waterhole
río —river
*tarope—*floating vegetation, usually *Eichhornia* or *Pistia*
terraplen—a roadbed, frequently unpaved, raised artificially above the surrounding country
yomomo—a swampy peat bog, saturated year round and covered with floating, and often rooted, vegetation.

After meeting with ranchers and landowners, the field team surveyed the caiman populations on a number of locations scattered through the departments of Santa Cruz and the Beni. An attempt was made to spread effort over a large geographical area and a range of habitat types within these departments. While caiman populations exist in Pando and La Paz Departments, we focused our survey efforts to Beni and Santa Cruz where the necessary infrastructure exists to initiate the program. The following maps are provided for reference for the ensuing survey descriptions.

SURVEY METHODS. Surveys were conducted following the methods set forth in the 'Guidelines on Monitoring Crocodilian Populations' (Crocodile Specialist Group 1994). Most surveys were conducted at night using a spotlight to count the caimans' reflected eyeshine. A few daytime surveys were carried out in areas that could not be accessed at night. Surveys were sometimes conducted on foot, horseback, tractor or pickup truck. We used dugouts, canoes, aluminum skiffs, and the project's 3.5 m Avon inflatable boat for on water surveys. These boats were powered by pole, paddle, electric trolling motor, or outboard motor.

Nighttime surveys usually employed the use of a handheld, one million candle power halogen spotlight ('Q-beam') powered by a 12v deep cycle 100 amp/hour battery. Two such batteries were alternated for use and recharged with a portable Coleman 1000w gasoline generator. When it was not feasible to transport this equipment, a 20,500 candle power 6 D-cell halogen MagLite was used. All spotters, guides, and other team members were also fitted with 4 D-cell JustRite adjustable focus headlamps.

Using the most powerful spotlights can have particular problems. On close approach for identification or capture, the brightly lit surrounding area 'drowns' out and overpowers the reflected eyeshine needed for spotting individuals. At times, the spotlight was shut off so location could be made with dimmer headlamps. These beams allowed 'Eyes only' counts in inaccessible areas. The light also penetrated deep into water depending on the turbidity.

First, a total count was taken using eyeshine, or if during the daytime survey, a total head count. A sample of the caiman surveyed at most sites were grouped according to size classes of half meter increments. This was done predominately by estimating total length from the skull profile by experienced researchers. During surveys of most *atajados*, the sample was taken viewing from a single point on the bank and surveying as far as the spotter felt he could reasonably judge size class. On surveys of the larger lakes, caños and rios that required navigation, observation was often performed at very close quarters. Animals were usually approached as closely as possible to ascertain the true size class. In the areas of clear water, especially in Santa Cruz, it was often possible to see the whole animal during night surveys. Animals often submerged quietly in place as a defense, frequently in less than one meter of water where our light might penetrate. We also sought identification to determine the species as *C. yacare* is sympatric with the genera *Melanosuchus* and *Paleosuchus*.

Daytime surveys were undertaken only in a few instances. For logistic reasons, some sites could only be visited once, during the daylight hours. Artificial cattle tanks were often small enough and free from floating vegetation to give free view to all surfaced caiman. Tame caiman, habituated to disturbance by cattle and ranchhands, can frequently be surveyed in daylight with a high degree of confidence for the counts. Binoculars (Nikon Travelite III, 9x25) were also incorporated in daytime surveys to verify species and aid in counting. Total tallies were tabulated on handheld, mechanical counters, and always done first, day or night. Next, the size classes are called out verbally by the spotter and recorded by an assistant. If we were navigating and an additional spotter was available, (s)he would keep a separate running total as we surveyed.

To minimize the chance of introducing variation in survey results caused by the use of many different spotters, unless otherwise noted, all spotlight surveys reported here were conducted by FWK (F. Wayne King) and RG (Robert Godshalk). Other individuals who accompanied the team got the chance to learn and practice survey techniques, but their results are not included here.

Fixing the exact start and end points of the surveys is essential for subsequent researchers to repeat the surveys. For our surveys, a Garmin GPS 38, 40, or 45 was used to accurately determine the latitude and longitude in degrees, minutes and seconds for all start, end, and other points of interest. The South American 1969 mapping grid was chosen for latitude and longitude coordinates. Waypoints reported in the 1995 report were obtained using the WGS 84 grid. They have been converted here. Single waypoints given for navigated lakes refer to the launch site. Dual waypoints for lakes usually refer to a waypoint on the opposite shore. Single waypoints are also given for *atajados*, usually at the spot from which surveys were taken.

The Garmin mapping capabilities were explored in 1995 and used more extensively in 1996. In this mode, we were able to follow the bank of a lake and accurately map the shape of the shoreline. Specific waypoints entered, such as launch site, capture site, etc., also figure on the map and a calculation function gives the headings and distances between these waypoints. Because the mapping usually occurred 2-10m from the shore, sometimes more, total surface area may not be accurate. On some lakes, the floating or rooted vegetation prevented us from reaching the shore. In these cases, the maps accurately reflect the open water space as we travelled at the vegetation edge. Water bodies of lowland Bolivia are subject to the huge fluctuations of the wet and dry seasons. This will cause large changes in depth, size, shape, surface area, vegetation, wildlife and many other factors.

When possible, the GPS was used in combination with a KVH Datascope to make accurate measurements of the water bodies. These measurements are important because accurate maps of most lowland areas of Bolivia do not exist. Few maps are elaborated for regions north of the 14° S latitude. Maps (1:50,000) were available for only 3 of the ranches visited and they were based on 1975 aerial photography. This lack of adequate maps emphasizes the importance of recording localities with a GPS and thorough documentation.

We have used the local nomenclature for the names of geographic locations. In Bolivia, place names for caños and other features are often very localized and known only to nearby residents, thus the importance of the GPS precision. Other sites were also located using a combination of Bolivian hydrographic and political maps from the Instituto Geográphico Militar. Rivers traditionally change names downstream of major affluents so accounts can be confusing. River names may change seven times along the course.

Bolivia experienced an extreme drought in 1995. The dry season was dry and so was much of the wet season. This caused a variety of problems for the survey team. The water in many of the wetlands and waterways became too shallow to traverse by boat. Later, as the first rains came, caimans quickly migrated into the available habitat and densities reduced.

Some owners claimed certain water bodies on their property had dried up for the first time in memory. A number of rivers were reduced to series of disconnected pools and various lakes and lagoons were at the lowest levels 'ever seen'. The affluent streams were often disconnected due to reduced water volume. Even some sizable rivers were rendered unnavigable as low water exposed massive logjams. As a result, certain nighttime spotlight survey protocols such as recording location, size and species of every individual was not always possible. In many of the lakes, formed by shallow bajíos, our boat could approach the shore only to within 50 or a 100 m. In certain rivers, old river courses form large lagoons off the main flow. These connected oxbow lakes often contained excellent caiman habitat and were well populated but are were too shallow to penetrate by boat. We also found that the floating cover of aquatic vegetation was reaching its seasonal apex. When these conditions were encountered, our survey counts undoubtedly were low, though it is impossible to determine how much of the caiman population was not counted.

In addition, throughout the two departments where we conducted surveys, ranch hands claimed that as a result of the drought the caiman were estivating in the mud and more had been present at the beginning of the dry season. We did observe some mud-bound caiman and this effect, though very hard to quantify, may be very important to our survey counts. While this was certainly a factor in the 1995 surveys, estivation was only mentioned to us by rural people a few times in the Beni during 1996.

A related dry season problem involved large scale burning. Many mechanized farmers in Santa Cruz were burning refuse piles on large plots of newly cleared land. Slash and burn agriculturists in both departments burned in preparation for spring planting and ranchers were setting fire to large areas of pampas. This has occurred for centuries, but the extreme dry conditions of 1995 caused many fires to go wild. Due to restricted visibility from the smoke, light aircraft were grounded for a month. The Trinidad airport, in the Beni capital, was closed to both light and commercial aircraft on numerous occasions. Even the international airport at Santa Cruz, with superior navigation equipment, experienced smoke closures.

The severity of this problem should not be underestimated. In the town of Ascención de Guarayos, vehicles were obliged to use headlights during midday driving, and at least one person died of smoke inhalation. Many people fled the town for a couple of weeks in September and there were reports of asphyxiated wildlife from the surrounding area. Five wooden bridges on a main road through the Rios Blanco y Negro Reserve were burned.

Light reflection from the dense smoke reduced visibility to less than 30 m and frustrated survey efforts on a number of occasions. On many evenings we could see massive fires burning on the horizon. The smoke reduced the distance we could detect caiman eyeshine and undoubtedly lowered the number of animals sighted at some locations. Upon starting a night survey on a convoluted waterway, the dense smoke and surface waves from strong winds so disoriented us that we returned to our starting point before realizing our error.

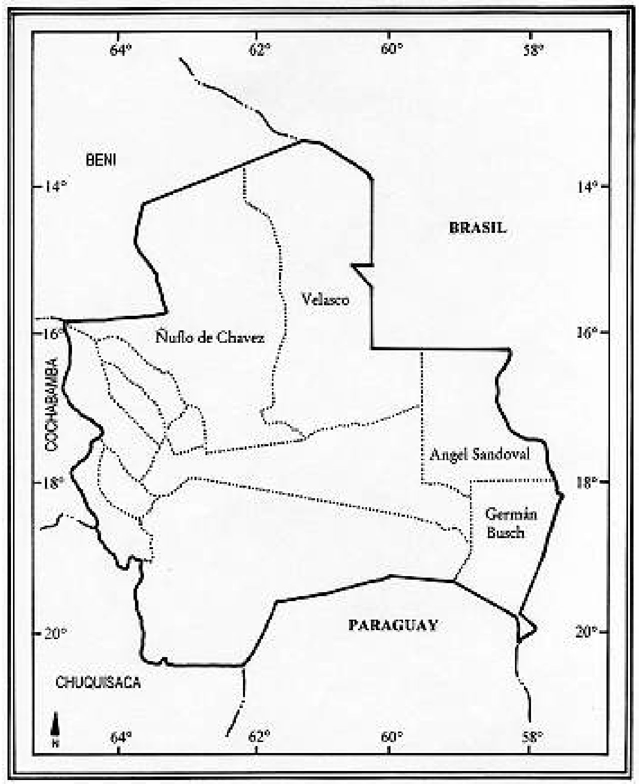
Fortunately, the burning season in 1996 was not so severe. Although most pampas were burned, landowners were able to keep the areas small and more manageable. Ash fell in the city of Trinidad, Beni, on many days of July and August and the smoke layer was often visible. Grounding of air traffic was sporadic and occurred on a much more local level compared to 1995. The pampa surrounding the Santa Cruz International airport did burn out of control, causing that airport to be shut down for a day.

DEPARTAMENTO SANTA CRUZ

The 1995 fieldwork began in the department of Santa Cruz and the 1996 field season ended there. Much of Bolivia's largest department (370,621 km^2) is unsuitable or marginal habitat for caiman. Santa Cruz is currently experiencing very high immigration which will continue to change the landscape. Land ownership tends to be in small parcels, compared to Beni, and the present trend omly increases land pressure. Large private lands tend to be for industrial agriculture, representing high habitat modification and degradation for wildlife.

The growing population has passed 1.2 million, over four times that of the Beni. Most of the population and growth is centered in the Santa Cruz urban sprawl. The northern and eastern areas contain the most promising caiman habitats, mainly in the provinces of Ñuflo de Chavez, Velasco, Angel Sandoval and Germán Busch (see Map 4). In 1995, we began our surveys on a ranch that protects its caiman and is situated in very suitable habitat.

The emergence of industrial farming, principally for cotton, soybeans, and wheat have led to large scale deforestation and environmental degradation of the central area of the department. The southern zones contain the xeric ecosystems of the Chaco and, while lagarto are present in small numbers in permanent water bodies, they are not considered numerous enough to be included in a sustainable program.



Map 4. Provinces of the Department of Santa Cruz. Named are the provinces with suitable caiman habitat and a high potential for inclusion in a future sustainable use program.

Departamento Santa Cruz, Provincia Angel Sandoval - Río Paraguay
EcoRegion No. 22

This Province lies within the Río Paraguay river basin and is part of the Bolivian Pantanal. The rainy season periodically floods the Río Paraguay, which inundates the majority of the ranch properties and surrounding lands. Because of the slight elevation of the ranches we visited (*pampa de altura*), most of the pastures drain completely as the waters recede during the dry season with few remaining natural water bodies. Ranchers have found that the artificial water holes they have created for their cattle have frequently become focal points for local wildlife, especially caiman. The caiman have open access during the flood months and then concentrate in these water holes during the dry season.

Estancia San Luis—The caiman of Estancia San Luis were surveyed by DVR in the late 1980's (Videz Roca 1987), and our 1995 visit provided a confirmation of that earlier survey. This large cattle ranch is situated in eastern Santa Cruz (see Maps 3 and 4) on the western edge of the Pantanal, extensive wetlands that lie mostly in Brazil. Estancia San Luis contains 68,000 ha, mostly composed of open pampa de altura, and islands of low forest, along with some palmares. To provide permanent water sources for the cattle, the owner began constructing small, rectangular ponds (*pozos* or *atajados*). The dirt scraped from the bottom of the pond is used to elevate the banks. The banks usually form an oval shape with a low aperture to allow refilling. The aperture is oriented away from the direction of the oncoming flood waters to help avoid sedimentation. About 3-5 ponds are constructed a year, and today over 40 tanks are dispersed among the fenced pastures (*campos*). A total of 21 tanks were surveyed on Estancia San Luis in 1995, 12 were surveyed in 1996.

The tanks (*pozos* or *atajados*) fill periodically with the seasonal floods and serve as water sources and refuges for fauna as the surrounding countryside desiccates during the dry season. The local lagartos migrate to these tanks and concentrate there. A natural division of lagarto size occurs, with certain tanks containing only small caiman, while others only have larger size classes. Some tanks contained no caiman but it appears that the tanks need to age before they become preferred habitat.

As the tanks age, they slowly fill with sediments and the banks erode and recede. The permanent water encourages woody growth and the older tanks are surrounded by small islands of low forest and bushes. Most of the tanks were nearly free of floating and/or emergent vegetation. This made for easy and accurate daytime head-count surveys for some tanks. The clear banks also allowed easy measurements of tank dimensions. Other tanks were covered with tarope (*Eichornia*) impedeing both daytime and nighttime surveys.

The lagartos appeared to be robust and healthy. They exhibited little fear of humans indicating that they are not being hunted. Individuals frequently allowed approach to within 8-10 m in daylight before retreating to the water and various specimens were noosed on dry ground at night. A number of tailless cadavers were found, a result of outsiders using the tail for fishing bait. He further that local people rarely eat caiman or their eggs.

<u>13 September 1995</u> - The Main Camp Tank (*atajado*), where cattle frequently are watered, was surveyed on the first night. Less than 100 m from the main ranch buildings, this tank contained hundreds of large lagarto and none were estimated to be smaller than 0.75 m. A daytime sample was taken to give relative size class percentages for the group. The high density and frequent movement by individuals hampered this type of classification. My movement along the bank caused animals to rush into the water, forcing others to move as well. The banks are devoid of vegetation and the surrounding area is open pampa prohibiting stealth during the day. Nighttime size estimates required close observation for accuracy and this too quickly led to confusion. A sample of 87 lagarto included the following: 11 (0.5 - 1 m), 27 (1 - 1.5 m), 31 (1.5- 2), and 18 (>2).

<u>6 September 1996</u> - We revisited Estancia San Luis in 1996 for a comparative re-survey. An 80 mm rain squall preceded us and left new waterbodies on the countryside, the first rain since last May. The Main Camp Tank was surveyed on the first night and it continues to have many large lagartos. Few individuals were under 1 m. A sample along a shore was taken for relative size classes: 76 lagartos included the following sizes: 1 (0.5 - 1 m), 25 (1-1.5 m), 39 (1.5-2), and 11 (>2). A survey the next night revealed 769 animals.

<u>13 September 1995</u> - The Campo Torunal, Pozo 1, tank had low banks with no vegetation on them. This old tank is surrounded by a secondary forest tree island. A small part of the tank had floating tarope (*Eichornia*) covering <5% of the surface area. The lagartos were generally smaller than the Main Camp Tank, but many were 1.5 - 2 m.

<u>13 September 1995</u> - The Campo Torunal, Pozo 2, tank was close to Pozo 1, and had similar properties, but with slightly higher banks. Lagarto size classes also appeared similar. The following day we visited various sites on the ranch (1995) including a huge rookery ('*garzero*') filled with storks, herons egrets. The large tank below was 80% covered with a thick *Eichornia* mat but many large lagarto were visible. in the open water and sunning on the bank.

<u>6 September 1996</u> - We attempted to return to Campo Torunal, Pozo 1, but the flooded savanna prevented us. Pozo 2 was revisited and it contained nearly 45% more caiman than last year. Only one end had tarope (*Eichornia*) covering <5% of the total surface area. The lagartos were large with none of the smallest size classes recorded. A 74 lagarto sample sighted were: 0 (0.5 - 1 m), 25 (1 - 1.5 m), 34 (1.5- 2), and 15 (>2).

<u>7 September 1996</u> - In 1996 we re-visited the impressive garzeros mentioned above. The bird population appeared to be less and the tarope cover was greatly reduced compared to the previous year so we were able to make a reasonable daytime survey. Tarope cover was about 20%, most at the near shore. The caiman were large, all over 1 m, and very abundant.

<u>7 September 1996</u> - This garzero pond (Garzero 2) had little tarope cover (<10%) and caiman were large and very abundant. Few caiman under one meter were observed. The pond is shaped in a "V'.

From the vee apex, 247 animals were visible. A short extension off one arm of the vee held 600 additional animals that were not visible from the first vantage point. The caiman are quite tame.

7 September 1996 - Campo 1, Pozo 4 had no tarope cover and caiman were large and very abundant. Few caiman less than one meter were observed. The pond is shaped in an oval and is located in the middle of open pampa. A sample of 106 lagartos sighted included the following sizes: 5 (0.5 - 1 m), 34 (1 - 1.5 m), 56 (1.5- 2), and 11 (>2).

7 September 1996 - This tank (Campo 1, Pozo 4A) had no tarope cover and caiman were large and very abundant. The pond is roughly oval shaped and is located in the middle of open pampa. A sample of over 126 lagartos sighted included the following sizes: 50+ (<.5m), 4 (0.5 - 1 m), 28 (1 - 1.5 m), 30 (1.5- 2), and 14 (>2).

7 September 1996 - The Campo 1, Pozo 5 tank had been recently constructed and had no caiman present.

7 September 1996 - The Campo 1, Pozo 1 tank had nearly 100% tarope cover and proved to be a natural nursery. Only 2 caiman over 0.5 m were observed. The tank is older, oval shaped and is bordered on one side by secondary forest. When we approached the tank, we flushed over 40 neonates from their communal hide in dry leaf litter under a bush, about 12 m from the water edge. No adult was seen in attendance. Seven hatchlings were caught and measured and which ranged in size from 35 to 48 cm total length.

14 September 1995 - The new Campo 2, Potrero, tank had not been populated by lagarto. Months must pass before the rather sterile soil and water of a new tank becomes sufficiently vegetated and stocked with fishes to provide suitable habitat for caiman.

6 September 1996 - The top of the banks of the Campo 3, Pozo 1, tank are clear of vegetation. No floating vegetation was found. A sample of over 56 lagartos sighted included the following: 0 (<0.5 m), 4 (0.5 - 1 m), 24 (1 - 1.5 m), 19 (1.5- 2), and 10 (>2).

14 September 1995 - The top of the banks of the Campo 3, Pozo 2, tank are vegetated, but clear areas allow for walking. No floating vegetation was found.

15 September 1995 - The Campo Jumechi, Pozo 3, tank was located in open pampa. It is a new tank with completely clean banks and devoid of floating vegetation. The lagartos sighted during the survey included the following size classes: 22 (<0.5 m), 8 (0.5 -1 m).

15 September 1995 - The banks of the Campo 5, Pozo 2, tank were clear of vegetation, allowing easy access on the perimeter. Small bushes occur on the top of the terraplein providing shade for resting lagarto during the day. Devoid of floating vegetation.

15 September 1995 - Campo 4, Pozo 1, tank is very similar to the preceding tank but slightly larger: clean banks, no floating vegetation, in surrounding open pampa.

15 September 1995 - Campo 5, Pozo 1, is a old tank located in open pampa. There is a tree island nearby. The elevated banks have no bushes and were clear of vegetation. There was no tarope or other floating or emergent vegetation in the water.

15 September 1995 - Campo 3, Pozo 4, is an older pozo. It is totally surrounded by a forest island with some large trees. The water was about 30% covered by tarope so a precise count could not be completed but the lagarto looked both numerous and large.

15 September 1995 -The Campo 3, Pozo 1 tank appeared to contain adequate habitat although no lagarto were found. There were reports that there always have been lagartos here in quantity. Emergent cañuela was present along the banks, with about 25% tarope cover, and low forest along one side. There was no obvious reason why no lagarto were present.

15 September 1995 -Campo 3, Pozo 3, is a small, 4 yr. old tank with very clean banks and no floating vegetation. The banks were gently sloped and the low level of water allowed us to walk the crescent-shaped perimeter easily. The lagarto sighted during the survey included the following size classes: 8 (<0.5 m), 11 (0.5 - 1 m).

15 September 1995 -Campo Jumechi, Pozo 2, is an old tank surrounded by a dense stand of low forest which limited surveys. The vegetation reached the edge of the tank for most of the perimeter. We only gained access to 2 small openings at opposite ends of the tank for our counts. No individual

was seen over 1.5 m and the majority appeared < 1 m. We had to make a reasonable count for half of the tank, move position and count the other half without missing or re-counting any. The pozo had about 20% tarope cover at one end.

16 September 1995 - We departed early for visiting tanks in daylight. Some are very difficult to locate in the open pampa with few reference points, and many are quite distant. The immense property was impractical to survey only at night. The first tank, Campo Pico Plancha, Pozo 1, was located within a mature tree island. The old banks are very low and it appears more like a small bajío. The tarope cover was about 60% and the water depth appeared no more than 0.5 m. About 40% of the lagartos appeared >1.5 m.

16 September 1995 - The Campo Las Gamas, Pozo 1, is free of tarope. The tank has steep banks free of vegetation, with bushes on top. A tree island is present nearby.

16 September 1995 - Campo Pirañas, Pozo 2, is a new pozo in open pampa. No vegetation was found on the terraplein or sloping banks. No tarope or emergent vegetation was present either. No lagarto less than 0.75 m were observed.

16 September 1995 - Campo Tacuaral, Pozo 2, also is a new tank located in open pampa, no growth on banks or tarope in water. Of the lagarto sighted, 25% were more than 1.5 m. There was a tree island nearby.

16 September 1995 - Like the previous two pozos, Campo Chacal, Pozo 2, also is a new tank with clean banks and no tarope. The top of the terraplein does have scattered bushes. A sample of lagarto sighted revealed a mixture of size classes from 0.75 m to 2 m.

16 September 1995 - The Campo Las Hormigas, Pozo 2, tank is located on the main road through the property. It appeared to be a natural bajío and was 95% overgrown with tarope. As we arrived, over 100 large basking lagarto entered the water quickly. This tank is fished by people from outside the ranch. Remains of two lagarto were found indicateing why the caiman here are more shy than at most other tanks. The high proportion of large lagarto that we observed suggests that hunting for skins has not occurred here recently.

16 September 1995 - The Campo Calvario, Pozo 2, tank has clean banks with bushes scattered around the top. We found two large *Caiman yacare* that had been killed for bait by fisherman. One had obviously been shot but the other appeared to have been hooked and then hauled to shore and killed with a machete. A tree island is located adjacent to the tank.

16 September 1995 - Campo Potrero Lecheria, Pozo 1, is an old tank surrounded by dense forest, which also made surveying difficult. We had to penetrate the undergrowth to get a good view. The water was about 60-70% covered with tarope. Most individuals appeared to be under 1 m and many under 0.75 m.

16 September 1996 - The surrounding forest made surveying difficult, and it was hard to get a good view. The water was about 10-15% covered with tarope, mostly in the less populated shallow end. Only about 60% of the surface was visible at one time due to the irregular shoreline and obstructing trees.. The majority of individuals were small, most appeared to be under 1.5 m and many under 1 m. . A sample of 73 lagartos included the following sizes: 0 (<0.5m), 24 (0.5 - 1 m), 32 (1 - 1.5 m), 17 (1.5 - 2), and 0 (>2).

Departamento Santa Cruz, Provincia Angel Sandoval - Río Paraguay
EcoRegion No. 22

Estancia Tel Aviv—We traveled south to a bordering ranch of about 20,000 ha. We were told that the ranch has 18 *atajados* and only 2 or 3 do not have caiman. Seven main tanks have good numbers of caiman. We traveled to the four tanks reported below during the day to verify reported caiman concentrations. The caiman were tame, numerous, and large.

8 September 1996 - The San Antonio, Pozo 1 tank, and the next two, are located in open pampa. The banks are not steep and are used for basking. The majority of lagartos were large, most individuals were over 1 m and a good number were >2. A daylight visit to this pozo during peak

basking time was impressive. A sample of 93 lagartos sighted included the following sizes: 0 (<0.5m), 5 (0.5 - 1 m), 35 (1 - 1.5 m), 33 (1.5- 2), and 20 (>2).

8 September 1996 - These individuals in San Antonio, Pozo 2 resembled the group found in Pozo 1. A sample of 100 lagartos sighted included the following sizes: 0 (<0.5m), 4 (0.5 - 1 m), 35 (1 - 1.5 m), 45 (1.5- 2), and 16 (>2).

8 September 1996 - The Cotoca, Pozo 1 is circular, in a pampa area surrounded by low forest. The majority of individuals were quite large, with none seen under 1 m. A sample of 65 lagartos sighted included: 0 (0.5-1 m), 23 (1-1.5 m), 28 (1.5-2), and 14 (>2).

8 September 1996 - Cotoca, Pozo 2 is the oldest tank at 20 years, and the only one with secondary forest at the water edge. This pozo is smaller than the rest and may have become a default area for younger animals. No very large caiman were seen. The 70 neonates were found along 50 m of shallow shoreline probably represent two clutches. The majority of individuals were under 1.5 m and many under 1 m. A sample of 114 lagartos sighted included the following sizes: 70 (<0.5m), 18 (0.5-1 m), 17 (1-1.5 m), and 9 (1.5-2).

We were unable to spend more time at this ranch. We saw numerous, large caiman in very fit condition. The owner claims that the caiman scare his cattle away from drinking (we have never seen evidence of this during our experience) and claims calves are in danger. He favors reduction in caiman numbers.

Estancias San Luis and Tel Aviv were the only properties surveyed in the Pantanal area. The populations of lagarto that we observed appeared numerous, reproductive and robust. The estancias incorporate important aspects needed: healthy caiman populations, easily censused areas, discreet habitat with potential for expansion, and enthusiastic landholders. Other ranches with similar conditions should be sought for inclusion in the future program. These properties lie within the Río Paraguay river basin of the Paraná - La Plata system, the rest of the surveyed areas of Santa Cruz and Beni lie within Amazonía

Medem (1983) incorrectly wrote that *Melanosuchus niger*, the black caiman, occurred in the Río Paraguay of Bolivia and Paraguay. In our surveys of Estancias San Luis and TelAviv, and in talks with ranchers and local people living in the Paraguay drainage of eastern Bolivia, we found no evidence of *Melanosuchus*, and after surveying all of Paraguay, Scott, Aquino, and Fitzgerald (1990) confirmed that the species is not found in Paraguay.

Table 1. Summary of surveys in the Río Paraguay basin, EcoRegion No. 22

Date	Locality	No.	Measurement		
13-Sep-95	Main Camp Tank	721	86x104 m	S 16°47’25.2”	W 58°46’07.3”
6-Sep-96	Main Camp Tank	614	86x104 m	S 16°47’25.2”	W 58°46’07.3”
13-Sep-95	Campo Torunal, Pozo 1	143		S 16°49’01.8”	W 58°47’12.1”
13-Sep-95	Campo Torunal, Pozo 2	202		S 16°48’31.5”	W 58°46’35.5”
6-Sep-96	Campo Torunal, Pozo 2	289	70x40m	S 16°48’31.5”	W 58°46’35.5”
7-Sep-96	Campo 1, Pozo 2 (Garzero 1)	337		S 16°48’00.1”	W 58°48’04.6”
7-Sep-96	Campo 1, Pozo 3 (Garzero 2)	800+		S 16°48’12.7”	W 58°48’12.4”
7-Sep-96	Campo 1, Pozo 4	429		S 16°48’23.8”	W 58°48’38.3”
7-Sep-96	Campo 1, Pozo 4A	194		S 16°48’14.9“	W 58°48’51.5”
7-Sep-96	Campo 1, Pozo 5	0		S 16°46’56.0”	W 58°48’02.4”
7-Sep-96	Campo 1, Pozo 1	50+		S 16°47’39.0”	W 58°47’49.7”
14-Sep-95	Campo 2, Potrero	0	52x74 m	S 16°48’29.5”	W 58°45’31.8”
6-Sep-96	Campo 3, Pozo 1	212	20x50 m	S 16°47’42.7”	W 58°45’20.0”
14-Sep-95	Campo 3, Pozo 2	467	43x57 m	S 16°49’55.3”	W 58°44’11.3”
15-Sep-95	Campo Jumechi, Pozo 3	30	30x40 m	S 16°47’09.5”	W 58°42’42.9”
15-Sep-95	Campo 5, Pozo 2	254	47x57 m	S 16°45’47.0”	W 58°43’08.7”

Date	Locality	No.	Measurement		
15-Sep-95	Campo 4, Pozo 1	372	52x73 m	S 16°49’54.7”	W 58°42’18.2”
15-Sep-95	Campo 5, Pozo 1	68	47x57 m	S 16°46’17.3”	W 58°44’19.3”
15-Sep-95	Campo 3, Pozo 4	198		S 16°48’16.9”	W 58°44’20.8”
15-Sep-95	Campo 3, Pozo 1	0		S 16°47’43.3”	W 58°45’40.1”
15-Sep-95	Campo 3, Pozo 3	19		S 16°50’31.7”	W 58°43’18.6”
15-Sep-95	Campo Jumechi, Pozo 2	503		S 16°47’46.7”	W 58°42’43.3”
16-Sep-95	Campo Pico Plancha, Pozo 1	58	47x64 m	S 16°43’22.7”	W 58°47’02.4”
16-Sep-95	Campo Las Gamas, Pozo 1	284	42x64 m	S 16°40’47.8”	W 58°41’59.6”
16-Sep-95	Campo Pirañas, Pozo 2	192	34x43 m	S 16°40’18.0”	W 58°39’39.8”
16-Sep-95	Campo Tacuaral, Pozo 2	182	43x57 m	S 16°39’33.9”	W 58°39’52.7”
16-Sep-95	Campo Chacal, Pozo 2	273	47x88 m	S 16°37’24.5”	W 58°41’27.7”
16-Sep-95	Campo Las Hormigas, Pozo 2	100+		S 16°36’55.0”	W 58°43’21.2”
16-Sep-95	Campo Calvario, Pozo 2	337	43x64 m	S 16°35’36.5”	W 58°50’59.7”
16-Sep-95	Campo Potrero Lecheria, P. 1	417	47x64 m	S 16°47’10.6”	W 58°45’52.2”
6-Sep-96	Campo Potrero Lecheria, P. 1	278	47x64 m	S 16°47’10.6”	W 58°45’52.2”
8-Sep-96	San Antonio, Pozo 1	320		S 16°49’52.3”	W 58°40’16.3”
8-Sep-96	San Antonio, Pozo 2	336		S 16°50’30.1”	W 58°40’54.3”
8-Sep-96	Cotoca, Pozo 1	244		S 16°52’45.2“	W 58°41’46.9”
8-Sep-96	Cotoca, Pozo 2	158		S 16°52’02.1“	W 58°41’42.1”

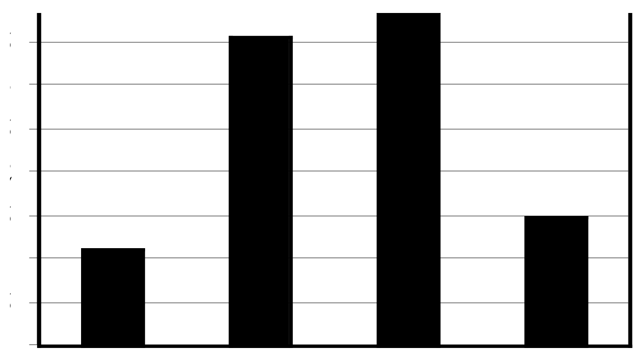


Figure 1 - Distribution of sample size classes of surveys in eastern Santa Cruz (EcoRegion No. 22) for field seasons 1995 and 1996. Classes are (left to right) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m. Not included are ‘Eyes only’ or class I: < 0.5 m. N = 860

Departamento Santa Cruz, Provincia Velasco - Río Paraguá
EcoRegion No. 18

Town of La Florida— The small town of La Florida is on the main road to the larger town of Piso Firme, on the Río Paraguá. The community consists of only 12 families dedicated to subsistence farming. The area has a reputation for abundant hunting and was previously a source for caiman hides during the legal (and certainly illegal) eras. We were offered a jaguar hide and feet the day we arrived.

The town is located on an old arm of the river (bahía) where one month previous a 3 m *Melanosuchus* was killed. The local people bathe and wash clothes there and black caiman were seen as a threat. Local people assured us that caiman hides are not worth anything (neither *Caiman* or

Melanosuchus) as there are no buyers. Nobody dedicates their time or resources to active hide hunting today. Caiman are occasionally hunted for food or fish bait.

19 September 1995 - We began our survey within the bahía, hoping to find *Melanosuchus*. The bahía has a lot of emergent cañuela (*Hymenachne* sp. or *Luziola* sp.) at one end and appeared to be good habitat, although the night survey found very low numbers, all appearing to be small *Caiman yacare*. They were all in the vegetation or shallows making size estimations difficult. A sample of lagarto included: 5 (0.5-1 m), 2 (1-1.5 m).

19 September 1995 - We traveled the Río Paraguá upriver during the day, and returned that night. The Río Paraguá runs off the Brazilian shield and is a clear, black water river with sandy shallows. The banks are generally low and support a continuous, mature gallery forest. Few homes were found along the stretch we surveyed. Many old river courses form dead-end bahias that could not be entered. The thick smoke from the dry season burning and strong waves encountered made the night work very difficult. . A sample of caiman sighted included the sizes: 4 (0.5 -1 m), 5 (1 - 1.5 m), and 2 (1.5-2 m).

Estancia Caparu—This ranch lies about 50 km SE of La Florida and upstream of El Refugio (see below). The administrator thought the ranch was about 20,000 ha. Here the rolling pampa has numerous *bajíos* that serve as headwaters for the Río Paraguá. During the wet season, there is a fluvial connection with La Florida for traffic and overland traffic is not possible. Later in the season the waters recede to the bajíos and water flow is reduced or cut off. The waterways become choked with floating vegetation and travel is only overland.

10 September 1996 - The Bahía San Roque is one of a series that follow a *bajío* north towards La Florida. A stretch of open water exists over 0.5 km long before it is closed off at either end with *Eichornia*. We paddled a dugout along the edge of the tarope that impeded our travel. No specimens were observed less than 0.5 m. The majority of the animals allowed very close approach, sometimes we touched them on the head with the spotlight! Some animals were in the tarope and size or species could not be identified. A sample of 65 lagartos sighted during the survey included the following size classes: 2 (0.5-1 m), 29 (1-1.5 m), 25 (1.5-2 m), and 9 (>2 m). The bahía was also resurveyed the next night. A sample of 85 lagarto sighted during the survey included the following size classes: 0 (0.5-1 m), 20 (1- 1.5 m), 53 (1.5-2 m), and 12 (>2 m). Four *Melanosuchus* were seen, 2 (1-1.5 m), 2 (1.5-2 m) but did not appear to be plentiful.

11 September 1996 - The Bahía Caparu is one in the same series as Bahía San Roque above. The approachable edge of the wetland had no bank, with a 100 m wide band of rooted, aquatic vegetation before reaching the small patch of open water. A 200 m stretch of edge was surveyed by walking. Caiman were seen in the open water but were more numerous in the vegetation which made a detailed survey impossible. Some neonates were observed as well as individuals up to 2 meters. All individuals identified (16) were *C. yacare*. Tarope cover was about 90% and navigation was impractical.

11 September 1996 - This survey was taken walking a 200 m terraplein which traverses a bajío on the main entrance road to the estancia. The total area inundated at this time was about 4 ha with only about 30 % open water. The water was shallow, generally less than 0.5 m, and floating or emergent vegetation certainly obscured some animals. Some neonates were observed and most of the animals were less than one meter, but individuals up to 2 meters were also seen. All individuals identified (22) were *C. yacare*.

Estancia La Union—This ranch lies about 20 km S of Estancia Caparu (see above), upstream on the Río Paraguá drainage. This region also has numerous *bajíos* that serve as headwaters for the Río Paraguá. During the wet season, a land connection by road south to San Ignacio de Velasco may be closed. The caños had continuos flow leading to the río Paraguá but later in the season, the water flow is reduced or cut off . The waterways become choked with vegetation, as above. The administrator tho8ught the ranch was 40,000 ha).

12 September 1996 - The small Bahía Piedritas looked promising when viewed during the day. Floating tarope barriers had enclosed a two hectare open water area. A gradually sloping dirt bank

on one side provided a potential basking area. At our return that night, we were surprised to find only two animals at the far bank. Perhaps recent terraplen building was responsible for few lagartos. The eyeshine color indicated *Caiman yacare*.

12 September 1996 - We paddled a 5 m aluminum skiff in Bahía Venecia for the survey. Mats of tarope blocked our way both upstream and down. A 30 m stretch of bare earth bank on the east edge, where we launched, formed one of the few beaches. Tarope and cañuela formed a vegetative edge of varied width for most of the survey perimeter. We captured four juvenile *Melanosuchus niger* at the launch site of 43, 48, 50 and 52 cm. The caiman we saw during the survey were tame and some allowed very close approach. Twenty of the 34 caiman surveyed were identified and only one, a class IV animal (1.5 - 2 m), was a Caiman yacare. . The sample of 20 *Melanosuchus niger* sighted included the following size classes: 11 (<0.5m), 5 (0.5 -1 m), 2 (1 - 1.5 m), and 1 (1.5-2 m). We saw no large adults. Sometimes the floating mat was >50m and 14 'Eyes only' were recorded.

Property El Refugio—El Refugio is located up the Río Paraguá from La Florida. This former cattle ranch was purchased for ecotourism by a conservation-minded investment group. They first removed all the cattle, and constructed two visitors cabañas.

El Refugio contains a variety of habitats. There are two very different types of open pampa, one with dense termite mounds and the other without. A forest occurs with both Amazonian and Cerrado floristic elements. The wildlife on the property is protected and reported to be quite tame. Pampas deer (*Blastocerus dichotomus*), Brazilian otter (*Pteronura brasiliensis*) and maned wolf (*Chrysocyon brachyurys*) are endangered species regularly seen.

20 September 1995 - The 50,000 ha property is crossed by approximately 60 km of rivers, the largest of which is the Río Paraguá. Due to the dense tarope (mostly *Eichornia*) growth, river travel was restricted from the main lodge in the center of the property. The first evening we went downstream as far as we could. The habitat looked very appropriate but we saw few caiman, all believed to be lagarto. Tarope was present along most of the bank and many lagarto disappeared before size could be ascertained. A strong Antarctic cold front had moved in, dropping the temperature to 17.5° C. A sample of lagarto sighted during the survey included the following size classes: 13 (0.5-1 m), 9 (1-1.5 m), and 4 (1.5-2 m).

21 September 1995 - The following evening we were joined by El Refugio director Ian Phillips and others, this time in two boats. We resurveyed the above stretch and with added people, we were able to drag the boats past the constriction and continue on for one km. This 'Eyes only' survey was conducted by Dr. Tim Killeen and Ingrid Fernandez in the lead boat, while RG followed in a second boat. Counts by the two observers were identical.

22 September 1995 - The next evening, we surveyed upriver. Only 24 *Caiman yacare* were found in 1.4 km of river that looked very suitable. We soon came to the upriver end to our journey as *Eichornia* blocked our path and we captured a 55 cm total length *Melanosuchus*. Sighting an adult across the laguna, RG began imitating the juvenile distress call. The adult responded immediately and swam swiftly toward the dugout. It was a *Melanosuchus niger* (approx. 2.5 m in length) which stayed just out of noosing range. In addition, a total of 9 juvenile (50-60 cm TL) black caiman were seen at this location.

We returned to La Florida the next day, and then continued south to Campamento, stopping at Toledo. This is within the confines of El Refugio. Unlike the isolated area we had just visited, this site lies on a well-traveled road. Locals know that wildlife is abundant here and come to hunt and fish.

Traveling east from Toledo one encounters Bahia de Toledo. This is an old course of the Río Paraguá that still maintains some flow from the main river. We employed a ranchhand to guide our night survey and used a small dugout to negotiate the shallow bahia. At both the bahia's entrance and exit channels we were unable to pass through the narrow shallows and enter the main river course. Wild fires raged at a close distance and at times the smoke passed over the bahia like a curtain, severely reducing the visibility to about 50 m and causing respiratory distress. Our route took us in a large oval, keeping one bank in sight at all times, with the distance from shore dictated by the shallows

23 September 1995 - We found the Bahía Toledo, even though on private land, to have far fewer caiman than expected. The conditions looked appropriate for caiman of various size classes. There were relatively deep areas in the main channel, shallow edges with emergent vegetation, some banks with fallen trees and some protected beaches for basking.

The animals were quite shy and if on dry land, moved into the water as soon as the light struck them, even though hundreds of meters away. Many submerged soon after being spotlighted. The bahia is close to the main road and is fished frequently. The area is perhaps under hunting pressure from La Florida. All identified caiman were *C. yacare*. A sample of lagartos sighted included the following sizes: 3 (0.5-1m), 3 (1-1.5 m), 1 (1.5-2 m), 2 (>2 m).

Town of Piso Firme—We continued north passing through Porvenir and on to Piso Firme where located a local guide and a skiff. We journeyed upriver about an hour and waited until nightfall. The river looked much as in La Florida, but with more volume, wider and abundant wildlife. *Podocnemis unifilis* were common in the water and some were seen dashing to safety from aborted nesting attempts.

25 September 1995 -The Río Paraguá here, as near La Florida, has many shallow bahias off the main channel that contained caimans recorded as 'Eyes only' as they could not be approached close enough to judge size. Several appeared to have only juveniles. A sample of lagartos sighted included the following: 86 (0.5-1 m), 13 (1 - 1.5 m), 7 (1.5 - 2m).

25 September 1995 - We decided to survey the bahia where the town is located. It was very shallow and we were not able to approach very close to shore. Most of the caiman were sighted in the edge vegetation and could not be identified for size or species.

The following day we traveled to Remanso on the Río Itenez. We were referred to a nearby ranch owner who had claimed large black caiman were found in a big laguna on his property. We spoke to his foreman and discussed visiting the ranch. It was some distance away, and was currently only accessible by horse. With only one entrance, property access is controlled and the caiman are said to have recovered from the prior hunting.

It was mentioned by several people that while the Bolivians respect the caiman hunting ban for the most part, Brazilians are crossing the river and hunting on the Bolivian side. They sometimes take the skins but are principally hunting for meat. This blamed on Brazilians, as we hear that Bolivians don't eat caiman meat.

26 September 1995 - We returned to Piso Firme and traveled upriver for two hours on the Río Paraguá and waited until dark. We were surprised to find 9 *Paleosuchus trigonatus* scattered over the first km. Four individuals were sitting on the bank and entered the water as we approached, the others were located under dead branches in the water; all eluded capture. Our guide was well aware of their difference from *Caiman yacare*. He mentioned that they were not found close to town. This survey is for the upper 10 km not traveled last night. A sample of lagarto sighted during the survey included the following size classes: 68 (0.5-1 m), 17 (1-1.5 m), 12 (1.5 -2 m), and 2 (>2 m), and the *Paleosuchus* sighted were the following size classes: 4 (0.5 -1 m) and 5 (1- 1.5 m). We resurveyed the lower 10 km for 'Eyes only'. No *Paleosuchus* or *Melanosuchus* were positively identified.

Table 2. Summary of surveys in the Río Paraguá basin, EcoRegion No. 18

Date	Locality	No.	Measurement		
19-Sep-95	Río Paraguá, la Bahía	11	1.1 km	S 14°36'36.5"	W 61°11'35.9"
19-Sep-95	Río Paraguá, start survey	39	6 km	S 14°35'30.9"	W 61°11'26.4"
	Río Paraguá, end survey			S 14°36'36.5"	W 61°11'35.9"
10-Sep-96	Bahía San Roque	146	1.5 km	S 14°55'32.5"	W 61°05'38.6"
11-Sep-96	Bahía Caparu	72	200 m	S 14°55'15.6"	W 61°06'13.8"
11-Sep-96	Terraplen Caparuchito	52	200 m	S 14°55'15.6"	W 61°06'13.8"
12-Sep-96	Bahía Piedritas	2	1 lake	S 14°55'32.5"	W 61°05'38.6"
12-Sep-96	Bahía Venecia	34	1 lake	S 15°03'58.7"	W 61°04'04.5"

Date	Locality	No.	Measurement		
20-Sep-95	Río Paraguá, abajo–start survey	38	1.4 km	S 14°4’00.6”	W 61°02’05.8”
	Río Paraguá, abajo–end survey			S 14°45’37.1”	W 61°02’45.6”
21-Sep-95	Río Paraguá, abajo–start survey	115	2.4 km	S 14°46’00.6”	W 61°02’05.8”
	Río Paraguá, abajo–end survey			S 14°45’53.6”	W 61°03’14.0”
22-Sep-95	Río Paraguá, arriba–start survey	34	1.4 km	S 14°46’00.6”	W 61°02’05.8”
	Río Paraguá, arriba–end survey			S 14°46’32.1”	W 61°01’50.9”
23-Sep-95	Río Paraguá, Bahía Toledo	29	3 km	S 14°42’37.3”	W 61°07’47.8”
25-Sep-95	Río Paraguá, arriba–start survey	153	10 km	S 13°38’20.5”	W 61°42’35.5”
	Río Paraguá, arriba–end survey			S 13°37’44.6”	W 61°43’55.1”
25-Sep-95	Río Paraguá, bahía at town	15	1.5 km	S 13°37’44.6”	W 61°43’55.1”
26-Sep-95	Río Paraguá, arriba–start survey	195	10 km	S 13°38’46.9”	W 61°41’54.5”
	Río Paraguá, arriba–end survey			S 13°38’22.0”	W 61°42’37.2”
26-Sep-95	Río Paraguá, arriba–start survey	188	10 km	S 13°38’22.0”	W 61°42’37.2”
	Río Paraguá, arriba–end survey			S 13°37’46.1”	W 61°43’56.7”

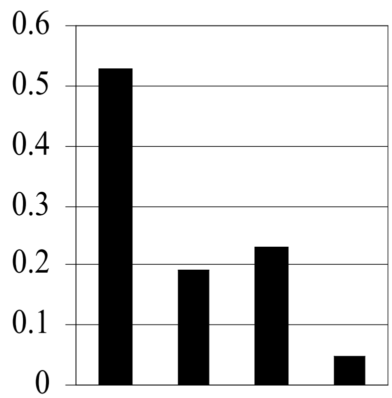


Figure 2 - Distribution of size classes from sample surveys in the Río Paraguá basin in north-central Santa Cruz (EcoRegion No. 18) for field seasons 1995 and 1996. Classes are (l to r) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m. Not included are ‘Eyes only’ or class I: < 0.5 m. N = 332.

We traveled the new road SW from Piso Firme, finally arriving at Ascención de Guarayos. It was along this road that the bridges had been burned by the wild fires mentioned in the introduction above. We could continue only by driving through the dry riverbed. The road would be impassible during the early 1996 rainy season without the bridges.

Departamento Santa Cruz, Provincia Ñuflo de Chavez - Río San Julian (Río Itonamas basin) - EcoRegion No. 23

Estancia San Miguelito—We first met with the ranch owner in Santa Cruz. He has owned the ranch for 23 years and has prohibited hunting on the property. It has nearly 60,000 hectares in the Río Itonamas basin and a large part is covered by a partly deciduous forest The Río San Julian is one of seven named segments of what becomes the Itonamas.

04 October 1995 -The severe dry season this year has dried up some lagoons for the first time for this owner. He constructed locks on the Río San Julián to control the drainage and retain water during the dry season. Only short sections were navigable due to *Eichornia*, and from the new bridge only a 100 m stretch of clear water could be seen. A total of 16 lagarto were seen, a sample included: 3 (0.5-1 m) and 1 (1-1.5 m); the rest are ‘eyes only.’

04 October 1995 - We crossed the river and continued on north towards the Río Sapocó Sur. The strong rainstorm had passed through and we got both four-wheel drive vehicles hopelessly stuck. We

continued on about 2 km on foot to the crossing. The river, about 4 m wide, had dried to a series of pools, without any evident flow. The surface was about 40% covered with *Eichornia* and the surrounding low forest reached the banks. RG hiked briefly through a short series of pools but soon realized that the habitat was severely limited and abandoned the survey. All lagartos were smaller than 1 m in length.

The next day we went to an area of the Río San Julián, the main river flowing through the estancia. Surveying on this ranch is very difficult as many sections of these roads were impassable from recent rains. The rivers were very low and choked with floating vegetation and the lagoons that historically held caiman were either dried or unreachable.

<u>05 October 1995</u> - This section of the Río San Julián occurs where the Río Tuná joins it. The riverbanks had a nearly continuous mat of *Eichornia* along the edge. The Río Tuná was too low to be entered and the San Julián was closed with tarope just a short distance upstream of the confluence. We were unable to approach the caiman closely during the survey but a sample of lagarto seen included: 7 (0.5-1 m), 6 (1 - 1.5 m), and 8 (1.5 - 2 m).

<u>06 October 1995</u> - The following day we hiked along the Río San Julián river, moving upstream from last night's survey area. We were surprised to see a clear area of river extending out of sight around the bend. We decided to haul the boat and equipment over the 100 m 'dam' of *Eichornia* and survey this area in the evening. We then traveled upstream to await nightfall. Wind raised chop on the river and the caiman sought refuge in the tarope. A sample of caiman seen included the following: 23 (0.5-1 m), 19 (1-1.5 m), and 16 (1.5-2 m).

Table 3. Summary of surveys in the Río San Julian basin, EcoRegion No. 23

Date	Locality	No.	Measurement		
4-Oct-95	Río San Julián, near main house	16	100x20 m	S 17°01'37.4"	W 61°51'39.7"
4-Oct-95	Río Sapocó Sur	12	100x4 m	S 17°02'04.4"	W 61°49'2"
5-Oct-95	Río San Julián, Palca de Tuná–start	42	.64 km	S 17°07'19.7"	W 61°45'45.0"
	Río San Julián, Palca de Tuná–			S 17°07'05.3"	W 61°45'23.7"
6-Oct-95	Río San Julián, Pto del Muerto–start	123	1.4 km	S 17°07'19.9"	W 61°44'49.8"
	Río San Julián, Muerto–end			S 17°07'07.8"	W 61°45'22.2"

Figure 3. Distribution of size classes from sample surveys in the Río San Julián, in the upper Río Itonamas basin in central Santa Cruz for field seasons 1995. Classes are (left to right) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m (none seen). Not included are 'Eyes only' or class I: < 0.5 m. N = 83.

The size distribution was unusual with no large animals seen. The sample was very small and represents only a subset of the population on this large ranch. We anticipated easier access to the habitats but we had problems with flooded areas blocking our overland passage and tarope blocking the waterways. We were unable to return for surveys in 1996.

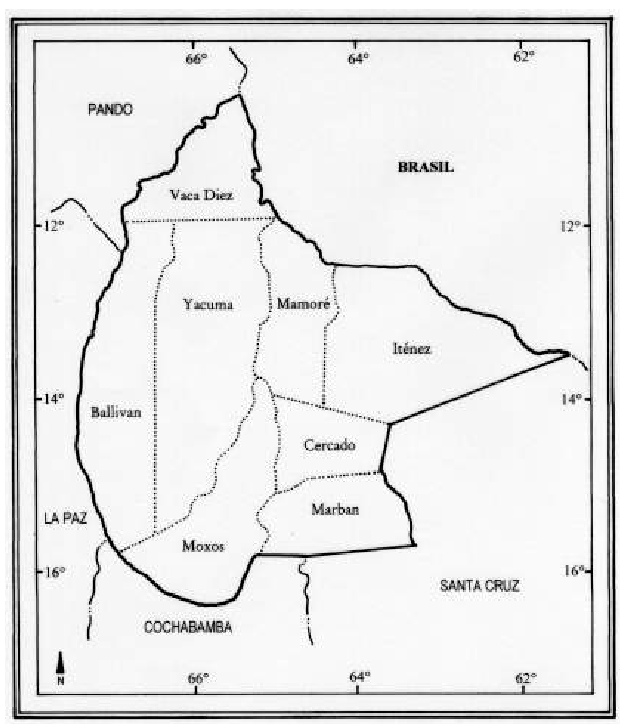
We prepared for our trip to Trinidad, capital of the department of Beni (1995). The road was then about 25% asphalted but now the all-weather road is now complete and will undoubtedly influence the rate of change in the Beni. The 400 km trip previously took about 10 hours in the dry season, and up to 24 hours during the rainy season when passable.

DEPARTAMENTO BENI

The Beni Department is covered with a rich mosaic of wetlands: rivers, streams, lakes and other water bodies. Most of the 213,654 km^2 is subject to seasonal flooding and all provinces contain habitat for *C. yacare*. This is the traditional center for caiman hunting in the Bolivian lowlands. The landscape is dominated by large cattle ranches, many having effected little ecological change due to extensive management. Three Indigenous Territories had been legally declared and all contain caiman habitat. For many factors the Beni is the logical center for surveys and future program development (see Maps 3 & 5).

Once in Trinidad (pop. 70,000), we met with the head of CDF to introduce our project (1995). CITES Scientific Coordinator, Dr. Obdulio Menghi, and FWK had met with CDF officials, ranchers and others in May 1995. A 20-year agreement was made designating ranchers *ad honoree* Forestry Wardens, responsible for conservation of flora and fauna on their property. The landholder becomes steward of the natural resources and assists CDF, which has neither the personnel, equipment, or funds for active enforcement in the Beni's 213,564 km^2. The incentives for the landowners' cooperation are for technical assistance from wildlife authorities, possible future commercial hunting, and permission to develop ecotourism. The caiman conservation project fits very appropriately into the agreement.

We began to arrange visits to cattle ranches and the Isiboro-Sécure Indigenous Territory National Park (TIPNIS - *Territorio Indígena Parque Nacional Isiboro-Sécure*). The area of the highest precipitation in Bolivia lies just south of TIPNIS (4000 mm) and we worried that early rains could affect the caiman concentrations there.



Map 5. Provinces of the Department of Beni. All provinces have suitable caiman habitat and a high potential for inclusion in a future sustainable use program.

By the start of the 1996 field season in the Beni, many administration changes had taken place. Forestry and wildlife issues are now under Centro Forestal in the Subsecretary of Economic Development. Wildlife was placed within Natural Resources of the Subsecretary of the Environment and Sustainable Use, as was done in Santa Cruz. This was done in an effort to be deal with the subjects at appropriate levels.

Ing. Dante Videz Roca (DVR), survey team member in 1995, was named the first Director of the Wildlife Unit for the Beni. He was able to accompany the team for most of the 1996 surveys in the Beni Department. Ing. Videz had previously contacted ranch owners, and scheduled some for re-surveys. Some ranchers expressed discontent that the government delaying the harvest yet another year. A few ranchers were first contacted by FWK in 1986. Some felt no assurance from the government and refused to invest any more money.

Departamento Beni, Provincia Iténez - Río Blanco
EcoRegion No. 4

Estancia Nazaret—In 1995, we flew from El Futuro (see below) eastward to Magdalena and a day later another short flight eastward brought us to Estancia La Esperanza along Arroyo Orope. We mounted horses and rode to Estancia Nazaret, a neighboring ranch on the Río Blanco lacking an airstrip. The area is open pampa with tree islands. We had to cross recently flooded savanna where the water sometimes reached the horses' belly. We waited for nightfall to ride back and see areas along the way

25 November 1995 - We approached Laguna El Cambarasal and the pampa became more saturated and then inundated with 10-30 cm of water. From our access point the big lake that looked largely devoid of caiman (relatively few eyeshines were seen). As we looked for another access point, we noticed that there were small caiman scattered across the open pampa. These were all under one meter and usually were found singly.

25 November 1995 - This bajío was a depression along the route back towards the airstrip where water and caiman were found.

25 November 1995 - As we approached the bridge over the Arroyo de Chacal, water and caiman increased in the path, and then decreased shortly after crossing the arroyo. These caiman also all appeared to be <1.0 meter long and the most in the 0.5 meter range.

25 November 1995 - The Arroyo del Bí (a native fruit tree) had little flooded pampa surrounding the crossing and no caiman there. The caiman in the arroyo were seen as 'Eyes only' from a bridge.

Impending weather and a soggy airstrip forced us to leave the ranch the next day. All caiman positively identified were *Caiman yacare*. Due to the clear water and open pampa, identification was simple for many animals. The caiman, having no vegetation to hide under, would submerge under only a few cm of water. Although we saw few adult individuals, the numbers of small caiman indicates that reproduction is functioning well on the ranch. We felt the property warranted a closer inspection during the 1996 field season.

We returned the next year for inspection of some of the major water bodies on the ranch. The terrain was undergoing the *sequia* and annual drawdown of the water bodies. Water distribution was different than in 1995, and we had a different set of water bodies to survey. Only Laguna Cambarasal, had water in 1996. We returned by flying into Estancia La Esperanza and then by horseback to Estancia Nazaret. We first went to the main building on the Río Blanco and used it as a base.

24 August 1996 - Laguna Puerto Feliz is a large lake, located less than one km due west of the main buildings, and is nearly surrounded by low forest. Bare, dirt banks bordered most of the lake edge, and little floating or emergent vegetation was present. We were able to maintain less than 10 m from shore during most of the census. The nighttime spotlight numbers were low, given the size of the lake. No large animals were seen and perhaps this lake has been subject to recent poaching. A sample of 133 lagartos sighted during the survey included the following: 17 (<0.5 m), 44 (0.5-1 m), 31 (1 - 1.5 m), and 41 'Eyes only'.

24 August 1996 - Laguna Surubí is a large lake is about 2 km due south of the main buildings. It is surrounded by low forest with a broad band of open pampa with short grasses around the edge. A 20

m wide mat of *Eichornia* bordered the waters edge, most of the caiman were seen there and most were small. The lake forms a right angle and we walked a survey line of 400 m along one shore of one arm. At the point where the lake turned east, it proved difficult to survey further, and both numbers and sizes of caiman were low. No large animals were seen. A sample of 58 lagartos sighted during the survey included the following size classes: 17 (0.5-1 m), 6 (1 - 1.5 m), and 35 'Eyes only'.

<u>24 August 1996</u> - We stopped by this large lake on our way south, located 2.7 km northeast of the puesto Colina. It is similarly surrounded by low forest with a broad band of bare dirt beach around the edge. The lake has a more convoluted shoreline than commonly found in the area. Very little emergent or floating vegetation was present. Ranch owner, Dr. Ali, told us that the mythical 'jiche' had been reported here. This anaconda-like beast, reported up to 40 m in length, is believed to be responsible for maintaining the waterbody. On numerous occasions, campesinos told us that a relative had "killed a jiche and then the lake dried up." No one we talked to had ever seen one, though the creature is widely believed to exist. The campesinos are very frightened it and belief that one is present in an area might give some measure of protection.

We found no protection value from the jiche here. There was no evidence of a jiche, or a large population of caiman either. We paddled the perimeter, keeping within 10-20 meters of the shore. The caiman were rather light shy, and in low numbers which may indicate hunting pressure. Few large animals were seen and no class V. The guides told us that people frequently come here to fish and caiman tail is commonly used as bait. A sample of 58 lagartos sighted during the survey included the following size the following size classes: 10 (<0.5 m), 56 (0.5-1 m), 23 (1 - 1.5 m), 10 (1.5 - 2 m) and 39 'Eyes only'.

<u>24 August 1996</u> - This large lake is formed in a bajío a few hundred meters northwest of the puesto Colina. We rode along the northeast shore where canuela emerged near the shoreline for most of the distance and a narrow band of tarope widened to engulf the shallow northwest end. The laguna is over 100 m wide at this end and tapers into an impassable bog. The caiman were shy, and in small size classes which may indicate hunting pressure. Few large animals were seen. A sample of 103 lagartos sighted during the survey included these size classes: 19 (0.5-1 m), 14 (1 - 1.5 m), 3 (1.5 - 2 m), and 67 'Eyes only'.

<u>Estancia La Esperanza</u>—We also conducted surveys at several sites on Estancia La Esperanza, the bordering ranch directly to the west of Nazaret. The owner, Sr. Hugo Jimenez, is Dr. Ali's uncle and is also interested in the program. We began on the arroyo Orope, at this time flow had been cut off and it had become a laguna.

<u>22 August 1996</u> - The arroyo forms one border of the ranch. When flowing, water moves northeast and finally reaches the Río Blanco. The ranch is at the north end of a large laguna several kilometers long. We surveyed a 2 km stretch in our raft, with a spotlight, maintaining at least 10 -20 m from shore. Forest bordered the lake edge, sometimes flooded, for nearly the entire portion surveyed. A few dirt beaches occurred along the shore.

This arroyo is used for transport in times of high water. As the arroyo flow subsides, the large surrounding bajío collects encompassing runoff and forms a long laguna. Many families live nearby and it is heavily used for fishing. The arroyo is a widely used, has open access and would not be suitable for inclusion in a program. The caiman were small and very light shy which may indicate hunting pressure. Some animals submerged while we were a great distance away. Few large animals were seen. A sample of 102 lagartos sighted included the following: 24 (< 0.5 m), 11 (0.5-1 m), 4 (1 - 1.5 m), 1 (1.5 - 2 m), and 62 'Eyes only.'

<u>22 August 1996</u> - Tapada is a small laguna which had a 5 – 20m wide *Eichornia* band around most of the perimeter. Most of caiman were in this floating vegetation. We were able to paddle the raft along the edge of vegetation during the survey and identify animals with the spotlight. No caiman of class IV or V or *Melanosuchus* were seen. A sample of 111 lagartos sighted during the survey included: 41 (0.5-1 m), 14 (1-1.5 m) and 56 'Eyes only'.

<u>22 August 1996</u> - This survey followed a small arroyo that had turned into a long laguneta that stretched along its bed in open pampa. We began at one terminus on our way toward laguna Vivisca.

We rode along the southwest bank for an 'Eyes only' count. Many animals were in the class II and small III size range.

23 August 1996 - The survey of Laguneta Marayaú followed the southern shore of a larger laguneta also found in open pampa. Emergent vegetation was dominant along this shore and we saw caiman there. The laguneta varied in width, sometimes over 75 m. The pampa sloped gently in the bajío forming the laguneta with saturated soil near the edge. We saw many caiman in vegetation on the inaccessible far side. Our vantage point was not good enough to assign size classes, so we made an 'Eyes only' count. The caiman were numerous.

23 August 1996 - We arrived for this survey prepared to see black caiman. Our guides, and others, had said they had seen the species here. The lake was surrounded by forest with some flooded forest areas. A large island was in the central part of the lake. The raft survey started on the southern shore and moved counter clockwise. Fishing activities had made these animals wary hence the high number of 'Eyes only'. The caiman were relatively abundant but no *Melanosuchus* was seen. A sample of 183 lagartos sighted during the survey included: 13 (< 0.5 m), 62 (0.5-1 m), 33 (1-1.5 m), 6 (1.5-2 m), and 56 'Eyes only'.

Date	**Locality**	**No.**	**Measurement**		
25-Nov-95	Laguna El Cambarasal, start	61	1 km	S 13°09'14.8"	W 63°45'10.6"
	Laguna El Cambarasal, end			S 13°09'18.3"	W 63°45'42.3"
25-Nov-95	Bajío	16		S 13°08'07.3"	W 63°45'28.6"
25-Nov-95	Arroyo del Chacal, start	53	.35 km	S 13°08'46.1"	W 63°46'47.5"
	Arroyo del Chacal, end			S 13°08'44.0"	W 63°46'58.6"
25-Nov-95	Arroyo del Bí	8		S 13°08'42.1"	W 63°47'21.7"
24-Aug-96	Laguna Puerto Feliz	133	3 km	S 13°08'14.5"	W 63°44'21.8"
24-Aug-96	Laguna Surubí	58	400 m	S 13°09'59.2"	W 63°43'27.1"
				S 13°10'09.0"	W 63°43'28.6"
24-Aug-96	Laguna Pampita	138	4 km	S 13°11'10.8"	W 63°44'08.9"
24-Aug-96	Laguna Masaví	103	500 m	S 13°11'30.9"	W 63°45'46.7"
22-Aug-96	Laguna Orope	83	4.2 km	S 13°09'09.3"	W 63°47'56.5"
22-Aug-96	Laguna Tapada	111	1.4 km	S 13°08'29.3"	W 63°47'45.3"
22-Aug-96	Laguna El Pío	71	1.3 km	S 13°08'07.4"	W 63°47'00.0"
				S 13°07'40.7"	W 63°47'15.1"
23-Aug-96	Laguneta Marayaú	242	400 m	S 13°07'34.5"	W 63°47'06.3"
				S 13°07'37.3"	W 63°46'59.3"
23-Aug-96	Laguna Vivisca	183	1.5 km	S 13°07'06.2"	W 63°46'44.2"

Table 4. Summary of surveys in the Río Blanco basin, EcoRegion 4.

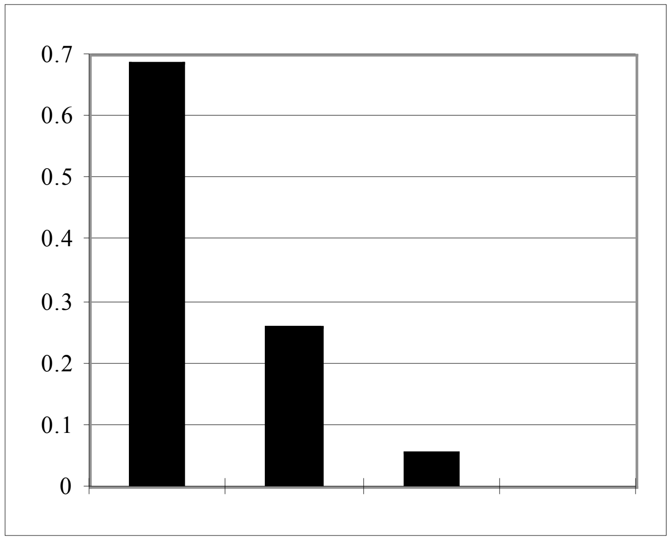


Figure 4. Distribution of size classes from sample surveys on two ranches in the Río Blanco basin in NE Beni for field seasons 1995 and 1996. Classes are (left to right) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m (none seen). Not included are 'Eyes only' or class I: < 0.5 m. N = 365.

The skewed distribution seen in Figure 4 indicates that severe hunting pressure may have occurred in the area recently or is still ongoing. We saw a very small number of class IV animals and no class V. The surveys were restricted in a very small geographical area.

Departamento Beni, Provincia Mamoré - Río Itonamas
EcoRegion 5

Many large ranches occur east of the Río Mamoré in the provincias of Mamoré and Cercado. Although some are very close to the Mamoré, examination of hydrologic maps shows that most of these ranches lie within the Río Itonamas basin. The system collects water that moves north where it unites with the Río Itenez (or Guaporé) along the Brazilian border.

Estancia Miguelito — The main road north from Trinidad, passes San Ramón and turns east towards Magdalena. Estancia Miguelito (also known as El Futuro) lies about 20 km further east. The ranch includes about 50,000 ha which has many hectares taken up by lakes and swamps. The owner was hospitable and interested in the project but he expressed no interest in a future harvest. Perhaps this could serve as a non-hunted control area.

22 November 1995 - The main ranch map lists Laguna Rosario as comprising 480 ha with a 380 ha swamp to the west of it. It is a large lake and like many of the lakes in the region, is a rough rectangle. It measures about 3 km by 1.5 and looked like suitable habitat. Access is hard to control and the owner has had a longstanding battle against wildlife poachers entering his property. The caiman were certainly not as numerous as we expected and they were somewhat light shy. The caiman sighted were of the following: 4(<0.5 m), 3 (0.5-1 m), 8(1-1.5 m), 10 (1.5-2 m), 2 (2-2.5 m), with 121 'Eyes only.'

23 November 1995 - Our intention was to survey Laguna Nicalapo, a much larger and more protected lake. As we readied the boat a wind came up and it began to rain. The rain and the increased wave height made it more difficult to spot caiman, and it also altered their behavior. Many individuals were out of the water and on the banks, seeking shelter from wave action. We joked, as it seemed some were about to 'climb' the trees. Finally, we were forced to abandon our survey efforts and, due to time constraints, could not return.

The laguna is a rough oval with the long axis E-W that measures about 5 kilometers as measured from an old ranch map. We entered the lake from a northern canal and stuck close to the western shore as we began a route counter clockwise around the lakeshore. We traveled south and then west until we reached the western-most end and had actually rounded that and just began heading eastward when we abandoned the survey. The small numbers of caiman seen were unexplainable, as the habitat seemed suitable. Conditions for the survey were less than ideal but we believe that the number seen was extremely low.

Estancia La Ceiba—This was our first survey in the Beni in 1995; it is owned by a prominent tanner. The ranch is located about 150 km northeast of Trinidad, on the road to El Carmen. The dry season had been severe in this area and the rivers we crossed en route were very low. Some were only pools with no discernible flow. Very few water bodies remained in the pampas and many ranchers were forced to water their cattle over long distances. Very few ranches have man-made water holes and even fewer have a well and pump system. As in Santa Cruz, we talked to people who said this was an unusually dry year.

7 October 1995 - We first were taken to Caño Chuto. This caño flows for much of the year but, at the time of our visit, had dried to only a short, shallow section of varying width (approximately 8-20 m). The banks were mostly forested and access was difficult. A small tree island divided the caño near the midpoint, making survey attempts difficult. Tarope chico (*Azolla* and *Pistia*) covered about 60% of the surface. The small leaf size of this plant masks the caiman heads making size estimates difficult. An additional 10-20% *Eichornia* cover and limited access sites forced an 'Eyes only' survey. Thirty-six lagarto less than 0.5 m in length, and 2 larger *Caiman yacare* about 1 m long were found in this 'nursery' area. The rest of the caño appeared to populated by a large proportion of medium sized animals. Several lagarto were seen which appeared to be about 2 m long.

18 October 1995 - We were taken to a very large lake, Laguna San Luis. It forms large 'U' that is reportedly 20 km in length, although that varies according to the season. It is said to contain large black caiman, anacondas, and the mythical '*jiche*', a giant anaconda (up to 40 m!) which roars, causes large waves, and leaves a 2 m wide swath in the vegetation as it passes. The legend states that once the *jiche* is killed, the laguna dries up.

The reduced water due to the drought caused a wide, barren 'beach' perimeter of dried mud. The shallow conditiions discouraged us from attempting to put our boat in the water. The general aspect did not look promising for abundant caiman and very few caiman were seen either in or out of the water. The combination of these factors, plus the fact that various ranchesborder the lake, forced our decision to abandon this survey. The locality given below is for the access point on Estancia La Ceiba to the western arm of Lago San Luis.

Estancia Villa Cristina—This is another estancia of the Quaino-Paz family and is very close to the Estancia La Ceiba. It was also showing signs of severe drought. We were led to a natural pozo, which is one of the main watering sites for the ranch. We were told it had never dried up and would be navigable.

18 October 1995 - It was evident that the small, round pozo, Ojo de Agua, was only a remnant, measuring about 10 m in diameter and perhaps 50-60 cm deep. The shores were densely covered with *Eichornia* and *Heliconia.* Only small *Caiman yacare* were present (±35 cm), probably representing a single pod, and no female in attendance was noted, although attempts were made to call her with hatchling imitations. The night survey was done by spotlighting and the lagartos sighted during the survey were the same size class: 34 (<0.5 m).

18 October 1995 - A short distance away (1.2 km) we went to a nameless caño that we were assured would be navigable, and where lagartos would be abundant in '*cualquier cantidad*' (boundless quantity). The 100 m caño was covered with *Azolla* and *Pistia* and about 30 cm deep. With difficulty we poled a small dugout through the 2-3 m wide caño, locating 32 small lagarto. All were the same size as found in Ojo de Agua (±35 cm). No attendant adult was sighted and attempts made to call her were unsuccessful. The lagartos sighted during the survey were all the same size class: 32 (<0.5 m). These two receding water bodies represented the only water available on the estancia during our visit. .

Table 5. Summary of surveys from the central Río Itonamas basin, EcoRegion No. 5

Date	Locality	No.	Measurement		
22-Nov-95	Laguna Rosario, start	148	8.5 km	S 13°14'22.6"	W 64°28'09.3"
	Laguna Rosario, end			S 13°29'26.3"	W 64°29'11.8"
23-Nov-95	Laguna Nicalapo, start	30	7 km	S 13°13'27.1"	W 64°23'08.1"
	Laguna Nicalapo, end			S 13°15'57.7"	W 64°23'18.4"
17-Oct-95	Caño Chuto–start	438	.42 km	S 14°23'41.9"	W 64°03'12.9"
	Caño Chuto–end			S 14°23'29.2"	W 64°03'18.0"
18-Oct-95	Laguna San Luis	15+		S 14°19'22.5"	W 64°03'28.9"
18-Oct-95	Ojo de Agua	34	10x10 m	S 14°25'17.4"	W 63°59'16.5"
18-Oct-95	Nameless Caño–start	32	.14 km	S 14°25'45.7"	W 63°58'50.8"
	Nameless Caño–end			S 14°25'47.7"	W 63°58'46.5"

Departamento Beni, Provincia Cercado - Río Itonamas
EcoRegion No. 9

Estancia La Havana—This large cattle ranch is bounded on the west by the great Río Mamoré, and on the east side by the Río Ipurupuro. Most of the ranch lies within the Río Itonamas drainage despite the proximity to Río Mamoré. The ranch originally was owned by Atilio Quaino, founder of the Moxos Tannery in Trinidad. He was formerly the main tanner of wildlife hides in the Beni. Thousands of *Melanosuchus niger* and *Caiman yacare* hides passed through his plant during the peak years. Sr. Quaino also established a small caiman 'criadero', or farm, with a future goal of production. No incentive existed for management as no commerce of hides was permitted.

7 July 1996 - We decided to census the main farm tank, which contains nearly all the caiman. The adjacent tank contained only 4 caiman, and an open cuneta across the service road had 3 (< 1 m). We had heard reports of 700-800 caiman in the main tank. In December 1996, DVR made a spotlight survey and found more than 230 caiman, with 1 black caiman. Seven months later, RG and thesis student Daysi Molina surveyed the captive caiman. Forty-six yacare caiman were found in the following size classes: 1 (1-1.5 m), 21 (1.5-2 m), and 24 (2-2.5 m). We saw no small caiman of class I or II, or any indication of recent nesting. One class IV *Melanosuchus niger* was also present.

The ranch originally comprised 36,000 ha, now divided among several estancias owned by Quaino siblings. In 1995, we flew from Trinidad to a northern estancia, La Esperanza, and from there traveled further north by jeep to La Papaya, La Esmeralda and to Arroyo Masineca. This is an affluent of the Río Machupo, which in turn flows into the Río Itonamas near its mouth on the Río Iténez (Guaporé). Due to the dry season, Arroyo Masineca was divided into short sections. Some sections were completely separated by dry land, while others were connected by narrow rivulets, 20-30 cm wide. The sections we observed were generally free of tarope.

These bodies of water often contained a mix of *Melanosuchus niger* and *Caiman yacare*. No individual of black caiman was observed so large that it could be identified solely by size which made censusing rather difficult. Due to the extreme drought, the shallow shorelines were unapproachable due to wide, mud barriers. These shallows were frequented by the majority of caiman. By walking the shoreline at other locations, it was possible to make an accurate count but often difficult to identify the species.

9 November 1995 - The guides had told us that they had seen some large black caiman out sunning at Arroyo Masineca. We walked the bank that night and took a census of 55 animals, seeing approximately 15 large (2 m) caiman, with the rest dispersed in size down to 0.75 m. None appeared distinctly like *Melanosuchus* by coloring or size from our vantage point on the shore.

The next day, we searched the lagoon with binoculars and, to our surprise, found that approximately 50% of the animals were black caiman. A nest was located under some low bushes, 3 m from the edge of the lagoon. It measured 1.3 x 1.4 x .6 m. Opening the nest, we discovered 53 eggs in a chamber 45 x 20 cm. The eggs were strongly banded. One egg was opened and the small embryo was estimated to be 2-3 weeks old. The size of the nest, and number and size of the eggs leave no doubt that this was a black caiman nest. Attempts to mimic distress calls failed to attract an attendant adult.

9 November 1995 - This arroyo is surrounded by open pampa, which reaches the banks. There is some growth of bushes and small trees (<10 m) along parts of the bank but generally it is open and allows for walking surveys. It also facilitated driving from site to site.

We made a return visit to the Estancia Esmeralda in 1996. The surrounding water bodies were not in the extreme state seen during the previous dry season. A wet *surazo* had passed through two weeks before and rendered much of the pampa impassable by vehicle. This restricted our plans but we were able to re-survey some areas.

We rode from Esmeralda to the first pozo where we started last year and we walked the same length of shore. At this point we were 7 km NW of Esmeralda. The sample of the *C. yacare* we identified for size were 4 (<0.5 m), 1 (0.5-1 m), 1 (1.5-2 m) and 2 (>2 m).

No new black caiman nest could be seen. One guide had returned last year and said the old nest had apparently hatched successfully. In 1996, the first section laguna had a very diminished population compared to 1995. We were able to distinguish 2 (0.5 - 1 m) and 1 (1 - 1.5 m) black caiman in the lagoon. We did not have the benefit of our powerful spotlight this night, and were not present during daylight to identify species of the few animals present.

9 July 1996 - We followed the arroyo for a long stretches without breaks, until the water terminated. The arroyo was quite variable in width, from 10 m with established banks to over 100 m where shallow *bajios* widen the course. Due to the less powerful light, we were obliged to be content with 'Eyes only' counts. At the end of the arroyo we found a pod of neonates in the 40 - 50 cm range. The sample of the *Caiman yacare* we identified for size were 19 (<0.5 m), 28 (0.5 - 1 m), 20 (1 - 1.5 m), 13 (1.5 - 2 m) and 7 (>2 m) and 96 'Eyes only.' Four black caiman were identified, 2 (1 - 1.5 m) and 1 (1.5 - 2 m).

9 July 1996 - After leaving the course of Arroyo Masineca, we traveled south toward Esmeralda. About 1.5 km further we crossed shallow Arroyo Rodeo. We rode east along the south bank for a brief survey. The caiman seemed fairly numerous for the distance but they were spread out in the ample habitat. Most of this arroyo dries up later in the dry season. The arroyo was quite variable in width, from 40 m to over 100 m. Many of the caiman were associated with vegetation for cover. Due to the less powerful light, again we were obliged to be content with 'eyes only' counts.

6 July 1996 - Caño Motacusalito too had undergone an amazing transformation. We were still able to drive there, the southern terminus was 1.8 km due north of Esmeralda, but much more water was present. A small mud hole last year had become a slender laguna over 2 km long. We traveled the banks and counted eyeshine with the spotlight. The density was much lower than in 1995. No black caiman were identified.

6 July 1996 - We stopped along the shallow Cañada del Corral located near one of the main corrals. The majority of the animals seen were class II. A pod of six neonates was seen. It appears to be a shallow bajío marsh that will be gone later in the dry season.

Estancia La Esperanza- This estancia is also part of the previous La Havana-complex under separate ownership. The main ranch buildings overlook the Río Ipurupuro.

10 November 1995 - We conducted a night spotlight survey at Laguna La Concha, a large natural lagoon bordered by low forest. A bird rookery is located at one end and is an attraction for the ranch's fledgling ecotourism business in the nesting season. The lake is rectangular in shape, about 1.4x0.8 km, oriented in a NE to SW direction.

FWK and Obdulio Menghi visited this site in May 1995 and saw a large (±3 m) black caiman, and we returned later take a new look. A dugout canoe was used to survey the lagoon but we could not get within 50 m of the shore. Caiman were not very abundant, but the lagoon contained a wide distribution of sizes. These were clumped geographically over the lagoon, with some areas with only large animals, some with mostly medium sized animals, and a few pods of young along the north edge. We saw over 50 identifiable *Melanosuchus*, but none appeared longer than 2 m.

5 July 1996 -. It was immediately evident that the lake did not have the great numbers of caiman in 1995, and the black caiman were not as numerous either. The rookery was heavily populated with storks and herons. We made a complete circuit of the lake, staying close to shore for mapping with the GPS. In some shallow areas we could not get close enough to judge total length. Other caiman were light shy or in the vegetation hence over 45% of the caiman seen were eyes only. The sample of the *Caiman yacare* seen were: 1 (<0.5 m), 41 (0.5-1 m), 88 (1-.5 m), 77 (1.5-2 m), 37 (>2 m) and 201 'Eyes only'. For *Melanosuchus*:, 2 (1-1.5 m), 1 (1.5-2 m), 3 (2-2.5 m) and 1 (2.5 - 3 m).

4 July 1996 - Many people had told us that the Río Ipurupuru had been a very productive river during previous caiman harvests. We were curious to see how this waterway compared to others found in the area. The caiman were well distributed on both banks, occurring in clusters of 5 - 20 animals with few or none until the next group. The caiman here, as in many of our surveys, were often strongly associated with logjams and debris that collects along banks where the caiman hid frequently at the edge of emergent branches.

We used our inflatable raft and outboard with a Q-beam for this survey. We had traveled the river by day about 5 km both upstream and downstream of the launch site to observe conditions. Lagarto (*C. yacare*) were common and quite unafraid. Some basking adults allowed very close approach before retreating to the safety of the river.

On this night we chose to concentrate on the upstream section (south), hoping to return later for a night survey downstream. The large number of young seen indicates reproduction in the area. The sample of the *Caiman yacare* were of the following size classes: 120 (<0.5 m) and 73 (0.5 - 1 m), 69 (1 - 1.5 m), 16 (1.5 - 2 m) and 4 (>2 m) and 42 'Eyes only'. No black caiman were identified. A *Paleosuchus* sp. was identified at the launch site in 1995.

8 July 1996 - We paddled our raft around the large lake with our halogen spotlight. We quickly noted that the caiman were not numerous. No factor appeared obvious as to why the caiman population was depressed. A sample of the *Caiman yacare* included: 1 (0.5-1 m), 5 (1-1.5 m), 32 (1.5-2 m), 5 (>2 m) and 78 'Eyes only.' No black caiman were identified.

Table 6. Summary of surveys in the Río Itonamas basin, EcoRegion No. 5

Date	Locality	No.	Measurement		
7-Jul-96	Criadero	119	Main tank	S 14°13'33.9"	W 64°59'00.7"
9-Nov-95	Arroyo Masineca, sect. 1	70	.2 km	S 13°56'47.9"	W 64°50'03.1"
9-Nov-95	Arroyo Masineca, sect. 2, start	247	.3 km	S 13°57'01.9"	W 64°49'57.1"
	Arroyo Masineca, sect. 2, end			S 13°57'11.8"	W 64°49'57.1"
9-Nov-95	Arroyo Masineca, sect. 3, start	167	.4 km	S 13°57'10.9"	W 64°50'31.0"
	Arroyo Masineca, sect. 3, end			S 13°57'02.1"	W 64°50'36.3"
9-Nov-95	Arroyo Masineca, sect. 4, start	55	.2 km	S 13°56'31.8"	W 64°50'15.8"
	Arroyo Masineca, sect.4, end			S 13°56'26.8"	W 64°50'18.9"
9-Nov-95	Arroyo Masineca, sect. 5, start	44	.1 km	S 13°56'56.6"	W 64°49'52.2"
	Arroyo Masineca, sect. 5, end			S 13°56'54.4"	W 64°49'52.5"
9-Jul-96	Arroyo Masineca, sect. 1	28	.2 km	S 13°56'48.7"	W 64°50'07.0"
9-Jul-96	Arroyo Masineca, start	183	2.5 km	S 13°56'51.0"	W 64°50'04.2"
	Arroyo Masineca, end			S 13°57'05.6"	W 64°50'08.1"
9-Jul-96	Arroyo Rodeo	127	500 m	S 13°58'22.0"	W 64°49'34.2"
10-Nov-95	Laguneta Motacusalito	84	.1 km	S 13°59'19.9"	W 64°48'24.6"
6-Jul-96	Caño Motacusalito	120	2.1 km	S 13°59'19.8"	W 64°48'07.9"
	Caño Motacusalito			S 13°59'41.4"	W 64°48'37.9"

Date	Locality	No.	Measurement		
6-Jul-96	Cañada del Corral	31	400 m	S 14°00'19.8"	W 64°48'44.9"
				S 14°00'13.5"	W 64°48'37.9"
10-Nov-95	Laguna La Concha, start	1,555		S 14°02'34.4"	W 64°54'10.3"
	Laguna La Concha, end			S 14°03'19.7"	W 64°54'57.4"
5-Jul-96	Laguna La Concha	452	5.21 km	S 14°02'34.4"	W 64°54'10.3"
4-Jul-96	Río Ipurupuru	324	4.7 km	S 14°04'20.6"	W 64°52'58.7"
				S 14°06'31.5"	W 64°53'04.9"
8-Jul-96	Laguna Almendrote	121	7.5 km	S 13°58'02.8"	W 64°51'45.1"

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EcoRegion 5

Estancia San Ignacio—From Trinidad we drove north on the road toward San Ramon, passing Estancia La Havana. About 150 km from Trinidad we arrived at Estancia San Ignacio. The owner is very keen on the caiman project and has recruited interest in neighbors who border the two large lakes, which lie partly on the property.

20 November 1995 - Laguna Todos Santos is rectangular and measures over 2.75 km long and 1 km wide. Due to problems with very low water depth, extensive mud flats, and vegetation, only about 2/3 of the laguna was surveyed. Only a partial survey was made as the shore could not be approached easily, a count was taken as 'Eyes only'.

13 July 1996 - Laguna Todos Santos had more water in it in 1996. The sample of the *Caiman yacare* we identified for size were 14 (0.5 - 1 m), 41 (1 - 1.5 m), 33 (1.5 - 2 m) and 8 (>2 m) and 206 'Eyes only'. No black caiman were identified.

21 November 1995 - Laguna San Ignacio is roughly a rectangle oriented NE - SW, and measures approximately 1 x 1.5 km. Eight *Melanosuchus* were identified, one being over two meters. The caiman sighted were of the following size classes: 36(<0.5 m), 13 (0.5-1 m), 11(1-1.5 m), 10 (1.5-2 m), 3 (2-2.5 m), with 186 'Eyes only'.

14 July 1996 - Laguna Todos Santos had more water in it in 1996. We were able to make a complete survey of the perimeter. The sample of 112 *Caiman yacare* we identified for size were 37 (<0.5 m), 31 (0.5 - 1 m), 25 (1 - 1.5 m), 12 (1.5 - 2 m), 7 (>2 m) and 163 'Eyes only'. Two black caiman were identified, 1 (1-1.5 m) and 1 (2-2.5 m).

14 July 1996 - We rode along one edge of this curiche for about one km. Due to the width of the curiche, and the low power spotlight, we could only attempt a census for 'Eyes only'. The few individuals close enough to identify along our route were *Caiman yacare*.

Estancia Belén—About 50 km north of Trinidadon the main road toward San Ramón is the 10,000 ha Estancia Belén. The owner is very interested in wildlife conservation and hopes to help develop an ecotourism business to supplement his cattle ranching. He also supports a sustainable use program for caiman.

24 Oct. 1996 - We reconnoitered rectangular Laguna Coitarama during the day. As with so many other lakes, we were greatly inhibited from nearing the shore due to lack of water. The lake is about 1.25 km wide and 2.9 km long. There was abundant vegetation along three sides of the laguna, both aquatic cañuela and shore vegetation, which appeared to be very suitable habitat. We returned in the evening for a survey. Virtually no mid-lake caiman were encountered and no *Melanosuchus* were identified. Very few caiman were counted along the one barren shoreline. The majority of caiman counted were close to, or within, the emergent vegetation making size and species identification impossible.

24 Oct. 1996 - Laguna Belén is a larger lake located adjacent to the main buildings. The black caiman skull in the ranch owner's home was taken from this lake. At the time of our survey, water

levels were so low that navigation by boat was impossible. As we drove past toward Coitarama, RG spotlighted a short section of shore, revealing more than 150 caiman.

Estancia Belén also encompasses part of the large Laguna Brava. The following day, we took a brief look at this exceedingly shallow laguna. It was alive with many species of wading birds, capybaras and caiman. The lake was vast, but it was very shallow due to the drought. All three lagunas warrant a detailed surveys in the future.

Table 7 - Summary of surveys in the western Río Itonamas basin, EcoRegion 5

Date	Locality	No.	Measurement		
20-Nov-95	Laguna Todos Santos, start	457	2.75x1.0 km	S 13°29'13.4"	W 64°49'36.2"
	Laguna Todos Santos, end			S 13°29'25.3"	W 64°48'52.6"
13-Jul-96	Laguna Todos Santos, start	282	2.75x1.0 km	S 13°29'18.9"	W 64°49'38.3"
21-Nov-95	Laguna San Ignacio, start	259	1.0x1.5 km	S 13°26'31.2"	W 64°49'57.8"
14-Jul-96	Laguna San Ignacio, start	275	1.0x1.5 km	S 13°26'30.4"	W 64°49'56.3"
21-Nov-95	Unnamed arroyo, start	88	1.2 km	S 13°28'31.4"	W 64°47'26.3"
	Unnamed arroyo, end			S 13°28'59.6"	W 64°47'01.5"
14-Jul-96	Curiche de la Pampa	88	1 km	S 13°28'55.6"	W 64°48'55.3"
24-Oct-96	Laguna Coitarama	621	8 km	S 14°30'05.8"	W 64°52'10.6"
24-Oct-96	Laguna Belén	150+		S 14°27'23.3"	W 64°51'41.9"

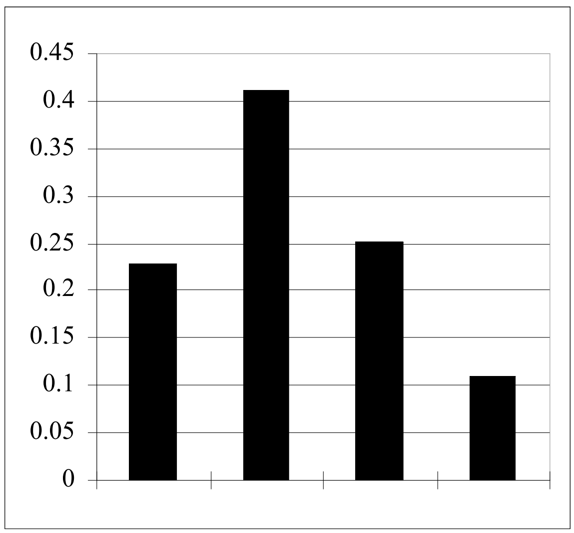

Figure 5. Distribution of size classes from sample surveys in the central Río Itonamas basin in northeastern Beni for field seasons 1995 and 1996. Data from Ecoregions, 5 and 9 in the basin (see reports above) have been pooled. Classes are (left to right) II: 0.5-1 m, III: 1-1.5 m, IV: 1.5-2 m, and V: > 2 m. Not included are 'Eyes only' or class I: < 0.5 m. N = 897.

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EcoRegion No. 10

Estancia Laguna Azul—We traveled 20 km southeast of Trinidad on the old road toward Santa Cruz. This estancia is one of three which border the Laguna Azul, a large lake that had a wide, baked mud apron around much of the perimeter. We visited the lake by day and noted a significant number of caiman in the water near our access point and determined to return for a night survey. Ranch hands said the lake was very well populated with yacare caiman, and black caiman could be seen as well.

22 Oct. 1995 - We were obliged to use paddles because the lake was too shallow for a motor. Three times we struck submerged caiman far from shore where water depth was insufficient to float our raft over them. Our minimum distance from shore was about 100 m and at times was greater than 200 m. Our route offshore that roughly described the lakeshore measured just over 2 km. Few mid-lake caiman were seen and none were identified as black caiman. All were recorded as 'Eyes only'.

24 June 1996 - The lake had changed significantly on our return in 1996. We came four months earlier than in 1995 and much more water occurred on the landscape in general. The lake level was deep enough to allow careful use of our outboard motor. RG and DVR undertook training for two evenings on the lake for wildlife personnel and also was our first test of the field equipment for 1996.

The rectangular lake perimeter was mapped and an 'Eyes only' survey done twice. We were able to maintain a distance of approximately 10 -20 m from shore at most times and most of the caiman were sighted near the shore. The lake is over 1.3 km on the long diagonal axis, and we saw caiman, usually single individuals, scattered in the central area as well. The caiman population in the lake in 1996 was only 12% of the 1995 level. Barring severe poaching unknown to us, we assume that caiman were still dispersed in surrounding habitat and migration later in the dry season would increase the lake population.

25 June 1996 - We returned the next night to do a size-class survey. The lake includes a variety of habitats that are suitable for all size classes. We were surprised at the relatively low numbers after the 1995 counts. A sample of lagarto sighted during the survey included: 12 (< 0.5 m), 14 (0.5 - 1m), 46 (1 - 1.5 m), 28 (1.5 - 2 m), and 13 (>2 m).

Estancia Ponderosa—This small estancia of about 2500 ha lies on the main road to Santa Cruz, about 20 km E. from Trinidad. The property includes a large yomomo and an arroyo and appears well suited for caiman. We visited the ranch in 1995 and found most of the water had dried up and most wildlife had disappeared. In 1996, the cunetas were full.

26 June. 1996 - We surveyed the cunetas on the side of the terraplen from a pickup. The mature cunetas on the first half of the road contained over 75% of the caiman. The remaining cunetas lack a maturation and associated vegetation in order to produce good habitat. The yomomo beyond the terraplen may contain large numbers of caiman but the flooded area and dense vegetation present great logistic problems for a future survey. A sample of lagartos sighted during the terraplen survey included the following size classes: 20 (< 0.5 m), 21 (0.5 - 1m), 18 (1 - 1.5 m), and 1 (1.5 - 2 m).

26 June 1996 - About 200 m southeast of the ranch entrance is a small laguna. We were able to count eyes from the bank but were not close enough to place them in size classes. The surveys indicate that caiman are not relatively abundant here.

Estancia El Toco—This estancia lies only 18 km straight-line east from Trinidad. The small ranch is in a relatively dry area with no permanent surface water and the owners have constructed atajados for watering cattle. These have, of course, become home for many caiman. Some are very small (15x15 m) water holes while others are much larger and contain hundreds of yacare caiman. A simple ranch road, running basically north-south for about 15 road kilometers, services the two main puestos and related waterbodies.

13 August 1996 - The atajado Toco, Pozo 1 has one of the more successfully established caiman populations. Many large specimens can be seen basking in the morning and it is an impressive sight to see all the heads in the water. About 10% of the surface is covered with *Eichornia*. A sample of lagartos sighted during the survey included the following sizes: 7 (< 0.5 m), 9 (0.5 - 1m), 23 (1 - 1.5 m), 40 (1.5 - 2 m), and 3 (>2 m).

13 August 1996 - The Pozo 2 tank is very close to Pozo 1, and only contains large individuals. None were seen less than one meter long. A sample of 66 *Caiman yacare* sighted during the survey included the following: 16 (1-1.5 m), 41 (1.5-2 m), and 9 (>2 m).

13 August 1996 - One adult individual about 1.5 m was in attendance with 13 juveniles (40-50 cm) in the small pond Pozo 3. A sample of lagartos sighted during the survey included the following size classes: 13 (< 0.5 m), and 1 (1-1.5 m).

13 August 1996 - The Atajado de Primavera tank contained mostly large individuals. A sample of lagartos included the following: 3 (0.5-1m), 20 (1-1.5 m), and 14 (1.5-2 m).

13 August 1996 - The Lucero, Pozo 1 tank had a high percentage of animals between 1 and 1.5 meters. One individual appeared to be look somewhat like *Melanosuchus niger* but we never could see this individual well enough for positivel identification. It was the only specimen seen on the ranch that was not distinctly *Caiman yacare*. A sample of 59 lagartos sighted during the survey included the following size classes: 2 (< 0.5 m), 6 (0.5 - 1m), 31 (1 - 1.5 m), 18 (1.5 - 2 m), and 2 (>2 m).

13 August 1996 - The Lucero, Pozo 2 was a small with only 4 (0.5 - 1 m) caiman.

13 August 1996 - A sample of lagartos sighted during the Lucero, Pozo 3 survey included the following: 7 (< 0.5 m), 9 (0.5-1m), 23 (1-1.5 m), 40 (1.5-2 m), and 3 (>2 m).

13 August 1996 - The lagartos sighted during the survey of the small Lucero, Pozo 4 pond included the following sizes: 1 (0.5-1m), 6 (1-1.5 m), 1 (1.5-2 m), and 3 'Eyes only'.

13 August 1996 - The lagartos sighted in Lucero, Pozo 5 during the survey were all large and included the following size classes were observed: 9 (1.5 - 2 m) and 4 (>2 m).

Although this ranch is small and has only a few atajados, it demonstrates the effect of providing caiman habitat. In the four most populous tanks we counted 679 animals. A sustainable use program for caiman might give incentives to landowners for new tanks.

Table 8 - Summary of surveys in the southern Río Itonamas basin, EcoRegion 10

Date	Locality	No.	Measurement		
22-Oct-95	Laguna Azul	1391	2+ km	S 14°59'10.5"	W 64°48'52.2"
24-Jun-96	Laguna Azul	160	4 km	S 14°59'12.2"	W 64°48'50.5"
25-Jun-96	Laguna Azul	152	4 km	S 14°59'12.2"	W 64°48'50.5"
26-Jun-96	Estancia Ponderosa - terraplen	152	3 km	S 14°48'43.1"	W 64°46'30.7"
26-Jun-96	Laguna Ponderosa - laguna	32		S 14°50'13.5"	W 64°47'17.5"
13-Aug-96	Toco, Pozo 1	308		S 14°53'06.6"	W 64°39'03.3"
13-Aug-96	Toco, Pozo 2	142		S 14°53'07.3"	W 64°39'02.1"
13-Aug-96	Toco, Pozo 3	14		S 14°53'09.8"	W 64°38'57.2"
13-Aug-96	Atajado de Primavera	63	50x20 m	S 14°51'31.7"	W 64°39'12.0"
13-Aug-96	Lucero, Pozo 1	166	70x70 m	S 14°50'59.0"	W 64°40'08.5"
13-Aug-96	Lucero, Pozo 2	4	15x20 m	S 14°50'59.7"	W 64°39'46.2"
13-Aug-96	Lucero, Pozo 3	30	20x30 m	S 14°51'09.3"	W 64°39'52.0"
13-Aug-96	Lucero, Pozo 4	11	15x15 m	S 14°50'23.2"	W 64°39'47.7"
13-Aug-96	Lucero, Pozo 5	13	15x15 m	S 14°50'27.7"	W 64°39'48.0"

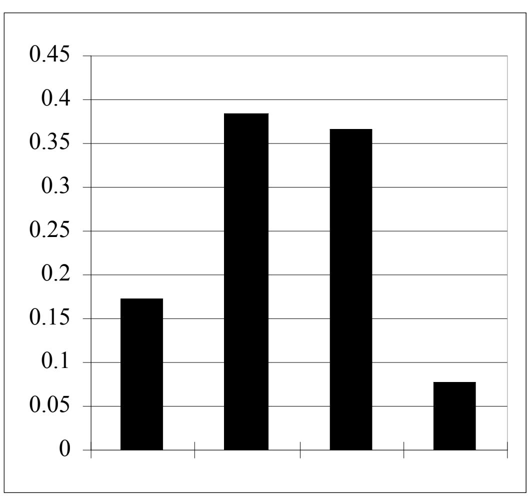

Figure 6. Distribution of size classes from sample surveys in the southern Río Itonamas basin in-eastern Beni for field seasons 1995 and 1996. Classes are (left to right) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m. Not included are 'Eyes only' or Class I: < 0.5 m. N = 677.

Departamento Beni, Provincia Moxos - Río Mamoré
EcoRegion No. 12

We prepared for our trip to the distant Territorio Indígena Parque Nacional Isiboro-Sécure (TIPNIS) and transported equipment to Varador

28 October 95 - After sunset, DVR took an informal 'Eyes only' count over part of the river course. The Mamoré is a very large river and generally does not have a high population of yacare caiman. On this night, however, caiman were spotted intermittently for most of the length to the mouth of the Río Isiboro where we stopped to sleep. Our Yuracare Indian guides claimed that the dry conditions in the area had forced some of the animals to enter the river. The caiman in this stretch of river were comparatively numerous.

30 October 1995 - We went up the Río Isiboro several hours until we entered the Territory. We stopped at Control Post No. 1 at the community of Santa Maria at the mouth of the Río Sécure, to inquire about a guide. One of our main objectives was to reach Laguna Bolivia. The lake had been a historic center for black caiman hides. One team member (RG) ascended Arroyo Negro in 1992 and was impressed by the number, size and tameness of the yacare caiman there. The arroyo was too dry that year to make it all the way to the lake.

We hired a local Yuracare for our guide. We traveled up the Isiboro until we arrived at a small cattle ranch located within the Territory, Estancia San Marcos. We first surveyed an old river course of the Isiboro located nearby. The caiman seen were wary and less common than expected after looking at the habitat. We were confined to the center channel and many flooded shallow areas to the sides could not be explored.

31 October 1995 - We continued up the Isiboro until we arrived at (another) Santa Maria and picked up another guide very familiar with Laguna Bolivia. After a short journey we turned up the Río Ichoa, and quickly arrived at the mouth of Arroyo Negro. The arroyo initially is a series of series of small, connected lakes that are entirely bordered by low forest. This section is not good caiman habitat, but as we ascended the waterway the trees receded and the banks became more open and exposed. Aquatic plants become more common and the river became more difficult to travel. We passed through a number of large lakes and areas of open pampa. The way was eventually blocked by solid mat of floating vegetation. We finally gave up our attempt, reaching only about half the distance achieved in 1992.

During the ascent of Arroyo Negro, very few caiman were seen. The caiman that were seen were distinctly shy, sometimes leaping off the banks to the water. Although more animals were detected during the nighttime descent, the caiman were not nearly as numerous as during the 1992 visit. The caiman also exhibited shyness to the spotlight. All caiman positively identified were *Caiman yacare*.

31 October 1995 - Upon arriving at Río Ichoa we turned again upstream to look at the area along the Rios Imose and Chimita. We traveled for about one hour until we reached a caño. The river was bordered by dense vegetation and virtually no bare banks, beaches or sandbars were present. We tried to ascend the caño but gave up after about 100 m. Our guide said that he was surprised to see it so dry and clogged with tarope.

1 November 1995 - The next day we continued up the Ichoa to the mouth of the Imose. We ascended until the entrance of Río Chimita. We saw that the river was closed by *Eichornia* after about 500 m. We turned up the Río Imose and traveled to the community of San Antonio. We employed a local guide us along the Río Imose above and below the village.

We traveled upstream during the afternoon, arriving at a large river lake, Laguna Monte Cristo. At this point the river enters an area of wide, flat, open pampa. The water covers a large shallow area and discharges through assorted outlets to continue the main river course. The laguna edge is completely hidden by emergent, rooted vegetation which extends out into the lake. The laguna was covered about 20% in *Eichornia*. The majority of the caiman, all positively identified were *Caiman yacare*, were seen as 'Eyes only' in vegetation.

1 November 1995 - Below Laguna Monte Cristo, Río Imose has a relatively swift current. At many bends in the river the current had deposited logjams or the banks had been carved away leaving steep, clean faces. Perhaps the current is responsible for the relatively small number of caiman seen. All caiman positively identified as *Caiman yacare*.

1 November 1995 - Río Imose courses through a largely forested area until it opens up to an immense open pampa. The community of San Antonio lies at the forest edge. We passed the village and continued downstream. Some areas had little embayments covered with tarope. These conditions looked much more favorable and we immediately noted more caiman. Our guide mentioned that several small lagoons that were populated with caiman were located not far from the river along this section. This part of the river has a fair amount of dugout traffic and perhaps some caiman have sought refuge in these lagoons.

1 November 1995 - We also surveyed a small unnamed lagoon on foot which is located less than 1 km from San Antonio, about 200 m away from an old Imose river course. During an afternoon visit only *Caiman yacare* could be identified. The lagoon is oval in shape, about 400 m long, with about 20% tarope cover. A sample of the lagarto sighted were of the following size classes: 14 (0.5 - 1 m), 4 (1 - 1.5m), 3 (1.5 - 2 m).

3 November 1995 – A full day was needed to return to Control Post No. 1 at the mouth of the Río Sécure. This meandering river has several communities along the lower reaches. We traveled by day, going approximately 40 km before reaching the community of Coquinal. We stayed there until nighttime and then began our return downstream.The river has high banks along most of the stretch surveyed, with many meanders and logjams occur frequently along the way. Many of the caiman seen were among the branches of the debris. Concentrations of caiman was highest in the upper reaches of the river, decreasing as we descended, with less than 10 individuals spotted in the last 5 km before reaching the river mouth. Although only a small number could be calculated for size, we felt over 50% were less than one meter long. Most animals were seen alone or in pairs. A sample of the caiman sighted included: 51 (< 0.5 m), 35 (0.5-1 m), 7 (1-1.5), 2 (1.5-2 m)

The caiman populations that were observed within TIPNIS were not as numerous as expected. A previous trip in 1992 had revealed far greater numbers, at least in Arroyo Negro on the way to Laguna Bolivia. When questioned about this discrepancy, Indigenous informants did not believe it was due to poachers. No hide buyers had made recent visits and no cadavers were noted. The dry conditions might have caused some caiman to estivate, or perhaps they were seeking refuge in lagunas off the main river course.

Bolivia will need to address the problem of Indigenous wildlife use within a National Park. While persons residing in the legal territories, now called TCOs (*Territorio de Communidad de Origen*) have authority to participate in commercial wildlife harvest programs, these activities are in conflict with National Park regulations. Currently, Indigenous communities in TIPNIS are prohibited from entering the caiman program. We have reliable information that skins have been extracted during the 2001 harvest from here as well other protected lands outside the permitted harvest areas.

Table 9. Summary of surveys in the Rios Isiboro-Sécure (Mamoré) basin (TIPNIS), EcoRegion No. 12

Date	Locality	No.	Measurement		
28-Oct-95	Río Mamoré	64	3 km		
30-Oct-95	Río Isiboro, old river course, start	26	3.8 km	S 15°46’27.5”	W 65°12’22.1”
	Río Isiboro, old river course, end			S 15°47’25.7”	W 65°13’41.5”
31-Oct-95	Arroyo Negro, start	143	15 km	S 15°54’01.6”	W 65°13’58.8”
	Arroyo Negro, end			S 15°50’40.6”	W 65°12’58.6”
31-Oct-95	Río Ichoa, start	92	16 km	S 15°50’41.0”	W 65°13’00.0”
	Río Ichoa, end			S 15°53’00.1”	W 65°15’57.1”
1-Nov-95	Río Imose, Lag. Monte Cristo, start	126	1.7 km	S 16°00’15.3”	W 65°21’26.7”
	Río Imose, Laguna Monte Cristo, end			S 15°59’21.0”	W 65°21’17.1”

1-Nov-95	Río Imose to San Antonio, start	24	7 km	S 15°59'21.0"	W 65°21'17.1"
	Río Imose to San Antonio, end			S 15°57'22.4"	W 65°21'14.8"
1-Nov-95	Río Imose, abajo, start	185	16 km	S 15°57'22.4"	W 65°21'14.8"
	Río Imose, abajo, end			S 15°55'47.9"	W 65°19'41.5"
1-Nov-95	No name laguna, start	83	.4 km	S 15°57'097.7	W 65°21'27.0"
	No name laguna, end			S 15°56'57.1"	W 65°21'35.0"
3-Nov-95	Rio Sécure, start	356	40 km	S 15°39'43.7"	W 65°19'45.7"
	Rio Sécure, end			S 15°35'53.5"	W 65°08'34.4"

Departamento Beni, Provincia Yacuma - Río Mamoré
EcoRegion No. 9

Estancia El Carmen—The small town of Rosario de Yacuma (also known as El Perú) lies on the Río Apere. We visited the Estancia El Carmen (San Miguel). We rode horses north across open pampa toward a small arroyo (Barcelona) contained within the property. The ranch hands report that this arroyo has traditionally had many caiman and in recent years, due to the hunting ban, their numbers have increased significantly.

6 November 1995 - Arroyo Barcelona, an affluent of the Río Matos, is bordered by a narrow strip of low trees and bushes, though in some areas the open pampa reaches the banks. The drought had so reduced the stream that it was broken into a series of pools with an average width of 15 m. Nearly all the caiman sighted were less than 75 cm long. A few individuals were 1 m, and only 3 specimens were sighted at 1.5, none larger. The local people all say that the larger caiman are either estivating (*enterrado*) or have migrated to the main river. We surveyed three sections that were accessible on horseback.

6 November 1995 - The section B was nearly covered with tarope and contained many individuals in the 0.5-0.6 m range.

6 November 1995 - Our guide led us a short distance away from the arroyo Barcelonato a 'permanent' laguna which was nearly circular in shape and an estimated 100 m in diameter. Thick mud blocked approach but the caiman appeared to be 0.75-1.5 m long.

6 November 1995 - Riding north from the laguna we arrived at the Río Matos. The highwater mark on the steep banks was 8-10 meters above the current water level. We attempted to survey but encountered an impassable logjam approximately 150m upstream as well as a large logjam downstream, and we abandoned our efforts.

Estancia Ceilan—This is a large ranch located nearly due west of Trinidad, across the Río Mamoré, on the main road to San Ignacio and San Borja. It has 54,000 hectares and about 60% is inundated during the rainy season. Aerial views of the property revealed a complex wetland. Both yacare and black caiman are known from the property. A large *Melanosuchus* skull and fresh skin was displayed at the owner's house.

The ranch has a series of elevated terrapleins, which serve as the only roads when the surrounding pampa becomes inundated. Along the sides of the terraplein are borrow pits, scraped out in the technique common throughout the Neotropics. These mature, vegetated borrow pits serve as excellent caiman habitat and often contain high concentrations during the dry season. Although most of these '*cunetas*' contained water, we were surprised to find low concentrations of caiman in these and many other bodies of water on the ranch.

14 November 1995 - We arrived at the ranch just after the start of the seasonal rains. We reconnoitered a few lagoons the first day, during the daylight, and noted the low water levels that would make surveys in a boat nearly impossible. Cursory inspection indicated low populations and we did not return at night. We traveled to arroyo Chimoro and embarked in a small aluminum skiff. The habitat looked excellent, low banks with a thin strip of low forest bordering along most of the area we navigated. At times the water entered 5-10 m into the woody vegetation, affording good cover. We saw some large specimens of *Caiman yacare* and a few *Melanosuchus niger*. Returning

at nightfall, however, we were disappointed to find very low numbers of caiman. We navigated a 5.1 km stretch of the arroyo until we could go no further. The caiman sighted were of the following size classes: 1 (<0.5 m), 2 (0.5-1 m), 16 (1-1.5 m), 7 (1.5-2 m), 5 (2-2.5 m), with 89 'Eyes only'.

14 November 1995 - On a shorter section we saw an even smaller representation. The caiman sighted were the following: 2 (<0.5 m), 2 (0.5-1 m), 4 (1-1.5 m), 8 (1.5-2 m), 2 (2-2.5 m), with 36 'Eyes only'.

15 November 1995 - Several large lagoons: Rodeo, Higuerote, and Ceilan, were visited during daylight hours, but were too shallow for a boat and too difficult to survey from the shore due to the mud, vegetation and large distances involved. None of the lagunas visited had visibly abundant populations of caiman. We searched with binoculars and found few animals. Localities listed below represent points on the shore where we made observations.

15 November 1995 - The terraplein near the main buildings affords good vantage points for surveying as it curves around the perimeter. Although the conditions look good for caiman, its proximity to too much human traffic, fishing, generator noise and livestock concentration may be causes for the low numbers seen.

Table 10. Summary of surveys in the southern Río Mamoré basin, EcoRegion 9

Date	Locality	No.	Measurement		
6-Nov-95	Arroyo Barcelona, sect. A, start	86	.2 km	S 14°33'06.0"	W 65°39'28.4"
	Arroyo Barcelona, sect. A, end			S 14°33'05.8"	W 65°39'34.7"
6-Nov-95	Arroyo Barcelona, sect. B, start	227	.8 km	S 14°32'58.2"	W 65°39'20.4"
	Arroyo Barcelona, sect. B, end			S 14°32'47.6"	W 65°39'04.7"
6-Nov-95	Arroyo Barcelona, sect. C, start	54	.2 km	S 14°33'06.0"	W 65°39'28.5"
	Arroyo Barcelona, sect. C, end			S 14°33'05.8"	W 65°39'34.7"
6-Nov-95	Laguna near Arroyo Barcelona	32	100x10m	S 14°31'58.3"	W 65°37'57.4"
6-Nov-95	Río Matos, start	71	.4 km	S 14°29'57.5"	W 65°38'36.5"
	Río Matos, end			S 14°29'55.4"	W 65°38'26.1"
14-Nov-95	Arroyo Chomoro, N-S sect., start	120	5.1 km	S 14°49'15.3"	W 65°10'55.3"
	Arroyo Chomoro, N-S sect., end			S 14°47'32.3"	W 65°10'51.2"
14-Nov-95	Arroyo Chomoro, E-W sect., start	54	3.5 km	S 14°49'05.8"	W 65°11'02.1"
	Arroyo Chomoro, E-W sect., end			S 14°49'15.2"	W 65°10'10.9"
15-Nov-95	Laguna Rodeo	10+		S 14°42'13.8"	W 65°11'12.7"
15-Nov-95	Laguna Higuerote	10+		S 14°45'33.6"	W 65°11'48.0"
15-Nov-95	Laguna Ceilan	10+		S 14°51'31.5"	W 65°11'40.3"
15-Nov-95	Main buildings, laguna	28		S 14°48'43.6"	W 65°13'51.1"
15-Nov-95	Terraplein SE, start	166	3.8 km	S 14°48'51.9"	W 65°13'39.3"
	Terraplein SE, end			S 14°49'39.8"	W 65°11'43.0"
15-Nov-95	Terraplein SE, start	166	3.8 km	S 14°48'51.9"	W 65°13'39.3"
	Terraplein SE, end			S 14°49'39.8"	W 65°11'43.0"
15-Nov-95	Terraplein NW/W, start	66	2.4 km	S 14°48'10.4"	W 65°14'03.8"
	Terraplein NW/W, end			S 14°47'35.5"	W 65°15'06.7"
15-Nov-95	Nameless arroyo, start	230	.35 km	S 14°46'59.9"	W 65°14'27.7"
	Nameless arroyo, end			S 14°46'49.3"	W 65°14'28.7"
15-Nov-95	Arroyo Calicto	81	1.8 km	S 14°48'38.7"	W 65°14'29.8"
				S 14°49'15.2"	W 65°10'10.9"

15 November 1995 - Terraplein to Dos Islas runs in a nearly straight line across open pampa, varying 120° to 150° SE. It is bordered by typical borrow pits, some filled by recent rains. Some pits contain open water, with no floating vegetation, while others have up to 90% cover of *Eichornia* and *Azolla*. Ranch hands reported that the caiman were more concentrated in these *cunetas* before the rains but now have dispersed.

15 November 1995 - The elevated terraplein NW/W to Babilonia was surveyed its entire length until it disappeared into open pampa with no attendant cunetas or lagunas.

15 November 1995 - We left the terraplein to Babilonia to visit a nameless arroyo. It contained the concentrations and size classes that we had expected to see on the ranch. The caiman sighted were of the following size classes: 1 (0.5-1 m), 12 (1-1.5 m), 13(1.5-2 m), 22 (2-2.5 m), with 182 'Eyes only'.

15 November 1995 - Arroyo Calicto cuts across the southern part of the ranch before joining the Río Mamoré. It runs along the terraplein to Babilonia for part of it's course. Like other arroyos on the property, it was broken into sections by dense mats of floating vegetation. We surveyed a short section along the terraplein where the water remained relatively open. All the caiman positively identified were *Caiman yacare* of the size classes: 2 (0.5-1 m), 10(1-1.5 m), 4 (1.5-2 m), 1 (2-2.5 m), with 64 'Eyes only'.

Departamento Beni, Provincia Yacuma - Río Mamoré
EcoRegion No. 1

Estancia Rancho Alegre—This ranch comprises about 35,000 ha. Río Yata borders it on the west and Arroyo Los Caimanes on the east. These waters flow north and join, forming the north boundary as well. The Yata flows north to meet the Río Mamoré just upstream of the Río Beni. On many maps, the Yata is pictured flowing into the Río Beni.

24 July 1996 - The main laguna is located about 2 km southwest of the main ranch buildings. The water was very clear and the lake had a sand and rock bottom. Perhaps poor primary production is responsible for such low numbers. Identified individuals were all black caiman of the size classes: 5 (<0.5 m), 3 (1.5-2 m), and 1 (2-2.5 m), with 9 'Eyes only'.

25 July 1996 - During the day we traveled to the farthest puesto, Puesto Brasil, along the main north-south ranch road. Several cunetas, two small arroyos, a few natural bajío wetlands and a sizable curiche occur along the road that provide habitat for caiman. There are few waterbodies outside these near the road. We saw caiman basking, all *Caiman yacare,* but not in the numbers seen in dry season concentrations.

That night we retraced our route north stopping at the appropriate spots. Our final site was 22 km north of the main ranch buildings. This first site, Pozo 1 is where the road crosses a small arroyo. The arroyo widened here to about 40 m. The caiman sighted were of the size classes: 1 (1-1.5 m), and 1 (1.5-2 m), with 2 'Eyes only'. A second arroyo is crossed at Isla de Amor and we walked 100 m both directions. The caiman sighted were the following: 1 (1-1.5 m), 1 (1.5-2 m), and 8 'Eyes only'. Pozo 2 is about 2.5 km by road after passing the buildings of Puesto Rodeo. The caiman sighted were of the following size classes: 3 (0.5-1 m), 1 (1.5-2 m), and 39 'Eyes only'. The rectangular Pozo 3A was in close proximity to the houses of Puesto Novillo Blanco. The caiman sighted were of the following size classes: 7 (0.5-1 m), 10 (1 - 1.5 m), 6 (1.5-2 m), and 33 'Eyes only'. About 200 m north of Pozo 3A, was the irregularly shaped pond Pozo 3B. The caiman sighted were of the following size classes: 16(<0.5 m), 1 (1-1.5 m), and 1 (1.5-2 m).

This small rectangular atajado, Pozo 4A, was perhaps 20x40 m. The caiman sighted were of the following sizes: 14 (0.5-1 m), 18 (1-1.5 m), 8 (1.5-2 m), and 12 'Eyes only'. Across the road from Pozo 4A was a flooded *bajío*, Pozo 4B. It stretched beyond our light and was not easily penetrated on foot. The edge was walked for about 300 m for a representative survey. The caiman sighted were of the following size classes: 16 (0.5-1 m) and 31 'Eyes only'. A relatively large curiche (various hectares), Curiche La Rana, was encountered about 500 m north Puesto La Rana. A portion of the bank was walked for the survey. We were surprised to see so few animals as Pozos 3A-4B were less than 5 km away. The caiman sighted included: 3 (0.5-1 m), 1 (1 - 1.5 m), and 9 'Eyes only'.

Table 11. Summary of surveys in the Río Yata basin, EcoRegion 1

Date	Locality	No.	Measurement		
24-Jul-96	Laguna Rancho Alegre, start	18	5.6 km	S 12°26'25.7"	W 65°31'27.1"

Date	Locality	No.	Measurement		
25-Jul-96	Road: Rancho Alegre-Puesto Brasil		start:	S 12°25’26.1”	W 65°30’48.2”
	Pozo 1	4	1 sm pond	S 12°24’49.9”	W 65°31’09.1”
	Isla de Amor	10	200 m	S 12°23’33.7”	W 65°31’53.5”
	Pozo 2	43	200 m	S 12°21’27.4”	W 65°31’37.3”
	Pozo 3A	56	1 sm pond	S 12°18’12.1”	W 65°32’37.6”
	Pozo 3B	18	1 sm pond	S 12°18’07.7”	W 65°32’33.6”
	Pozo 4A	52	1 sm pond	S 12°17’10.1”	W 65°33’02.7”
	Pozo 4B	52	300 m	S 12°17’10.1”	W 65°33’02.7”
	Curiche La Rana	13	200 m	S 12°14’36.7”	W 65°33’07.9”
26-Jul-96	Arroyo Los Caimanes	59	5.4 km	S 12°25’08.2”	W 65°27’35.1”
				S 12°24’16.6”	W 65°27’43.4”

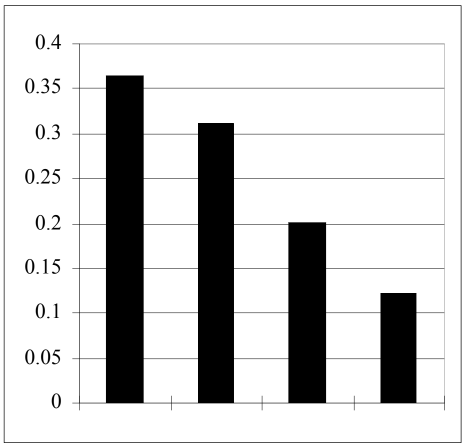

Figure 7. Distribution of size classes from sample surveys in the Río Mamoré basin in central Beni for field seasons 1995 and 1996. Classes are (left to right) II: 0.5-1 m, III: 1 - 1.5 m, IV: 1.5-2 m, and V: > 2 m. Not included are ‘Eyes only’ or class I: < 0.5 m. N = 312.

26 July 1996 - Arroyo Los Caimanes forms the eastern boundary of the ranch. It had been months that low water level had closed the arroyo to long distance traffic. We set off that night and had not gone 100 m when we saw a class V black caiman. Later we collected a specimen of *Paleosuchus trigonatus* on the downstream portion. The caiman sighted included: 5 (<0.5 m), 15 (0.5-1 m), 11 (1-.5 m), 8 (1.5-2 m), 4 (>2 m), and 16 ‘Eyes only’.

Departamento Beni, Provincia Vaca Diez - Río Beni
EcoRegion 1

RG traveled to the province capital, Riberalta, to gather some information on *Caiman yacare* in the area. The land is typically *altura*, relatively elevated terrain through which the rivers cut distinct channels. This region has forest cover and open pampa is not as common as in the central Beni. Land tenure is different and large ranches not so prevalent. The town survives on both timber and nontimber products and services. Sawmills line the waterfront and large warehouses store Brazil nuts. Rubber is tapped and the local residents hunt, fish and harvest many products from the surrounding landscape.

19 July 1996 - Although the Río Beni is a big river with a fair amount of river traffic, we wanted to see if caiman lived there. A guide and dugout were hired and we paddled north, upstream. After 3.8 km we passed the mouth of the Río Madre de Dios which flows from Peru. We continued on more than 2 km and floated the way back. The few caiman were very light shy and did not allow close

approach for identification or size estimate. Poaching pressure has probably produced these effects. We did see 3 caiman identified as *Caiman yacare*, 2 (0.5 - 1 m) and 1 (1 -1.5 m).

The guide suggested we look at Arroyo Pico Plancha where he had seen caiman. The caiman were very scarce, far from the bank and no identification could be made.

20 July 1996 - The following day, we entered the Río Madre de Dios, and continued over 10 km upstream of Riberalta. Our destination was Laguna Valparaiso, a well-known spot for fishing about 2.4 km northwest of our river landing. This laguna can be entered from the river in high water, but at this time it was cut off. We had a difficult survey along the shore of the long waterbody. The wary nature of the caiman was probably testament to the popularity of the place by fisherman. A small sample of 12 *Caiman yacare* were identified from the following size classes: 6 (0.5-1 m), 3 (1-1.5 m), and 3 (1.5-2 m).

On return to Riberalta along the Río Madre de Dios I saw single caiman every few hundred meters but they were quite shy. Nine *Caiman yacare* were seen from the size classes: 5 (0.5-1 m), 3 (1-1.5 m), and 1 (1.5-2 m).

21 July 1996 - Carretera de tejerías road runs to a ferry crossing on the Río Beni. One small *Paleosuchus trigonatus* was captured (41 cm) and released. Four *Caiman yacare* were identified from the following size classes: 3 (0.5-1 m) and 1 (1-1.5 m).

Laguna El Corredor lies about 2 km southwest of the main port, a sliver-shaped remnant from a course change of the Beni river. The habitat looked appropriate but the numbers were very low. Thirteen *Caiman yacare* were identified from the following size classes: 6 (<0.5 m) 4 (0.5-1 m), and 3 (1-1.5 m).

Table 12 – Summary of suveys of the lower Río Beni basin, EcoRegion No. 1

Date	Locality	No.	Measurement		
19-Jul-96	Río Beni	11	6 km river	S 10°59'52.6"	W 66°04'52.6"
				S 10°58'13.6"	W 66°06'06.9"
19-Jul-96	Arroyo Pico Plancha	8	600 m bank	S 10°58'01.6"	W 66°06'06.1"
				S 10°57'42.1"	W 66°06'07.4"
20-Jul-96	Laguna Valparaiso, start	43	800 m bank	S 10°58'01.6"	W 66°06'06.1"
20-Jul-96	Río Madre de Dios, start	21	10.8 km river	S 10°54'46.3"	W 66°07'15.0"
	Río Madre de Dios, mouth			S 10°58'02.7"	W 66°05'48.3"
	Río Beni, Riberalta			S 10°59'52.6"	W 66°04'52.6"
21-Jul-96	Carretera de tejerías, start	5	2.5	S 11°00'34.6"	W 66°05'07.1"
21-Jul-96	Laguna El Corredor, start	19	300 m laguna	S 11°00'19.7"	W 66°05'19.7"
				S 10°00'12.3"	W 66°05'19.1"

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EcoRegion 6

A short trip was made by RG to Rurrenabaque and the immediate area. Wild meats and fish were often on restaurant menus. But recently ecotourism has hit the area in full force and eight tour agencies offer "jungle and pampa" trips. Tourists uniformly report that caiman are seen regardless of destination. Reports by reliable sources say that *Melanosuchus niger* can still be found in the area. Locally made artisan products, available in the Sunday port market, include both yacare and black caiman products.

The main road was driven northeast toward Reyes, 27 km distant.. Continuing roadwork on this stretch, plus a high number of roadside dwellings, make this section unsuitable for good caiman populations. After passing Reyes the main road turns eastward and passes into sparsely inhabited ranchland. The road here been constructed using borrow pits but the cunetas here proved to be very sparsely inhabited. Twenty-five *Caiman yacare* were identified from the following size classes: 14 (<0.5 m) 7 (0.5-1 m), and 4 (1-1.5 m). Another trip was made further east on the road. The cunetas became further apart as the road went east. Thirteen *Caiman yacare* identified included: 9 (<0.5 m) 2 (0.5-1 m), and 2 (1-1.5 m).

Table 13. Summary of surveys in the upper Río Beni basin, EcoRegion No. 6

Date	Locality	No.	Measurement		
1-Aug-96	Carretera Reyes-east, start	31	5.5 km road	S 14°17'42.6"	W 67°20'03.4"
				S 14°17'17.2"	W 67°17'01.6"
2-Aug-96	Carretera Reyes-east, start	24	10.5 km road	S 14°17'17.2"	W 67°17'01.6"
				S 14°15'39.9"	W 67°11'29.8"

As a result of a national decentralization program, the Departments are currently in more direct control of the harvest program. But if the caiman program is to be successful, fulltime field staff must be found and financed. Mechanisms must be developed that lead to a self financed system. By comparison, Colombia, Nicaragua, and Venezuela have assigned fulltime field biologists and staff to oversee the caiman programs in those countries. It should be noted that the caiman programs in those countries generates sufficient revenue to pay for the cost of the field staff. It is reasonable to believe that Bolivia's caiman program could generate sufficient funds to pay for the needed field staff.

SUMMARY. Although the 1995 field season started late, most of the objectives of the program for the sustainable utilization and management of caimans in Bolivia were met. Consultations were held with government officials in La Paz, Santa Cruz, and Trinidad, and with ranchers, landowners, representatives of indigenous groups, natural history museum staff, and university faculty and students during which the benefits of a scientifically based management program of the caiman populations based on sustainable utilization were presented. In addition, lectures on the program were given for the general public, and press conferences were convened for the newspapers, radio, and television in Santa Cruz and Trinidad. Additional presentations in 1996 continued the education process begun in 1995.

Wild populations of caiman were surveyed to establish their relative abundance and to provide information on the age/size structure of the populations. The results of these surveys are summarized in the tables below. We have made simple calculations for comparison with past and future surveys. We present results in individuals per km shoreline and per area. Some of the recent harvest program surveys were calculated in terms of caiman/hectare of water which we feel is a mistake. After discussions with Bolivian wildlife authorities on the problems of fluctuating water surface area and reliance on extrapolated population estimates, use of the more reasonable caiman/hectare of land method has been adopted.

Table 14. Summary of survey data from Depto. Santa Cruz. Bold entries indicate low densities due to small sample size.

Year	Ranch	Area (ha)	Water Bodies	Survey	yac/ha: land	yac/ha: water	yac/km
1995	San Luis	68,000	19 (40+)	4,820	0.07	821	1151
1996	San Luis		9 (40+)	3,203	0.05	884	1448
1995	Tel Aviv	20,000	4 (18+)	1,058	0.05		
1995	El Refugio	50,000	4	192	**0.004**		27
	Caparu	20,000	3	270	**0.014**		142
1995	río Paraguá A			50			7
1995	río Paraguá B			186			8.5
1995	San Miguelito	50,000	4	193	**0.003**	116	78.5
Totals	(partial)	88,000		5,878	0.07		

Table 15. Summary of survey data from northern Beni Department. Bold entries indicate low densities due to small sample size.

Year	Ranch	Area (ha)	Water Bodies	Survey	yac/ha: land	yac/ha: water	yac/km
1995	Nazaret		2	114			84
1996	Nazaret		4	432			59
1995	Esperanza A		5	690			78.5
1995	Ceiba		1	438			1043
1995	Crisitina		2	66		340	366.5
1995	Futuro		2	178			11.5
1995	Havana	2405	5	583	0.24		486
1996	Havana		6	685	0.28		99
1995	Esperanza B	3450	1	1,555	0.45	11.8	246
1996	Esperanza B		3	897	0.26		51.5
Totals			31	5,638			

Table 16 – Summary of survey data from southern Beni Department. Bold entries indicate low densities due to small sample size.

Year	Ranch	Area (Ha)	Water Bodies	Caiman	yac/ha: land	yac/ha: water	yac/km
1995	Sn Ignacio	2741	3	804	0.29	1.89	61
1996	Sn Ignacio		3	645	0.24	1.31	49.5
1995	lag Azul		1	1391		1.11	348
1996	lag Azul		1	160		0.13	40
1996	Ponderosa		1	152			50.5
1996	Belén	10,000	1	771	**0.08**	1.72	75
1996	Toco		9	751		1036	388
1995	TIPNIS		8	1035			10.5
1995	El Carmen		5	470		3.2	235
1995	Ceilan	54,000	6	717	**0.01**		42
1996	Rancho Alegre	35,000	10	325	**0.01**		16.5
1996	Riberalta		6	107			5
Totals			54	7,328			

It was not our intent to gather data for generating a large-scale harvest quota. We were trying to establish indices for relative abundance over a wide area for a limited, experimental hunt. More sampling time is required to obtain detailed information. In Venezuela, for example, all available water bodies on a property are sampled to give a true caiman/ha land estimate. Though we usually surveyed only a few areas on each property, many surveys revealed a caiman density per area comparable to those from Venezuela. This underscores the general health of the populations of *Caiman yacare* in Bolivia.

Instances of very low densities usually reflect a small number of samples on a large property, and not necessarily a low total number of animals.

RECOMMENDATIONS. During discussions with the national and departmental wildlife officials, we stressed the need for the administrative and institutional infrastructure in order to operate a successful caiman management program. A draft program for implementing a caiman program in Bolivia was submitted to the Dirección Nacional de Conservación de la Biodiversidad and to the CITES Secretariat. A draft of regulations encompassing aspects for the sustainable use of *Caiman yacare* and an annual timetable was also submitted.

We presented the following recommendations, which are here updated with new information and suggestions based on recent developments. They are based on the results of our survey experiences, examination of existing sustainable use programs in other countries, and analysis of the program development in Bolivia. These recommendations were founded on the assumption that the Bolivian government wished to conduct a limited experimental hunt starting in 1995. A very limited hunt took place in 1997, but the first serious harvest did not occur until 2000.

Regulations: These important instruments govern all aspects of the program and must be finalized and passed into law. We supplied a draft that included detailed articles covering: terminology, official size classes, essential pre-harvest census results, minimum individual size limits, license petition requirements, individual property plan requirements, conditions for negating licenses, official calendar for activities including fixed dates for hunting and transport of products, specific techniques required for hunting, hide flaying and storage, hide size control and CITES tag fixation, permits and rules for transport of hides, meat or other products, centralized auction sites, exportation of products, opposition to license petitions, value-added service fees for direct return to the program, and legal sanctions for infractions.

We stressed the fact that this program must be viewed as a year long endeavor, with related activities occurring during every calendar month. The program is multi-faceted and incorporates many activities outside the short harvest period. However, as a central concept, we emphasized that the DNCB incorporate value-added conservation by requiring service fees. This is essential for developing a self-financing program in the future.

Regulations for a successful harvest have been passed and refined over time, in a large part due to recommendations by Alvaro Velasco (1998), regional Vice-Chairman for the CSG. A mechanism for allowing rapid adjustments to the Regulations is in place. We are looking into ways to incorporate self-financing mechanisms.

General Public Education - This must be considered a year-round activity. A vigorous and complete campaign of public education must be undertaken to inform the general public about the caiman program. Unlike the previous decades where the entire lowlands was open to any hunter, the new program allows hunting only on specific properties, with the hunting license given only to persons legally responsible for those properties. This program is based primarily on the conservation of wild caiman populations, with quotas given as compensation for successful conservation efforts.

A serious public education effort must be undertaken by the government to explain these aspects which are novel for Bolivian wildlife use. This should be a multi-media campaign, which includes radio spots, television interviews and printed materials such as newspaper and magazine articles and brochures for the public consumption. New regulations must be diffused and widely understood by the general public well before the harvest, in order to avoid hunting by non-licensed persons or on non-designated properties. The harvest in 2001 was compromised by a misinformed public due to a lack of information. Hides were stockpiled and ready before the harvest officially began. We recommend that the DNCB begin a permanent program for public education immediately.

Stakeholders - The overall objective is to promote conservation of *Caiman yacare* through economic incentives. To be effective, the program must reach the people who control the land, the animals and habitat. A diversity of stakeholders has benefits.

Ranchers: The members of FEGABENI, CDF, the Beni provincial government and the DNCB signed a convention naming the landholders as honorary wildlife wardens. The intent was to foster conservation amongst the ranchers who own the vast majority of the private lands in the department. We recommend that these efforts be energetically continued. With the demise of CDF, wildlife employees at the department level have changed and momentum was lost. A similar *convenio* should pursued in Santa Cruz as well.

Although the ranchers were traditionally the most interested parties, they have lost much of the initial interest due to government delays, bureaucracy and a falling hide prices.

Indigenous People: Indigenous people have the legal right to exploit natural resources in their territory. They are low-income rural inhabitants who live through use of the wild resources. We are proud to note that all the skins harvested in 2001 were permitted to Indigenous groups. This future income potential can have a large impact on the lives of these people and their communities. We recommend that the DNCB actively pursue the inclusion of more Indigenous people in the sustainable use program for caiman.

Communities: Other rural inhabitants also live from a natural resource base but often have smallholdings or no formal land tenure. Landscape and wildlife conservation could be promoted by developing relationships with certain communities. Economic incentives for family and community profit might prove to be valuable tools. We propose exploring possible pilot programs with the communities of San Matías and Piso Firme.

Licensee Education: Due to the completely new system for extraction of hides under this program, mandatory educational workshops for the license holders should be conducted. Topics should cover the new regulations and include skinning patterns, hunting techniques, and tagging and shipping requirements. The details need to be carefully and clearly explained to participants. These workshops should include printed materials for future reference.

Technical Training: The DNCB must make all efforts to have trained personnel for future surveys. During the 1995 field season we located four interested university students, but only one was free to travel with us. Trained personnel are crucial to collecting accurate data. We recommend that the DNCB plan personnel training soon so they can be authorized for future surveys. The number of properties included in the program should not be allowed to exceed the capacity of the wildlife authorities to adequately perform census duties.

Survey Data: Due to the stochastic nature of the lowland environment and natural wildlife populations, surveys should be conducted during the same harvest season. The survey data, including both population census and habitat assessment information, form the basis for hide quotas formulated by the DNCB. We recommend that the DNCB conduct surveys with time enough to complete necessary pre-harvest activities such as licensing, and setting quotas.

Ecoregioalization: Caiman densities vary across the landscape for a variety of reasons. The concept of dividing the lowlands into management areas is central to an adaptive strategy. Venezuela has 6 regions that encompass about 90,000 km^2 plus the Orinoco delta as a separate region. We feel that the 30 EcoRegions system currently in Bolivia place unrealistic responsibilities on the administration for ground-truthing habitat, conducting population surveys, establishing quotas, overseeing harvests, etc. The divisions evolved from a satellite imagery GIS project and is too fine scale for the requirements of the caiman program. Complexity depends, to some extent, on the number of Ecoregions included in the program.

Harvest Season: Due to the extremes of the wet and dry season in Bolivia, surveys and harvest must be conducted during the concentration of caiman near the end of the dry season. For this to occur on schedule, the above points be accomplished by the end of July of the harvest year. We recommend that the DNCB develop a chronogram and fix a harvest schedule. A priority for adhering to the schedule must be adopted to insure correct timing.

Size Limits: There exists a debate among specialists regarding minimum allowable harvest size. The projected pilot program was designed to be experimental. We felt that training survey personnel and hunters might be facilitated by using half-meter increments for the size classes. We chose 150 cm total length (75 cm snout-vent length) harvest size for a number of reasons. Although hunters always seek large animals, errors in judgement occur. Caiman above 150 cm total length are primarily adult males, and some large females that may be entering reproductive senescence. Currently, the Venezuelan size-class system using 0.6 m increments is used with a minimum size put at 1.8 m. Neither system is biologically based, but instead exists for the convenience of size classification

Controversy has arisen in the harvest of other wildlife species regarding the consequences of the removal of the largest reproductive males. Discussion is beyond the scope of this document, but subsequent research may show this to have overall detrimental effects. We recommended taking detailed data on sex ratios from the first years of harvest to help determine if changes are required, and to define the appropriate sizes for future harvests.

Tagging and CITES Permits: Tagging should occur at the harvest site when possible. We heard about many logistic problems in the hunt of 2001 and it appears that in many instances tagging should take place at the Central Warehouse. During that harvest hides were tagged only after purchase by tanners. This led to an unfortunate situation where legal size hides, which had been brought for sale, were refused in favor of larger skins. This undoubtedly contributed to a harvest excess as hunters sought to fill the quota with large animals. We recommend tagging all legal size skins as they arrive at the warehouse. The tanner then would select the skins he wishes to purchase from the limited, tagged offering, rather than, as done previously, selecting from untagged hides.

We heard uniform complaints from tanners and researchers about the inordinate time required for the issuance of CITES permits. The process must be streamlined, at least for the case of a legal and commercially important species. It is counter-productive to develop an efficient sustainable use system that is constrained by a bureaucratic bottleneck. Although the system has improved, more work is required. We recommend a system with a two-week mandate for denial or approval, including issuance of the export permits.

Captive Production: The DNCB must address the private sector, which has interest in captive production systems, and prepare guidelines for control and uniform standards. The key is to embody conservation benefits. We feel that if the wild populations and habitat have financial value and importance, this strengthens the conservation efforts. The CSG does not endorse closed reproduction systems that do not rely on wild resources for eggs or young. We recommend that the DNCB develop regulations for captive production systems based on programs that are currently installed in other countries employing egg or hatchling collection from the wild.

Conclusion: At the beginning of the project we insisted that the legal framework, consisting primarily in the regulations, be installed immediately so that work could begin on developing a pilot harvest program. Both the regulations and initial harvests have been developed but constant refinement is necessary. We believe the real experiment in the harvest consists in exercising an administrative framework that encompasses all the above.

The success or failure of a sustainable use program for caiman in Bolivia depends greatly on the resolve of the wildlife authorities to assure that all the necessary elements of the project are completed and adhered to in a timely fashion. We foresee the greatest problems, not with conducting surveys or fixing quotas, but with the granting of licenses, hide inspection and tagging, auctions and transport, effective tannery inspection, efficient CITES certification and expedient export – in essence, the non-biological portions of the program. The harvest schedule also requires a precise and fixed timetable of events that must occur sequentially. These processes require time and experience to develop and refine. This evolution of the sustainable use program is possible now that the program is in motion.

Success in a conservation program such as this requires good cooperation and interest from the landholders. Some ranchers were involved in the first surveys in 1986 but lost interest along the way. With each successive year, their private funds were invested in transport, food and lodging to support the project, and their good will and interest was abused. Every year they were told "next year" and many became very skeptical and lost interest. Some tanners have gone out of business while waiting for the program to begin. We feel these people need tangible reassurance that these efforts, both physical and financial, will finally produce some benefit. This means that the government will have to show some reassuring action towards improving the program to reinforce their interest

Bolivia experienced positive results from the national ban on hunting with the recuperation of certain species that were over hunted for commercial purposes. The lack of local markets has rendered most hides virtually worthless. An untanned yacare caiman hide in 1996 was worth less than US$ 2, a ridiculous price compared to countries that have sustainable programs in place. During the 2001 harvest, raw hides were being purchased by middlemen for resale to tanners for US$ 5. Similar, legal skins from Venezuela and Colombia sell for US$ 30 to $50. But the Bolivian economy is such that poor campesinos find it profitable even at such low value of $ 2. In 2001, 17,000 yacare hides, illegally smuggled in from Bolivia, were confiscated in Paraguay, representing no benefit to the conservation of the species, wildlife programs or to the nation. If the Bolivian authorities do not begin to promote conservation with economic incentives such as proposed in the sustainable use of caiman, we believe there will be a constant low level loss of biodiversity and commercially valuable wildlife The flight of hides to neighboring countries will continue as has been seen in the past. We hope the Bolivian government will respond with resolve and accelerated action.

ACKNOWLEDGMENTS. This survey would not have been possible without the support of the CITES which provided the majority of the funding. Special thanks go to Dr. Obdulio Menghi, CITES Scientific Coordinator, who took special interest in this project. Additional funding was also obtained from Biodiversity Services, Inc., from a Tropical Conservation and Development Graduate Field Research Grant, a Tinker Graduate Field Research Grant, the Netherlands Embassy to Bolivia, and from Ernest L. Godshalk.

The Bolivian Min. of Sustainable Development and the Environment provided support through Lic. Alexandra Sanchez de Lozada, Eliana Flores, and her staff, and Luis F. Pacheco. Thanks are also extended to Senator Oswaldo Monasterio A., Lic. Arturo Moscoso of the Netherlands Embassy, and Lic. Luz Maria Calvo from the Direction of Indian Affairs.

The fieldwork that took place in the Departments of Santa Cruz and Beni would not have been possible without support of government officials, ranch owners, managers and staffs. The head of CDF in Santa Cruz, Dr. Alberto Vasquez E., made available a vehicle and driver for our use. Thanks also to biologist Lic. Hugo Hurtado B., CDF Santa Cruz wildlife office, and Mario Hernández. Our work in Santa Cruz was facilitated by Oswaldo Monasterio N., Ian Phillips and Randy Brooks, Jaime Rozeman A., General Moises Shiriqui, Marco Ferrero M., and Ron Larsen. Dr. Marcello Zalles of the Mus. of Natural History 'Noel Kempff Mercado' (1995) arranged for students to join our team, among them Ingrid Fernandez S. (1995), Lic. Alfonso Llobet and UMSA student Eddy Perez (1996). Thanks also to Lic. Luis Bowles C., President, FEGASACRUZ, Tim Killeen, René Guillen, Ignacio Riojas, Juan Alberto Rojas, Damian Rumiz, Andrew Taber, and Wendy Townsend for their part in our studies.

We thank the officials of CDF: Beni Lic. Pablo Yañez F, wildlife head Dr. Carlos Vargas, and his staff (1995), and Wildlife Unit Director Dante Videz R. (1996) and student Daysi Molina R., (1996). For our survey of TIPNIS, thanks to Zulema Lehm of CIDDIBENI, Adrian Nogales, Virgilio Nosa, Inocencio Yibánure, Ruben Yuco of TIPNIS administration, guides Felix Cayuba, Luciano Gutierrez, Esteban Yacuiba, and the people of TIPNIS communities that assisted during our visits. We were assisted by the Beni Cattlemen's Federation, Presidents Fernando Sattori (1995) and Fernando Velasco C. (1996), and especially by the many landholders: Dr. Eduardo Alí, Mario Ávila, Roberto Cavanagh, Hugo Chavez Lopez, Jaime Cuellar, Hugo Jimenez A., Juan Manuel Paz, Sebastian Paz, Carlos Quaino, Cristina Quaino de Paz, Miguel Angel Villavicencio, and Roberto Viera. Special thanks to all the rural people who made our lives possible "out there" - the cooks, ranch managers, cowboys, paddlers, motoristas, guides, pilots and scores of others. Some of note are Francisco Aulo, Carlos Becera, Earle Camayo, Gilberto Cuellar, Arnulfo Cuellar O., Ricardo Edgley, Ilmar Guamayo, Demetrio Mareca, Julio Cesar Mercado, Edgar Pachurí, Lucian Petigas, Vicente Roca, Herzon Rodriguez, Adrian (Pocho) Sapani G., Rodolfo Sapani G., Justo Sibrón, and Erlin Tamayo.

All credit for the excellent maps must go to Vicki McGrath, thanks. We offer apologies to anyone overlooked.

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Comercio de los Crocodylia de Nicaragua

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ABSTRACT: National laws with incidence on the harvesting of the Crocodylia of Nicaragua are the Hunting Law (1956), CITES Convention (1977), Politic Constitution of Nicaragua (1987), Biological Diversity Convention (1995), Environment and Natural Resources General Law (1996) and Ministerial Resolution 023 – 99 (1999) which established hunting seasons and restrictions for both species present in the country. I made a total of 129 interviews with hunters along the distribution area, 10 with intermediate buyers (N = 11), 19 to tanners (N = 36), one taxidermist shop (N = 2) and 36 Crocodylia selling stores. In each interview I asked about production costs, needed capital, net benefits, buy and sell prices, common sizes of the skins, etc.. The intermediate buyers are the ones whom perceive the most net benefits, followed distantly by hunters and tanners. The skins used come mainly from the Caribbean coast. At least 44,438 caimans and 5,000 crocodiles are being harvested annually from the countries wetlands, according to CITES – Ni office, the Exportation Tramits Center (CETREX) and the World Conservation Monitoring Centre (WCMC).

Key Words: Crocodylia*, Caiman crocodilus, Crocodylus acutus*, Nicaragua, comerce, skins, tanning, souvenirs, hunting, intermediates, taxidermy, market, harvest, benefits.

INTRODUCCION

Desde la cuna de la humanidad, la vida silvestre ha jugado un papel importante en el desarrollo de la sociedad. Los tipos de aprovechamiento de fauna más practicados en la Mesoamérica actual incluyen la cacería de subsistencia, cacería deportiva, uso comercial, usos tradicionales, reproducción en cautiverio para abastecer los mercados, el uso recreativo y turístico (Vaughan 1994).

El aprovechamiento de los Crocodylia en Centroamérica se remonta a más de un siglo (Bovallius 1887). En la actualidad el uso comercial que hace Nicaragua de una de sus especies de Crocodylia, el cuajipal (*Caiman crocodilus*) en el ámbito internacional, da una idea de la importancia económica de este grupo taxonómico. Los reptiles destacan como la clase con la mayor proporción de especímenes exportados durante todos los años desde 1986 (76 - 94%), las pieles de caimán constituyen por lo menos el 75% del total de los volúmenes reportados para el comercio de reptiles dado en Nicaragua (Pérez 1999).

Nicaragua es signataria de CITES (Convención sobre el Comercio Internacional de Especies en Peligro de Extinción de Fauna y Flora Silvestre) (USAID/ELP & SAIC 1996) y otros convenios que legalmente procuran la protección de especies de fauna silvestre amenazada (Sáenz 1997), además, nacionalmente cuenta con algunas normas orientadas a la racionalización del aprovechamiento de las mismas como la Resolución Ministerial 023 – 99, referida a las especies nicaragüenses cuyo aprovechamiento se encuentra vedado total o parcialmente.

Las cifras presentadas por Pérez (1999) referentes al comercio legal de fauna silvestre en Nicaragua, indican claramente la tendencia al aumento que el país ha seguido en este rubro. Los altos volúmenes de exportación de fauna silvestre en la última década son alarmantes, en ausencia -o suma escasez- de procedimientos técnicos y científicamente respaldados para el establecimiento adecuado de cuotas. Este problema se ve acrecentado por la existencia de un gran volumen desconocido de comercio doméstico legal e ilegal de fauna silvestre, además del tráfico ilegal internacional (Pérez 1999). Los Crocodylia no son la excepción a este problema. Por otro lado, el conteo nacional de Crocodylia de Nicaragua, realizado a inicios del año 2000 (Buitrago 2000), indica que las poblaciones evaluadas han decrecido significativamente en los últimos siete años.

El presente documento reporta una estimación de la magnitud de la cosecha anual de cuajipal (*Caiman crocodilus*) y lagarto (*Crocodylus acutus*), y describe algunos elementos de mercado que intervienen en el comercio de pieles y productos de los mismos.

METODOS

Area y fecha de estudio

Realicé las entrevistas con los cazadores en las zonas rurales comprendidas en elevaciones inferiores a los 200 msnm, área de distribución de los Crocodylia; entrevisté acopiadores e intermediarios en las cabeceras departamentales del área de cacería; las taxidermias y curtiembres se ubican en la región del Pacífico del País, al igual que los mercados locales en donde se comercian los artículos de las especies en cuestión. Realicé todas las entrevistas entre los meses de Febrero y Diciembre del año 2000; aprovechando el recorrido realizado para el conteo nacional de los Crocodylia en el país.

Marco legal del aprovechamiento

Revisé la documentación existente sobre mecanismos y herramientas legales que regulen el aprovechamiento de la fauna silvestre nicaragüense; de ésta extraje decretos presidenciales, resoluciones ministeriales, leyes y convenios internacionales en los cuales Nicaragua se compromete a velar por el uso racional de los Crocodylia del país.

Entrevistas con cazadores

Realicé entrevistas informales semiestructuradas a cazadores del área de estudio; en cada entrevista pregunté por las rutas seguidas para llegar a los sitios de venta, los gastos en que debe incurrir por cada noche de caza, así como por el valor de los aperos, equipos y medios utilizados en la actividad. Por último, pregunté los precios a los que vende las pieles de acuerdo al tamaño y la especie de la misma. La información fue transcrita inmediatamente después de la entrevista.

Identifiqué a los cazadores por referencias de pobladores, realicé entrevistas en aquellas comunidades que coincidían con paradas o estaciones del itinerario logístico para el conteo nacional, o en las que se consideró estrictamente conveniente por el tamaño de población (superior a 100 personas), la ubicación de éstas (cercanía a humedales o zonas costeras) y la comunicación con las cabeceras departamentales y la capital del país (anexo 1).

Entrevistas con acopiadores e intermediarios

Visité acopiadores de pieles de Crocodylia que operan en el área de estudio, a los que encontré por indicaciones de los cazadores. A cada uno le pregunté por los sitios de procedencia de las pieles, los precios de compra, las cantidades mensuales adquiridas, los sitios en donde vende las pieles acopiadas, las rutas empleadas para trasladar las pieles, los precios de venta, los costos operativos y requerimientos legales (permisos) para poder operar.

Entrevistas con curtidores y taxidermistas de pieles de Crocodylia

De 38 talleres de curtido existentes en el país (Luna, 2000 com. pers.), elegí 19 para realizar entrevistas, empleando como criterios de selección la capacidad instalada de cada uno de los talleres: los que poseen maquinaria y equipos propios, contratan al menos un ayudante y requieren más de 500 pieles de caimán por año. Para ello, elaboré una lista que inicia con los taxidermistas y curtidores más fuertes y finaliza con los de menor capacidad, de modo que se incluyeran todos los grandes, casi todos los medianos y algunos pequeños productores. Las entrevistas fueron formales y estructuradas con anterioridad. Esta selección me permitió conocer la cantidad de pieles utilizadas por los grandes productores, quienes emplean la mayoría de las pieles, la cantidad relativa de pieles utilizada por los pequeños y medianos productores, y el promedio anual de pieles requeridas por cada curtidor por año.

A cada propietario de taller le pregunté por la procedencia de las pieles, los precios de compra por cada una de las tallas demandadas, la cantidad de cueros requeridos por año, el rendimiento de cada una de las tallas (medida a través del número de fajas que puede elaborar de cada piel), los artículos que elabora, sitios y precios de venta, costos de producción y funcionamiento, y beneficios estimados de la elaboración y venta de cada artículo.

Entrevistas con vendedores de mercados locales

Ubique a los vendedores por referencia de los curtidores y taxidermistas. En cada uno de los mercados o sitios de venta entrevisté la mayor cantidad posible de vendedores de artículos de Crocodylia. En cada puesto de venta identifiqué los artículos vendidos y pregunté por los sitios y los precios de compra, la nacionalidad de los principales compradores dividida en dos categorías: Nacionales o Extranjeros; precios de venta y la cantidad de cada uno de los artículos vendida semanal, mensual o anualmente, dependiendo del artículo.

Análisis de distribución de utilidades

Consideramos los costos fijos de cada uno de los eslabones de la cadena comercial por cazar un caimán de cuatro pies y un cocodrilo de cinco pies, trasladar la piel, procesar el cuero, preparar el producto o vender en los mercados nacionales, dado sea el caso. Utilicé estas tallas como referencia, pues son las tallas más comunes que llegan a los marroquineros.

Para calcular las utilidades, deduje los costos fijos del ingreso bruto para cada eslabón de la cadena comercial; ilustré los datos resultantes en una figura en la que ordené los eslabones de acuerdo a la magnitud de sus utilidades.

Realicé la conversión de Córdobas a Dólares utilizando la tasa de cambio de vigente en ese momento: C$ 12.72 por cada Dólar.

Revisión de exportaciones

a) Oficina CITES - Nicaragua

Estimé las exportaciones en función de dos fuentes de información: (1) un informe especial que inicialmente elaboró para mi la Oficina CITES – Nicaragua, sobre las exportaciones de piel o productos de caimán en los últimos 20 años (desde 1977 hasta 1997), y (2) los datos de exportaciones que extraje de la revisión de cada uno de los permisos emitidos por CITES – Nicaragua en los últimos diez años (de 1990 hasta el 2000). De cada uno reporté la cantidad de pieles enteras, flancos, vientres, colas y artículos elaborados comercializadas cada año.

En ambos casos, consideré las pieles enteras reportadas como un individuo cosechado; de las colas, vientres y flancos reportados utilicé el valor que representa la mayor cantidad de individuos cosechados por año (el número mayor de la mitad de los flancos, las colas o los vientres); de los artículos elaborados consideré en este análisis únicamente animales disecados, contando cada uno como un individuo cosechado. Al final se sumaron los valores de individuos cosechados cada año de cada uno de los análisis, con los que realicé un promedio simple de cada fuente de información, que indica la cantidad media de individuos cosechados por año en el país con destino a exportación en cada caso.

b) World Conservation Monitoring Centre (WCMC, Cambridge, Inglaterra)

Con base en el informe sobre comercio internacional elaborado por el WCMC, el que comprende información de exportaciones de pieles enteras de caimán desde 1992 hasta 1996, construí un tercer escenario que me permitió estimar las pieles cosechadas anualmente con destino a la exportación.

c) Centro para el Trámite de Exportaciones (CETREX, Managua, Nicaragua)

Empleé los datos de exportaciones de pieles de caimán registrados para los últimos cuatro años (1997 – 2000), de los cuales calculé un promedio simple de pieles exportadas cada año.

Estimación de la cantidad de individuos cosechados en el país cada año

Con la información obtenida en las curtiembres y taxidermia estimé la cantidad total de pieles de cada especie utilizadas nacionalmente cada año.

Con la información obtenida de CITES – Ni, WCMC y CETREX estimé cuatro escenarios de la cantidad de pieles exportadas anualmente.

El total de pieles utilizadas por año fue el resultado de la suma de las pieles comercializadas dentro y fuera del país. Los resultados se presentan en cuatro escenarios, uno con los datos del informe CITES, el segundo con los datos obtenidos de la revisión de los permisos emitidos por CITES – Nicaragua, el tercero con los datos del WCMC y el cuarto con los datos provistos por CETREX.

Para realizar el cálculo de la demanda nacional empleé el promedio anual demandado por cada curtiembre, y multipliqué por el número de curtiembres existentes. A la cantidad resultante adicioné el promedio de pieles requeridas por las taxidermias entrevistadas, con lo cual obtuve el estimado de las pieles demandadas por el mercado nacional. Al estimado resultante adicioné el promedio de pieles exportadas calculado según los datos provistos por cada fuente de información, con lo que se obtuvo cuatro estimados de la cantidad de individuos cosechados por año en el país.

Para conocer la tasa y la tendencia de la cosecha de individuos por año, elaboré una regresión simple empleando como insumos los datos del informe de CITES y los datos obtenidos de la revisión de los permisos emitidos por la misma oficina.

RESULTADOS

1.- Marco legal del aprovechamiento

El Ministerio del Ambiente y los Recursos Naturales (MARENA) es la institución de gobierno responsable de la regulación del aprovechamiento de los recursos naturales del país. Este ha establecido una serie de normas que persiguen la conservación del patrimonio natural nacional sin que esto impida el desarrollo de las poblaciones humanas del país.

En este esfuerzo, Nicaragua ratificó su suscripción a la Convención Mundial para la Protección de la Flora y la Fauna y las Bellezas Escénicas de los Países de América en el año 1946. Este es el primer instrumento jurídico que obliga a Nicaragua a tomar medidas jurídicas para la protección de sus recursos naturales. Sin embargo, el nivel de desarrollo de nuestras instituciones en aquella época impidió la adecuada implementación de dicha convención (Sáenz 1997).

La Ley General sobre la Explotación de Nuestras Riquezas Naturales fue aprobada por el Congreso Nacional en el año 1948. En esta se define por primera vez el concepto de Recursos Naturales y los clasifica en renovables y no renovables, los Crocodylia entran dentro de la primera categoría.

En el año 1956, el Estado de Nicaragua dictó la Ley de Caza, la cual tiene como objetivo regular la caza de todas las especies de fauna silvestre del país. Esta establece una prohibición total para la cacería para cuatro categorías de fauna silvestre, dos de ellas podrían incluir a los Crocodylia: (1) especies declaradas como "raras", (2) e individuos que se encuentren en áreas protegidas. La misma ley establece que es facultad del Ministerio de Agricultura y Ganadería declarar las especies raras y establecer las épocas de veda (Gaceta Nº 250, 1946. Decreto Nº 206 del Poder Ejecutivo).

Las primeras restricciones de caza aplicables a la cacería de los Crocodylia, las dictó el Ministerio de Agricultura y Ganadería en el año 1972, a través de una resolución ministerial (Sáenz 1997).

En el año 1977 Nicaragua se suscribió a la Convención Internacional de Especies Amenazadas de Fauna y Flora Silvestre (CITES), lo cual constituyó el primer esfuerzo de país por regular el tráfico internacional de especies silvestres.

La Constitución Política de la República creada en 1987 y reformada en 1995 es la "Carta Fundamental de la República, las demás leyes se subordinan a ella" (Arto. 182). La misma establece que "Los Recursos Naturales son Patrimonio del Estado" (Arto. 102), o sea que los Crocodylia son patrimonio del estado.

La Convención Mundial sobre la Diversidad Biológica fue ratificada por Nicaragua en el año 1995. El énfasis de dicha convención es la "promoción de procesos nacionales para la adopción de decisiones", a través del desarrollo de estrategias, planes o programas nacionales por cada contraparte para la conservación de la diversidad biológica y la utilización sostenible de sus componentes (Glowka et al. 1996), con base en ello, Nicaragua estableció una cuota nacional de aprovechamiento para los caimanes y una veda indefinida para los cocodrilos, como medida estratégica para lograr la conservación y uso sostenible de los mismos.

En el año 1996 fue emitida por el Poder Ejecutivo la Ley General del Ambiente y los Recursos Naturales, la que establece que es deber del Estado y todos sus habitantes velar por la conservación y aprovechamiento de la diversidad biológica, además establece una serie de criterios que deben ser tomados en cuenta para poder aprovechar una especie silvestre como los Crocodylia*,* y otorga al Ministerio del Ambiente y los Recursos Naturales (MARENA) la potestad para restringir el aprovechamiento de determinadas especies, de acuerdo a su categoría de abundancia, y velar por la conservación de éstas en el país.

También señala que el MARENA tiene la obligación de realizar inventarios y registros de la diversidad biológica del país, establecer sistemas de veda y fijar cuotas de aprovechamiento (Arto. 71), bajo este marco, el MARENA emitió la Resolución Ministerial 023 – 99, en la que establece una veda parcial del 1º de Marzo al 31 de Junio para el caimán y una veda indefinida para el cocodrilo; de la misma manera estableció una cuota de 10,000 caimanes por año para el mercado internacional, procedentes de la Región Autónoma del Atlántico Norte, la Región Autónoma del Atlántico Sur y el Departamento de Río San Juan únicamente (Morales *com pers.* 1995); el mercado nacional no cuenta con cuota de aprovechamiento.

2.- Entrevistas con cazadores

Realicé un total de 129 entrevistas a cazadores y habitantes de humedales del país (RAAN = 43, RAAS = 26, Río San Juan = 27, Granada = 9, Managua = 3, Carazo = 2, León = 8, Chinandega = 5 y Rivas = 6), de las cuales obtuve información relevante sobre el comercio de pieles de Crocodylia en el país, la cual se describe a continuación.

En la Región Autónoma del Atlántico Norte (RAAN) las pieles obtenidas por los cazadores son trasladadas por agua hasta Puerto Cabezas, desde donde son posteriormente enviadas a Managua, por tierra o en los vuelos de carga de aviones del Ejército de Nicaragua.

Varias veces obtuve testimonios de los cazadores indicando que los compradores de pieles llegaban a las comunidades a encargar las pieles, unos meses después de la primer visita, pasaban a retirarlas. Por las pieles de caimán pagaban aproximadamente C$ 15.00 (US$ 1.17) por pie, mientras que por la de Cocodrilo Negro entre C$ 25.00 (US$ 1.96) y C$ 30.00 (US$ 2.35) por pie.

Varios cazadores de la RAAN afirmaron haber observado cazadores hondureños vendiendo pieles en Puerto Cabezas y a los compradores ambulantes.

En el comercio de pieles en la Región Autónoma del Atlántico Sur (RAAS) y el departamento de Río San Juan, existen dos personas clave que controlan todo el mercado. Dichas personas habitan en la ciudad de Bluefields, a donde son trasladadas todas las pieles de la región. Estas compran las pieles a los cazadores desde Río Grande de Matagalpa hasta el Río San Juan, incluso uno de ellos tiene una viñeta en la radio, en la que anuncia que compra pieles de caimán y aletas de tiburón. Los precios de compra se mantienen similares a los obtenidos en la RAAN. Las pieles de caimán son vendidas a aproximadamente C$ 15.00 (US$ 1.17) el pie y las de cocodrilo a C$ 28.00 (US$ 2.20) el pie, dependiendo de la talla del animal: el pie de piel de los animales pequeños es pagado a menor precio que el de los animales grandes.

Todas las pieles obtenidas por los cazadores en la RAAS y el municipio de San Juan del Norte, en el departamento de Río San Juan, son trasladadas a la Ciudad de Bluefields, desde donde las llevan por el río Escondido hasta la ciudad del Rama y posteriormente por tierra hasta Managua y Granada. Algunos embarques salen de Bluefields por vía aérea empleando los vuelos de pasajeros de la línea aérea La Costeña o los vuelos de carga que hacen aviones del Ejército de Nicaragua.

En el sector correspondiente al Río San Juan (municipios de El Castillo y San Carlos) y los bordes de los Lagos Cocibolca y Xolotlán las pieles obtenidas por los cazadores son trasladadas a Granada en su totalidad; tanto de cocodrilos como de caimanes. Los precios por pie oscilan entre C$ 7.00

(US$ 0.55) y C$ 15.00 (US$ 1.17) para caimanes; y entre C$ 10.00 (US$ 0.78) y C$ 20.00 (US$ 1.57) para cocodrilos. En algunos casos, sobre todo en el Departamento de Río San Juan, las pieles son vendidas a intermediarios, pero dada la cercanía de la mayoría de los sitios a la ciudad de Granada, muchas veces son los mismos cazadores los que llevan las pieles a las curtiembres.

Debido a la poca actividad de cacería que se lleva a cabo en los Esteros del Pacífico del país, no pude obtener detalles de los precios de venta y épocas de venta. Sin embargo se sabe que los animales cazados – en su mayoría cocodrilos - son vendidos en las curtiembres de Granada en su totalidad. Los cazadores indicaron que en promedio pueden capturar diez caimanes y un cocodrilo por noche en la RAAN (n = 43), siete caimanes y 0.3 cocodrilos (un individuo cada tres noches) por noche para la RAAS (n = 26).

Los costos de una noche de cacería para un cazador son de aproximadamente C$110.00 (US$ 8.47), calculados con base en los costos fijos y variables indicados en el cuadro 1.

Cuadro 1. Costos fijos y variables para cada eslabón de la cadena comercial de aprovechamiento de los Crocodylia de Nicaragua (US$)

Rubro	Costos	Utilidad	Costo diario
Cazador Costos Fijos			
Lampara de mano	4.00	30 días	0.13
Arpón de Madera	3.00	7 días	0.43
Machete	10.00	60 días	0.17
Cayuco	200.00	180 días	1.11
Transporte de pieles a acopio	10.00	30 días	0.33
Subtotal			**4.17**
Cazador Costos Variables			
Baterías	2.00	1 día	2.00
Salario	0.38	Hora (6/día)	2.30
Subtotal			**4.30**
Total Costos Cazador			**8.47**
Acopiador Costos Fijos			
Transporte de pieles	200.00	30 días	6.66
Alquiler de local	20.00	30 días	0.66
Publicidad	150.00	30 días	5.00
Subtotal			**12.32**
Acopiador Costos Variables			
Salario	230.00	30 días	7.6
Compra de Pieles de Cuajipal	1,170.00	7 días	167.14
Compra de Pieles de Lagarto	735.00	7 días	105.00
Subtotal			**279.74**
Total costos acopiador			**292.06**
Marroquinero Costos Fijos			
Maquina de Zapatero	400.00	360 días	1.11
Cuchillas	20.00	360 días	0.06
Barriles	30.00	360 días	0.08
Martillo	15.00	360días	0.04
Bojo (Pulidor)	10.00	180 días	0.06
Cuadrado (Rebajador)	20.00	360 días	0.06
Afiladores	5.00	180 días	0.03
Transporte a Mercados	2.50	7 días	0.36
Subtotal			**1.74**

Rubro	Costos	Utilidad	Costo diario
Marroquinero Costos Variables			
Cromo	20.00	30 días	0.67
Tintes (Quebracho, Anelina)	15.00	45 días	0.33
Cal	20.00	90 días	0.22
Hilo	10.00	30 días	0.33
Pega	30.00	30 días	1.00
Cuero de Res	50.00	30 días	1.67
Agujas	5.00	7 días	0.71
Cebo	0.50	7 días	0.07
Agua	10.00	30 días	0.33
Impuesto Alcaldía	50.00	360 días	0.14
Salario	250.00	30 días	8.33
Contratación de 2 Personas	250.00	30 días	8.33
Alquiler de Local	30.00	30 días	1.00
Compra de Pieles de Cuajipal	6,280.00	360 días	17.44
Compra de Pieles de Lagarto	2,594.00	360 días	7.20
Subtotal			**47.78**
Total Costos Marroquineros			**49.51**
Vendedores Costos Fijos			
Impuestos Alcaldía	50.00	30 días	1.67
Alquiler Local	100.00	30 días	3.33
Subtotal			**5.00**
Vendedores Costos Variables			
Contratación de 1 persona	125.00	30 días	4.16
Publicidad	5.00	30 días	0.17
Mobiliarios	30.00	360 días	0.08
Compra de Artículos	735.76	30 días	24.53
Subtotal			**28.94**
Total costos vendedor			**33.94**
GRAN TOTAL			**383.98**

Si a los cazadores les pagan el pie de piel de caimán a un valor de C$15.00 (US$ 1.17), éstos necesitan cazar 7.23 pies de caimán por noche para cubrir los costos de la cacería; de la misma manera, si un cocodrilo se les paga a C$ 30.00 (US$ 2.35) el pie, necesitan cazar 3.60 pies de cocodrilo por noche para cubrir sus costos de cacería.

3.- Entrevistas con acopiadores e intermediarios

Realicé un total de diez entrevistas a acopiadores de pieles en la región del Caribe y Río San Juan (RAAN = 6, RAAS = 3 y RSJ = 1). En el resto del área de estudio, el control del comercio es mayor, por lo cual hay menos acopiadores y éstos son clandestinos y mucho más cuidadosos que los del Caribe, razón por la cual no pudimos realizar más entrevistas.

Los siete acopiadores identificados en la RAAN afirman obtener sus pieles de los cazadores de las cuencas contenidas entre el río Coco y el río Prinzapolka inclusive. Algunos hacen recorridos por las comunidades miskitas de la región encargando y comprando pieles. Dichos recorridos los hacen por agua, exceptuando la laguna de Bismuna, en donde existe acceso por vía terrestre, y desde donde las pieles son llevadas a Puerto Cabezas.

Los precios de compra de pieles de caimán oscilan entre los C$ 15.00 (US$ 1.17) y C$ 20.00 (US$ 1.57) el pie, mientras las de Cocodrilo entre C$ 25.00 (US$ 1.96) y C$30.00 (US$ 2.35) el pie. Estos precios coinciden con los reportados por los cazadores (ver arriba). En promedio, cada acopiador recibe unas 200 – 300 pieles de caimán y 50 – 100 de lagarto por semana, en los meses comprendidos entre Marzo y Junio, o sea un total anual de entre 3200 y 4800 pieles de caimán, y entre 800 y 1600 pieles de cocodrilo por acopiador por año. En los demás meses del año el acopio de pieles se reduce considerablemente.

Las pieles de la RAAN son trasladadas por tierra, en su mayoría, hasta Managua y posteriormente hasta Granada; algunas pieles llegan a Managua en vuelos de carga de aviones militares. Los precios de venta de las pieles de caimán a las curtiembres y taxidermias oscilan entre los C$20.00 (US$ 1.57) y C$ 25.00 (US$ 1.96) el pie, y las de Cocodrilo entre los C$ 50.00 (US$ 3.93) y C$ 60.00 (US$ 4.71) el pie.

Ninguno de los acopiadores de la RAAN tiene permisos de acopio por parte del MARENA. En la mayoría de los casos desconocen la existencia de un procedimiento para obtener permisos de acopio.

En Bluefields pude identificar tres acopiadores de pieles de Crocodylia. Dos de ellos poseen grandes letreros en sus casas que dicen “Se compran pieles de caimán y Tiburón”. Los tres acopian pieles de toda la Región Autónoma del Atlántico Sur y el municipio de San Juan del Norte. Los precios de compra de las pieles oscilan alrededor de los C$ 15.00 (US$ 1.17) el pie para caimán y, C$ 25.00 (US$ 1.96) el pie para cocodrilo.

Los dos acopiadores mayoritarios sí tienen permiso de las autoridades competentes para acopiar pieles de Crocodylia, sin embargo pude constatar que no existe ningún control sobre cada uno de los embarques de pieles.

Semanalmente estimo, según las entrevistas, que cada acopiador en la RAAS puede estar comprando unas 240 pieles, de las que un 80 % (192) son de caimán y un 20 % (48) son de cocodrilo. Las pieles son acopiadas en los meses de la estación seca comprendida entre los meses de Febrero a Junio; posteriormente la cantidad de pieles comerciada es reducida casi en su totalidad por la aplicación de sanciones por parte de las autoridades gubernamentales.

De Bluefields las pieles salen por agua hasta la ciudad del Rama, desde donde continúan por tierra hasta Managua y luego Granada. También pudimos identificar una ruta aérea empleando aviones del Ejército de Nicaragua o los vuelos regulares de La Costeña. Las pieles son vendidas en Granada a las curtiembres y taxidermias a precios que oscilan entre los C$20.00 (US$ 1.57) y C$ 30.00 (US$ 2.35) el pie de caimán y entre los C$ 50.00 (US$ 3.93) y C$ 60.00 (US$ 4.71) el pie de cocodrilo.

En San Carlos de Río San Juan supimos de la existencia de acopiadores de piel de Crocodylia por la delegación del MARENA, quien tiene una lista de los cazadores y acopiadores de la ciudad. Esta es la única Ciudad del país en donde se han realizado decomisos de pieles por parte del MARENA.

Los costos enfrentados por un acopiador en general son el envío de las pieles saladas (cinco sacos por quincena) a la ciudad de Granada, el alquiler del local, publicidad (reparación de rótulos, cuñas radiales), el salario de la persona que se hace cargo del acopio, y la compra de pieles. Los costos de envío oscilan alrededor de los C$ 250.00 (US$ 20.00) por saco de pieles, con capacidad para 100 pieles cada uno; el local tiene un valor de alquiler promedio de C$ 250.00 (US$ 20.00) mensuales, la publicidad puede tener un costo mensual de C$ 1,900.00 (US$ 150.00); estimo que el salario del acopiador puede ser de C$ 3,000.00 (US$ 230.00) mensuales; la compra de 250 pieles de caimán tiene un costo de C$ 15,000.00 (US$ 1,170.00) por semana; y la compra de 75 pieles de cocodrilo un costo de C$ 9,350.00 (US$ 735.00) semanales aproximadamente (Cuadro 1).

4.- Entrevistas con taxidermistas y curtiembres

En total entrevisté 19 propietarios de talleres de curtido de pieles de caimán y cocodrilo, y un taller de taxidermia de los mismos. Obtuve la siguiente información.

Las pieles de caimán utilizadas provienen principalmente de la RAAN, RAAS y Río San Juan, aunque también mencionaron otros sitios como Puerto Díaz, Muelle de los Bueyes, Chontales y Malacatoya. Todos los entrevistados afirmaron que aproximadamente el 90 % de las pieles proviene del Caribe del país (RAAN, RAAS y RSJ) y el 10 % restante del centro y Pacífico. De las provenientes del Caribe aproximadamente el 60 % proviene de la RAAN, 30 % de la RAAS y 10 % de Río San Juan.

Las pieles de caimán son compradas de acuerdo a la talla; las pieles de 1 a 2 pies son pagadas entre C$ 5.00 (US$ 0.39) y C$ 15.00 (US$ 1.17) cada una, las de 2 a 3 pies entre C$ 20.00 (US$ 1.57) y C$

30.00 (US$ 2.35), las 3 a 4 pies entre C$ 30.00 (US$ 2.35) y C$ 80.00 (US$ 6.28) cada una, las de 4 a 5 pies entre C$ 60.00 (US$ 4.71) y C$ 150.00 (US$ 11.79) por pieza. En tamaño superiores, la compra se realiza de acuerdo a la longitud de la piel, en este caso el pie lineal tiene un valor que oscila entre los C$ 20.00 (US$ 1.57) y C$ 30.00 (US$ 2.35).

Las pieles de Cocodrilo provienen de la RAAN, RAAS, Puerto Díaz, Tipitapa, San Francisco Libre, Tepalón y Apanás en algunos casos. La mayoría de pieles, aproximadamente un 80 %, provienen de la RAAN. Los precios de piel de cocodrilo son similares a los de piel de Caimán en las tallas inferiores a los 5 pies, a partir de esta talla, el pie tiene un valor que oscila entre C$ 50.00 (US$ 3.93) y C$ 120.00 (US$ 9.43).

Estimo que las 19 curtiembres visitadas utilizan por lo menos 20,000 pieles de caimán, pues cada una utiliza 1,200 en promedio por año, y unas 2,500 pieles de cocodrilo por año, pues en 6 de las curtiembres entrevistadas constaté la producción de artículos de piel de cocodrilo por observación directa e indagué por los volúmenes anuales, de las cuales se elaboran billeteras, fajas, fajones, zapatos, carteras, prensapelos, aros para pelo, monederos, portafolios, maletines, chequeras, bolsos, pañueleras, joyeras, pureras, binders, coquetas, tarjeteros, llaveros, cigarreras, sandalias, anteojeras y brujitas. Los artículos mencionados tienen precios variables, de acuerdo a la calidad de la piel con que se elaboran, al tamaño y a la calidad del acabado de cada producto. Si en total son 38 talleres de curtido entre Masaya y Granada, la demanda de pieles de caimán es de 40,000 pieles por año y la de cocodrilo de 5,000 pieles por año.

Los curtidores indicaron que de una piel de 3 a 4 pies pueden elaborar 2 fajas, una pañuelera o 2 billeteras; de una piel de 4 a 5 pies pueden elaborar un bolso, 5 billeteras o 4 fajas; y de una piel de 5 a 6 pies 7 fajas, dos bolsos o 6 billeteras.

Los artículos elaborados son distribuidos en los Mercados de Artesanías (viejo y nuevo) de Masaya, el Mercado Roberto Huembes en Managua, El Centro Comercial Managua y el Aeropuerto Internacional.

Visité una taxidermia ubicada en Sapoá, en la cual se disecan diferentes animales, principalmente caimán. Los individuos llevados al taller provienen de Colón y Cárdenas principalmente. El propietario compra las pieles de caimán a C$ 30.00 (US$ 2.35) el pie cuando las pieles son mayores de 4.5 pies; las pieles menores tienen un precio que varía entre los C$ 10.00 (US$ 0.78) y C$ 20.00 (US$ 1.57) por pieza. Los productos que elabora reciben el nombre de perezoso (acostado), ceniceros (caimán sosteniendo un cenicero), guitarra (caimán tocando la guitarra), entre otros menos comunes. Las tallas preparadas son principalmente menores de tres pies. Los precios de los artículos elaborados varían grandemente, dependiendo de los accesorios utilizados (cenicero, marimba, guitarra, broches, hebillas), del tamaño de la pieza, del tipo de arreglo (solitario o grupal) y de la nacionalidad del cliente (nacional o extranjero).

Los artículos elaborados en esta taxidermia son vendidos en los mercados de Masaya, el Huembes en Managua y unos 80 artículos se exportan a Estados Unidos cada mes. Este taller emplea en promedio como mínimo unas 1000 pieles por año.

Las curtiembres y taxidermias tienen un costo fijo de aproximadamente C$ 22.00 (US$ 1.74) por día de trabajo, el que incluye reparaciones de la máquina de coser (de zapatero), cuchillas, barriles, entre otros, y un costo variable de C$ 600.00 (US$ 47.78) por día incluyendo cromo, tintes, cal, hilo, pegamento, agujas, cuero de res, cebo, servicio de agua potable, impuestos a la Alcaldía, el salario del marroquinero, el dinero necesario para la contratación de dos ayudantes, el costo en que incurriría si alquilase el local y el dinero necesario para comprar pieles de ambas especies (Cuadro 1).

Si de una piel de tres a cuatro pies los marroquineros pueden producir dos fajas, y cada faja es vendida a C$ 75.00 (US$ 5.80), calculamos que de un individuo de tres a cuatro pies los marroquineros obtienen un ingreso bruto de C$ 150.00 (US$ 11.60), y necesitan vender aproximadamente diez fajas (cinco individuos) diario para cubrir sus costos fijos y variables.

5.- Entrevistas con vendedores en mercados locales

Entrevisté un total de 36 vendedores (18 en el mercado de artesanías de Masaya, 6 en el Mercado Nuevo de Masaya y 12 en el Mercado Roberto Huembes). El 95 % de los vendedores compra los artículos a los curtidores de Granada, el 5 % restante compra los productos a curtidores de Masaya. Todos los animales disecados provienen de la taxidermia de Sapoá.

Los precios de venta varían de acuerdo al mercado, al puesto de venta y al comprador: si es extranjero se vende más caro. Los compradores en su mayoría son extranjeros (70 %, n = 36) (Cuadro 2).

Cuadro 2. Precios, cantidades e ingresos generados por la venta de algunos artículos de piel de Crocodylia en los mercados nacionales de Nicaragua.

Articulo	Precio de compra (C$/US$)	Precio de venta (C$/US$)	Cantidad vendida por mes	Ingresos por día
Fajas	75.00 / 5.89	100.00 / 7.86	12	0.788
Billeteras	80.00 / 6.28	100.00 / 7.86	15	0.790
Prensapelo	5.00 / 0.39	10.00 0.78	5	0.065
Aros	15.00 / 1.17	20.00 / 1.57	10	0.133
Monederos	40.00 / 3.14	50.00 / 3.93	6	0.158
Bolsos	250 / 19.65	350 / 27.51	2	0.524
Pureras	110.00 / 8.64	200.00 / 15.72	2	0.472
Sandalias	200.00 / 15.72	350.00 / 27.51	24 pares	9.432
Anteojeras	35.00 / 2.75	45.00 / 3.53	8	0.208
Carteras	150.00 / 11.79	250.00 / 19.65	3	0.786
Disecado	150.00 / 11.79	190.00 / 14.93	4	0.419
Total				**13.775**

Tipo de Cambio Oficial: C$12.72 X US$ 1.00
n = 25 entrevistas

Cada vendedor tiene un costo fijo de C$ 65.00 (US$ 5.00) por día, que incluye los impuestos de la alcaldía y el costo de alquiler del local; además tienen un costo variables diario de C$ 370.00 (US $ 28.94), que incluye la contratación de una persona, publicidad, reparación de mobiliarios y la compra de los artículos elaborados a los marroquineros (Cuadro 1).

6.- Análisis de distribución de utilidades

La cadena comercial está compuesta por lo menos por unas 534 personas, siendo los cazadores el grupo mayoritario y los acopiadores la minoría (Fig. 1).

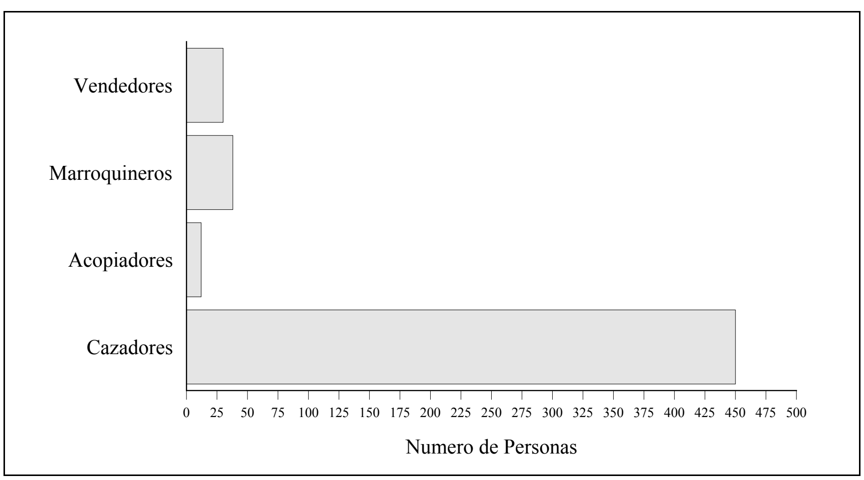

Figura 1. Estimación de la cantidad de personas involucradas en cada eslabón de la cadena comercial de aprovechamiento de los Crocodylia de Nicaragua

Los cazadores afirman cazar en promedio diez caimanes de tres o cuatro pies por noche y un cocodrilo de cinco pies por noche en la RAAN. Considerando ese volumen diario de extracción, cada cazador obtiene un ingreso bruto de C$ 450.00 (US$ 35.00) por noche de cacería de caimanes (US$ 1.17 el pie x tres pies del individuo x diez individuos cazados por noche), de los cuales debe pagar C$ 110.00 (US$ 8.47) de los costos fijos y variables, dejando una utilidad neta de C$ 340.00 (US$ 26.53) (Fig. 2).

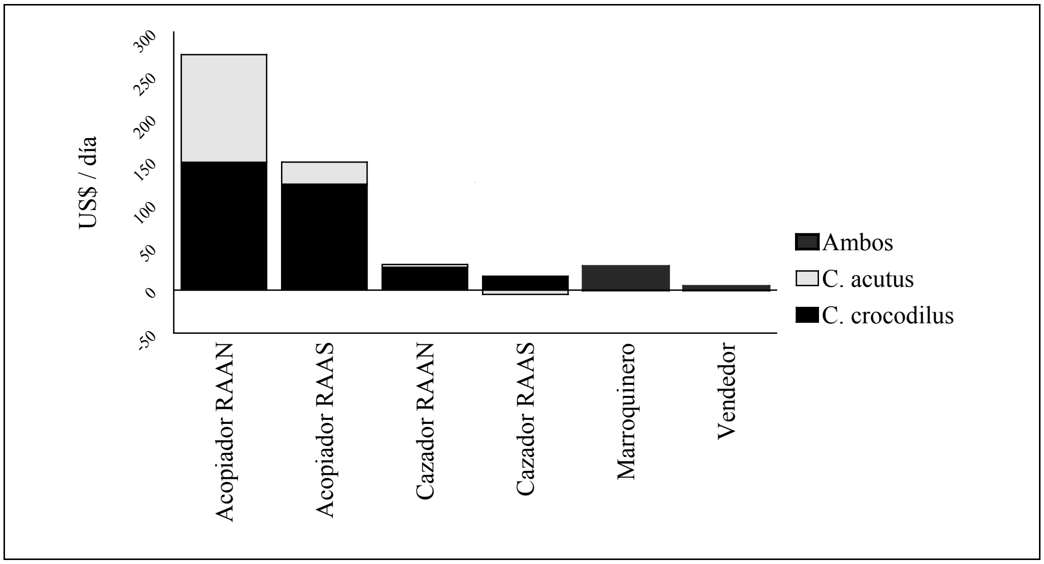

Figura 2. Distribución de las utilidades *per capita* en la cadena comercial de aprovechamiento de los Crocodylia de Nicaragua

Si el cazador caza cocodrilos el ingreso bruto sería de C$ 150.00 (US$ 11.75) por noche (US$ 2.35 el pie x cinco pies x un individuo), de los cuales, deduciendo los C$ 110.00 (US$ 8.47) de costos fijos y variables, obtiene una utilidad neta de C$ 40.00 (US$ 3.28) por noche de cacería (Fig. 2).

En la RAAS un cazador puede extraer la cantidad promedio de siete caimanes y 0.3 cocodrilos por noche, lo que según el cálculo anterior dejaría un ingreso bruto de C$315.00 (US$ 24.57) por noche. Deduciéndole los costos fijos y variables C$ 110.00 (US$ 8.47) obtuvimos un ingreso neto de C$ 204.00 (US$ 16.10) por noche de caza de caimanes. Si cazara cocodrilos, obtendría un ingreso bruto de US$ 3.5 por noche (US$ 2.35 el pie x 5 pies x 0.3 individuos por noche), y un ingreso neto de US$ -4.97 por noche de caza de cocodrilos (Fig. 2).

Un acopiador en la RAAN tiene un costo total por día de acopio de US$ 187.06 considerando la compra de 250 pieles de caimanes de cuatro pies por semana aun precio de US$ 1.17 por pie, y los demás costos fijos y variables indicados en el cuadro 1. Al vender las pieles de caimán a los marroquineros a un precio de US$2.35 el pie obtiene un ingreso bruto de US$ 2,350.00 semanal (US$ 2.35 el pie x 4 pies del individuo x 250 individuos por semana), o sea un ingreso bruto por día de US$ 335.71, de donde obtiene una utilidad neta de US$ 148.65 por día de acopio de caimanes (US$ 335.71 de ingresos – US$ 187.06 de egresos). Por la compra de 75 cocodrilos de 5 pies cada semana a un precio de US$ 1.96 el pie, más los costos fijos y variables, tiene un costo total por día de US$ 124.92. El pie de cocodrilo es vendido a los marroquineros a US$ 5.00, lo que deja al acopiador un ingreso bruto de US$ 250.00 (US$ 5.00 el pie x 5 pies x 10 individuos por día), equivalente a una utilidad neta de US$ 125.08 (US$ 250.00 de ingresos brutos – US$ 124.92 de egresos) por día de acopio (Fig. 2).

En la RAAS, un acopiador tiene un costo diario total de US$ 187.06 considerando un flujo mensual de 1000 caimanes (33 caimanes por día) a un precio de compra de US$ 1.17 el pie, y los demás costos fijos y variables (Cuadro 1). Los caimanes son vendidos a los marroquineros en US$ 2.35 el pie, lo que deja un ingreso bruto de US$ 310.20 (US$ 2.35 por pie x 4pies x 33 caimanes cada día), dejando una utilidad neta de US$ 123.14 (US$ 310.20 de ingresos – US$ 187.06 de egresos). Al acopiar 3 cocodrilos por día, el acopiador tiene un costo total diario de US$ 49.32 (3 individuos x 5 pies x US$ 1.96 el pie más los demás gastos descritos en el Cuadro 1); al vender los 3 individuos a los marroquineros a un precio de US$ 5.00 el pie, obtiene un ingreso bruto de US$ 75.00 (3 individuos x 5 pies x US$ 5.00 el pie), de lo que deducimos una utilidad neta de US$ 25.68 por día de acopio (Fig. 2).

Para un marroquinero los costos totales por día son de US$ 49.51 por acopio de caimanes y cocodrilos, pues debe hacer una inversión de US$ 9.40 para comprar un caimán de 4 pies (US$ 2.35 el pie); si en promedio cada marroquinero puede comprar 1000 pieles de caimán por año (2.7 caimanes por día) necesita invertir un total de US$ 25.38 por día (US$ 2.35 el pie x 4 pies por 2.7 individuos). Si de un caimán de 4 pies puede sacar tres fajas que tienen un valor de US$ 5.80 cada una, obtiene una utilidad neta de US$ 23.20 por caimán utilizado. Si a diario utiliza 2.7 caimanes obtiene un ingreso bruto de US$ 62.64 (US$ 23.20 por caimán x 2.7 caimanes cada día). Si de un cocodrilo de 5 pies puede sacar 4 fajas que se venden a US$ 10.00 cada una, obtendrá un ingreso de US$ 40.00 por cocodrilo; de 0.36 cocodrilos, que es lo consumido cada día, obtiene un ingreso bruto de US$ 14.4 por día, De modo que la utilidad neta de un marroquinero por trabajar las pieles de caimanes y cocodrilos es de US$ 27.53 (US$62.64 de ingreso bruto del curtido de caimán + US$ 14.4 del curtido de pieles de cocodrilo – US$ 49.51 de costos totales) (Fig. 2).

Los vendedores tienen un costo total de US$ 33.94, considerando la compra de los artículos y las cantidades de cada uno descritas en el Cuadro 2. De acuerdo a los precios de venta de ese mismo cuadro, el ingreso de un vendedor es de US$ 1,149.01 por mes de trabajo, o sea US$ 38.30 por día, equivalente a una utilidad neta de US$ 4.36 por día de trabajo (Fig. 2).

El total de los beneficios producidos por la cadena nacional de aprovechamiento es de US$ 495.38 por día, de donde el mayor porcentaje lo reciben los acopiadores de las Regiones Autónomas del Atlántico (Fig. 3).

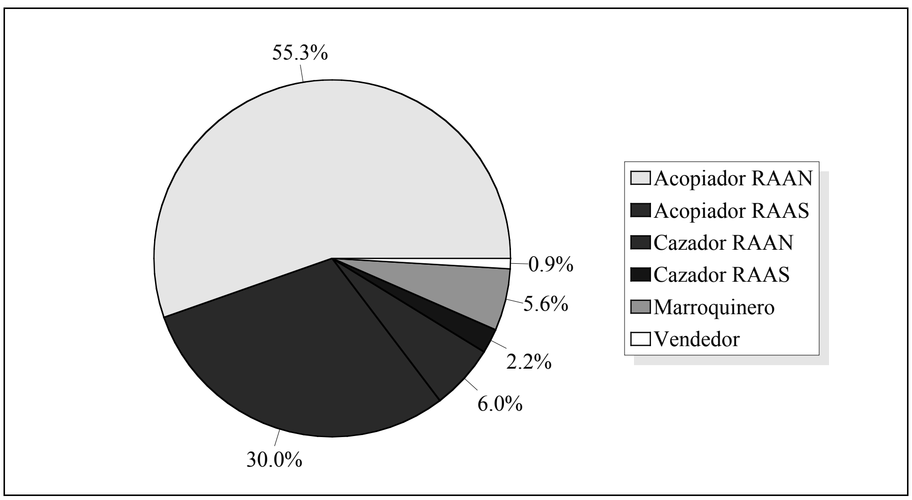

Figura 3. Porcentaje de las utilidades totales recibidos per capita por cada eslabón de la cadena comercial de aprovechamiento de los Crocodyila de Nicaragua

7.- Revisión de exportaciones

a) Oficina CITES - Nicaragua

Las exportaciones de pieles y productos de caimán se registran de acuerdo a las categorías a) Piel, b) Flanco, c) Cola, d) Vientres, e) Artículos elaborados, y f) Taxidermia. Las cantidades exportadas por año de cada categoría, según informe de CITES – Ni, se describen en el Cuadro 3. En este cuadro se puede observar los valores mayores de cada categoría utilizados para calcular el total de individuos cosechados del país con destino a exportación.

Cuadro 3. Exportación de pieles de caimán y sus productos desde Nicaragua en los últimos 10 años, según informe de Oficina CITES - Nicaragua.

Año	Piel	Flancos	Cola	Vientres	Articulo	Taxidermia	Permisos
1990	8,050*	14,000*	5,000	5,000	-	-	6
1991	4,854*	13,126	8,001*	7,489	-	-	8
1992	-	7,210*	3,432	3,294	-	-	2
1993	-	19,920	9,960*	9,624	949	-	14
1994	478*	16,882*	8,070	7,147	1,461	-	9
1995	-	8,476*	-	-	1,002	-	10
1996	-	7,590	5,650	7,000*	2,729	-	26
1997	246*	-	-	-	11,243	-	24
1998	3,282*	-	-	-	6,606	504*	-
TOTAL	16,910	87,204	40,113	39,554	23,989	504	99
Individ. Cosecha.	16,910	23,284	17,961	7,000	-	504	

Fuentes: 1) Morales 1998, y 2) Castrillo & Ramos 1999

* Datos empleados para calcular el total de individuos cosechados del país con destino a exportación según la fuente de información (los flancos solamente la mitad del valor indicado).

Los datos obtenidos de la revisión de los permisos emitidos por la oficina de CITES – Ni en los últimos diez años se resumen en el cuadro 4. En el mismo se indica el total de individuos cosechados del país con destino a exportación.

Cuadro 4. Exportaciones de pieles de caimán y sus productos desde Nicaragua en los últimos 10 años, según permisos emitidos por CITES – Nicaragua.

Año	Piel	Flanco	Cola	Vientres	Articulo	Taxidermia	Permisos
1990	8,000*	14,000*	5,000	5,000	415	0	11
1991	4,854*	14,446	8,001*	7,489	0	0	9
1992	0	18,252	9,126*	9,100	640	0	6
1993	3*	19,920	9,960*	9,626	939	0	10
1994	956*	21,338*	10,298	9,375	1,438	2*	10
1995	0	8,443*	1,743	0	0	0	2
1996	0	7,604	6,750	7,000*	2,745	0	22
1997	859*	1,610*	0	0	2,392	63*	26
1998	4,697*	0	0	0	394	118*	27
1999	1,546*	0	0	0	3	22*	25
2000**	326*	0	0	0	0	80*	7
Total	**21,241**	**106,013**	**50,878**	**47,590**	**8,966**	**285**	**148**
Individ. Cosecha.	**21,241**	**22,696**	**27,087**	**7,000**	**-**	**285**	

* Datos empleados para calcular el total de individuos cosechados del país con destino a exportación según la fuente de información (los flancos solamente la mitad del valor indicado).

** El año 2000 solo incluye los datos de los primeros 4 meses (Enero, Febrero, Marzo y Abril).

En general, el informe de CITES – Nicaragua presenta datos menores que los encontrados en la revisión de los permisos (Cuadro 4) emitidos por la misma oficina.

b) World Conservation Monitoring Centre (WCMC, Cambridge, Inglaterra)

El informe del WCMC (1998) difiere de los datos provistos por CITES y los contenidos en los permisos emitidos por la misma oficina, en cuanto a los volúmenes de exportación (Cuadro 5).

Cuadro 5. Exportación de pieles de caimán desde Nicaragua entre 1992 y 1996, según World Conservation and Monitoring Centre (1998).

Año	**Numero de pieles**
1992	20,472
1993	9,964
1994	41,446
1995	10,021
1996	22,319
Total	**104,222**
Promedio anual	**20,844.4**

Fuentes: 1) WCMC 1998; y 2) Cedeño y Drews 2000.

Los datos provistos por el WCMC son equivalentes a la cantidad de individuos cosechados del país destinados al mercado internacional. Desde esta óptica, representan un número bastante superior a los reportados en los cuadros anteriores.

c) Centro para el Trámite de las Exportaciones (CETREX, Managua, Nicaragua)

Revisé el informe de la oficina central del CETREX en Managua, del cual extraje datos de exportación de pieles de Caimán (Cuadro 6).

Cuadro 6. Exportación de pieles enteras de caimán desde Nicaragua entre 1997 y 2000,

según el Centro para el Trámite de las Exportaciones - Nicaragua

Año	**1997**	**1998**	**1999**	**2000**
Pieles de Caiman	2,041	3,521	1,640	6,552

Fuente: CETREX, Managua, Nicaragua, 2000.

Los volúmenes de exportación reportados por CETREX no coinciden con ninguno de los escenarios anteriores, siendo los datos de los años 1998 - 2000 inferiores a los indicados por las fuentes anteriores.

8.- Estimación del aprovechamiento anual de pieles de caimán

Estimamé el promedio anual de exportaciones en cuatro escenarios, el primero es utilizando los datos del informe proporcionado por CITES – Ni, en el cual obtuve el promedio sumando la cantidad de pieles y vientres, colas o flancos (empleando el que representa el mayor número de individuos cosechados del país) reportadas para cada año y realizando un promedio simple. El segundo escenario lo constituyen los datos que obtuvimos revisando los permisos emitidos por CITES – Ni, siguiendo el mismo proceso para calcular el promedio que el escenario uno. El tercer escenario emplea los datos reportados por el WCMC, de los cuales calculé un promedio simple. El cuarto y último escenario está construido con los datos de exportación reportados por CETREX. En todos los escenarios se considero el estimado anual promedio de exportaciones reportadas.

Los estimados de individuos cosechados por año en el país se presentan en el cuadro 7.

Cuadro 7. Caimanes cosechados anualmente de Nicaragua con destino a la exportación, según cuatro diferentes fuentes de información.

Año	**Informe Cites**	**Permisos Cites**	**Wcmc**	**Cetrex**
1990	15,050	15,000	-	-
1991	12,855	12,855	-	-
1992	3,605	9,126	20,472	-
1993	9,960	9,960	9,964	-
1994	8,919	11,627	41,446	-
1995	4,238	4,422	10,021	-
1996	7,000	7,000	22,319	-

Año	Informe Cites	Permisos Cites	Wcmc	Cetrex
1997	246	1,727	-	2,041
1998	3,786	4,815	-	3,521
1999	-	1,568	-	1,640
2000	-	406	-	6,552
TOTAL	65,659	78,506	104,222	13,754
PROMEDIO	7,295	7,136	20,844	3,438

Fuentes: 1) Morales 1998; 2) Castrillo y Ramos 1999; 3) CITES – Ni 2000; 4) WCMC 1998; 5) Cedeño & Drews 2000; 6) CETREX 2000

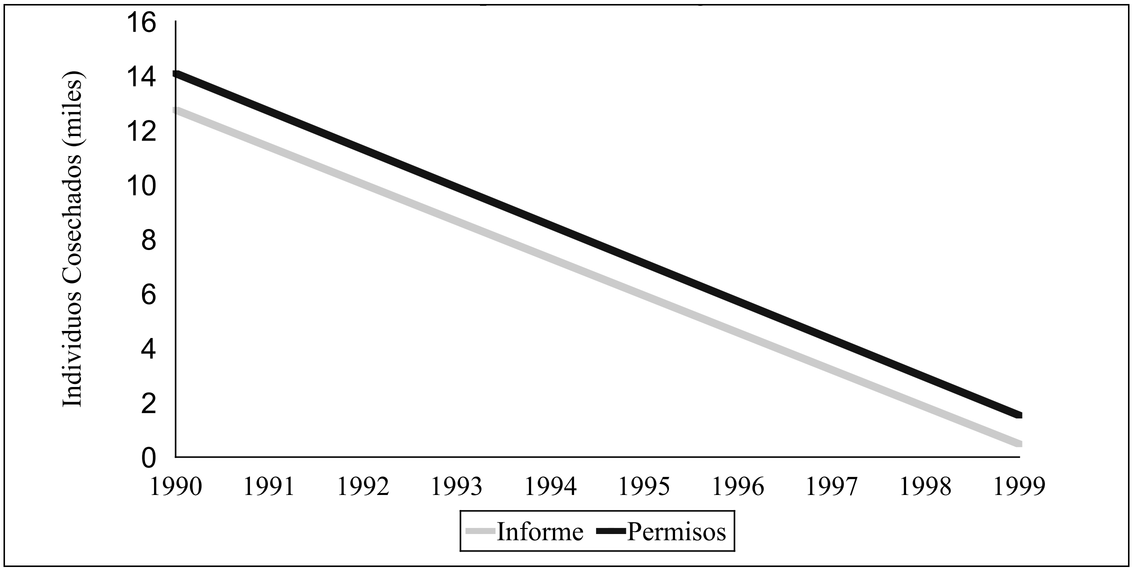

Figura 4. Tendencia anual de la cosecha de individuos destinados a la exportación en Nicaragua
Fuentes: (1) Informe oficial de la oficina CITES – Nicaragua, 1997;
(2) Revisión directa de permisos para exportación emitidos por CITES – Nicaragua, 2000

El mínimo estimado de pieles de Cocodrilo utilizadas cada año es de 5,000 de acuerdo a la información provista por los marroquineros. No se reportaron exportaciones, ya que el cocodrilo es Apéndice I de CITES, lo que restringe su comercialización.

La tendencia de cosecha de individuos con destino a exportación es negativa, siendo la tasa anual de 1363 individuos según los datos del informe de CITES, y de 1395 individuos según los datos de los permisos emitidos por CITES (Fig. 4). Lo que indica que cada año se cosechan del país alrededor de 1300 individuos menos, con destino a la exportación.

DISCUSION

1.- Marco legal

La norma legal de mayor importancia para el aprovechamiento de los Crocodylia del país es la cuota de aprovechamiento establecida, la cual se encarga hasta la fecha, de limitar la cantidad de pieles que salen del país. Sin embargo no existe una capacidad local, por parte de las autoridades, para poder regular el comercio nacional de Crocodylia, lo que hace bastante difícil el cumplimiento de las normas establecidas.

La temporada de veda establecida para el caimán es una de las medidas tomadas por el gobierno que va en beneficio de la conservación de esta especie, pues los caimanes son cazados durante la época seca, de febrero a junio, en la cual anteriormente se permitía la cacería. La reproducción de esta especie tiene lugar en el territorio nacional a partir de mayo. La veda anterior permitía la caza de caimanes en la época pre reproductiva, por lo que estaba reduciendo el número de reproductores, y consecuentemente el potencial de reclutamiento de las poblaciones de esta especie.

En Nicaragua se tiene cierto control sobre el comercio de pieles de Caimanes hacia el exterior, sin embargo no se controla en lo absoluto el comercio nacional.

En el caso de los cocodrilos, la veda indefinida establecida no se aplica realmente, pues pude constatar la compra de pieles de esta especie por los acopiadores y marroquineros, así como la compra de artículos elaborados por los vendedores en los mercados locales.

2.- Situación de los cazadores

La gran mayoría de los cazadores de Crocodylia son habitantes de humedales ubicados en zonas remotas del país, en donde una de las fuentes de ingresos es la venta de animales silvestres y sus derivados. A pesar de ser una actividad que puede ser contraproducente para las poblaciones de éstos reptiles, la cacería es una actividad que deja cierto lucro a familias campesinas de escasos recursos económicos. Una buena parte de los cazadores entrevistados, practicaban la actividad por necesidad económica, lo que hace muy complicado la toma de decisiones al respecto, pues son muchas las familias que dependen económicamente de la cacería o el comercio de productos de los mismos.

La época de veda establecida perjudica a los cazadores pues prohibe la cacería en los meses de menor pluviosidad, meses en los que la cacería es mucho más fácil.

El lagarto es una especie muy codiciada por los cazadores, pues se paga a un precio mucho mayor (las pieles grandes) que el caimán, lo que hace que la cacería de este reptil sea altamente rentable en la RAAN, sin embargo en la RAAS, dada la escasez de esta especie, la renta disminuye, pues es necesario invertir más tiempo en la búsqueda que en la RAAN.

3.- Acopiadores

Los acopiadores de pieles son los que reciben el mayor beneficio de todos los involucrados en el comercio de pieles de Crocodylia. Dada la gran cantidad de pieles que suelen transportar en cada viaje, los costos económicos de la actividad se diluyen, y las ganancias por día de acopio aumentan.

La mayoría de acopiadores se encuentra en la RAAN, lo que puede significar que en esa región haya una mayor cacería y por ende mayor producción de pieles, o que los acopiadores de la RAAS tienen el capital suficiente como para funcionar a gran escala, limitando las oportunidades para pequeños empresarios interesados.

4.- Curtidores y Taxidermistas

Los curtidores y taxidermistas son uno de los eslabones más importantes en la cadena comercial, pues son los últimos en recibir la piel entera, y por donde pasan todas las pieles que se destinan al mercado nacional.

Están ubicados principalmente en la Ciudad de Granada, lo sugiere que el curtido de pieles y la elaboración de productos artesanales más que un negocio es una tradición que se ha transmitido por generaciones, pues Granada ha sido desde mucho tiempo atrás el sitio en donde se curten cueros de Crocodylia y se elaboran productos artesanales de los mismos. A diferencia, en León se curte solamente cuero de res. Algunas nuevas curtiembres han aparecido en Masaya, pero curiosamente éstas contratan trabajadores de Granada, pues no hay conocimiento de las técnicas para la actividad en el departamento.

Muchos de los curtidores y taxidermistas manifestaron en las entrevistas el problema de la reducción de la cantidad de pieles o de las tallas suministradas cada año. Ellos mismos hacen referencia a pieles enormes y en mayores cantidades hace 10 años, lo que les preocupa de sobre manera, pues “se están quedando sin materia prima”.

5.- Problemática de la venta de artículos en los mercados nacionales

Los vendedores hicieron referencia a una serie de problemas que los afectan diariamente. Uno de ellos es que los extranjeros, quienes poseen el mayor poder adquisitivo, no quieren comprar los productos, pues se lamentan de la crueldad que han hecho a los animales. Otros no compran los artículos por temor a que se les decomisen en los aeropuertos por donde transitan. Algunos vendedores se lamentan de que los precios deseados por los compradores son demasiado bajos, por lo que la actividad cada día es menos rentable.

6.- Registro de CITES

La oficina de CITES emite permisos de exportación según las solicitudes que reciba, sin embargo, las exportaciones no siempre se llevan a cabo. Existe entonces una cantidad de permisos emitidos que no finalizan en la exportación del cargamento. Probablemente esta razón contribuye a la diferencia entre las cantidades de pieles exportadas reportadas por CITES y el WCMC.

Los datos reportados en el segundo escenario (revisión de permisos) son conservadores, pues no consideran la cantidad de individuos cosechados en el país destinados a la exportación como producto elaborado. De la misma manera, no incluye los datos de reexportaciones, lo que garantiza que la estimación está por debajo de lo que realmente se cosecha en el país destinado a la exportación.

7.- Informe del WCMC

El informe del WCMC hace referencia a varias subespecies *de Caiman crocodilus* que no están reportadas para Nicaragua, lo que nos sugiere que son pieles reexportadas desde nuestro país. Estas están incluidas dentro del cálculo de individuos cosechados realizado con los datos provistos por esta fuente de información, sin embargo, en la revisión de permisos de CITES no consideré las reexportaciones, lo cual puede explicar la diferencia.

8.- Aprovechamiento anual.

La cantidad total de aprovechamiento de pieles está dada por la sumatoria de pieles exportadas y pieles utilizadas en el mercado nacional. La estimación basada en los datos de revisión de permisos emitido por CITES es la estimación más consistente, pues pude constatar personalmente la cantidad de pieles exportadas cada año. En este caso, el análisis para obtener un estimado de la cantidad mínima aprovechada (Cuadro 8) es bastante conservador, pues el promedio anual de individuos cosechados en el país no incluye los datos de reexportaciones, permisos anulados u otras posibles fuentes de error.

Cuadro 8. Caimanes cosechados anualmente de Nicaragua de acuerdo a cuatro escenarios de información

ESCENARIO	CITES 1	CITES 2	WCMC	CETREX
CURTIEMBRES	40,000	40,000	40,000	40,000
TAXIDERMIA	1,000	1,000	1,000	1,000
INFORME CITES	7,295			
PERMISOS CITES		7,136		
WCMC			20,844	
CETREX				3,438
Total	**48,295**	**48,136**	**61,844**	**44,438**

Estoy seguro de que tanto los curtidores como los acopiadores comercian con una mayor cantidad de pieles, tanto de caimán como de Cocodrilo que las reportadas en la entrevista, pues ninguno de ellos quería aparentar ser un "depredador irresponsable", es decir, tengo plena seguridad que los datos que nos proporcionaron, y que utilicé en los análisis de este documento, son inferiores a la realidad para las dos especies.

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Protección de las Poblaciones Amenazadas del Cocodrilo Americano *Crocodylus acutus* en el Parque Nacional Cañón del Sumidero, Chiapas, México, durante el Año 2001.

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RESUMEN: Con el apoyo del FWS, realicé en 2001 actividades para la conservación del cocodrilo americano en este parque nacional. Hice 11 censos mensuales y contabilicé 28.7 cocodrilos en promedio (min.13 y máx. 49) en una distancia de 15 km. Calculé la densidad en 3.26 cocodrilos /km. Agrupé a los cocodrilos observados de acuerdo a la longitud total en milímetros en seis clases cada 600 mm excluyendo neonatos. Obtuve la siguiente proporción: CI: 14.28%, CII: 28.57%, CIII: 26.53%, CIV: 10.20%, CV: 16.32% y CVI: 4.08%. Encontré seis nidos, cuatro de ellos fueron depredados durante la incubación y dos eclosionaron naturalmente, marqué 19 de estos neonatos. Recapturé 30 cocodrilos y aprecié un 23% de sobre vivencia de cocodrilos liberados en años previos. Aprecié que la población de cocodrilos se incrementa por el manejo que hacemos de huevos y crías, pero es lamentable que la depredación de nidos sea tan alta (66%). El componente social del proyecto lo abordé mediante un taller con los guarda parques y otro con las cooperativas de paseos turísticos en lancha. Para incrementar la divulgación de las actividades de conservación, realicé en conjunto con la Unidad de Difusión del ZOOMAT un cuadernillo, un cartel y un video.

A New Ranching Program for *Caiman latirostris* in Formosa Province, Argentina

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ABSTRACT: Following the success of the *Caiman latirostris* ranching program in Santa Fe Province, there is a new project developing in Formosa, Northern Argentina. Formosa is limiting in the North with Paraguay through the Pilcomayo River; in the South, with Chaco Province through the Bermejo River; in the West with Salta Province; and in the East, also with Paraguay trough the Paraguay River. There are reports on well established populations of both *Caiman latirostris* and *Caiman yacare* all over the Province.

The project will basically follow the techniques used in Santa Fe, but with some practical differences, because the scale of the work. As an example, we will perform workshops and courses to the local inhabitants, in order to teach them the basic principles for the harvest of the eggs. On the other hand, due to the fact that both species live in almost the same environments, and that it is not possible to differentiate the nests in between, harvest of eggs of the two species will be carried out.

This year (2002) we will start with the monitoring program of the wild populations, in order to also evaluate not just the situation of the species in the wild, but the real potential of eggs harvest there.

The *Caiman latirostris* Ranching in Santa Fe: A Sustainable Use Program

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ABSTRACT: The sustainable use of wild animals and plants of commercial interest, leading to economic benefit and the stimulus of *in situ* conservation, clearly is, nowadays, the realistic approach to conserving natural ecosystems. The Proyecto Yacare, which have been carried out for the last 10 years, stands as an example of that being possible. Proyecto Yacare aims to achieve sustainable use of the wild wetlands of Northern Santa Fe in Argentina, through caiman ranching, benefiting the local inhabitants who are usually employees of the cattle ranches. There is a team of 10 people who work on different aspects of the biology of the broad-snouted caiman including reproduction, growth, and feeding habits in the wild. They are also working on an ecotourism project where tourists can take part in the field work such as night counting and catching animals in the wild for the different research activities. Transport is usually by horseback as this is the only way to get around much of the region.

When the project started, the broad-snouted caiman was considered technically extinct in the Province of Santa Fe, and those who eventually found an animal in the wild would kill it immediately through fear. Today, thanks to the communication of the work, and to the transfer from Appendix I to Appendix II of CITES, which occurred in 1997, Santa Fe commercialises caiman skins, nationally and internationally, its meat is sold in restaurants, and it is possible to see the animals very near populated areas without people disturbing them. Since its beginning, Proyecto Yacare has released 12,000 juveniles into the wetlands of Santa Fe, and some of them, are now healthy breeders in the wild. The most important thing is the detected population recovery and the commitment of the local residents and landowners to the protection of the natural ecosystems, from which eggs are harvested, generating income and sustainability of the programme. Right now there are over than 3,500 caymans reared a year for the commercial program, but it is scheduled to increase significantly that number for the next season.

The Commercialization of *Caiman crocodilus* Skins Coming from Venezuela

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The Program of Commercial Use of *Caiman crocodilus* (Baba) in Venezuela begins in the year 1983, allowing the crop of individuals coming from the natural populations of the Venezuelan plains (Velasco & De Sola, 1999), for obtaining skin and meat. Among the years 1993 at 1997 its implements a similar program in the Orinoco Delta, with the same goals and managed to the indigenous and rural communities.

The commercialization of the skin at domestical level is carried out for vests, piece made up of two flanks united by the intermandibular section, sale that is carried out among the owners of the ranches that obtain a license of commercial hunt and the tanneries or their representatives. These harden the skin in crosta and they market those at international level the flanks and measured in squared foot.

Venezuela like a party country integrantre of the Convention on the International Trade of threatened species of Fauna and Flora Wild (CITES), has the commitment of presenting a annually report before the Secretariat on the international trade of the fauna and flora in the country that contains the statistics of the exports, imports and re-exports of the especímeneses or their products allowed by the Convention.

One of the utilities of these reports is to know the tendencies of the international trade of the different species and their products which are the main countries buyers of the raw material, as well as the monitoring of the production levels and their bid and ask at world level.

These annual reports once correspondents to the CITES Secretariat who later on remits them to the World Conservation Monitoring Center (WCMC), institution that organizes and it takes the statistics of the trade of the fauna and wild flora at world level.

This information is available and reflective the statistics of the international trade, with base to that reported by each integral country of the CITES Convention. However differences are observed when the information is revised offered by WCMC and the national reports, like in the case of Venezuela for the species *Caiman crocodilus* (Babas).

The present work consists of the revision of all the annual reports on the trade of the wild fauna and of its products, presented before the CITES Secretariat for the Ministry of the Environmental and Natural Resources of Venezuela, analyzing the Cayman crocodilus flanks exports, from the year 1994 up to the 2000 (MARN 1995, 1996, 1997, 1998, 1999 and 2000).

In Venezuela have been harvested until the year 2000, in 17 years of the Baba program in the inundables plains and 5 years in of the Orinoco Delta, approximately about 1,153,488 animals, equivalent to 2,306,976 flanks (table 1).

Table 1. Caiman skins and flanks harvested in Venezuela.

Year	Skins Harvested Plains	Flanks Harvested Plains	Skins Harvested Delta	Flanks Harvested Delta	Total Skins Harvested	Total Flanks Harvested
1983	2,319	4,638			2,319	4,638
1984	85,233	170,466			85,233	170,466
1985	231,453	462,906			231,453	462,906
1986						

Year	Skins Harvested Plains	Flanks Harvested Plains	Skins Harvested Delta	Flanks Harvested Delta	Total Skins Harvested	Total Flanks Harvested
1987	92,530	185,060			92,530	185,060
1988	169,878	339,756			169,878	339,756
1989	126,662	253,324			126,662	253,324
1990	86,365	172,730			86,365	172,730
1991	133,392	266,784			133,392	266,784
1992	18,682	37,364			18,682	37,364
1993	23,147	46,294	274	548	23,421	46,842
1994	25,621	51,242	915	1,830	26,536	53,072
1995	48,592	97,184	2,837	5,674	51,429	102,858
1996			5,025	10,050	5,025	10,050
1997	59,882	119,764	4,605	9,210	64,487	128,974
1998	15,139	30,278			15,139	30,278
1999	8,112	16,224			8,112	16,224
2000	12,825	25,650			12,825	25,650
Total	**1,139,832**	**2,279,664**	**13,656**	**27,312**	**1,153,488**	**2,306,976**

Of the total of flanks taken place by Venezuela, they have been exported to the international market about 2,219,508 flanks, what represents 96.23% of the Babas production in Venezuela (table 2), the difference 87,468 flanks has been used in the domestic trade.

These results contrast with that reported by Asley (1998) and Ross (1998) where the quantities differ considerably of the analysis of the trade annual reports, presented by Venezuela before the CITES Secretariat (table 2).

Table 2. *Caiman crocodilus* flanks exported by Venezuela

Year	Flanks exported	Skins exported	Skins Ashley 1998	Skins Ross 1998
1983				
1984	103,221	51,610.5		3,487
1985	211,787	105,893.5		125,566
1986	251,026	125,513	128,095	128,095
1987	128,025	64,012.5	73,990	73,990
1988	173,159	86,579.5	224,650	224,650
1989	194,850	97,425	170,347	170,347
1990	285,209	142,604.5	204,206	204,206
1991	168,640	84,320	117,687	117,687
1992	141,363	70,681.5	123,594	123,594
1993	84,840	42,420	87,314	87,314
1994	110,633	55,316.5	73,909	54,038
1995	99,880	49,940	65,856	55,195
1996	52,692	26,346	32,108	29,996
1997	73,645	36,822.5		
1998	67,991	33,995.5		
1999	25,238	12,619		
2000	47,309	23,654.5		
Total	**2,219,508**	**1,109,754**	**1,301,756**	**1,398,165**

The reasons to these differences can be several, just as Ross the expressed thing in 1998:

1. Errors, mis-reporting and poor records in both production estimates and MENTIONS export reports. It i unclear why such errors would be so consistently in the direction of an excess of exports.
2. Introduction of illegal skins into trade within the country of export. E.g. illegal wild skins claimed ace farmed and issued false documents and tags.
3. Introduction of illegal skins into trade from other sources which decetively claim to be from the country. E.g. illegal skins from country X presented with false documents and tags indicating from country Y.
4. Double (Multiple?) reporting of re-exported legal skins. E.g. skins from Venezuela exported to USES, re-exported to Italy reported on Italian reports ace" origin Venezuela.." with legal documents and VZ tags and therefore counted twice in you MENTION reports ace exported from Venezuela.

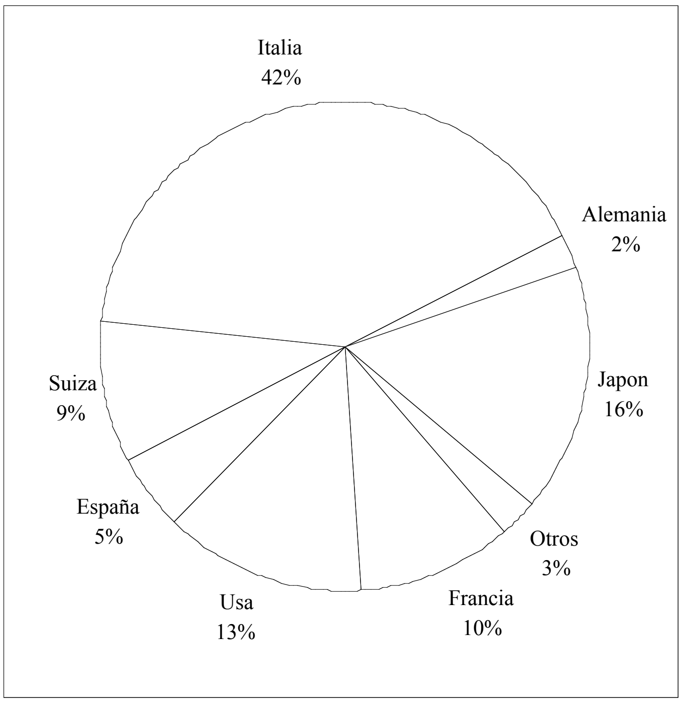

Figure 1. Countries imported *Caiman crocodilus* flanks.

The main countries that have cared Babas flanks from Venezuela are: Italy (42%), Japan (16%), it USA (13%) and France (10%) (figure 1), the rest composes it Switzerland, Spain, Germany, Panama, England, Singapore, Thailand, India, Honk Kong and Colombia.

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Cria en Condiciones Controladas del *Crocodylus Acutus* (Cuvier 1807), en la Granja C.I. Caicsa S.A. en la Región Caribe de Colombia

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ABSTRACT: A partir de un plantel parental fundador constituido por cuatro ejemplares silvestres (dos machos y dos hembras), capturados mediante un permiso de caza de fomento otorgado por las autoridades ambientales de Colombia y que se mantuvieron aislados en reproducción hasta 1996 cuando se obtuvo la segunda generación filial F2, se conformó el actual plantel reproductor (81 hembras y 21 machos) y se obtuvieron hasta finales de 2001 un total de 3791 individuos. El nivel medio de natalidad alcanzado correspondió al 78% de los huevos puestos anualmente por las hembras, determinado por la infertilidad y la mortalidad embrionaria. Los valores de mortalidad muestran una alta variación (5% a 58%) y poca correlación con la edad; esta se asocia y explica tanto por las condiciones de manejo, incluyendo la disponibilidad de infraestructura, como por el normal proceso de aprendizaje e implementación de un sistema de manejo apropiado y eficiente.

Se prevé que entre los años 2002 y 2006 la granja podrá operar con cinco corrales de reproducción; nuevos grupos de reproductores podrían constituirse con los restantes ejemplares que ya han alcanzado 6 a 8 años de edad y que pertenecen a la primera generación filial de la granja. Así entonces, el grupo de parentales estará constituido como mínimo por 102 ejemplares, los cuales se mantendrían hasta que se puedan constituir nuevos grupos de reproducción con los ejemplares de la F2. En la actualidad se tramita el registro de la granja como “Establecimiento de Cría en Cautividad con Fines Comerciales de Especies Animales del Apéndice I de CITES” y conjuntamente con otras dos granjas que trabajan igualmente con *C. acutus* en Colombia, se está diseñando una estrategia con el objeto de mejorar su actual estado de conservación.

First record of Sexual maturity in wild farm released *Caiman latirostris* (Crocodylia : Alligatoridae)

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ABSTRACT: Sexual maturity is one variable in population dynamics, and a useful data for recovering population programs such as Proyecto Yacare, however there is few works about age at sexual maturity in crocodilians. Available information about age of first reproduction in *Caiman latirostris* is scare, only two papers were recently published, but they refereed to captive animals in São Paulo, Brazil. Since 1990, Proyecto Yacare (*Caiman* Project), have been working recovering wild population in Santa Fe province, Argentina using Ranching technique. Following hatching, Caimans are marked in the caudal scutes (referring to hatching year and nest of origin). Hatchlings are raised in concrete pools until November, so animals are keep, at most, nine months in captivity, and then reintroduced in the same place where the eggs were collected. During summer 2001-2002, we have captured seven age-known females at their nests with a snare. All seven females are part of the released stock of *Caiman latirostris* from Proyecto Yacare. Four females have constructed the nest in savanna habitat, the remaining in forest habitat. Once cough, females were measure to the nearest cm in total length (TL) and weighed with 0.1 kg precision scale (BM). Once in the laboratory, we weighed clutch and calculated average egg mass (clutch weight / clutch size; precision 0.05 kg). In this study we tested if females Body mass (BM), Total length (TL), Clutch mass (CM), Clutch size (CS), and Egg mass (EM) were different among habitats. We also tested CS of the seven females and a subset (31 nests) from the total nests harvested in the season (N = 196). Of the seven females five were nine years old, the remaining were ten. Females in this study have the same BM, TL, CM, CS, and EM among habitats. CS of the seven age known females was similar to a subset of data from the same season of unknown age females. Female age at sexual maturity was the same previously reported, nine years for *C. latirostris*, but those animals were keep in captivity. In order to start breeding *C. latirostris* should be at least four years old, and weight at least 12.4 kg. This is the first report of wild reproductive female age of broad snouted caiman.

Use of DNA Analysis to Study Early Embryonic Mortality in Florida Alligators

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ABSTRACT: Reduced viability of Alligator eggs has been observed in some lakes from central Florida. Although eggs from these lakes have measurable concentrations of organochlorine pesticides and PCBs, the relationship between egg viability and contaminants is unclear. In order to determine if undeveloped ("unbanded") eggs are the result of non-fertilization or early embryonic mortality, DNA from blastodisks of these eggs was compared to DNA of females captured at the nest. Differences in DNA composition between an adult female and its clutch would indicate a paternal genetic contribution, and thus that fertilization has occurred. A preliminary study conducted in 1999 using microsatellite analysis, found that 4 of 5 nonviable eggs/clutches from Lake Apopka had evidence of fertilization. During 2000, a total of 157 blastodisks (24 clutches) were collected from Lakes Apopka and Griffin and from Emeralda Marsh, and their DNA profiles compared to those obtained from blood of females captured at the nest. Preliminary microsatellite analyses of blastodisks indicate these eggs were fertilized, suggesting that developmental failure was the result of early embryonic mortality. Early embryonic mortality could be the result of exposure to environmental contaminants, and/or to alterations in egg structure and composition. (Funded by NIEHS-SFBRP).

The Effectiveness of Using Topical Treatments of Alligator Eggs for Contaminant Studies

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ABSTRACT: In order to study the effects of contaminants on embryo survival of oviparous species, the contaminant must enter the egg in some manner. One such method is to paint the egg with a solution containing the chemical under study in a solvent that will facilitate absorption through the shell. Although several studies have used this method to expose developing embryos to different chemicals, very few have verified exposure after treatment. We applied a 65 μl solution of either DDE (0.4, 4, 40 ppm) or dieldrin (0.04, 0.4, 4 ppm) in DMSO to the surface of 30-day old alligator eggs. Controls were either painted only with DMSO, or not treated at all. Two yolks/treatment were analyzed for each pesticide 10 days post-application. The remaining eggs were artificially incubated, and hatch rates compared among treatments. Although the technique proved to be safe in that it induced low mortalities in the controls (72% hatch rates, compared to 68% from the treated eggs), absorption into the yolk was poor. Only eggs from the highest doses contained concentrations above background (1.4 ppm DDE and 0.3 ppm dieldrin). We conclude that this method of treating eggs does not produce good absorption of contaminants into the egg. (Funded by ACC & NIEHS-SFBRP).

Alligator Surveys at the A. R. M. Loxahatchee National Wildlife Refuge, Florida, USA

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ABSTRACT: Alligators are a conspicuous feature of the Arthur R. Marshall Loxahatchee National Wildlife Refuge and are considered a keystone species in the Everglades. Relative abundance of alligators is an attribute that will be measured as a means of tracking the responses of the Everglades to restoration activities. The natural variability and the appropriate temporal and spatial scale for assessing responses of an attribute must be known in order for the attribute to be useful in measuring responses. Evaluation of historic and current data provides the basis for understanding natural variability and predicting future responses.

Historic data on alligators at the refuge consists of narrative accounts in annual reports, sporadic alligator surveys conducted in the canals during the 1960s, regular surveys conducted in the canals from 1979-1987, and regular surveys conducted in canal and marsh habitats from 1998 to the present.

Preliminary results indicate that water level and water temperature are important in explaining relative abundance in the canals and water levels and survey distance are important in the marsh. These data and the results of this study will be used for evaluating and assessing responses of alligators to planned and implemented changes in hydrology that will occur with Everglades restoration.

Gharial Conservation in Nepal: First Results of a Population Reinforcement Program in the Narayani River, Royal Chitwan National Park

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ABSTRACT: Two species of the family Crocodylidae are found in Nepal: The marsh Mugger*, Crocodylus palustris*, and the freshwater Gharial, *Gavialis gangeticus*. The gharial has a long and extremely slender-snout. The adult male gharial with a skull length exceeding 60cm develops a large cartilaginous protuberance on the end of its snout which is resembles to a clay pot called ghara in Northern India. Thus, among all the crocodilian species, the gharial is the only one who exhibits sexual dimorphism (Maskey and Schleich, 2002). It is listed as endangered in National Parks and Wildlife Conservation Act 1973 of Nepal and on Appendix I of CITES. Gharials are specialised fish-eaters. At present, the population are distributed in isolated remnant areas in the Karnali, Babai, Narayani and Sapta Kosi river systems of Nepal. All habitat areas are located inside or adjacent to protected areas. The population of Gharial in the Sapta Kosi River is very low numbering about 10. According to an estimate by Department of National Parks and Wildlife Conservation the gharial numbers in wild (about 80-120) and captivity (about 200).

Since 1981, the "Gharial Conservation Project" was initiated in Royal Chitwan National Park, Kasara to ensure the long term crocodile conservation in Nepal. Till now more than 500 gharials have been released in Karnali, Babai, Narayani and Koshi rivers to sustain their population in its former habitats. In order to achieve efficient management and long term survival of this endangered species, a solid knowledge on the biological and ecological requirements is needed. For the long term conservation of this species, a monitoring program has been designed in collaboration with the Ferme aux Crocodiles, Pierrelatté (France), the CEPA (Conservation des Espèces et des Populations Animales) and Department of National Parks and Wildlife Conservation, Nepal. To achieve this objective we released ten new gharials in Chitwan with radio-telemetry since March 2002.

Keywords: Gharial, *Gavialis gangeticus*, threats, monitoring, restocking

INTRODUCTION

Nepal is more often mentioned for its famous snowy summits, rather than its sub-tropical plains called the Terai. Nevertheless, half of the population of the country lives today on this narrow earth band fertilised since millenniums by waters descending from the Himalayas that runs for more than 800 kilometres between the Indo-Nepal border and the mountains. Today some parts of these areas are protected as the National Parks and Wildlife Reserves. Royal Chitwan National Park (RCNP) is one of them, which was identified as the priority area in the Terai for conservation of important faunal elements, particularly One-horned rhinoceros (*Rhinoceros unicornis*), Royal Bengal Tiger (*Panthera tigris*) Asian Elephant (*Elephas maximus*) and Gharial (*Gavialis gangeticus*).

Species studied

The subfamily Gavialinae is represented by a single species, the Gharial. The adult male gharial developed a large protuberance of connective tissues on the end of its snout which is resembled to a clay pot, locally known as ghara in Northern India. Thus, the name of this species derived from the presence of ghara. The large protuberance on the end of the male's snout is generally considered to be sexual characteristics of very large animals, although it is not obviously present in all males. Its function is apparently a visual sex indicator, a sound resonator, or as a special structure for bubbling and spouting during sexual behaviours (Martin and Bellair, 1977).

Beside the saltwater crocodile, it is considered as one of the largest living crocodilians (adults up to 6-7m) in the world. Of all living crocodilians, this species is the most closely bound to its aquatic environment because its legs are weak and not well-suited to walk on land. It only hauls itself out of the water on exposed sand banks to bask, to build its nest, and to lay its eggs. On the other hand, its broad oar-like tail helps propel this species in the water, making it highly mobile in an aquatic environment. It is typically a resident of deep, fast flowing rivers, preferring areas where the water current is low (Whitaker and Basu, 1983).

The gharial appears to be primarily a fish-eating species, but some time a large adult individuals were observed eating wild ducks in the Narayani River. Gharials are predictably synchronised nesters in Nepal. All clutches were deposited between March and April. Female gharial lays 10 – 60 eggs in the Narayani River (Maskey, 1989).

Threats

Reasons for the decline of the gharials are largely attributable to the construction of dams for hydroelectric power and irrigation. These dams create abnormally high water during the monsoon which floods practically all nests near the dams. The use of large seines and gill nets in the major rivers of Nepal not only have reduced the fish population, (gharial's major food) but also caused direct mortality to gharial because of entangle in their expensive nets. The third measure cause of population decline is the poaching of gharial eggs by the local communities for its medicinal and food values.

Conservation program

The gharial is one of the most endangered among all crocodilians (Table 1). However, unlike the other seven most endangered crocodilians, gharial conservation programs are now in place over much of its range. The species was literally brought back from the brink of extinction by restocking programs initiated in India (1975) and in Nepal (1978). Gharial eggs were collected from wild nests for captive raising and released them back into the main rivers of India and Nepal. In India, over 3,000 juveniles have been released at 12 sites mainly in the Gangese drainage (Chambal, Ramganga, Girwa and Sharada rivers). The follow-up surveys of released gharials indicates overall increase in the total wild population which has levelled off since 1990 as the number of available sites have become filled. Current wild population is estimated to be more than 1,500 individuals of which about 1,000 are found in the Chambal River with around 64 nest a year at 15 different sites (Rao and Singh 1994).

Table 1. Gharial status

CITES	Appendix 1
IUCN Red List (1996)	Endangered
Principal threats	Habitat destruction Limited distribution

In Nepal, gharials are restricted to remnant populations in the Karnali, Babai and Narayani rivers (all tributaries of the Ganges). Despite, the captive rearing program which has released more than 500 juvenile gharials since 1978 in the different rivers, the present population estimated about 100 wild individuals (Maskey and Percival 1994).

Our team, supported by La Ferme aux crocodiles of Pierrelatte (France) in collaboration with the Conservation des Espèces et des Populations Animales (C.E.P.A.) and the Department of National Parks and Wildlife Conservation (DNPWC), tried to investigate the reasons of the disappearance of the last gharials (*Gavialis gangeticus*).

During the monsoon season (between June and September), the flooding of the rivers and the continuous rains render monitoring impossible. During winter, the level and the temperature of water facilitate the observation of the crocodiles on the sand bank because of their basking behaviour. In the month of November 2001, we counted only around fifty individuals, solitary or in small groups disseminated along the river, revealing the poor health of the wild population.

Since 1981, approximately 140 young animals originating from the Gharial Conservation Project were released in Narayani and Rapti rivers. In the past, the released gharials were monitored over a short period during the research work carried out by one of the author (T. M. Maskey). No systematic monitoring was carried out after that. After our first expedition in the Narayani River, we envisaged to monitor the released gharials with telemetry to collect the systematic data on the movement of released gharials in the Narayani River.

Monitoring of Released gharials

In March 2002, after three months of our first expedition in the Narayani River, we selected 10 young gharials (2 males and 8 females) from the Gharial Conservation Program, Kasara and were measured, marked with notches and were implanted with INDEXEL® radio-transmitters furnished by MÉRIAL (Table 2). They were also equipped with electronic chips using an individual frequency. All young gharials were first placed into an acclimatisation enclosure prepared near Almatari in the Narayani River. One week later, the marked gharials were released into the Narayani River.

Table 2. Release gharials characteristics

Notch number	Sex	Weight (in kg)	Length (in cm)	Age (in years)
1	female	22	208	9
2	male	22.5	210	9
3	male	20.5	201	9
4	female	19	204	9
5	female	10	156	7
6	female	23.5	208	9
7	female	15.5	181	9
8	female	18	185	9
9	female	14.1	172	9
10	female	11	163	7

We started our monitoring after lift off of temporary acclimatisation enclosure in the Narayani River. During first month of monitoring, we found three individuals remained at proximity of the acclimatisation enclosure site. The six other gharials went rapidly in different direction, up and down the river. Four individuals seemed to let them be transported by the river current and went further down stream in the direction of Tribenighat. By the end of March, the gharials moved more than 25 kilometres downstream from the release site (Figure 1).

Since we are not able to stay for longer period in Nepal, we trained rangers from the Royal Chitwan National Park and several guides from the Tiger Tops Jungle Lodge to keep on the monitoring of released gharials. Our objective was to keep on locating each animal at least once a week. We plan to return twice a year (before and after the monsoon) during the two years equivalent of the life of the radio transmitters.

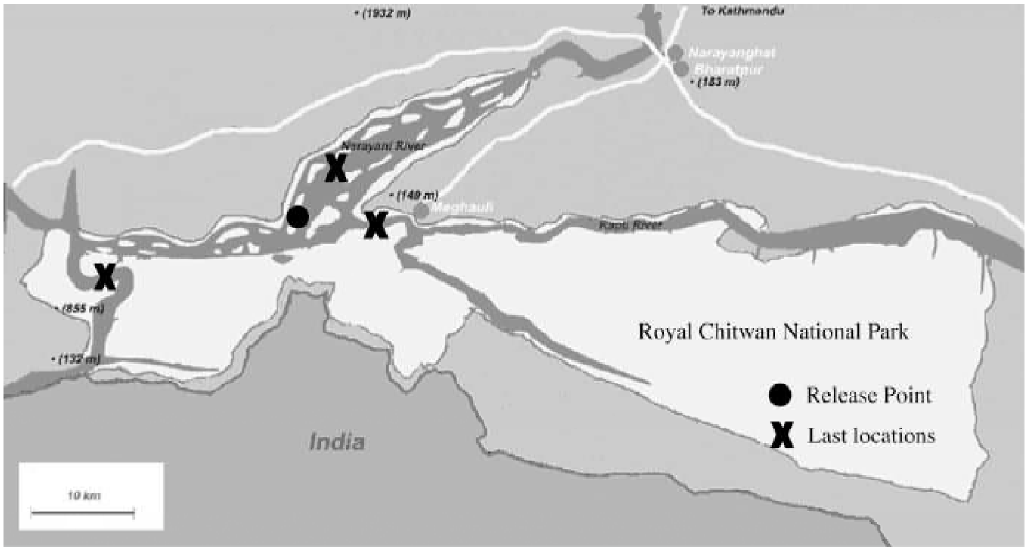

Figure 1. Map of the release site with the extreme gharial locations one month after.

During the short period monitoring of released gharials in Narayani River, we observed most of them moving downstream of the river and finally move to the river in India. Since the populations share its habitat between Nepal and India, it is necessary to strengthen the bilateral coordination between India and Nepal for long term survival of gharial in the Narayani and Gandak river of Nepal and India. A joint survey (especially for Nepalese released gharials, which can cross the frontier), is recommended to study the trends of the gharial population in the transborder area of the Narayani River. This will help to design a long term conservation and management strategy of gharial in the Transborder area.

ACKNOWLEDGEMENTS

We wish to express our sincere thanks to Dr F. Huchzermeyer (Chairman of the Veterinary Science of the Crocodile Specialist Group) and Dr H. Schleich (Amphibian and Reptile Conservation of Nepal) for their encouragement to carry out this research program. We also like to thank equally the Rangers of the Gharial Conservation Project and the Tiger Tops naturalists team for keeping up the monitoring program of the released gharials. We are also grateful to T. Culoma (Art Dental Design) for fixing the transmitters.

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Conservation Status of *Crocodylus acutus* and *Crocodylus moreletii* in Bahia de Chetumal and Rio Hondo, Quintana Roo, Mexico Preliminary Results

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ABSTRACT: According to the Status Survey and Conservation Action Plan for Crocodiles of the IUCN, projects on Mexican crocodilians have high priority, particularly those focused on the status of wild populations. Because of the lack of a base line information about the conservation status of crocodiles in the study area, I started this project, which represent the thesis to get de degree of Master in Sciences at El Colegio de la Frontera Sur (ECOSUR). The objectives are in order to assess the current population status of the American and Morelet´s crocodiles (*Crocodylus acutus* and *C. moreletii*, respectively), through determining population structure (both by sex and class ages), relative abundances, distribution and habitat use in Chetumal bay and Rio Hondo. This bay and the Rio Hondo, its main tributary, have been identified as critical for regional biodiversity conservation and belong to the Mesoamerican Biological Corridor. Preliminary results from spotlight counts and mark and recapture surveys, conducted from February to September 2002 are presented. Final results will be the start point to establish a long term monitoring program as well as a management plan for crocodilians and their habitat in the area.

INTRODUCTION

According to the Status Survey and Conservation Action Plan for Crocodiles of the IUCN, projects on Mexican crocodilians have high priority, particularly those focused on the status of wild populations (Ross, 1998). Because of the lack of a base line information about the conservation status of crocodiles in the study area, I started this project in order to assess the current population status of the American and Morelet´s crocodiles (*Crocodylus acutus* and *C. moreletii*, respectively), through determining distribution, population structure (both by sex and size classes), relative abundance and habitat use in Chetumal bay and Rio Hondo. These crocodile species are included in the Appendix I of CITES, the IUCN Red List 1996, and the list of threatened species of the Mexican law on protected species. Preliminary results from spotlight counts and a capture-mark-recapture program conducted from February to September 2002 are presented. Final results will be the start point to establish a long term monitoring program for estimation of population trends as well as a management plan for crocodilians and their habitat in the area.

METHODS

Systematic nocturnal surveys were conducted during the reproductive season and after hatching, from February to September 2002, aboard of a 15 feet boat equipped with a 15 HP outboard motor. A total of 17 locations were surveyed in the Chetumal bay (natural reserve "Manatee Sanctuary") and its main tributary, the Rio Hondo, which have been identified as critical for the regional biodiversity conservation and belong to the Mesoamerican Biological Corridor (Fig. 1).

A team of two observers, one annotator and a boat driver conducted the surveys. Night spotlight counts (Bayliss, 1987; King et al, 1994; Messel et al., 1981;Thorbjarnarson, 1988; Woorward and Marion 1978) were done on established survey routes to determine relative densities in each location. The distance in km of each survey route as well as the the spatial and temporal distribution of crocodiles were documented and mapped using a GPS and the ArcView GIS 3.1 software. Total length of sighted crocodiles was estimated to determine population structure by size class. When possible we captured animals and took standard measurements, sex, weight and marked them (both by attaching numbered metallic tags and by cutting tail crests). Wary animals we could not approach close enough as to determine species and estimate size class were recorded as "Eyes Only". The size classes were established according to the criteria proposed by Sigler (1988), based on the total length in cm:

Size class		Species	
		Crocodylus acutus	*Crocodylus moreletii*
I	(hatchlings and young)	<60	<50
II	(younger juveniles)	60.1-120	50.1-100
III	(older juveniles)	120.1-180	100.1-150
IV	(subadults)	180.1-240	151.1-200
V	(reproductive adults)	>240.1	>200.1

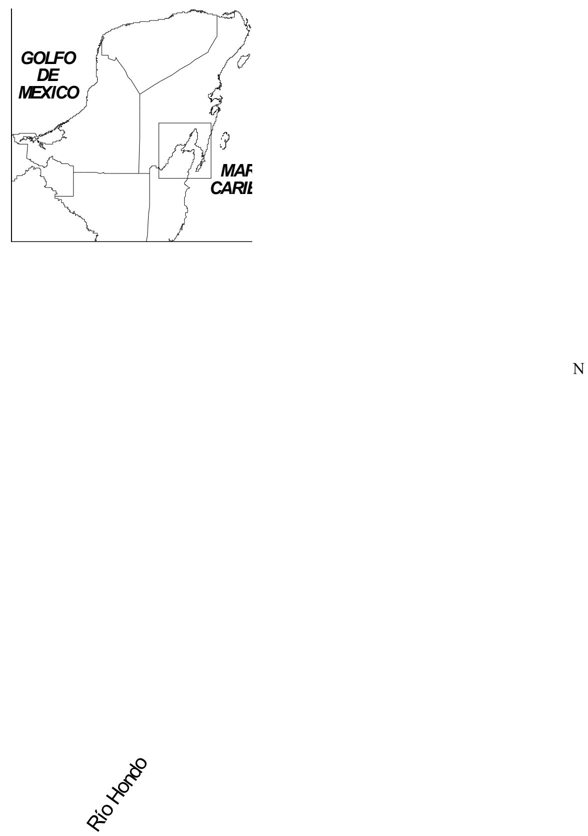

Figure 1. Study area and survey locations:1. Rio Hondo, 2. Tres Rios swamp, 3. Chile Verde lagoon, 4. Laguna Guerrero stream and creeks, 5. Rio Cacayuc, 6. Chac Chili creek, 7. Jas creek, 8. Rio Creek, 9. Siete Esteros creek, 10. Punta Calentura, 11. La Aguada, 12. Canecax lagoon, 13. Bacalar Chicolagoon , 14. Zaragoza channel, 15. Cementerio lagoon, 16. X-Calak lagoon y 17. Rio Huach lagoon.

RESULTS AND CONCLUSIONS

Distribution

On the basis of incidental deaths and captures (Cedeño-Vázquez, 1999) as well as reconnaissance trips realized in April and December 2001, the presence of both crocodile species had been verified in the area (Fig. 2).

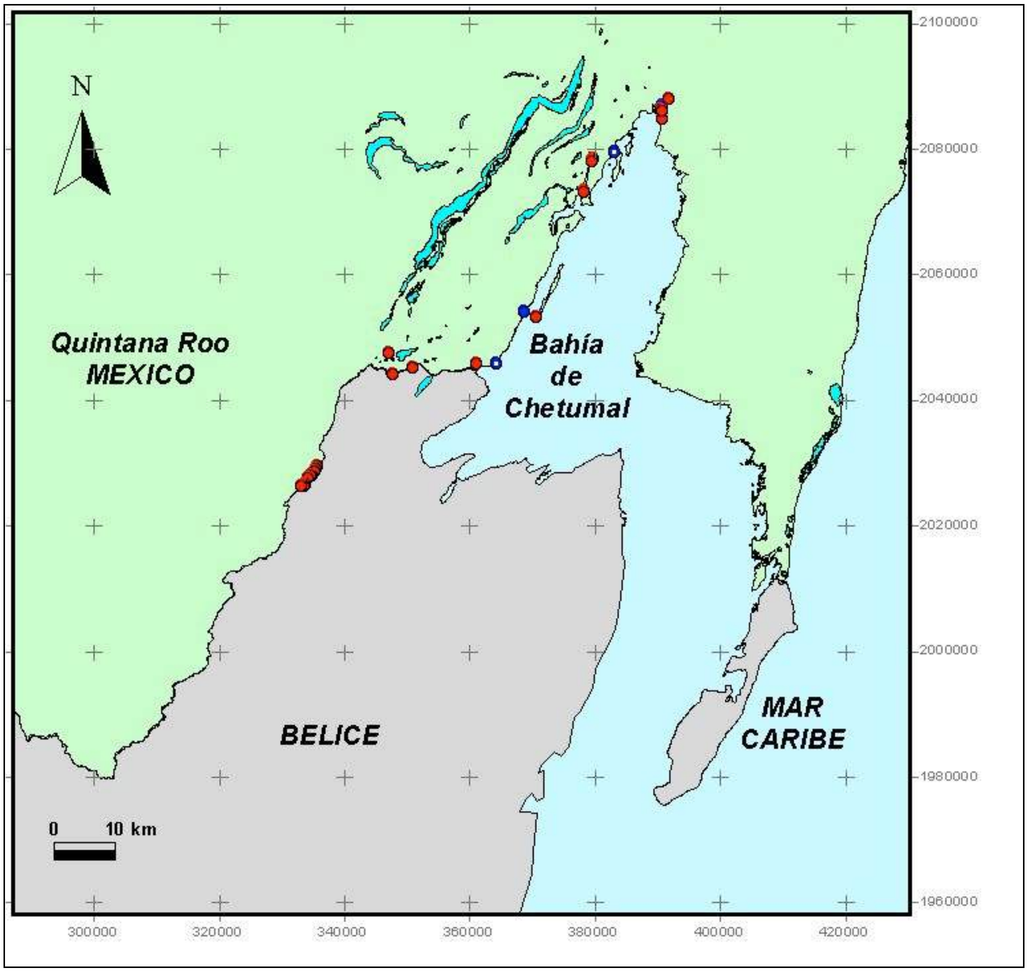

Figure 2. Preliminary records of *Crocodylus acutus* (black circles, those with clear center correspond to dead animals) and *C. moreletii* (gray circles) in Chetumal bay and Rio Hondo.

During the surveys realized from February to early September 2002, a total of 773 crocodiles were recorded in the study area (49 *C. acutus*, 711 *C. moreletii* and 12 individuals not identified), which are spatially distributed as showed in the Figure 3. Results indicate that these sympatric species overlap only in the creeks located on the northern portion of the Chetumal bay, with a dominance of *Crocodylus moreletii* over *C. acutus* judging by their numbers. While *C. moreletii* inhabits inland locations characterized by freshwater (1-3 $‰_o$) such as Rio Hondo and Tres Rios swamp, *C. acutus* occupies the costal area where salinity is higher (14-38 $‰_o$).

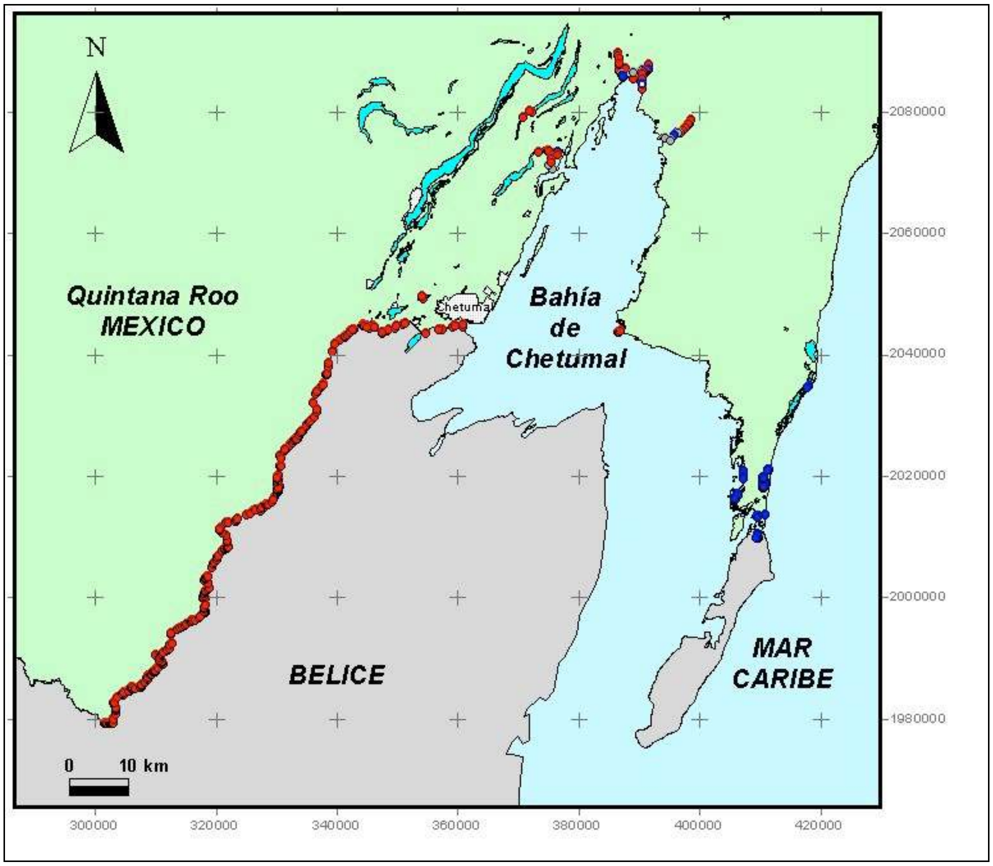

Figure 3. Distribution of *Crocodylus acutus* (black circles) and *C. moreletii* (gray circles) in Rio Hondo, Chetumal bay and surrounding areas.

Population structure

According to the results the population structure by size class (Table 1), presence of all ages indicate that current populations tend to reach a healthy status; however, *C. acutus* shows a slower recuperation possibly due to its older reproductive age compared to *C. moreletii*. Presence of three groups of *C. moreletii* hatchlings in the September survey confirms the existence of active reproductive adults in the population.

Sexual ratio of captured animals of *C. acutus* is close to 1:1, whereas in *C.moreletii* males dominate in classes I and II, close to 1:1 in class III, and in classes IV and V ratio is 1:1 (Table 2).

Table 1. Records of crocodiles on the Rio Hondo, Chetumal Bay and surrounding areas

Location	Survey	Species	Sizeclasses						CAPTURES		Total
			I	II	III	IV	V	E.O.	Females	Males	COUNTS
	1) March-April	*C. moreletii*	21	32	21	14	9	60	11	16	157
1. Río Hondo	2) May	*C. moreletii*	16	51	41	32	24	19	10	18	183
	3) August	*C. moreletii*	5	36	42	23	16	19	9	16	141
	4) September	*C. moreletii*	26	28	41	27	22	14	12	33	158
	1) February	*C. moreletii*		3	1			1	2	2	5
2. Tres Ríos swamp	2) May	*C. moreletii*	1	2					2	1	3
	3) September	*C. moreletii*	6		1			1	2	3	8
3. Chile Verde lagoon	1) February	*C. moreletii*		1	1	1					3
	1) June	*C. moreletii*		1	3	2			1	1	6
4. Laguna Guerrero stream	2) July	*C. acutus*			1				1		1
and creeks		*C. moreletii*	1	4	2	1			3	3	8
5. Río Cacayuc	1) April (2001)	*C. moreletii*		2			1	2	1		5
	2) June										
	1) February	*C. moreletii*	1		1	1			1		3
								1			1
	2) June	*C. moreletii*	1		1	1			1	1	3
6. Chac Chilí creek								2			2
		C. acutus				1			1		1
	3) July	*C. moreletii*	1		1				1	1	2
								3			3
		C. acutus			0	1					1
7. Jas creek	1) February	*C. moreletii*		1			1				2
								2			2
	2) June							1			1
	1) April (2001)	*C. acutus*			1						1
		C. moreletii		3	1	1					5
		C. acutus			1				1		1
8. Río Creek	2) June	*C. moreletii*		1	2	3			2		6
								3			3
	3) July	*C. acutus*				2					2
		C. moreletii			4	1			3	2	5
		C. acutus			1				1		1
	1) June	*C. moreletii*	1	1	1	2			3	1	5
9. Siete Esteros creek								1			1
		C. acutus			1				1		1
	2) July	*C. moreletii*	1	3	2				4	2	6
								2			2
10. Punta Calentura	1) July	*C. moreletii*		1	1	1	1		2	1	4
	1) February	*C. acutus*			2	1		1	2		4
11. La Aguada	2) June										
	3) July										
	1) April	*C. acutus*		1		1	1	1	1	1	4
12. Canecax lagoon	2) June										

Location	Survey	Species	Sizeclasses						CAPTURES		Total
			I	II	III	IV	V	E.O.	Females	Males	COUNTS
	3) July										
13. Bacalar Chico lagoon	1) June	*C. acutus*			2	1				1	3
	2) July	*C. acutus*						2			2
14. Zaragoza channel	1) June	*C. acutus*			2				1	1	2
	2) July	*C. acutus*			1	1				1	2
	1) April	*C. acutus*	1		2	1		1			5
15. Cementerio lagoon	2) June	*C. acutus*			4	1	1	2		3	8
	3) July	*C. acutus*		2	5			1	1	1	8
	1) Abril	*C. acutus*			1						1
16. X-Calak lagoon	2) June	*C. acutus*			1						1
	3) July										
17. Río Huach and Santa Cecilia lagoon	1) June	*C. acutus*			2				1	1	2

E.O. = "Eyes Only", correspond to wary individuals that did not allowed to estimate class size and species identification

Table 2. Structure by size classes and by sex of captured crocodiles (*n*=183).

	Crocodylus acutus			*Crocodylus moreletii*		
Class	**females**	**males**	**Total**	**females**	**males**	**Total**
I (hatchlings and young)	0	0	0	13	36	49
II (younger juveniles)	0	1	1	21	33	54
III (older juveniles)	7	6	13	16	18	34
IV (subadults)	1	2	3	11	11	22
V (reproductive adults)	1	0	1	3	3	6
Total	**9**	**8**	**18**	**64**	**101**	**165**

Abundance

In the study area abundance indices are low (0-1 crocodiles_km^{-1}) to medium (2-10 crocodiles_km^{-1}) (scale by Ross, unpubl.) (Table 3). According to local inhabitants, this corresponds to an increase (more remarkable in *C. moreletii*) of the populations, probably as a result of the hunting ban decreted in the 70's and respected in the area from the early 80´s.

Table 3. American and Morelet´s crocodiles observed during spotlight surveys

Location	Distance km	Survey	*C. acutus*	*C. moreletii*	Encounter rate Crocodiles/km	
					C. acutus	*C. moreletii*
1. Rio Hondo	105.7	1	0	157	0.00	1.48
		2	0	183	0.00	1.73
		3	0	141	0.00	1.33
		4	0	158	0.00	1.49
2. Tres Rios swamp	0.9	1	0	5	0.00	5.55
		2	0	3	0.00	3.33
		3	0	8	0.00	8.80
3. Chile Verde lagoon	13	1	0	3	0.00	0.23
4. Laguna Guerrero creeks	9.5	1	0	6	0.00	0.63
		2	1	8	0.10	0.84
5. Río Cacayuc	17	1	0	5	0.00	0.29
		2	0	0	0.00	0.00
6. Chac Chilí creek	4.5	1	0	4	0.00	0.88
		2	0	5	0.00	1.11
		3	1	5	0.22	1.11
7. Jas creek	4.2	1	1	4	0.23	0.95
		2	0	1	0.00	0.23
		3	1	5	0.22	1.11
8. Río Creek	4.5	1	1	9	0.22	2.00
		2	2	5	0.44	1.11
9. Siete Esteros creek	7.5	1	1	6	0.13	0.80
		2	1	8	0.13	1.06
10. Punta Calentura	0.9	1	0	4	0.00	4.44
11. La Aguada	8	1	4	0	0.50	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
12. Canecax lagoon	3	1	4	0	1.33	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
13. Bacalar Chico lagoon	3.7	1	3	0	0.81	0.00
		2	2	0	0.54	0.00
14. Zaragoza canal	1.5	1	2	0	1.33	0.00
		2	2	0	1.33	0.00
15. Cementerio lagoon	4.5	1	5	0	1.11	0.00
		2	8	0	1.77	0.00
		3	8	0	1.77	0.00
16. X-Calak lagoon	3.5	1	1	0	0.28	0.00
		2	1	0	0.28	0.00
		3	0	0	0.00	0.00
17. Río Huach lagoon	8.5	1	2	0	0.23	0.00

AKNOWLEDGEMENTS

Janneth Padilla Saldivar elaborated the maps. I specially thank my thesis committee: Perran Ross, Sophie Calmé and Eloy Sosa, and all the persons involved in this study, most of them as volunteers. The Secretaría de Marina, Armada de México through the Sector Naval of Chetumal helped with personnel and boats. This project is funded by the Consejo Nacional de Ciencia y Tecnología (CONACYT), El Colegio de la Frontera Sur (ECOSUR) and the Wildlife Preservation Trust International (WPTI). Idea Wild provided part of the equipment and supplies. Permits were awarded by the Secretaria de Desarrollo Urbano y Medio Ambiente (SEDUMA/052/2002) and by the

Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) through the Subsecretaria de Gestion para la Protección Ambiental and the Direccion General de Vida Silvestre (OFICIO NÚM/SGVS/DGVS/2850).

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Effects of Release Date on Survival of Farm-Raised American Alligators

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ABSTRACT: Juvenile farm-raised American alligators (*Alligator mississippiensis*) were tagged and released in Louisiana to maintain wild populations in areas with egg collection programs. Survival rates of alligators released in April and August in a freshwater marsh were compared by determining the number of tags of released alligators that were in stomachs of wild adult alligators taken in the release area during a September harvest. Of 1,962 alligators released in April, tags from 29, (1.48%) were recovered the first September after release and 7 (0.35%) were recovered the second September. Of 1,035 August releases, tags from 35 (3.38%) were recovered the first September after release and 22 (2.12%) were recovered the second September. The second year recovery rate was considered an indication of the proportion of the released alligators still alive at the beginning of the second year. The second year recovery rate of alligators released in August was 6.0 times greater than the recovery rate of alligators released in April.

INTRODUCTION

Collection of eggs of the American alligator (*Alligator mississippiensis*) from the wild on private lands began in Louisiana 1986. In order to maintain wild populations in areas with egg collection programs, state regulations initially required that a portion of the alligators hatched in captivity from wild produced eggs (ranched) be returned to the wild when they reached 1.2 m total length (TL), which was at approximately 20 months of age. This percentage was derived from the proportion of wild hatchlings surviving to 1.2 m TL (Taylor and Neal 1984). In 1992, a sliding scale was developed that allowed for return of alligators from 0.9-1.5 m TL with the return rate based on the proportion surviving at those sizes as reported by Taylor and Neal (1984) and extrapolated for sizes between 0.9 m and 1.5 m.

State regulations required that farm-raised alligators be released between March 15 and August 25. Farm-raised alligators are subject to heavy predation from adult wild alligators in the release area (Chabreck et al. 1998). The time of release of the farm-raised alligators could affect their vulnerability to predation because wild alligators do not feed aggressively during cold weather (October-March) (Rootes et al. (1991). Farm-released alligators have not developed predator avoidance skills before release, but may develop such skills after release if they are able to escape predation. Consequently, we hypothesize that farm-raised alligators released in April, at the beginning of the feeding period for wild adult alligators, would have a higher predation rate than farm-raised alligators released in August, at the end of the wild alligator feeding period. Farm-released alligators that survive until October would have until April of the next year to gain some predator avoidance skills before wild adults begin their aggressive feeding period.

The study was funded by the Louisiana Agricultural Experiment Station, Louisiana Sea Grant College Program, the Gheens Foundation, Inc., Louisiana Department of Wildlife and Fisheries, The Louisiana Land and Exploration Company, Williams Inc., McIlhenny Company, Avery Island Inc., E.A. McIlhenny Enterprises Inc., and Sweet Lake Land and Oil Company Inc. We are grateful for their contribution to the study. The assistance of B. Addison, D. Bossert, B. Crain, C. Chance, H. Robichaux, R. Moertle, and students at Louisiana State University and Nichols State University is greatly appreciated.

METHODS

The study was conducted in LaFourche Parish, Louisiana, on the 20,235-ha Golden Ranch Plantation (GRP) located approximately 33 km southwest of New Orleans. The study area was located in freshwater marsh and consisted of approximately 50% open ponds and 50% marsh. Pond depths ranged from 30-90 cm. The intensive study area contained 23 km of canals that were approximately 3 m deep and 15 m wide, and approximately 25 km of ditches about 1 m deep and 2 m wide.

Farm alligators released into the wild as part of the egg collection program were sexed, tagged and measured by personnel of the Louisiana Department of Wildlife and Fisheries and released in GRP in April and August of 1991 and 1993. In 1991, farm alligators had 1 monel tag, which was attached to the webbing of a hind foot. In 1993, farm-released alligators were tagged in the webbing of one front foot and one hind foot.

The survival rate of farm alligators can be evaluated based on the recovery of farm alligator web tags from stomachs of wild adult alligators captured during an annual September harvest program (Chabreck et al. 1998). Adult alligators were captured by trappers using baited hooks and were harvested throughout GRP where farm alligators were released. All harvested alligators were marked with a numbered tag; and after each animal was skinned, stomachs were removed from alligators $\geq$2.2 m TL, and the contents were visually inspected for web tags. Stomach contents were then radiographed with standard x-ray equipment to locate tags not found during visual inspections.

We assumed that the number of farm alligators cannibalized by larger alligators was proportional to the number of farm alligators present We compared the proportion of April and August releases of tagged farm alligators cannibalized by comparing the number of tags from juvenile farm alligators tagged and released in 1991 and 1993 and recovered from predator alligator stomachs from 1991-1994. We used a series of 2 x 2 contingency tables to test the null hypothesis that the portion of tags of April releases of farm alligators recovered did not differ from the proportion of tags of August releases that were recovered.

Most web tags are eventually expelled from the stomach of a live alligator by regurgitation (Chabreck 1996). Consequently, the number of tags from April and August releases that were present in stomachs of predator alligators taken the first September after release would vary because of tag loss. Therefore, we used the tag recovery rate during the harvest of the second September after release as an index of the number of farm-released alligators still alive at that time. We assumed that all tags present in alligator stomachs would be lost by the beginning of the second year when wild adult alligators began aggressively feeding.

RESULTS AND DISCUSSION

Of 1,962 farm-raised alligators released in April, tags from 29 (2.48%) were recovered from stomachs of adult alligators the first September after release. Of 1,035 August releases, tags from 35 (3.38%) were recovered from stomachs the first September after release (Table 1).

Table 1. Number of farm-raised alligators released on Golden Ranch Plantation, Louisiana, during April and August and the tag recovery rate after Year 2

Month released	Number released	Number recovered	Number recovered	
		Year 1	Year 2	After Year 2
April	1962	29	7	0.35%
August	1035	35	22	2.12%

April releases of farm alligators were subject to predation for 5 months before the September harvest of adult wild alligators at GRP. August releases were subject to predation for only 1 month before the wild harvest. The proportion of April 1991 releases (1.36%) that were recovered in September 1991 did not differ (P>0.05) from the proportion of August 1991 releases (2.61%) that were recovered. However, in 1993 the first September recovery rate of August 1993 releases (3.92%) was greater (p<0.01) than the recovery rate of the April 1993 releases (1.56%). This indicates that the tag loss from stomachs of predator alligators was very large and that most of the tags retained from the April releases of 1991 and 1993 were from farm-released alligators eaten shortly before the first September harvest.

Because wild alligators in Louisiana normally do not feed from October through March, a 6-month period, most tags would have been lost by the time they resumed feeding in April. Therefore, the adult wild alligators would have had an opportunity to cannibalize April and August releases of farm-raised alligators for 5 months during the second year after their release and prior to the second September harvest. The tag recovery rate from stomachs should serve as an index to the proportion of April and August releases of farm-raised alligators still alive at the end of the second year after release.

Of the 1,962 farm-raised alligators released in April, tags from 7 (0.35%) were recovered from stomachs of adult alligators the second September after release. Of 1,035 August releases, tags from 22 (2.12%) were recovered the second September after release (Table 1). The second September recovery rate of August farm-released alligators was 6.0 times greater (P<0.01) than that of the April releases. This indicates that the proportion of August releases of farm-raised alligators that survived to the end of the second summer after release was over 6 times greater than the proportion of April releases to survive to same period.

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GIS Application on Data Base of Baba (*Caiman crocodilus*) Program in Venezuela

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ABSTRACT: GIS was applied to a database produced by the Program of Management of Baba (*Caiman crocodilus*) in Venezuela since 1991 to 2000. The database was built with harvests and population censuses recorded in geo-positioned farms located in seven ecological regions located in southwestern Venezuela. It includes number of harvested skins classified by industrial size classes, densities of animals estimated in surveys, type of farm accordingly to its land surface, and ecological characteristics of water bodies. The series of obtained thematic maps on harvests and densities, allows a historical spatial vision of the development of the Program results during its application. The areas with extraction of large skins for each ecological region showed a reduction since 1998 to 2000. The Ecological Regions Bajo Apure and Hoya de Arismendi presented the highest historical densities. Cumulative data since 1992 to 2000 allows establish general population trends in a spatial view.

RESUMEN: Se aplicó SIG a una base de datos producida por el Programa de Aprovechamiento de la Baba (*Caiman cocodrilus*) en Venezuela desde 1991 a 2000. La base de datos se construyó con las cosechas y censos poblacionales registrados en fincas geo-posicionadas, ubicadas en siete regiones ecológicas al suroeste de Venezuela. Incluye el número de pieles cosechadas clasificadas por clases de tamaño industriales, densidades de animales estimadas en censos, tipo de finca de acuerdo a su superficie de terreno, y características ecológicas de los cuerpos de agua. La serie de mapas temáticos obtenida con las cosechas y densidades, permite una visión histórica del desarrollo del Programa durante su aplicación. Las áreas con extracción de pieles grandes para cada región ecológica mostraron una reducción desde1998 hasta 2000. Las regiones ecológicas Bajo Apure y Hoya de Arismendi presentaron los valores históricos más elevados de densidad. Los datos acumulados desde 1992 hasta 2000 permiten establecer tendencias poblacionales generales en una vision espacial.

INTRODUCTION

GIS relates geo-positioned locations on digital cartographic images with an associated database, allowing interactive achievement of a full description of the attributive database used to develop the system. Use of Geographical Information System (GIS) as a tool for spatial studies of crocodilians, including its biology, distribution, restoration, monitoring, modeling among other applications, have been recently transformed in one of the most efficient support for design and control of sustainable management programs (Miller et al. 1998, Campbell 1999). In this way, any population or descriptive information can be obtained directly from the thematic map. The present work describes the development of GIS application for the Program of Rational Use of the Baba Species (*Caiman crocodilus*) of the Ministry of Environment (MARN) in Venezuela.

METHODS

An attributive database containing information from all the farms involved in the Program since 1991 to 2000 was prepared, including land surface, cartographic position and location in the ecological regions defined by MARN: Aguas Claras, Alto Apure, Bajo Apure, Cajón of Arauca, Hoya of Arismendi, Llanos Boscosos and Guárico (Velasco & Ayarzaguena 1995).

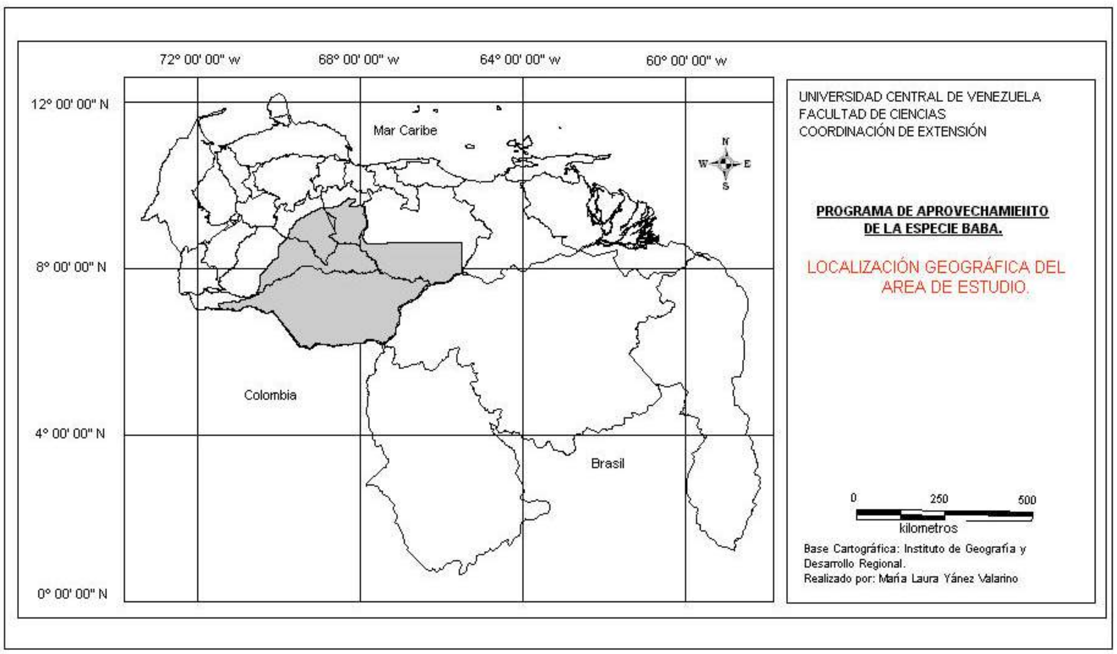
Ranches and farms participating in the Program were classified accordingly to their land surface. The number of harvested skins assigned for each ranch or farm is included, classified by industrial classes of size since 1981 to 2000 (Velasco & De Sola 1999); also, results of population censuses with estimations of density (number of counted babas / land surface in hectares), abundance and size structure in classes, type of water body, and environmental characteristics of habitat (border and aquatic vegetations) are included. Monitoring of population was performed during 1992, 1995, 1996, 1998, 1999, and 2000 to estimate wild population's densities and size classes. These results were grouped in three periods (1992, 1996 y 2000) in which all the ecological regions were surveyed (Colomine *et al*. 1996, Velasco *et al*. 1997 (1, 2), Colomine *et al.* 2000, Villarroel *et al*. 2000).

The database was applied to a Geographical Information System MAP-INFO to prepare thematic maps on farm location, harvests and estimated densities.

RESULTS AND DISCUSSION

NOTE: maps in text can be distorted.

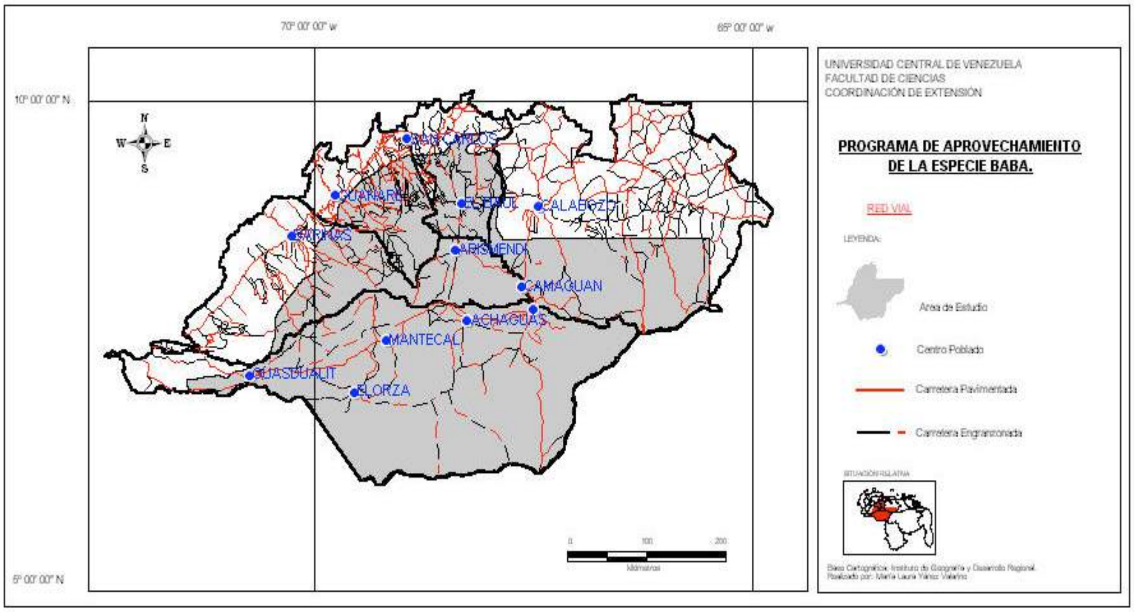
MAP 1: Study Area



The first GIS product is the location of the study area, on a cartographic base scaling 1:100.000. Map shows the limits of the ecological regions on the Western Llanos, grid in degrees, minutes and seconds.

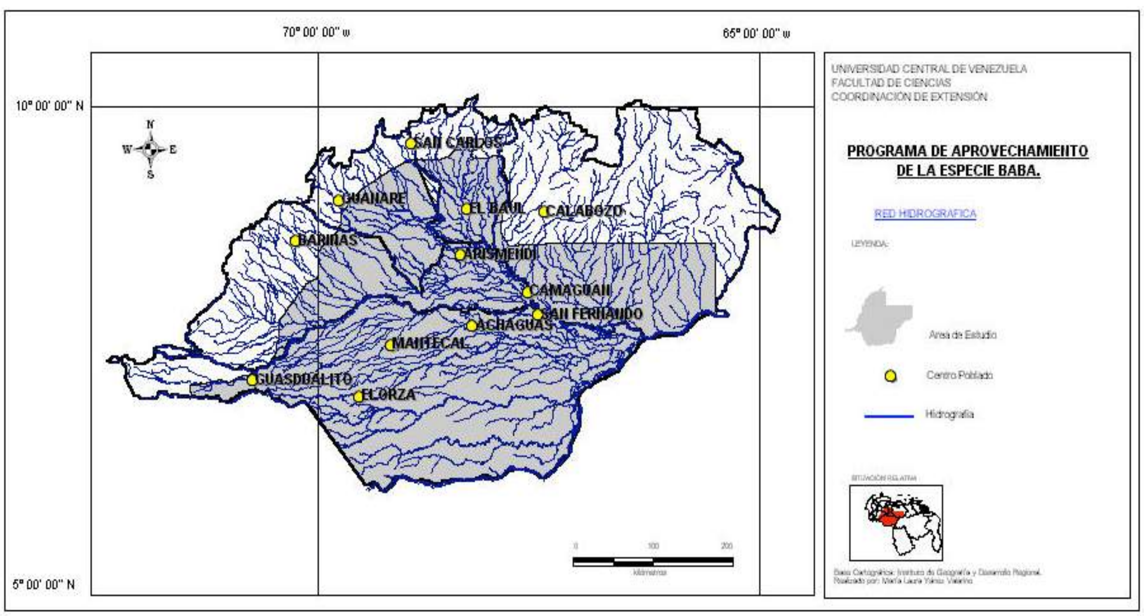
Map 2: Roads and main urban centers

On the map political limits of the States Apure, Barinas, Cojedes, Guárico and Portuguesa are included, marking the limit of ecological regions in which the Program is applied.



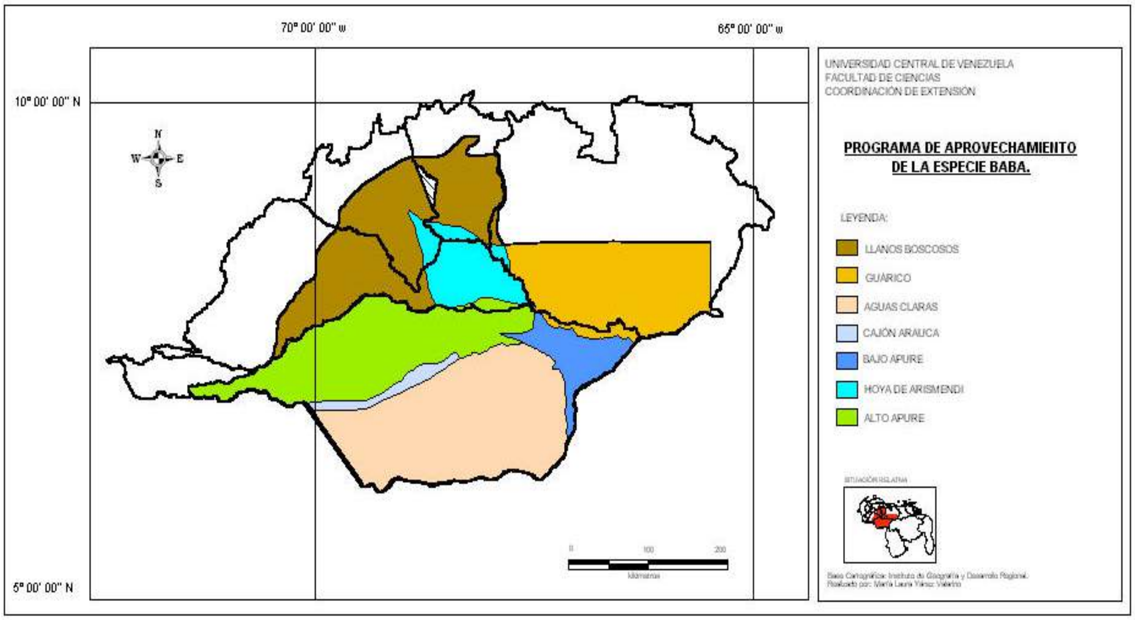
Map 3: Hydrographic system

Main rivers and natural drainages in the study area are presented .



Map 4. Ecological Regions

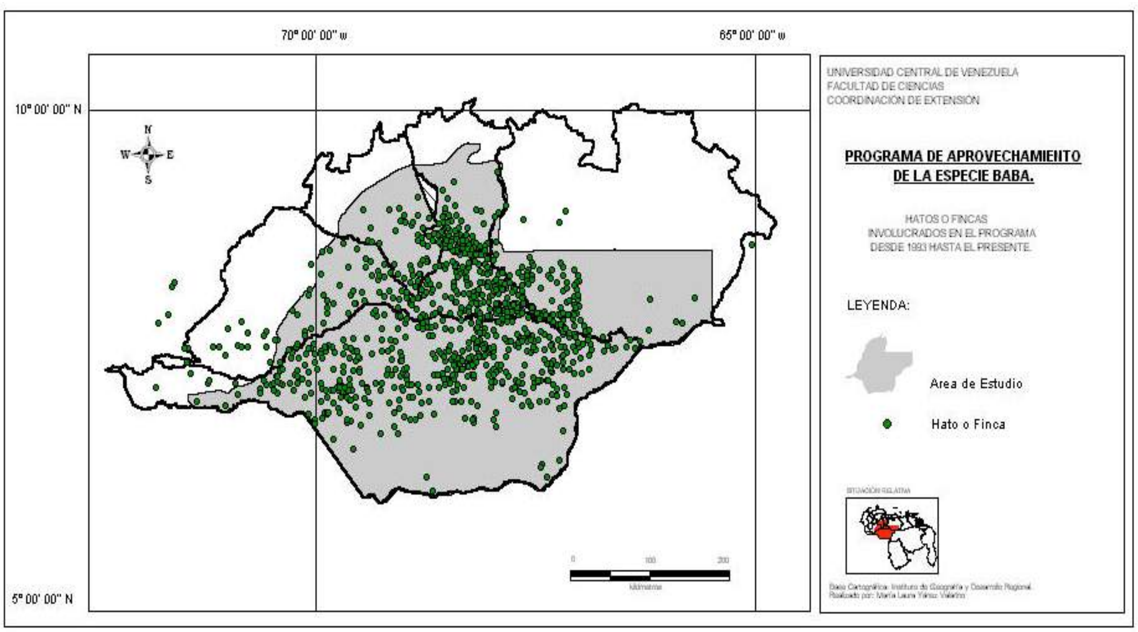
Limits of the ecological regions defined by MARN are presented.



THEMATIC MAPS ON BABA HARVESTS

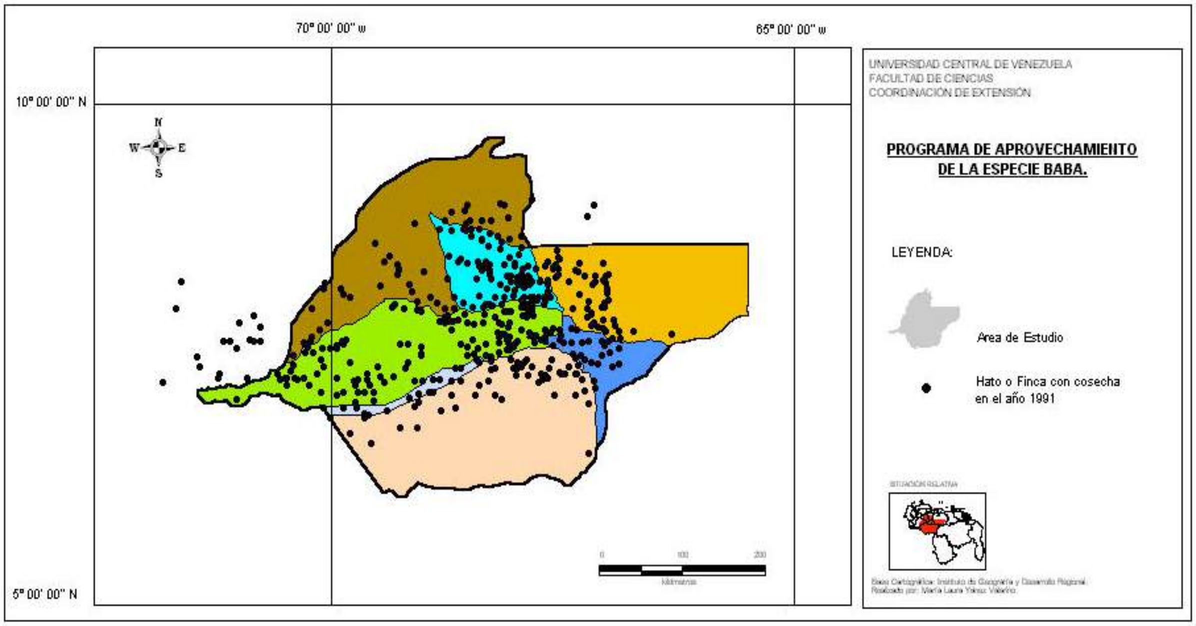
Map 5. Ranches and farms involved in the Program since 1990 to 2000.

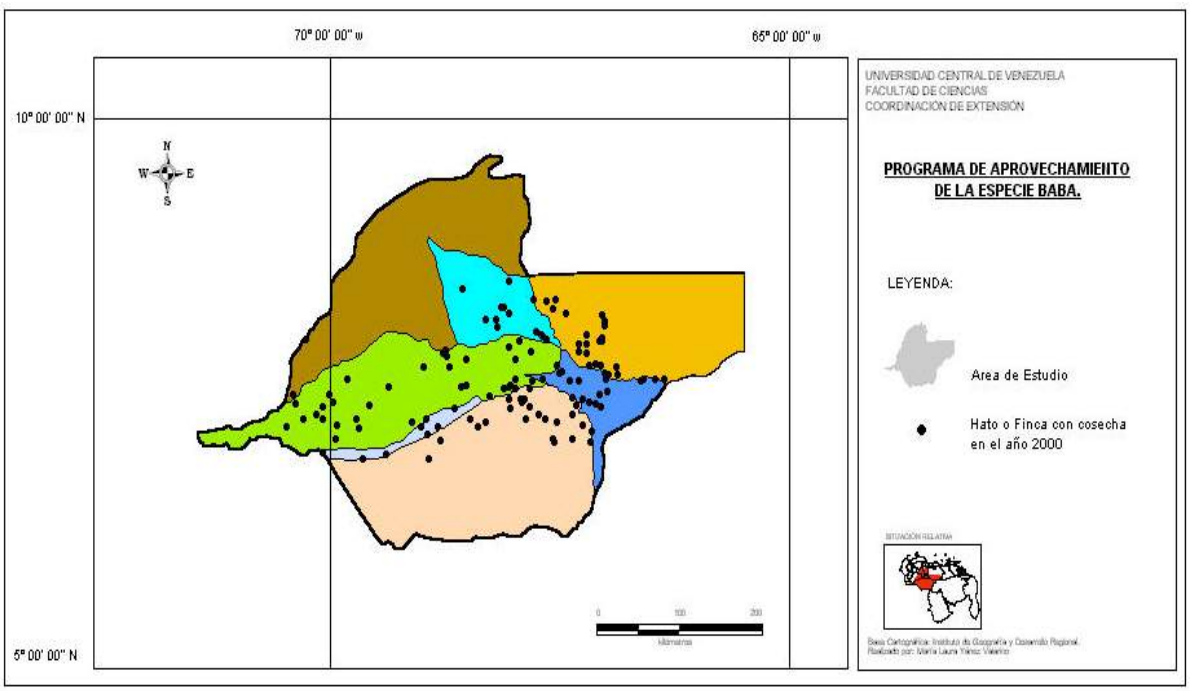
This map contains all the geo-positioned points from the database. Points out of limits of the ecological regions are farms participating in the program before 1992, when ecological regions were defined. Each point is associated by GIS to its individual data in the database.



Maps 5.1 to 5.2. Ranches and Farms involved in the Program in 1991 and 2000

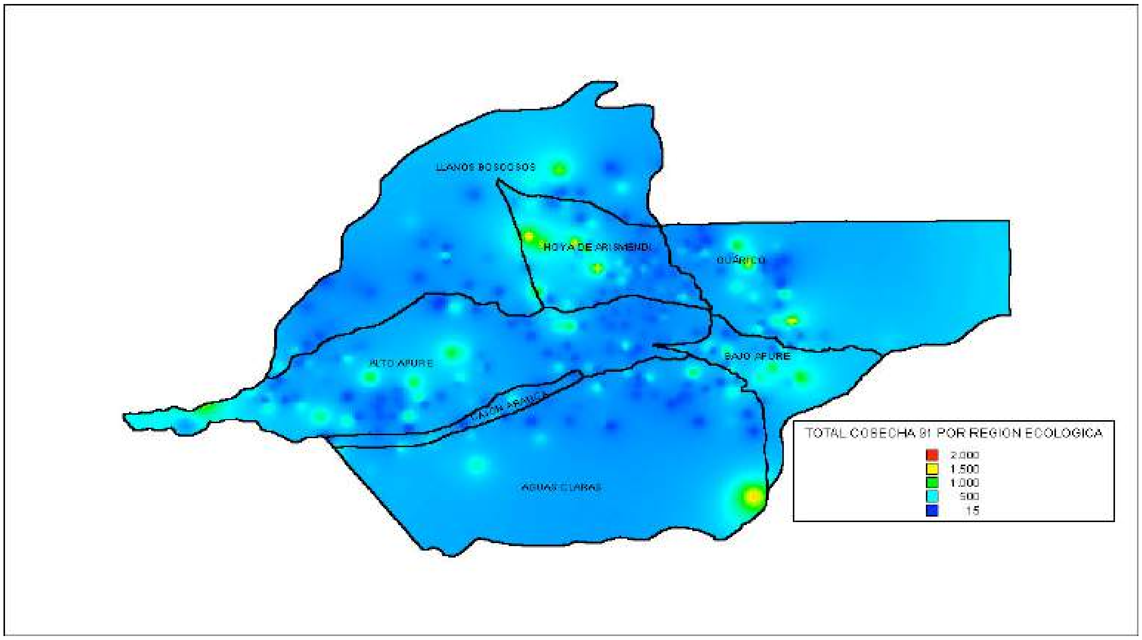
A strong reduction of the amount of ranches/farms participating in the program can be appreciated in 1991 and 2000.

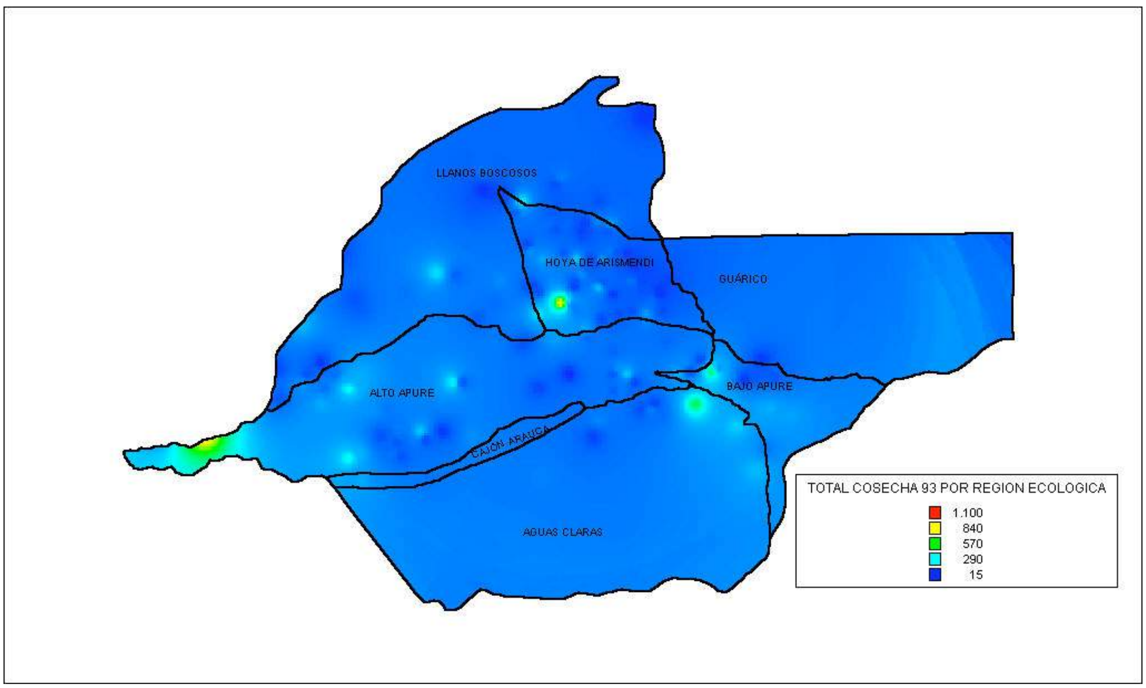


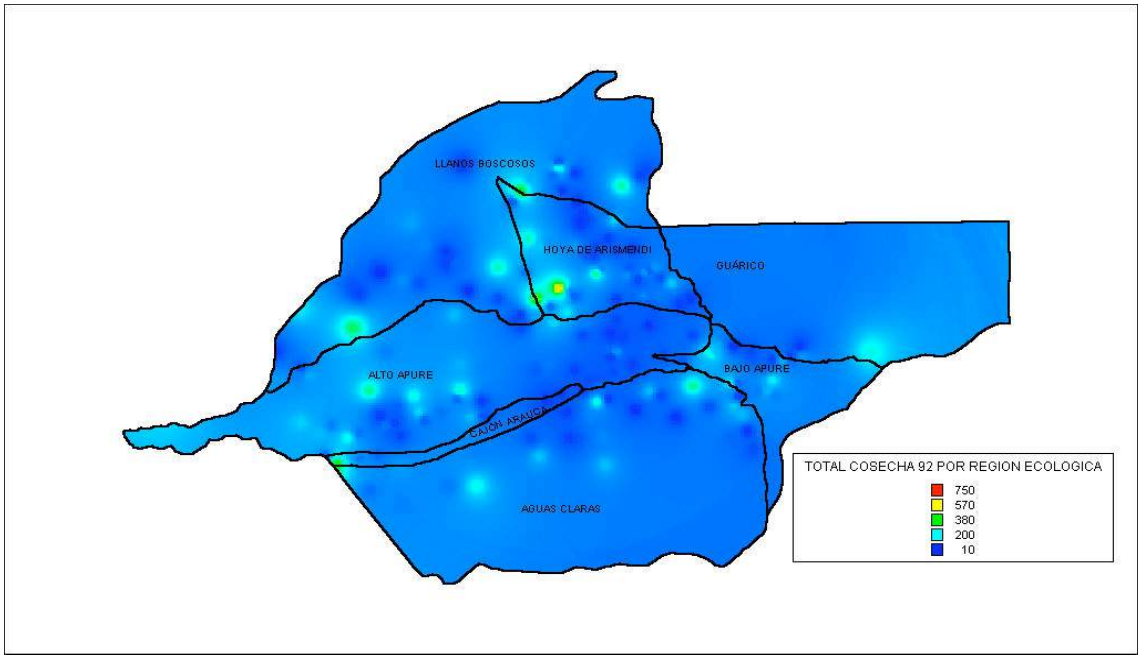


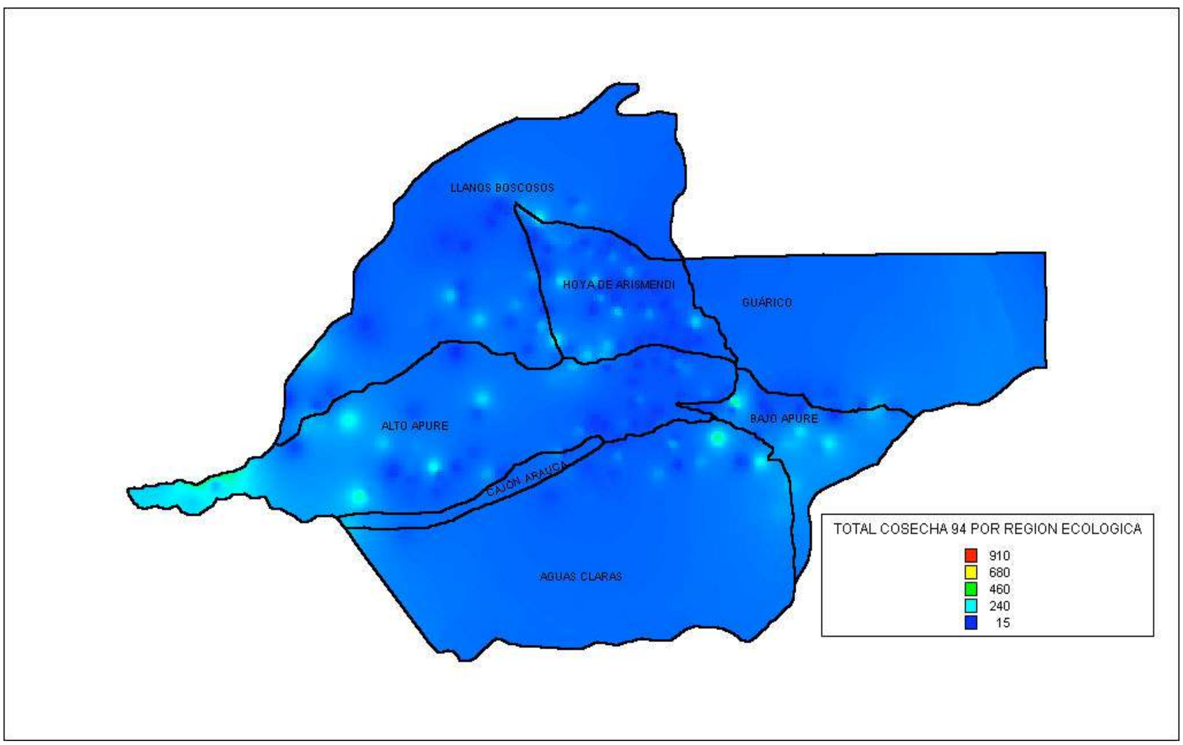
Maps 5.3 to 5.12. Thematic maps representing harvests of skins since 1991 to 2000 (except 1996 = Ecological Pause of MARN).

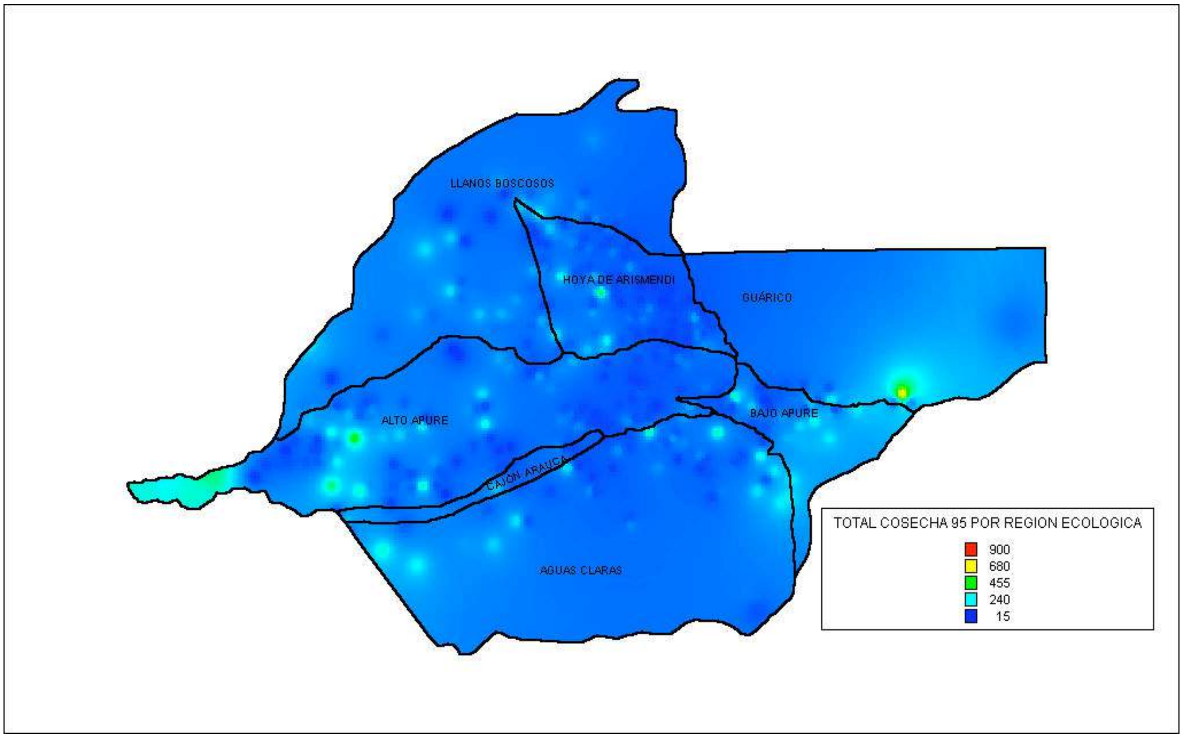
The amounts of skins were grouped into five intervals to show ranches/farms with these levels. The representation allows the location of areas from which these amounts of skins were harvested. Each map is linked to database with GIS.


LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
ALTO APURE
BAJO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 91 POR REGION ECOLOGICA
2.000
1.500
1.000
500
15


LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
ALTO APURE
BAJO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 93 POR REGION ECOLOGICA
1.100
840
570
290
15


LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
ALTO APURE
BAJO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 92 POR REGION ECOLOGICA
750
570
380
200
10


LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
ALTO APURE
BAJO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 94 POR REGION ECOLOGICA
910
680
460
240
15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GUÁRICO
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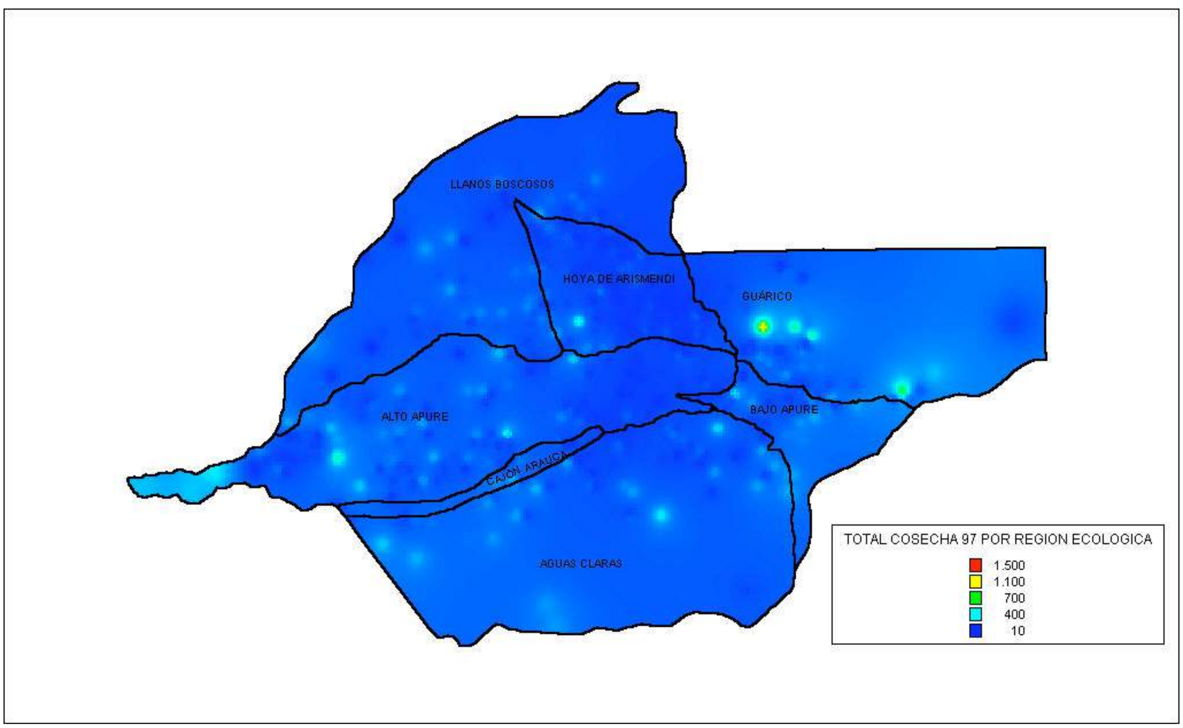
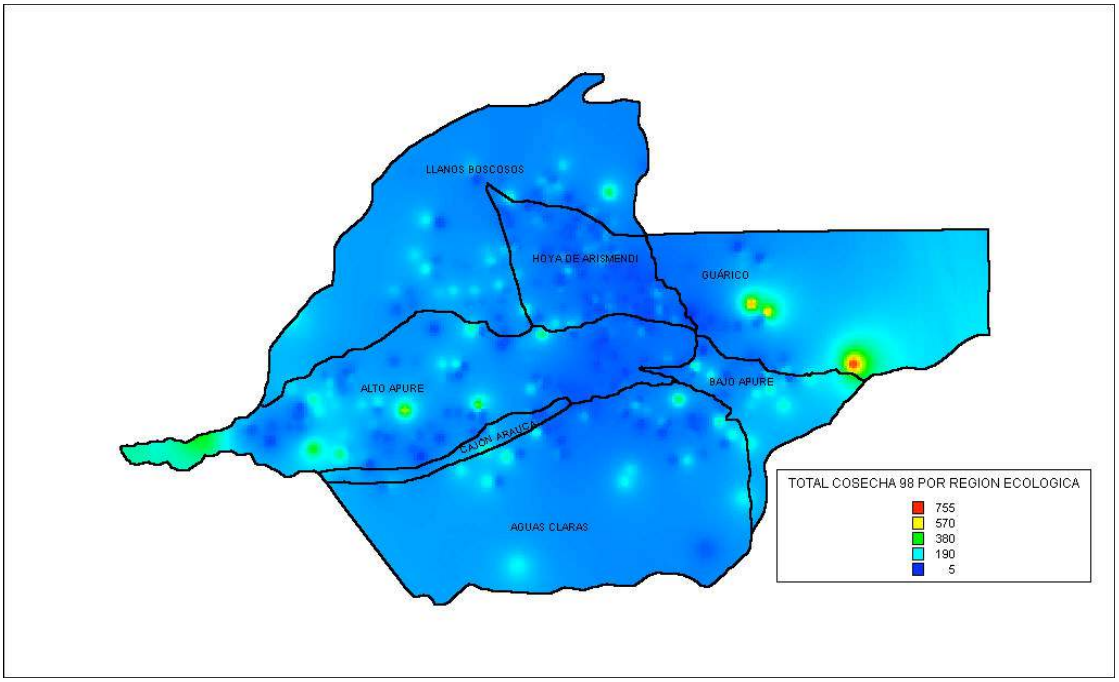
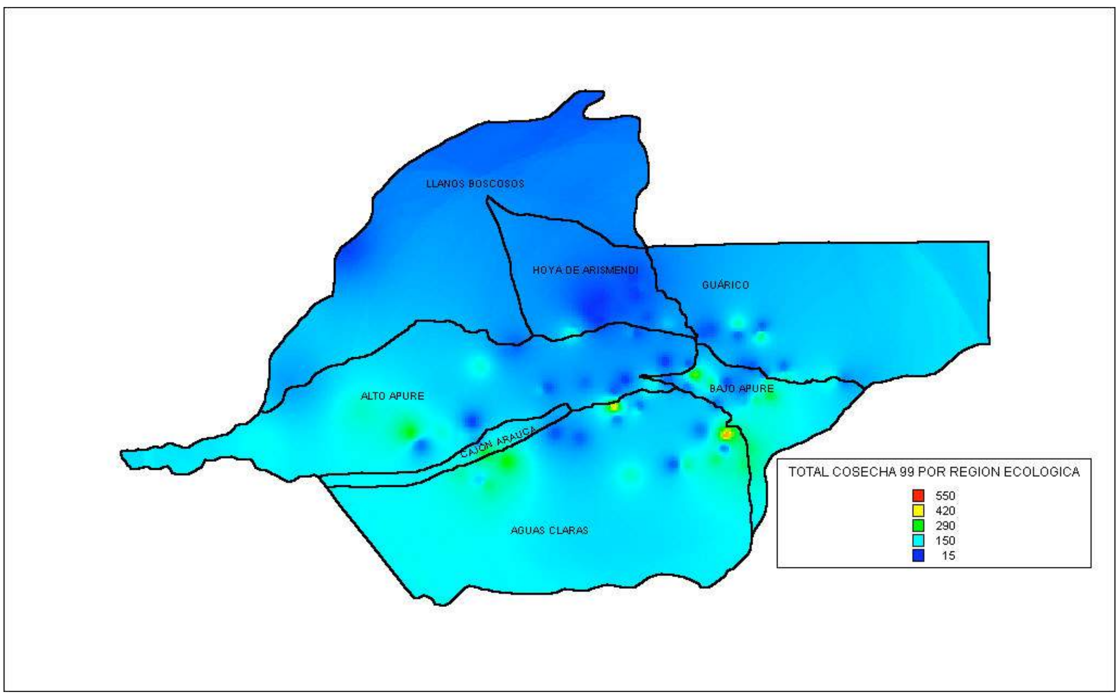
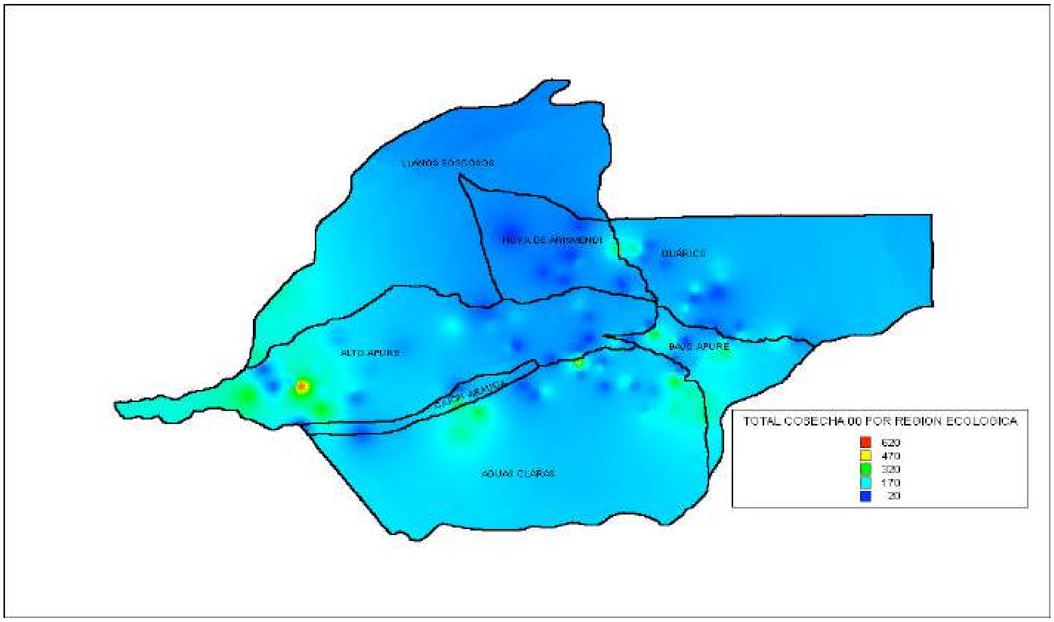
ALTO APURE
CAJON ARAUCA
AGUAS CLARAS
TOTAL COSECHA 95 POR REGION ECOLOGICA
900
680
455
240
15


LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
BAJO APURE
ALTO APURE
CAJON ARAUCA
AGUAS CLARAS
TOTAL COSECHA 97 POR REGION ECOLOGICA
1.500
1.100
700
400
10

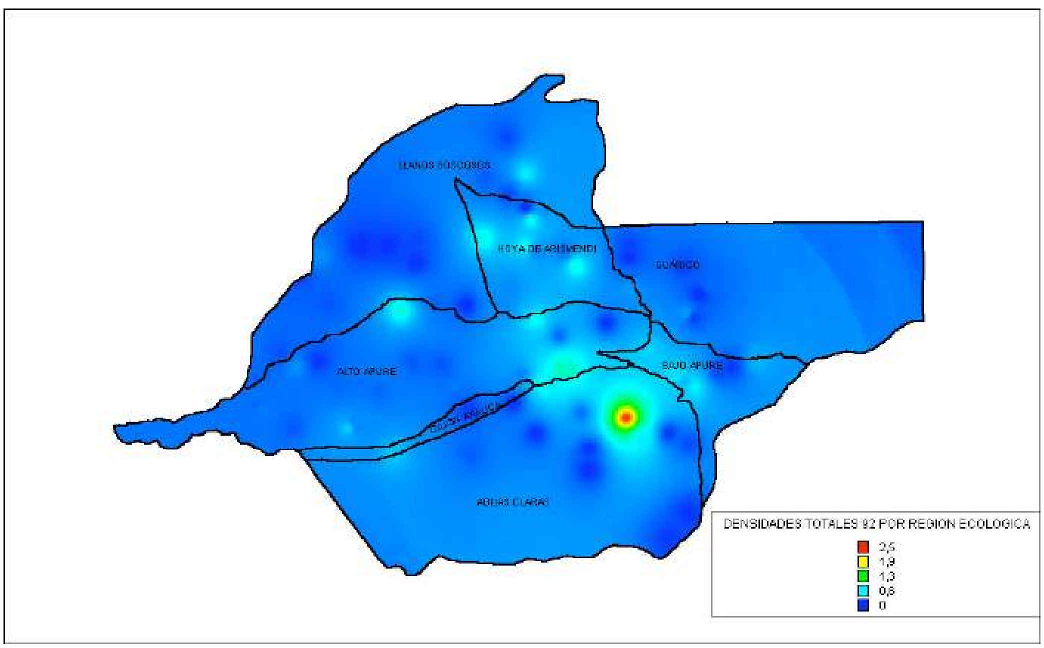

LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
BAJO APURE
ALTO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 98 POR REGION ECOLOGICA
755
570
380
190
5

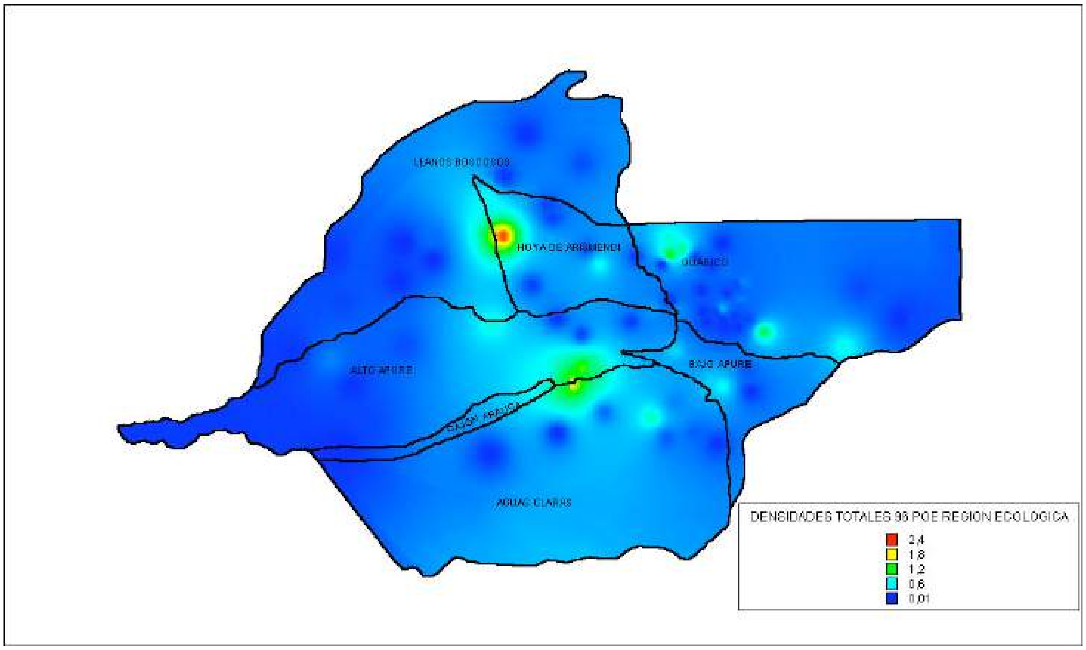

LLANOS BOSCOSOS
HOYA DE ARISMENDI
GUÁRICO
BAJO APURE
ALTO APURE
CAJÓN ARAUCA
AGUAS CLARAS
TOTAL COSECHA 99 POR REGION ECOLOGICA
550
420
290
150
15

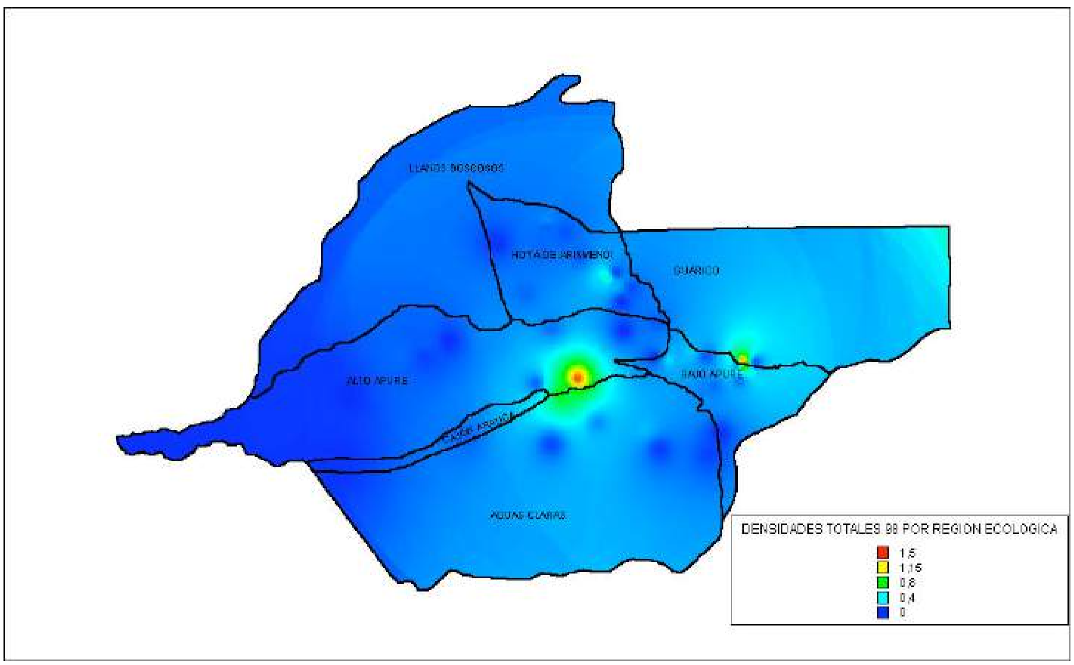


Map 6.1 to 6.3: Densities in 1992, 1996 and 1998-2000.

The amounts of densities were grouped into five intervals to show ranches/farms with these levels. The representation allows the location of areas from which these densities were determined. Each map is linked to database with GIS.







CONCLUSIONS

The yearly series of thematic maps on harvests and densities, allows a spatial vision of the historical sequence of the Program during its application. The areas with extraction of large skins for each ecological region are presented. High densities were recorded in all the censuses for the Ecological Regions Bajo Apure and Hoya of Arismendi.

Cumulative data since 1992 to 2000 (new data from 2002 are not included) are used with GIS to establish general population tendencies in a spatial view. Analysis of numerical population variables (skin harvest, densities, abundance of individuals) are currently in development using factors as aquatic and terrestrial surface, habitat characteristics and variations in time. These analyses are facilitated by the use of GIS as a tool for supporting decision making by the Program Administration.

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Role of American Alligator (*Alligator mississippiensis*) in Measuring Restoration Success in the Florida Everglades

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fjma@mail.ifas.ufl.edu

ABSTRACT: The American alligator (*Alligator mississippiensis*) was abundant in the pre-drainage Everglades in Southern Florida, USA. The largest populations occurred in the broad marl prairies to the east and west of the southern ridge and slough and in the freshwater mangrove zone (Figure 1). Development and water management practices have reduced the spatial extent and changed the hydro patterns of these habitats. As a result of these activities, alligator populations have decreased. Currently, restoration of hydrologic pattern and ecological function is beginning in the Everglades. Due to the alligator's ecological importance and sensitivity to hydrology, salinity, habitat and system productivity, the species was chosen as an indicator of restoration success. A number of biological attributes (relative density, relative body condition, nesting effort, and nesting success) can be measured, standard methods for monitoring have been developed, and historical information exists for alligator populations in the Everglades. These attributes can be used as success criteria at different spatial and temporal scales and to construct ecological models used for predicting restoration effects. Here, we discuss Everglades alligator population status and its role in evaluating restoration success of the Southern Everglades.

The Effect of Imposing Hunting on an Unhunted Population of the American Alligator

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ABSTRACT: The American alligator (*Alligator mississippiensis*) was considered endangered, threatened, or threatened due to similarity of appearance once throughout much of its historic and present range. The American alligator was studied in Texas to determine the effect of hunting and the role of climatic conditions on size class structure, sex composition, population, and nesting effort. The study areas were the J. D. Murphree Wildlife Management Area (JDMWMA), Jefferson County, and Jefferson County in its entirety. Methods used to assess and interpret alligator populations were night-count lines, nesting surveys, harvest data, and weather conditions. Breeding populations of alligators were stable. Average size class had been reduced, but not enough to cause alarm from a management standpoint. Sex ratio of harvested alligators was not considered detrimental to the alligator population. Climatic influences played an insignificant role in night-counts and nesting surveys. Night-counts and nesting surveys were highly affected by minimum temperatures. Night-counts were moderately correlated with daily air temperature, average air temperature, and minimum air temperature on the JDMWMA. Precipitation was correlated to nesting in Jefferson County, but not on the JDMWMA.

Seasonal Thyroxine in the American Alligator (*A. mississippiensis*)

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ABSTRACT: Little information is available on the role of thyroid hormones in regulating reptilian metabolism. Wild alligators were captured throughout the year at the Rockefellar Wildlife Refuge in Grand Chenier, LA. Both males and females (N=1054) ranging from 58 cm to 361 cm in length were captured between 9 A.M. and midnight from May 2000 to April 2001. Animals were captured from a variety of habitats including marsh, open water, canals, and ponds. Thyroid hormones were measured by radioimmunoassay. Four criteria were used to evaluate changes in hormone levels: sex, total length, season, and time of day. Thyroxine (T_4) was found to be highly variable with levels ranging from 0.5 to 57 ng/mL. Triiodothyronine (T_3) levels were below the sensitivity of the assay (0.5ng/mL). No T_4 differences between the sexes were observed. A distinct seasonal peak in T_4 was observed between December and April, peaking in March with highest levels observed in the evening. No consistent relationship between hormone levels and length was observed. Alligators thus exhibit T_4 levels among the highest recorded for reptiles. The seasonal data suggest that behavioral or environmental conditions during early spring activate T_4 production in alligators.

Variation in Gonadotropin-Induced Testosterone Synthesis in Juvenile Alligators from Contaminated and Reference Lakes

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Keywords: endocrine disruption, xenoestrogens, American alligator, FSH, gonadotropin challenge, testosterone, embryogenesis

ABSTRACT: Previous research on alligators living in Florida's Lake Apopka (contaminated with organochlorines and other known endocrine disrupting chemicals) has shown that males have severely reduced plasma testosterone levels compared to males from Lake Woodruff National Wildlife Refuge (relatively uncontaminated). However, in vitro incubations of alligator testes from the two lakes resulted in similar testosterone production. Therefore, we hypothesized that the observed testosterone reduction is due to decreased testicular response to gonadotropin, resulting in low testosterone synthesis. Furthermore, we hypothesized that this is a persistent deficiency initiated during embryogenesis. Juvenile male alligators from Lake Apopka and Lake Woodruff were hatched and raised together in an enclosed outdoor pen in Gainesville, Florida. To test testicular response, each alligator was injected with a superphysiological dose of ovine FSH (150ng/mL plasma). Plasma testosterone was measured (by radioimmunoassay) in repeated blood samples taken at 0, 0.5, 1, 2, 3, 6, 12, 24, 48, and 72 (May and July only) hours after injection. To capture seasonal variation in response, we repeated the experiment three times during the normal breeding season (March, May, and July, 2000). All alligators responded to exogenous FSH by synthesizing increased levels of testosterone ($p<0.0001$ for all months). However, alligators from Lake Apopka synthesized significantly less testosterone in July than those from Lake Woodruff ($p=0.027$). In addition, alligators from Lake Woodruff exhibited strong seasonal variation in their response to gonadotropin, making more testosterone in July than in March or May ($p<0.02$). No seasonal variation was observed in alligators from Lake Apopka ($p>0.11$). We conclude that the reduction in plasma testosterone observed in wild alligators from Lake Apopka is due in part to decreased responsiveness to gonadotropin, and that this effect is initiated during embryogenesis.

Alligator Nest Attendance: Observations on Timing and Behavior

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ABSTRACT: The relationship between female alligators and their nests was investigated on Sabine National Wildlife Refuge, LA. During 1998 and 1999, 212 nests were monitored and 112 females captured and associated with specific nests. Data from 17 infrared activity monitors located at the base, and 16 at the top of randomly selected alligator nests provided activity information. Remote video verified that most records were alligators. Alligators spent less than 10% of time at nests and more time was spent at the base than the top of the nest. Visits to the top of nests were less frequent late in incubation and more time was spent at the base during daytime than nighttime. Visits did not differ between successful and unsuccessful nests or between nests with eggs and empty nests. Visits were less frequent at nests with fire ants. Alligators added material to nests early in incubation, but did not repair damage incurred later. Nests with structural manipulations (n=20) were not less successful than unmanipulated nests. Females located at nests rarely showed aggression. At #5 m of a nest all alligators located were female. Males were found near nests, but at distances >5 m.

Adult alligators (*Alligator missipiensis*) in proximity to nests are presumed to be the attending maternal parent of the clutch within. Some researchers reserve this label for animals seen within 20 meters of a nest (Metzen, 1977; Hunt and Ogden, 1991). Others restrict the definition to include only animals found at the nest itself (Joanen, 1969; Deitz and Hines, 1980; Kushlan and Kushlan, 1980; Platt et al., 1995; Reagan et al., 2000). There has been little effort made to test the presumption of maternity for observed attending alligators. Hunt (1987) observed the same individuals, identified on the basis of distinctive morphological characteristics, attending nests throughout incubation, but did not confirm sex.

Functions of alligator nest attendance are described as nest maintenance and nest protection. Descriptions of nest maintenance have included repair of damaged nests (Deitz and Hines, 1980; Ruckel and Steele, 1984; Hunt and Ogden, 1991) and regulation of temperature and moisture (McIlhenny 1935). Lower rates of depredation have been found in conjunction with female activity at a site (Metzen, 1977; Deitz and Hines, 1980; Hunt and Ogden, 1991) and is considered evidence that females actively protect their nests. Aggression towards humans at nests is also considered an indication that protective behavior is directed towards smaller nest predators (Deitz and Hines, 1980; Hunt and Ogden, 1991).

Researchers report regular attendance (Deitz and Hines, 1980; Kushlan and Kushlan, 1980; Hunt and Ogden, 1991), maintenance (Ruckel and Steele, 1984; Hunt and Ogden, 1991), and protection (Joanen, 1969; Metzen, 1977; Deitz and Hines, 1980; Kushlan and Kushlan, 1980; Hunt and Ogden, 1991) of nests by adult alligators. The frequency of these behaviors, however, are not consistent within or across studies. Nest attendance ranges from only 14.9% (Dietz and Hines, 1980) to 66% (Hunt and Ogden, 1991). Nest maintenance is reported by several researchers (McIlhenny, 1935; Deitz and Hines, 1980; Ruckel and Steele, 1984; Hunt and Ogden, 1991), but is not noted in other nest ecology studies. Rates of female aggression towards humans at nests range from 0% (Goodwin and Marion, 1978; Platt et al., 1995) to 33% (Hunt and Ogden, 1991). Researchers have witnessed nest protection against simulated natural predators (Kushlan and Kushlan, 1980) and lower predation rates at attended nests (Metzen, 1977; Deitz and Hines, 1980; Hunt and Ogden, 1991). However, there are no observed occurrences of defense against natural predators reported, and Joanen (1969) saw predation of nests by racoon in the presence of attending adults.

Despite the purposes ascribed to attendance, constancy and aggressive defense do not fully characterize alligator nest attendance. Joanen (1969) recorded visitation to four nests and concluded that alligators pay little attention to their nests after egg deposition. Reagan et al. (2000) developed a model based on 137 nests that hatched indicating alligator nest attendance was influenced by fire ant presence, but attendance did not influence final nest success.

The goal of this study is to clarify the relationship between female alligators and their nests by describing nest attendance. Patterns of visitation at a random sample of nests are described, and individuals in proximity to nests are identified.

MATERIALS AND METHODS

The research was conducted on Sabine National Wildlife Refuge (Sabine NWR) in southwestern Louisiana. The coastal marsh study area included fresh (8 km^2) and intermediate (21 km^2) marsh impoundments (Chabreck and Linscombe, 1988). Bordering levees were dominated by Chinese tallow-tree (Sapium sebiferum) and interior areas by marshhay cordgrass (Spartina patens). The extensive areas of Spartina patens were broken by patches of roseau cane (Phragmites communis), cattail (Typha spp.), and by numerous small pools and shallow open water flats.

Nests were located during 1998 from an airboat and from an airboat and a helicopter during 1999. Nests were marked and monitored repeatedly throughout incubation. The areas around nests were searched for the presence of dens and submerged alligators by feeling the bottom of pools with a pole and investigating visual cues to alligator presence. When found, alligators were captured and marked with a tail-scute notch and a Passive Integrated Transponder (PIT) tag (American Veterinary Identification Devices [AVID], Norco, CA). Body measurements, sex, and general comments were recorded for each captured animal. The tail-scute notch served as a non-unique external visual mark. The PIT tag was an unique identifier and was used to re-identify individuals. Total length was used to assign adult animals to size classes; Small (<1.83 m), Medium (1.83 - 2.12 m), Large (2.13 - 2.42 m), and Very-Large (>2.42 m).

The association of captured alligators with nests was based on proximity, connecting trails, and the sex and size of the animal. Alligators were associated with nests if they were female, adult size ($1.52 m total length), and in close proximity of a nest. Alligators within 5 m of a nest, or greater than 5 m and connected to the nest by a distinct trail, were considered to be in close proximity of the nest. An associated female alligator was assumed to be the maternal parent of the clutch in the respective nest. The behavior of associated female alligators was categorized on the basis of the attendance behaviors described by Kushlan and Kushlan (1980). Alligators that showed behaviors of 'Submerged' or 'Approach' were termed non-aggressive, while animals that used more aggressive behaviors were termed aggressive.

Activity monitors using active infrared light (TM-1500, Goodson and Associates, Lenexa, KS) were placed at nest sites to document visits by adult alligators throughout incubation. The activity monitors used infrared light pulses to establish an active line between two units, a flashing infrared light and recorder. Time and date were recorded with each interruption of the active line. A one-second interruption, the maximum possible, was specified to minimize records of non-target species. Active lines were placed at 20 - 26 cm above the ground surface or 10 - 16 cm above water.

During the nesting season of 1998, activity monitors were placed at the base of 19 randomly selected nests. They were placed tangential and within one foot of the nest base. The active line covered access to the most active aspect of the nest. Depending on the site specific habitat, the active line of the timer ran above mud, grass or water. During the nesting season of 1999, timers were placed with the active line crossing above the top center of 19 randomly selected nests. Vegetation was trimmed to maintain clear active lines.

The reliability of the activity monitors was tested using a linked 35 mm camera and video camera system (TM 35-1 Camera Kit, TM500 and TM Video Camera, Goodson and Associates, Lexana, Kansas). The video system had a four second time delay following interruption of the active line.

Activity monitor reliability was also tested by placing monitors across 2 nests inside alligator exclosures.

Activity monitor data were expressed as the presence or absence of a visit during each 15-minute block of the monitored time. The data for each sampled nest were summarized using three measurements: the proportion of time that received visitation; the mean duration of visits; and the mean interval between visits. The proportion of time that nests received visitation was defined by the number of 15-minute blocks including visitation among those blocks monitored. The mean duration of visits at nests was defined by the number of consecutive 15-minute blocks including visitation. The mean interval between visits at nests was defined by the number of 15-minute blocks between successive visits. Nests monitored for less than 25% of the incubation season were excluded from analysis, two from 1998 and three from 1999. Nests without eggs (empty nests), three from 1998 and one from 1999, were excluded from all analyses excepting the comparison between empty nests and nests with eggs.

Patterns of visitation were assessed by comparing visitation during the following four incubation periods; early incubation (days 1-30 after deposition), temperature sensitive period (days 31-45 after deposition), late incubation (days 46-60 after deposition) and pre-release (>60 days after deposition). Single annual dates of deposition were defined for this purpose and correspond to dates of peak deposition in this study area. Daily patterns of visitation were assessed by comparing visitations during the following two daily periods: daytime (06:00 - 19:59 hours), and nighttime (20:00 - 05:59 hours). Visitation patterns were also compared based on nest success and physical characteristics of nests and associated females. Visitation at successful nests was compared to visitation at failed nests. Visitation was compared between nests with adjacent water and those nests without adjacent water. Visitation at nests with fire ant colonies was compared to nests without colonies, and visitation at empty nests was compared to visitation at nests with eggs. Visitation at nests with associated females was compared between nests with females of different size classes.

All comparisons were made using Analysis of Variance with an alpha level of 0.05 and nests as the experimental unit. Comparisons were made between the activity monitor location (base of nest, top of nest) , the group (incubation periods, daily periods, or physical characteristics), and interactions of the location and group. The sample year (1998, 1999) and location were confounded in these analyses.

Modifications to the structure of 20 randomly selected nests were made during days 30 or 31 of incubation in 1999. Nest material was removed and left at the base of 10 nests; removal halved the depth to the top of the clutch. At the remaining 10 modified nests, nesting material was gathered on site and added to nests; additions doubled the depth to the top of the clutch. Strings were placed across the top of modified nests to assist in recognition of alligator nest repairs by researchers during successive visits. Two-tailed Fisher's Exact tests were used to compare the observed and expected counts for success of nests modified by addition and removal of material, and 38 randomly selected and unmanipulated control nests.

RESULTS

During the 1998 and 1999 nesting seasons 117 adult alligators were captured in close proximity to alligator nests. The proportion of captured adult alligators in proximity to nests that were female decreased with increasing distance from the nest (Table 1). Within five meters of nests all 81 adult alligators found were female. At distances greater than five meters, not all adult alligators found in proximity of nests were female. Five adult male alligators were found in proximity to nests, but were excluded from association due to their sex. All associated females were located within 30 m of the nests, except one female at 100 m. This animal was linked to the nest by a single, clear trail across drying mud flats between the nest and the den. The alligator at a nest was identified more than once during incubation at five nests. At two nests the associated female was identified within 20 m of the nest twice and at one nest, a third time as well. At one nest the same large male was identified within 20 m of the nest two times, and at the final nest a large male replaced the female identified earlier during incubation. No female was located in proximity of the nests at the same time these males were present.

Table 1. Adult alligators found in proximity to alligator nests, Sabine NWR, 1998-99

Distance from a nest	No. of animals captured	Proportion female
≤ 5 meters	81	1.00
6 - 10 meters	13	0.92
11 - 15 meters	12	0.83
>15 meters	11	0.82

A total of 212 nests with eggs were monitored throughout this study. Female alligators were associated with 52.8% of these nests. The majority (99/112) of all associated females identified were submerged in a den during researcher visits to the nest. Alligators displayed aggression towards humans at only five (2.4%) of all monitored nests. In all cases, these individuals were adult females within 5 m of a nest. In two of these cases, the females were captured on land and did not have water available at the site.

Nests were visited by researchers an average of 6.6 times during each nesting season. Associated females were found during only 8% of all visits at nests. Nest material was added by alligators after egg deposition to 21 nests during 1998 and 15 nests during 1999. In 1998, 90% of new material applications were made before day 30 of incubation. During 1999, 93% of new material applications were also made before day 30 of incubation. The latest addition of material by alligators was by day 34. None of the 20 nests with applied structural modifications were repaired by alligators. The success of nests with researcher additions of material was not different than those treated with removals of material (Fischer's exact test: P=1.00). When these treatment nests were pooled and compared to control nests, there was no evidence that nest success differed (Fischer's exact test: P=0.731).

A total of 126,649 15-minute blocks were monitored for visitation during 1998 and 1999. Activity data indicated visitation to nests occurred at relatively low levels throughout incubation, regardless of location of the monitors (Table 2). At the base of the nest the proportion of time spent visiting was greater ($F_{1,27}$=53.83, P<0.01), the duration of visits was longer ($F_{1,27}$=70.74, P<0.01), and the interval between visits was shorter ($F_{1,27}$=7.80, df=1, P<0.01) than at the top of the nest (Table 3).

Table 2. The amount of visitation at alligator nests, Sabine NWR, 1998-99.

Incubation Period	Mean Proportion of Time Spent (SE)	
	Base of nest	Top of nest
Early Incubation	0.104 (0.018)	0.014 (0.018)
Temperature-Sensitive Period	0.060 (0.018)	0.009 (0.017)
Late Incubation	0.048 (0.018)	0.003 (0.017)
Pre-Release	0.142 (0.030)	0.004 (0.017)

Table 3. The overall amount of visitation at alligator nests, Sabine NWR, 1998-99.

Visitation Measurement	Base of nest			Top of nest		
	Mean	Among nest SE (df)	Within nest SE (df)	Mean	Among nest SE (df)	Within nest SE (df)
Proportion of time visiting	0.071	0.008 (13)		0.007	0.006 (14)	
Duration of visits, in hours	0.735	0.175 (13)	0.034 (1019)	0.313	0.066 (14)	0.011 (358)
Interval between visits, in hours	14.023	7.443 (13)	0.361 (1898)	86.257	93.097 (14)	4.374 (339)

Comparisons among the base of nest measurements indicated significant differences occurred between the proportion of time spent during daily periods ($F_{1,54}$=6.14, P<0.02) and the proportion of time spent ($F_{2,9}$=9.59, P<0.01) and duration of visits ($F_{2,9}$=5.44, P<0.03) between size classes of females. Visits included a greater proportion of daytime (0.086, SE=0.0068) than nighttime (0.049, SE=0.0068) hours. Very-Large females (n=5) spent a greater proportion of time visiting (0.104, SE=0.0063) and had longer visits (0.859 hours, SE=0.0507) than females in smaller size classes. Large females (n=4) also spent a greater proportion of time visiting (0.061, SE=0.0071) and had longer visit duration (0.686 hours, SE=0.0567) than Medium females (n=1)(0.009, SE=0.0141)(0.318 hours, SE=0.1133).

Differences occurred among top of nest measurements for the interval between visits for incubation periods ($F_{3,84}$=3.20, P<0.03)(Table 4) and nests with and without fire ant colonies ($F_{1,25}$=5.21, P<0.03). The pre-release period had longer intervals between visits than any earlier period, and late incubation had longer intervals than early incubation. The interval between visits was much longer for nests with ants (182.45 hours, SE=35.79) than nests without ants (62.21 hours, SE=17.9). Visitation measurements were not statistically different between successful and unsuccessful nests, nests with eggs and empty nests, or nests with water on site and those without (P>0.10).

The video camera confirmed that at least 61% of records were caused by adult alligators. An additional 16% were explained by purple gallinule (*Porphyrula martinica*), common moorhen (*Gallinula chloropus*), and boat-tailed grackle (*Quiscalus major*). The remaining 23% were unexplained because the source of the record could not be seen. Activity monitors within alligator exclosures recorded nine erroneous visits, which represent 0.07% of the 12,719 15-minute blocks monitored.

Table 4. Intervals (hours) between visits at alligator nests, Sabine NWR, 1998-99. Comparisons not significantly different at the 0.05 level are indicated by same letter groupings.

Incubation Period	Mean Interval Between Visits at the Top of Nest, in hours (SE)			
Early Incubation	20.617 (32.057)	a		
Temperature-Sensitive Period	74.080 (28.416)	a	b	
Late Incubation	133.365 (33.622)		b	
Pre-Release	236.996 (30.692)			c

DISCUSSION

Alligators spent less than 10% of the time during incubation at the randomly selected and monitored nests. Alligators spent a greater proportion of time at the base of the nest than at the top. The difficulty of locating and associating females with nests corroborates these low visitation rates. Despite repeated visits and thorough searches at each nest site during both years, adult females were located during only 8% of all visits and at only roughly half of all nests. Overall, alligators visited the base of nests on average every 14 hours and stayed for three-quarters of an hour. On average, visits to the top of nests occurred every 86 hours, and lasted one-third of an hour. Female alligators do maintain a loose association with their nests throughout incubation, however they do not spend much of their time at the nest itself. The high variability in visitation measurements among nests suggests that unexplained variability among females is substantial. This substantial variation also impacts our ability to detect differences in means between groups.

Although alligators spent little overall time at nests and variation between nests was high, some patterns of visitation across nests were identified. Similarly to the findings of Joanen (1969), nest top visits did not show the frequency or patterns of visitation expected of alligators performing regular nest maintenance. The differences in visitation across incubation periods may indicate that nest top visits are influenced by time; visitation to nests decreased as incubation progressed. Additions of nesting material were documented during early incubation (days 1-30), but nest repair could not be stimulated with human-caused damage after day-30 of incubation. Deitz and Hines (1980) also saw additions of nest material during the first four weeks of incubation, and Hunt and Ogden (1991) observed repairs made to damaged nests prior to July 10, but not later. Alligators appear to have a long period of nest construction, but after this period interest in the nest structure wanes. Unrepaired modifications to nest structure after day 30 of incubation did not affect nest success. Repair by females was apparently not necessary for successful incubation and the structural modifications did not inhibit subsequent release of hatchlings. Nest maintenance seems to be an early incubation behavior and may be better described as a continuation of nest construction behavior than as on-going maintenance of nest structure.

This study suggests that fire ants in alligator nests affect alligator nest visitation, but that visitation does not affect nest success. These observations of nest visitation support the model developed by Reagan et al. (2000) predicting these same relationships. The interval between alligator visits to the top of nests with fire ants was roughly three times longer (7.6 days / 2.6 days) than that at nests without ants. Apparently site conditions, such as aggressively stinging ants in the nest, can be associated with modified attendance behavior of females, in this case decreased frequency of visits. These data also indicate success of nests is not associated with the level of visitation to a nest. Studies that have shown relationships between nest attendance and nest success (Metzen, 1977; Deitz and Hines, 1980; Hunt and Ogden, 1991) have focused on broadly categorized levels of attendance and failure due strictly to mammalian predation.

Use of the nest base was relatively constant regardless of the stage of incubation. There was also no difference in visitation detected between nests with eggs and those without; both types of nest sites received similar levels of visits. These observations suggest that alligators visit nest bases because of site preference rather than in response to the status of the clutch. Rootes and Chabreck (1993) hypothesize that behavior interpreted as nest attendance actually represents a tendency for females to localize near dens during summer. More time was spent at the base of nests during the daytime, which suggests use of nest sites for basking or resting as suggested by LeBuff (1957). Larger animals spent more time at nest sites than smaller animals, which may reflect affects of female experience, social patterns among females, or habitat quality. If larger females nest in better quality habitat then their summer core use areas may be smaller and, therefore, used more intensely than those of smaller females.

Few incidences of aggression by nesting female alligators were seen. Two of the five aggressive animals had no den or water available as escape cover. These cases of aggressive behavior could be considered self-defense. The majority of alligators at nests were retiring, and such alligators were often found within 1 m of the nest and submerged, but had not indicated their presence in any way. Deitz and Hines (1980) suggest that approach of nests by airboat may decrease visual estimates of attendance and defense. Most nest visits during this study were made by airboat, but retiring behavior by females also occurred when nest sites were approached by foot. All animals that showed aggression were at nests approached by boat. Researchers describing alligator attendance behavior (McIlhenny, 1935; Kushlan, 1973; Kushlan and Kushlan, 1980; Hunt, 1987; Hunt and Ogden, 1991) have focused their observations only on alligators that display strong protective behavior, and sample sizes have been low. These reports over-emphasize aggressive behavior, which was seen at only 2.4% of nests at Sabine NWR and at a reported maximum of 33% (Hunt and Ogden, 1991) of nests in other areas.

Identification of animals in proximity of nests showed that the assumption that an adult near the nest is the maternal parent is not always reasonable. Within 5 meters of nest sites all adult animals found were females, but at distances greater than 5 meters adult males were also found in proximity to nests. Also, at some nests with adults identified more than once, they were not found to be the same individual or sex. However, at nests with repeated identifications involving only females, it was the same individual female near the nest repeatedly. This study did not demonstrate that females found at nests were the maternal parents of the respective clutches. However, given that exclusively females were found within 5 m of nests while both sexes were found at greater distances, and in the absence of genetic evidence, it seems a reasonable working assumption that animals seen at distances within 5 m of a nest are the maternal parent, but not those seen at greater distances.

This study suggests that alligators spend a small proportion of time during incubation at nests, alligator presence at nest sites indicates use of preferred habitat rather than strictly nest attendance, alligator contact with the nest may not affect nest success, and alligators near nests are not necessarily the maternal parent. It is, therefore, more representative to discuss females as being 'in association' with nests, rather than 'in attendance'. These conclusions are in conflict with some earlier published works on nesting ecology (McIlhenny, 1935; Metzen, 1977; Deitz and Hines, 1980; Kushlan and Kushlan, 1980; Hunt and Ogden, 1991) but are consistent with suggestions made in other works (LeBuff, 1957; Joanen, 1969; Rootes and Chabreck, 1993; Reagan et al., 2000). Alligator activity at nests and its affect on nest success needs to be further tested.

ACKNOWLEDGMENTS

We thank the staffs of Sabine and Cameron Prairie National Wildlife Refuges for their assistance and support during this project. Special thanks are due to Diane Borden-Billiot of Sabine NWR for making possible the use of a remote video system during this study. The U.S. Fish and Wildlife Service provided funding for this research. The Louisiana State University Agricultural College provided facilities and additional funding support.

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Heart Rate Reflexes and Hysteresis during Thermoregulation in the Estuarine Crocodile, *Crocodylus porosus*

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The effect of heating and cooling on heart rate in the estuarine crocodile, *Crocodylus porosus* was studied in response to different heat transfer mechanisms and heat loads. Three heating treatments were investigated. *C. porosus* were:

1. exposed to a radiant heat source (infrared lamp) under dry conditions;
2. heated via radiant energy while half submerged in flowing water at 23°C; and
3. heated via convective transfer by increasing water temperature from 23 to 35°C.

Cooling was achieved in all treatments by removing the heat source and with *C. porosus* half submerged in flowing water at 23°C. In all treatments, the heart rate of *C. porosus* increased markedly in response to heating and decreased with the removal of the heat source. Heart rate during heating was significantly faster than during cooling at any given body temperature, i.e. there was a significant heart rate hysteresis. There were two identifiable responses to heating and cooling. During the initial stages of applying and removing the heat source, there was a dramatic increase and decrease in heart rate, respectively, indicating a possible cardiac reflex. This rapid change in heart rate with only a small change or no change in body temperature (< 0.5°C) resulted in Q_{10} values greater than 4000, calling into question the usefulness of this measure on heart rate during the initial stages of heating and cooling. In the later phases of heating and cooling, heart rate changed with body temperature with Q_{10}'s = 2-3. The magnitude of the heart rate response (reflex and hysteresis) differed between treatments, with radiant heating during submergence eliciting the smallest response. The heart rate of *C. porosus*, outside of the reflex periods, was found to be a function of the heat load experienced at the animal surface. Heart rate increased or decreased rapidly when *C. porosus* experienced large positive (> 25 W) or negative (< -15 W) heat loads, respectively.

Our data indicate that changes in heart rate constitute a thermoregulatory mechanism that is modulated in response to behavioural posture, but that heart rate during heating and cooling is, in part, controlled independently from body temperature.

Orinoco Crocodile (C. intermedius) Breeding in two Venezuelan ranches for Re-introduction Purposes

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ABSTRACT: Since February 2001, FUDECI has been in charged of the Orinoco Crocodile breeding operations at Agropecuaria Puerto Miranda (APM) and collaborated with Hato Masaguaral (HM) in order to increase growth rates through applied research. Refuges assays were conducted at APM producing higher growth rates with larger refuges within the pens. Fixed-density assays showed that 1.25 ind/pen was the optimal, being recommended to reduce it as time goes by. At HM, a faster growth rate was recorded with a shallow level of water. In June 2001, 318 15-months-old juveniles were released at the Caño Guaritico Wildlife Refuge, the Aguaro-Guariquito National Park, and for

the first time at the Cinaruco river, located in the Cinaruco-Capanaparo National Park. From the total, 202 corresponded to APM with an average TL: 808.09 mm and W: 1,839.38 g; and 116 from HM with TL: 726.64 and W: 1,576 g. In July 2002, 294 16-months-old individuals were also released in almost the same locations: 188 from APM (LT: 891.72 mm, W: 2,635.75 g), and 106 from HM (LT: 838.16 mm, W: 2,136.79 g). This research is being funded by the National Office on Biological Diversity – Ministry of Environment and Natural Resources.

Effects of Egg Shell Marking on the Viability of American Alligator Eggs

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ABSTRACT: Crocodile research and management programs routinely mark alligator eggs with waterproof pens or pencil to maintain their orientation. The possible toxicity of these marking pens has been a concern. In order to test the effect of various marking methods on alligator egg hatchability and hatchling survival, alligator eggs were marked with one of five methods and a sample of eggs were not marked. Study eggs were collected from various wetlands and placed in an incubator. The hatch rate and hatchling survival of the marking methods were compared with unmarked eggs. There was not a significant difference in hatchability or survival between the marking methods. However, unmarked eggs had a significantly lower hatch rate than marked eggs.

Using the Market to Create Incentives for the Conservation of Crocodilians: A Review

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on behalf of the IUCN/SSC Crocodile Specialist Group

EXECUTIVE SUMMARY

In many countries, programmes for the conservation of crocodiles, alligators and caimans - collectively known as crocodilians – have been designed around the marketing of products from the consumptive use of wild animals. Some of these schemes have been in operation for over 25 years, and in general they have delivered tangible conservation benefits. However, there have also been difficulties and failures, which are more rarely documented. In reviewing the relationship between markets and conservation here, we have not dwelt on the successes, which are reasonably well known. Rather we have sought to document many of the problems experienced, in the hope that the inherent lessons will be useful to policy-makers, regulatory agencies, academics and practitioners of market-driven conservation.

The general findings are:

1. Markets have created economic incentives for crocodilian conservation in a diverse range of circumstances and contexts. Sustainable use has been achieved many times and some of the most commercially valuable species are widespread and abundant, rather than being threatened with extinction. There is no doubt that the economic importance of crocodilians has often led directly to stronger institutional arrangements for their conservation and ongoing management.

2. The most successful crocodilian programmes are those that: encouraged a broad range of inputs during their preparation and implementation; were flexible enough to adapt to changing circumstances; accounted for the socio-economic environment in which the programme was expected to work; and, ensured that institutions of regulation could operate in an environment as free of perverse incentives as possible.

3. The six most endangered crocodilians in the world today include both commercially valuable and valueless species. In almost every instance, a strong case can be made that the factor most influencing survival is the status of their habitat – not the level of exploitation. With some species there may be little or no scope for conservation strategies based on the marketing of biodiversity products. Other approaches will be required, despite resources being typically limited for such approaches. Unfortunately, one perverse effect of the market is that it has resulted in new and additional resources being found for the most economically important species, while the most critically endangered species have tended to remain neglected.

4. As a generalisation (to which there are some notable exceptions), it has proved more difficult than anticipated to design and implement market-driven schemes which result in crocodilians becoming a significant economic asset to the private or community landholders who live with them, and on whose goodwill their survival will ultimately depend. Government agencies, crocodilian producers (farmers, ranchers) or traders have been the most obvious beneficiaries of market-driven conservation programmes. They have received the conservation incentives and have typically been most active in ensuring that resources for crocodilian conservation keep flowing.

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5. Crocodilian resources exist mainly in less-developed countries, yet finished products are sold mostly in the more affluent industrialised nations. International trade is fundamental to programmes based on the exploitation of crocodilians, and thus CITES, the convention that controls international trade in wild species, has had an enormous impact on all operations. In the case of crocodilians, CITES has encouraged sustainable commercial use and has devised highly sophisticated mechanisms for the regulation and control of trade. Despite many historical predictions to the contrary, one outstanding result of the market-driven conservation of crocodilians is that illegal trade has all but been eradicated in the face of well-regulated legal trade. Governments and business interests have worked against illegal trade which might compromise their investment in conservation, management and production.

6. Although most crocodilian production programmes started with strong conservation objectives, it has often been difficult to adhere to these over the long term. In this respect, one important lesson from crocodilians is that success hinges on the relationship between government regulators and business interests, from the planning stages forward.

7. The private sector may not understand the conservation focus of crocodilian management programmes as much as governments, but tends to tolerate expenditure during start-up phases even if it considers it cosmetic or unnecessary. However, investment has proved to be a powerful political tool and once programmes are established, economic interests have often conflicted with, and sometimes prevailed over, conservation interests. The financial stress of falling markets in the early 1990s provides an extreme example. In many countries it has resulted in pressures to reduce the costs associated with resource monitoring and other regulation and in some cases there is reason to believe that resources were harvested illegally to bypass regulatory costs. On the other hand, government regulators often have little understanding of, or sympathy for, the needs and realities of sustaining a business. Conservation objectives have sometimes been compromised by governments, notably when they expose business to insecurity with respect to long-term access to wild resources.

8. Even where programmes have been well planned, and income from high-value wild crocodilian resources is generated, reinvestment in the resource has not always followed. Government agencies have sometimes preferred to use revenues for other priorities. Fiscal priorities of governments change regularly, at all levels of administration, and even where the wildlife authority rather than central government receives the funds, other issues can take priority over crocodilians. In some countries, other perverse outcomes have absorbed funds from crocodilian programmes.

9. A central lesson from experiences with crocodilians is that flexibility and a willingness to change is essential to success. It is not simply a matter of implementing a rigid programme and letting it operate indefinitely without change. This is an area where CITES has created problems. Despite its overall positive role in the creation of successful market-led conservation, CITES has been relatively slow to respond to changing circumstances. As a consequence, management has often been restricted to a narrow range of fixed options, such as ranching and captive breeding, regardless of whether these are the best options for conservation or business.

10. A perceived shortcoming of CITES is that it emphasises the biological determinants of sustainability, while the success or failure of most conservation programmes is ultimately determined by economic and social factors. Even at the national level, the biological elements of market-driven conservation programmes tend to be subjected to close scrutiny, while only scant attention is paid to the social, cultural and economic elements. This is perhaps a legacy of wildlife management decisions having been taken largely by biologists who often seem to assume that the marketing of products – a key element of success – has no relevance to conservation.

11. The market for crocodilian raw materials is determined largely by the economic status of consuming nations and superimposed on this are the unpredictable vagaries of the fashion industry. Demand tends to be elastic while supply is relatively inelastic. As a result the market is characterised by marked price fluctuations with at least two severe crashes in the last 30 years. Although overall production has continued to increase, this is the result of a drive for increased efficiency rather than new investment. Indeed, a number of individual producers have gone out of business during the difficult periods and several national programmes have become uneconomic to operate, which in turn has removed the incentives for conservation.

12. Where the impact of market-related problems on conservation has been recognised, some producers and regulators have been able to work together to reduce costs and increase demand. However, conflicts have arisen between transparency and the protection of intellectual property rights, particularly as new technologies and marketing strategies have been developed.

13. When initiating market-driven conservation programmes for crocodilians, advice has often been sought from experts. There are clear cases where poor information has resulted in unrealistic expectations, poor investment strategies and badly designed programmes, generating neither conservation nor economic benefits.

14. In some circumstances, the drive to reduce costs through increased efficiency has had conservation benefits (more production can be achieved for the same level of harvest from the wild). However, problems with access to the wild resource have tended to encourage captive breeding, perhaps the first step towards domestication. Captive breeding may be a valuable strategy to boost production, or reduce dependence on an unpredictable wild resource (or regulator), but it breaks the link between the market and the wild population, removing incentives for conservation.

15. There have been no real global efforts to regulate supply or demand. On the supply side, there is no international producers' cartel, nor have the costs and benefits of such an approach been evaluated. Producers often seem to react to falling prices and overproduction by increasing production in an effort to maintain profitability. It is also common, particularly in developing countries, for the supply of raw crocodilian materials to continue below financially viable levels due to the attraction of foreign exchange earnings, either to the producer or to the government which then may respond with subsidies. On at least one occasion, producers have been provided with subsidies due to the conservation value of production.

16. A common response to weak markets has been: value-added production, the diversification of products and the creation of new markets. On the whole, outcomes have tended to be positive, but it has not proved easy to add value to the raw product in producer countries due to vested interests. In addition, the technology is expensive and expertise is not freely available. It has proved difficult for many developing countries to produce the high quality required by a market specialising in luxury items. Most success has come, not from the penetration of the luxury market, but rather from the creating of new markets, often of a domestic nature, providing goods of lesser distinction to ordinary consumers.

17. The dynamics of demand for luxury leather products is complex and poorly understood by most producers. While the post-CITES trade has seen a reduction in the number of the intermediaries between producer and consumer, vertical integration has consolidated the critical role of tanneries. They act as the principal buyers and wholesalers. The number of tanneries has declined, partly due to environmental regulation, and while there is not yet a monopoly, the few tanneries that remain are probably in a position to exert the largest single influence on the market.

18. A significant obstacle to the market-led conservation of crocodilians is the widely held opinion that the economically-driven consumptive use of wildlife is incompatible with conservation. This lingers on, despite dramatic changes in our understanding of the reasons why difficulties

occurred so commonly in the past. Wildlife trade is, in some cultures at least, now considered undesirable and even immoral.

19. In order to strengthen markets, producers, traders and some conservationists have called for the endorsement of market-driven conservation programmes by international conservation agencies and have suggested the introduction of a certification or eco-labelling schemes. These possibilities merit detailed investigation, though it is far from clear where the lead will come from and who will benefit most.

20. As far as the market is concerned, the burden of regulation that has been imposed over recent years, often with the best of intentions, has been a major disincentive for business to invest in conservation. Eco-labelling may help, but restrictions on the movement of personal possessions made of crocodilian leather, combined with information discouraging consumers from buying wildlife products (even if these are directly linked to improved conservation) are obvious disincentives to investment. The practice of adopting domestic control and regulation measures that are more restrictive than CITES, which is common in OECD countries, adds a further tier of complexity. If we want to encourage business investment in conservation, these issues must be addressed as a matter of urgency. It is not clear whether this might be best pursued on a generic basis or with respect to crocodilians alone.

INTRODUCTION

The natural "ecosystems" and "biodiversity" of resource-rich tropical countries are said to be important and highly valued public goods. Accordingly there is considerable alarm at their current rate of erosion. Part of the concern stems from an appreciation that in many developing countries the use of wild species is essential to human livelihoods and even survival. In addition it is often argued that biodiversity is important for maintaining long-term agricultural output and for producing new generations of medicines. There are also fears that the depletion of natural ecosystems may threaten human well-being more generally: for example, through the destabilisation of local water cycles or even the global climate. Finally, there appears to be a growing acceptance, particularly within economically-powerful industrialised countries, that the natural world should be preserved for its intrinsic values.

Over the last century, our attempts to maintain natural ecosystems and biodiversity have tended to revolve around the regulated protection of land or species against damaging human influences, notably agriculture and harvesting. This reflects the fact that two of the greatest threats to biodiversity are land clearance for farming and the direct exploitation of species, whether for subsistence or commercial purposes. Unfortunately, even where protected areas have been effective, their relatively small size, coupled with human population pressures and the competitive advantage of farming over livelihoods based on the harvesting of wild resources, has resulted in a landscape dominated by agriculture. This is a landscape that is always biodiversity-unfriendly to some degree and which, where agriculture is at its most industrial, specifically excludes most wild species – irrespective of whether or not direct exploitation is prohibited. The conventional response to this situation, as exemplified by the US Endangered Species Act, is to extend regulation still further to include the prohibition of any act that harms a species of particular interest – including the conversion of its habitat for agriculture (Littell, 1995).

In recent years, there has been growing recognition that it is beyond the law enforcement capacity of most governments to implement restrictive regulations, and that for many it is worth more than their political survival to try to do so. As a consequence, wild species continue to disappear despite efforts to save them. As an alternative, two general mechanisms have evolved. In the first, society is asked to pay the true cost of the public goods, usually through direct subsidies to the landholder. However, transfers of this sort are notoriously difficult, especially between developed and less-developed countries. In the absence of workable mechanisms for internalising the cost of public goods, there have been attempts in many parts of the world to overcome macro-economic market failures by reversing the dominant paradigm in which exploitation is outlawed in an attempt to reduce economic rent. Instead, models have emerged in which rents from wild ecosystems are encouraged through markets and enough rent captured by the landholder[4] to provide an incentive for conservation of the "resource". This new paradigm is often called "sustainable use", but we prefer the more accurate term "market-driven conservation". Market-driven conservation is often controversial and not even its most enthusiastic proponents are suggesting that it is a universal panacea against biodiversity loss. However, there are now many programmes in which markets for biodiversity products and services have successfully been harnessed to generate conservation incentives. At the same time, others have failed conspicuously to do so. We argue here that it is essential for resource managers to review and draw lessons from operating programmes so that we can better understand the factors that contribute to success – and those that lead to failure.

Crocodiles, alligators and caimans (collectively known as "crocodilians") are found in 90 or more countries around the world. They have been exploited for generations, usually but not exclusively for their hides, used to make fashionable leather items. Over the last 20-30 years there has been a dramatic shift in the relationship between conservation, exploitation and trade. Initially seen as a conservation problem, trade has increasingly been co-opted as a conservation solution. The IUCN/SSC Crocodile Specialist Group (CSG) has responded positively as both a facilitator and arbiter in this process, working with elements of business to promote the sustainable use and legal trade of many crocodilian species all over the world. Management programmes allowing for the consumptive use of crocodilians now operate in some 30 different nations (Table 1). Each programme has its strengths and weaknesses. Over time, the dependence or near dependence of many crocodilian conservation programmes on international markets has highlighted issues which we believe have relevance to other markets for biodiversity products and services. There are many examples where conservation and economic benefits have been achieved simultaneously with crocodilians and we remain confident that:

1. Conservation incentives can and have been generated by markets.
2. The economic importance of the resource has led directly to stronger institutional arrangements specifically for conservation and sustainable management.
3. Illegal international trade, which flourished before CITES encouraged legal trade, has been all but eradicated.

On the other hand, there have been failures. There are dangers in assuming that all conservation programmes involving markets will be successful.

Here we review the many practical lessons learned from the market-driven conservation of crocodilians, in the hope that the insights gained will be of broader value to policy-makers, regulatory agencies, academics and practitioners. That we tend to concentrate on the problems and difficulties rather than the successes, should not be misinterpreted. Successes tend to be much better known than failures, but there are important lessons in both.

FROM CALAMITY TO CONSERVATION

Of the 23 crocodilian species generally recognised, 15 or more have commercially valuable hides. They have experienced remarkably similar histories of utilisation, conservation and management, regardless of the countries in which they occur (Ross, 1989). In historical times, most crocodilian species were regarded as pests. Control measures resulted in local declines and, in some areas, eradication. From the 1800s onward, crocodilian skins were also used commercially in some countries. In the USA, for example, trading firms in New York were handling up to 60,000 American alligator *Alligator mississippiensis* skins a year in the late 19th Century (Fuchs *et al*., 1989). Demand appears to have increased exponentially after World War II. In the late 1940s it is reported that 120,000 Nile crocodile skins were being exported annually from Madagascar alone to tanneries in France (Games, Ramandimbison and Lippai, 1997) and in the mid-1950s, nearly 60,000 Nile crocodile skins were exported from East Africa every year (Fuchs *et al*., *op cit*). By the 1960s almost all wild populations of commercially important species were being exploited for trade to some degree, and in many if not most cases, wild crocodilian densities fell dramatically, sometimes to levels where the populations

[4] The individual or group that has defined, exclusive and enforced property rights over the resource.

were in danger of becoming extinct (e.g. Cott, 1961: p215). At that time, few people were concerned about crocodiles and those who were, tended to advocate conservation responses prohibiting use. Research into the biology and population dynamics of crocodilians was in its infancy and the concept of managed harvests that would maximise the long-term benefits derived from the commercial use of crocodilians, had not yet evolved.

The development of programmes through which wild populations of crocodilians were harvested on a sustainable basis in order to generate ongoing economic and conservation benefits, gathered momentum in the 1970s and 1980s. It started in several countries with diverse economic, social and cultural settings, notably Australia, the USA, Papua New Guinea, Venezuela and Zimbabwe, and the impetus for market-driven conservation often came from quite different directions (Webb, Manolis and Whitehead, 1987). Some harvested species had recovered from historical declines and were becoming common in the wild. Others were still classified as "endangered" when the programmes were initiated[5]. In Zimbabwe, for example, Nile crocodile populations were recovering after protection and it was recognised that, as dangerous predators of people and their livestock, crocodiles would soon find themselves in conflict with legitimate human interests. Thus using the market to drive conservation was a pragmatic and contrived response to the need to find alternative long-term conservation strategies (Child, 1987). In contrast, the harvesting of wild crocodiles in Papua New Guinea was a well-established livelihood strategy for rural people and even though wild populations may have been reduced relative to historical times, there was never any serious suggestion that the outlawing of use could be a viable response to the conservation dilemma. The challenge facing wildlife managers in Papua New Guinea was to change existing patterns of exploitation so that use would once again be at sustainable levels (e.g. Genoloangi and Wilmot, 1990).

Those designing market-driven conservation programmes for crocodilians tended to start their work from one of two directions. The first approach was characterised by the gathering of copious biological data on the species and its population ecology[6], so that harvesting models could be constructed and tested with a view to the establishment of commercial programmes in which the regulator could have a high degree of confidence from day one (e.g. Joanen *et al*., 1997; Webb, Whitehead and Manolis, 1987). Indeed, there was strong public expectation that this would be the case in some countries. The second approach has been described as 'adaptive-management'. Baseline indices of abundance were established for the target crocodilian population, commercial harvesting introduced and the effects monitored in order that harvesting levels might be adjusted if the population entered a period of decline beyond expected levels (e.g. Fernandez and Luxmoore, 1996). In reality, these distinctions were blurred and despite a commitment to biological research, a great deal of trial and error was involved in all programmes, while biological research was introduced into many adaptive-management schemes (e.g. Loveridge, 1996).

Today, crocodilians are subject to biologically sustainable harvests linked to markets in a diverse range of circumstances and contexts (Fernandez and Luxmoore, 1996; Joanen *et al*., 1997; Loveridge, 1996; Thorbjarnarson and Velasco, 1998; Webb, Whitehead and Manolis, 1987). As a result, eleven of the most commercially valuable species are now the species *least* threatened with extinction (Ross, 1998). The six most endangered crocodilians include some species that have commercial valuable and others that have never been traded. The main process threatening their survival in each case is the status of their habitat (Ross, op cit.). In these worst cases, there may be little or no scope for conservation strategies based on the marketing of biodiversity products, because: there is insufficient wild habitat; national conservation policy precludes such approaches (e.g. Hutton 1993); or the species is not attractive in the market. The conservation challenge in these cases is considerable, because funding tends to be available for economically important species rather than critically endangered ones (Ross 1997; Thorbjarnarson, 1999).

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[5] Because the exploitation of endangered species has been allowed in order to generate tangible incentives for conservation, crocodilians are widely regarded as pioneer species for the concept of market-driven conservation.
[6] An expensive and time-consuming approach.

Despite many predictions to the contrary, one outstanding result of the market-driven conservation of crocodilians is that illegal trade has all but been eradicated by supply from well-regulated legal trade. Both government and business have worked against illegal trade as it compromises investment in management, production and conservation (Anon, 1998).

THE RACE TO REGULATION

The exploitation of crocodilian resources is largely a sovereign national issue, but although the wild resources most often originate in developing countries, processing and the markets for finished products are located mainly in the more affluent industrialised nations (Brazaitis, 1989) most of which are OECD members. International trade is fundamental to programmes and thus CITES[7], the convention that controls international trade in wild species in order to prevent them from becoming endangered, impacts on all operations. Enthusiasts of CITES as a conservation tool point to crocodilians as a success story for the convention. Others question whether the gains have been made because of CITES or despite it (e.g. Kievit, 2000). Regardless, there is no doubt that the way that the way in which CITES has impacted upon crocodilians is central to any discussion of the regulated exploitation of these animals. Country after country has had to experience the rigours of international scrutiny before their crocodilians could be transferred from Appendix I to Appendix II of CITES so that market mechanisms could be mobilised for conservation.

Although empirical information is limited, conventional wisdom holds that, as recently as the early 1970s, over two million crocodilian skins were traded each year. The vast majority, perhaps as many as 1.5 million, were caiman *Caiman crocodilus* [8] originating in Bolivia, Brazil, Paraguay and Venezuela. The balance was made up of alligator skins from the USA and crocodile skins from many other parts of the world (e.g. Brazaitis, 1989). When CITES came into force in 1975, all crocodilians were listed on the Appendices even though the true status of many was unknown and there were no explicit criteria to guide the listing process (Kievit, 2000). In what was seen as a precautionary move, most species were included in Appendix I which prohibited commercial international trade, and the remainder in Appendix II where trade could take place if the exporting country made certain findings and implemented trade controls (Luxmoore, 1992).

In reality, Appendix I listing in 1975 did not stop commercial trade. Trade was often able to continue through several different mechanisms. Firstly, at that time a number of important producer and consumer nations were not Parties to CITES (including Zimbabwe, France and Italy) and continued to trade. Secondly, as more and more countries did joint CITES in the 1970s and 1980s, many took 'reservations'[9] on crocodilian species, which protected their harvesting and industry programmes (including, for example, Botswana, Zambia, Zimbabwe, France, Italy and Japan). In addition, Appendix I still allowed products from animals that were bred in captivity for commercial purposes to be traded. Perhaps most importantly, illegal trade continued to thrive because of a combination of continuing high demand for crocodilian hides and poor national controls and regulation in several countries.

During the 1980s, loopholes were gradually tightened. With more countries in CITES the scope for trading amongst non-members declined rapidly. Member countries came under pressure to withdraw their reservations[10] and it was decided that 'bred in captivity' excluded specimens taken from the wild when young, which was the basis of several important new market-driven conservation programmes such as that in Zimbabwe (Kievit, op cit.). Finally, CITES began to make some headway against the widespread unregulated or illegal trade (Anon, 1998). With the closure of these loopholes the attention of many countries, especially those with newly developed exploitation programmes, turned to ways in

[7] The Convention on International Trade in Endangered Species of Wild Fauna and Flora.
[8] The taxonomy of the caiman is subject to considerable debate. For the purposes of this paper the term 'caiman' includes all variations of *Caiman crocodilus* including what is sometimes known as *Caiman yacare*.
[9] A country that takes a 'reservation' against the listing of a species in CITES is not bound by that listing decision.
[10] For example, the EC required member nations to withdraw their reservations.

which crocodilians could be transferred from Appendix I to Appendix II to allow legal, well regulated trade to continue. Others focused on captive breeding that could benefit from the exemptions afforded to Appendix I species under such programmes.

During the early days of CITES the only mechanism for transferring species from Appendix I to Appendix II was the Berne Criteria[11], but this required evidence that species had recovered sufficiently to allow trade. Since there had been no data on the status of most crocodilian species at the time of listing it was often impossible to prove that the species had recovered. The only crocodilian ever downlisted pursuant to these criteria was the American alligator in 1979. CITES overcame this problem for crocodilians by introducing the concept that came to be called 'ranching'. Implicit within this was the recognition that exploitation based on the collection of young life-stages (ranching)[12] was both biologically safe and could provide economic incentives for conservation.

A new CITES resolution was adopted that allowed the transfer of individual national crocodilian populations from Appendix I to Appendix II if it could be demonstrated that a ranching programme was in place, and that it was contributing positively to the conservation of the species. Zimbabwe was the first country to achieve an Appendix II listing based on ranching of its Nile crocodiles. It was followed by Australia which transferred its saltwater crocodile *Crocodylus porosus* to Appendix II under the ranching scheme a few years later. However, ranching proved technically complex and expensive in terms of infrastructure and management, and start-up difficulties prevented many other countries, particularly less developed countries, from following suit. To deal with this problem, CITES introduced an interim system of quotas through which crocodilian populations could be transferred to Appendix II on a temporary basis. Eventually the Berne Criteria were abandoned in favour of new, scientifically-based criteria for listing on the Appendices which allowed both ranching and quotas to be used as precautionary measures in a management programme.

Table 1. List of countries with crocodilian production programmes indicating mode of use. Wild harvest is direct harvest of adults or sub-adults from the wild. Ranching is collecting eggs from the wild for hatching and raising in captivity. Captive breeding is the production of eggs from adults held in captivity

Country	Species	Mode of use
United States	*A. mississippiensis*	Ranching, wild harvest and captive breeding
Mexico	*C. moreletii*	Captive breeding, ranching under development
Honduras	*C. acutus*	Captive breeding
Nicaragua	*Caiman crocodilus*	Wild harvest
Cuba	*C. rhombifer*	Captive breeding
Colombia	*Caiman crocodilus*	Captive breeding
Venezuela	*Caiman crocodilus*	Wild harvest and captive breeding
Guyana	*Caiman crocodilus*	Wild harvest
Brazil	*Caiman crocodilus*	Captive breeding, Ranching under development
Bolivia	*Caiman crocodilus*	Wild harvest
Paraguay	*Caiman crocodilus*	Wild harvest
Argentina	*Caiman latirostris*	Ranching
South Africa	*C. niloticus*	Captive breeding, ranching

[11] Laid out in Resolution Conf. 1.2

[12] Ranching is considered a highly precautionary and biologically "safe" method of harvesting because it relies on harvesting of the youngest life stages that regularly experience high mortality in the wild.

Country	Species	Mode of use
Mozambique	*C. niloticus*	Ranching
Botswana	*C. niloticus*	Ranching
Malawi	*C. niloticus*	Ranching
Zimbabwe	*C. niloticus*	Ranching, captive breeding
Zambia	*C. niloticus*	Ranching
Uganda	*C. niloticus*	Ranching
Kenya	*C. niloticus*	Ranching, captive breeding
Tanzania	*C. niloticus*	Wild harvest, ranching
Ethiopia	*C. niloticus*	Ranching
Madagascar	*C. niloticus*	Ranching, captive breeding
Thailand	*C. siamensis*	Captive breeding
China	*Alligator sinensis*	Captive breeding
	C. porosus	Captive breeding
Cambodia	*C. siamensis*	Captive breeding
Indonesia	*C. porosus*	Captive breeding, wild harvest
	C. novaeguineae	Wild harvest
Malaysia	*C. porosus*	Captive breeding
Singapore	*C. porosus*	Captive breeding
Papua New Guinea	*C. porosus*	Ranching, wild harvest
	C. novaeguineae	Ranching, wild harvest
Australia	*C. porosus*	Ranching, captive breeding
	C. johnsoni	Ranching, captive breeding

CITES was central to the gradual replacement of unregulated crocodilian exploitation with exploitation based on sustainable resource management. Today, CITES allows at least 30 countries to use wild harvests, ranching and captive breeding to produce crocodilians of 12 species for international trade (Table 1), but only on the understanding that these programmes do not threaten the future of any of the species in the wild. This proviso is by no means cosmetic. For example, it is quite possible to find examples where one species found in eight countries is much sought after by the market, but only one country is considered by CITES to have met the requirements for legal export.

PATTERNS OF PRODUCTION

The articles and regulations of CITES have marked effects on trade in both raw and manufactured crocodilian products. CITES influences which species can be sold, when they can be sold, to whom they can be sold, and in what form they can be sold. In determining the terms of trade in this way, CITES has a fundamental impact on the traditional crocodilian leather industry in which the relative occurrence of different species in trade has always been of critical importance. The American alligator and most crocodiles are considered to have high value 'classic' belly skins because they are free of osteoderms[13], while the belly skins of caimans, especially the larger sized ones traditionally taken from the wild, are strongly ossified and less valuable, and only the flanks are used to produce leather goods (e.g. Thorbjarnarson, 1999). Even within the classic species there are differences in value based on

[13] Boney plate-like growths within the skin

various perceived skin characteristics or supply differences, with saltwater crocodiles traditionally being favoured ahead of other species.

In the early 1980s, CITES began severely to impact both the number and composition of species in trade.

By 1989, the total volume of crocodilian skins in trade had been reduced from an estimated high of 1.5 million a year to a low of about 500,000. Thereafter it began to rise again until it reached a new peak of almost 1.2 million skins in 1999 creating a U-shaped historical supply. This pattern broadly mirrors the end of unregulated exploitation, dominated by illegal trade, and the ushering in of sustainable use. However, things become more complicated when the composition of species in trade and the mode of their production (and in association with this, their size) are considered.

The total number of "classic" skins from crocodiles and alligators entering trade before 1977 is unknown. The best known estimate of 300,000 is largely speculative (Ashley & David 1985). Figures for legal trade are available from 1977 when 40,000 skins entered trade, almost all from cropping in the wild, until 1999 when 390,000 skins entered trade. The number of animals taken from the wild hardly changed over the period. Almost all the increase came as a result of production from ranching, which rapidly increased from 6,500 in 1983 to 263,000 in 1999, and captive breeding, which increased from 5,600 in 1988 to 73,000 in 1999 (MacGregor, 2001, in prep.).

The data show a very different pattern for South American caimans. Here wild harvesting remained the dominant form of production until 1985, when more than 1.4 million wild-taken skins were reported in trade. Thereafter the number of wild skins in trade dramatically decreased to as few as 34,000 by 1999, principally from just one country, Venezuela. Amazingly, over the same period the number of caiman skins produced by captive breeding (principally in Colombia) increased from zero to over 770,000 (Table 1) (MacGregor, 2001 in prep).

The marked changes in the source of skins reflect two paradigms within crocodile conservation that have been supported by the evolving regulations of CITES. For some years it was held as conventional wisdom that the preferred conservation strategy for crocodilians, and many other species, was "captive breeding" in which adult animals were held in farms to produce eggs so that production could be completely independent of wild populations. The usual justification for this approach was that, in situations where demand for wildlife products persisted, the production of captive bred specimens would take the pressure off wild populations.

The feathers of this dogma were severely ruffled in the late 1980s when it became clear that the effective conservation of crocodilians often depended on giving wild populations an economic value in order to provide conspicuous and tangible incentives for their long-term sustainable management. Not only was captive breeding eroding the pivotal link with the wild, but production was beginning to move *ex-situ*, from the Range States[14] to important consuming countries, or even to countries that hitherto had played no role in the crocodilian industry. As noted by Thorbjarnarson (1999) this had the effect of "reducing the potential for developing sustainable-use programmes based on native species and increasing the likelihood of introducing exotic species through escapes." Colombia commenced the captive breeding of caiman in the late 1980s and by 1995 was producing over 700,000 skins a year in what is, essentially, a new agricultural business. The industry no longer impacts on the wild, but nor does it provide obvious incentives for conservation. A similar situation exists in Thailand, where virtually all the production of Siamese crocodiles *Crocodylus siamensis* is based on captive breeding, and the wild population, reduced to a few individuals at best, benefits little if at all. Today, commercial production through captive breeding remains controversial as it is often perceived as a threat to incentive-based conservation, although an element of captive breeding may be needed to sustain the business elements of a ranching programme, providing security of through-put and insurance against regulatory and other changes out of the investor's control.

As our experience mounts, flexibility and a willingness to change are emerging as the essential ingredients of successful market-driven conservation programmes for crocodilians. It is not simply a

[14] The countries in which the resource occurred naturally.

matter of implementing a prescriptive programme and letting it operate indefinitely without change. Rather, it is one of implementing a programme that can adapt rapidly and smoothly to changed circumstances. Unfortunately, the machinery of CITES is not designed to adapt rapidly to change. It tends to force new programmes of economic consumptive use into a narrow range of fixed options, such as captive breeding and ranching[15.] Market-driven conservation programmes based on ranching require a major investment in infrastructure to collect and incubate eggs, and to grow the young animals. In times of weak markets, governments and investors have often wished to switch to less expensive forms of production to maintain incentives for conserving wild stocks: options such as the export of eggs and hatchlings or the cropping of larger, market-ready animals directly from the wild. But the export of eggs or hatchlings is generally frowned upon, partly because it is assumed that value-adding of the resource benefits a nation, even if it is not economically viable to do so. Direct cropping from the wild may be the only viable option for poorer countries to participate in the market, and generate incentives for conservation, but despite compelling economic arguments, it is commonly resisted because it is less precautionary in biological terms.

Because the economics of the market-driven conservation of crocodilians has never been examined in any detail, the nature of the relationship between conservation objectives and financial returns is largely speculative. However, preliminary examination of the economics of the crocodilian industry has suggested that demand is elastic and supply is relatively inelastic (Woodward, Dennis and Degner, 1993). As a result, the market is characterised by marked price fluctuations. During the 1980s prices steadily increased as the demand for legal classic hides exceeded supply. It appears that some traders, tanners and manufacturers responded to the rising market by increasing their stocks, without fully considering the many new production facilities coming online. In 1990, prices started to fall and then crashed as speculators tried to cut their losses (Figure 1). The downturn was less severely felt by the producers of saltwater crocodiles, a species which has traditionally been in short supply, than by the producers of other species, where prices often fell to uneconomic levels and remained there for several years.

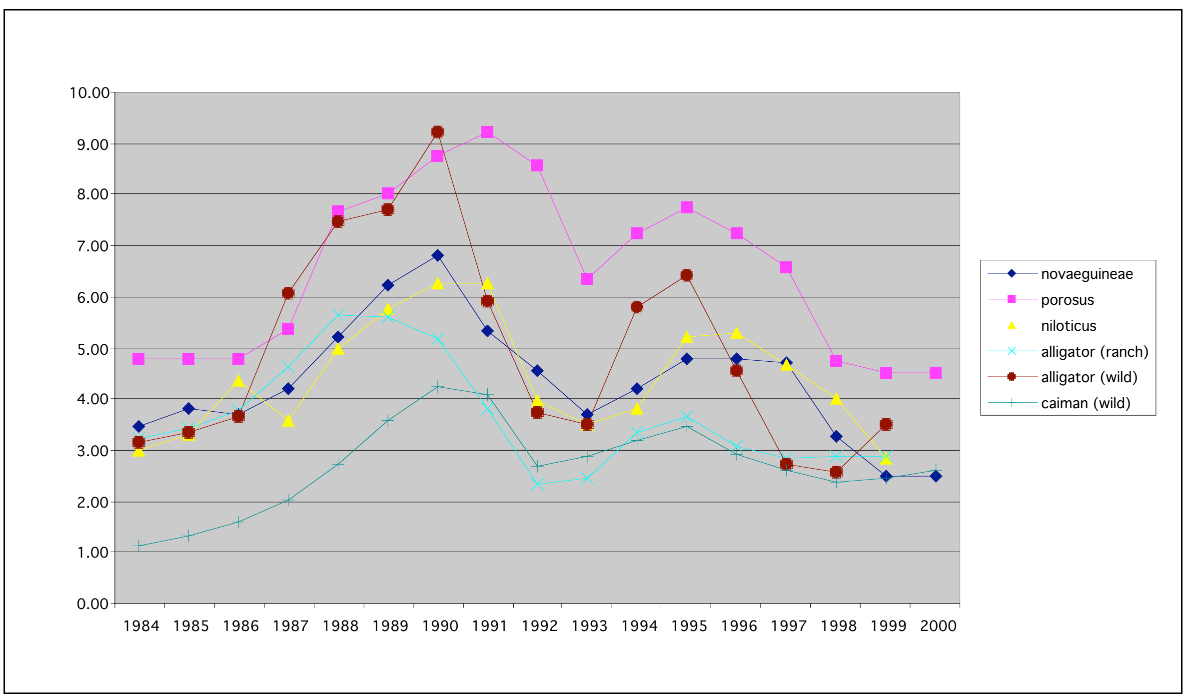

Figure 1. Producer Price Indexes for Crocodilian Skins, 1984–2000

Prices started to rise again in 1993, but crashed again in 1996 – almost certainly in response to the Asian economic crisis. Asia is the principal end-market for luxury goods, including leather goods

[15] The terminology in crocodilian production can be confusing. In terms of the wild population there is a major distinction between 'captive breeding' and 'ranching', but this distinction is not always made clear. The term 'farming' is commonly used to describe both forms of production.

made from crocodilians (Woodward, Dennis and Degner, 1993). The price for crocodilian raw materials is determined largely by the economic status within consuming nations, although superimposed on this are the unpredictable vagaries of the fashion industry. During these two difficult periods a number of individual producers went out of business and several national market-driven conservation operations (particularly in Africa, which had a number of new programmes in which the costs of investment had not yet been amortised) were reduced to holding-operations, or closed altogether. This created conservation crises in some instances (Thorbjarnarson, 1999). However, global production continued to increase (Figure 2) as producers increased efficiency and adopted new strategies to produce economies of scale within the industry.

It has long been recognised that one of the potential problems with market-driven crocodilian conservation is that considerations of sustainability may be set aside in order to overcome short-term, economic problems (e.g. Loveridge, 1996; Thorbjarnarson, 1999; Woodward, Dennis and Degner, 1993). The responses to a weaker market in the early 1990s were varied. There were attempts to better control market fluctuations through producers working together to reduce costs, restrict supply and increase demand. Attention to production efficiency on most farms resulted in more production or profit from the same level of harvest. In some countries producers tended to swing towards captive breeding rather than ranching, which although more secure economically, eroded conservation advantages.

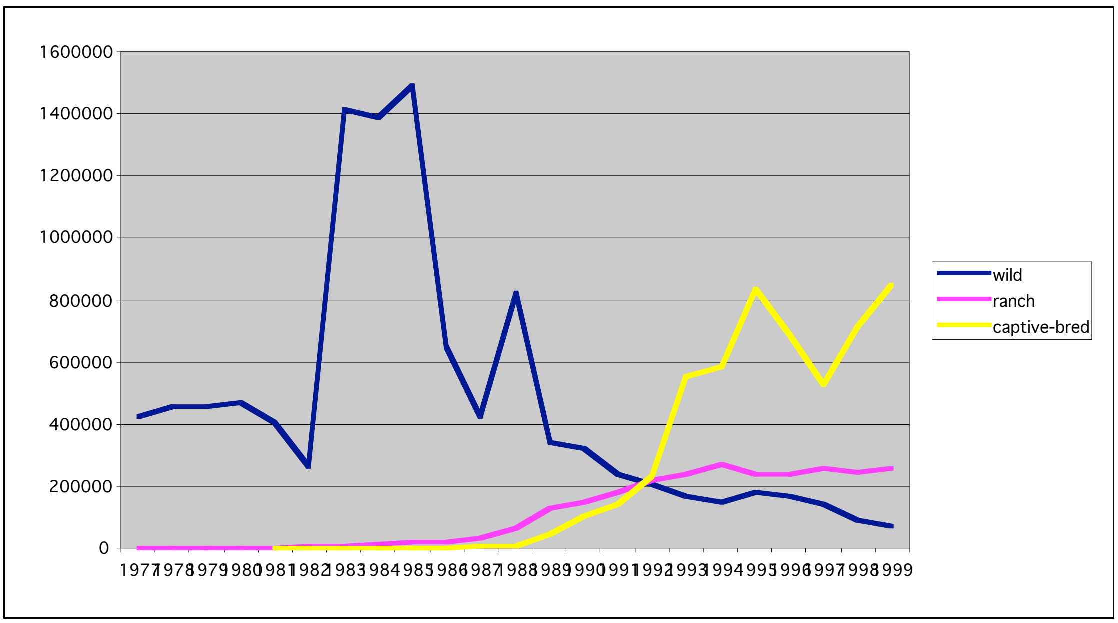

Figure 2. Estimated Trade in Crocodilian Skin by Method of Production, 1977–99

It appears that producers and conservationists met little success in controlling either supply or demand. On the supply side, the concept of an international producers' cartel to restrict production was neither researched in depth nor implemented. Indeed, some producers reacted to falling prices by increasing production in an effort to maintain profitability. In some developing countries, the subsidised export of raw crocodilian materials continued, regardless of viability, because there was an acute need for foreign exchange. In a positive vein, on at least one occasion producers were provided with a subsidy in recognition of the conservation value of production[16] (Loveridge, 1996).

On the demand-side, producers tended to have such a poor understanding of the dynamics of the traditional luxury crocodilian leather industry that they were unable to exert any influence. While trade over the last 20 years has seen a reduction in the number of the intermediaries between producers and consumers, vertical integration has consolidated the critical role of tanneries which have become the

[16] Crocodile farmers in Zimbabwe were preferentially issued permits to catch fish to feed crocodiles on farms.

principal buyers and wholesalers. The number of tanneries has also declined, partly due to environmental regulation, but their capacity has increased. While there is not yet a monopoly, the few remaining tanneries probably exert the largest single influence on the market. The concept that producers, tanners, manufacturers and retailers could work together to influence demand, remains embryonic; it would require levels of transparency unlikely to be forthcoming.

Finally, when considering the economics of production it is appropriate once again to visit CITES as it affects the final price of items in numerous ways. Regulation and control systems create costs and these are largely borne by the producer. Even the price of the permits and skin tags that are required by CITES can be a significant part of the profit margin with some species. As larger and larger numbers of specimens are produced, the resources needed for regulating trade at the level of the individual animals or even parts of individuals (such as teeth and other curios), as required by CITES, may increase out of all proportion to the value of the resource and to the conservation priorities that spawned the need for regulation.

BIOLOGY, BUSINESS AND BENEFITS

Although many, if not most, crocodilian production programmes started with strong conservation objectives, it has often been difficult to adhere to these over the long-term. For example, even where programmes have been well planned in biological terms, the high value of wild crocodilian resources has not always resulted in re-investment in the resource. Government agencies have sometimes preferred to use revenues for other priorities.

Most of these difficulties could have been predicted if broader expertise had been included in the development of programmes, because the success or failure of these programmes has ultimately proved to be governed largely by economic and institutional factors. Key questions that should be considered are: Is the programme profitable for those investing? Is the structure of incentives likely to deliver the desired results?

These elements are largely ignored by CITES which emphasises the biological determinants of sustainability. This is not surprising, because most of the 'actors' in wildlife management are biologists or aspiring biologists. However, it has resulted in the biological elements of market-related programmes being subjected to close scrutiny while the social, cultural and economic elements have often been ignored. With crocodilians, biologists have tended to play the leading role in developing market-driven conservation programmes despite most of them having limited skills in marketing, animal production, economics, or the socio-economic constraints on business. With the benefit of hindsight, biology has proved to be one of the least relevant (and most easily addressed) factors in achieving sustainability, despite the disproportionate emphasis given to it by CITES. In contrast, conservation benefits ultimately depend on the socio-economic context and the institutional mechanisms in place. Yet business risk and uncertainty analysis are not involved in most proposals to CITES.

One important lesson from crocodilian management is that success has always hinged on the establishment and maintenance of good relations between the government regulators and business interests, from the planning stages onwards. Business may not understand the conservation focus of management programmes as much as governments, but tends to tolerate expenditure during start-up phases even if it considers it cosmetic or unnecessary. But investment has proved to be a powerful political tool and once programmes are established, economic interests have often conflicted with, and sometimes prevailed over, conservation interests. The financial stress of falling markets in the early 1990s provides an extreme example. It resulted in pressures to reduce the costs associated with resource monitoring and other regulation in many countries. In some cases, it promoted efforts to bypass regulation completely (illegal harvesting), and some wild-caught animals probably entered trade under the guise of farm-raised animals.

On the other hand, government regulators often have little understanding of, or sympathy for, the needs and realities of sustaining a business. They have sometimes compromised the conservation objectives of programmes themselves, by inappropriate actions that directly affect the interests of the business partner. In some instances the state regulator has introduced uncertainty over long-term access to wild resources. The principal lesson here is that compromises between conservation and business interests are commonplace, and they need to be accepted as a normal part of any market-linked programme. If short-term business interests are put before sound long-term conservation gains, sustainability can be compromised, but it can equally be compromised by the reverse situation. There is no easy answer to this problem, although building in transparency - where changes have to be justified publicly - may perhaps be one step in the right direction.

Long-standing and effective partnerships between government and business have sometimes been compromised by staff changes and loss of institutional memory. Any programme trying to achieve sustainability will have to confront an array of new and unpredictable problems born of the interaction between social, cultural, economic and biological variables. Yet as staff change in regulatory institutions, the experience of resolving these complex issues is often lost. This difficulty is perhaps most critical in small and poorly financed institutions within developing countries, where changes in personnel and record-keeping protocols occur at a much faster rate than would normally be the case in any business operation. New regulators facing experienced business interests for the first time often face a series of difficulties in rebuilding partnerships based on confidence. The original conservation focus may have changed over time, perhaps for sound reasons, but if these are not well understood by both parties, distrust can be created and programmes compromised. The results of these difficulties sometimes benefit business interests in the short-term, but are often costly in the longer term. Governments typically have problems with:

- Keeping track of the changes in policy and management plans that have been implemented over time, and of the original reasons for those changes;
- Training staff so that programmes are not compromised by individuals leaving or being promoted;
- Maintaining long-term monitoring programmes with the necessary levels of accuracy and precision;
- Making commitments for long-term monitoring in say, three or five year cycles;
- Maintaining a stable relationship between business and regulatory interests;
- Maintaining a clear understanding of the interactions between social, cultural, economic and biological variables that govern success or failure;
- Maintaining records in such a way that past experience can be readily called upon.

Unfortunately, government regulators have been known to compromise sustainable use programmes for political or personal gain. Where impoverished government agencies have the opportunity to receive significant revenues from crocodile production there have been instances where the regulator has raised unrealistically high "taxes" on business, issued harvest quotas beyond levels likely to be sustainable, tried to enter the production business as a competitor to private investment, or used potential financial benefits as a political tool (e.g. Loveridge, 1996). There are also examples of rent-seeking on the part of individual bureaucrats. All of these have detracted from the sustainability of management programmes.

Despite these negative observations, the economic importance of crocodilians has usually led directly to stronger institutional arrangements for their sustainable management, largely because governments are often obvious beneficiaries and have a strong incentive for conservation. The benefits that flow to a handful of crocodilian producers or traders create a potentially powerful supporting constituency and many programmes rely on this dualism. Often, however, the State is not the 'owner' of the resource or the land on which it is found. In Australia the state claims ownership of wildlife including crocodiles (e.g. Webb *et al*., 2000), but the situation varies from country to country. In Papua New Guinea, crocodiles are owned legally by rural communities (e.g., Fernandez and Luxmoore, 1996), whereas effective ownership is bestowed upon private land-owners in a number of countries, for example Venezuela (Thorbjarnarson and Velasco 1998). Unfortunately, with a few well-known exceptions, it has often proved to be a challenge to design schemes in which crocodilians become a significant economic asset to private or community landholders who live with them, and on whose goodwill their survival will ultimately depend (e.g., Loveridge, 1996).

THE MISSION TO MARKET

Conservationists, particularly those who focus on the biological and regulatory aspects of management, often assume that the marketing of products is a strictly private, commercial element of the programme, with little relevance to management of the resource. Yet marketing, sales and profitability are absolutely fundamental to the success of these conservation schemes. There can be no economic incentive without profitable sales, and conservation interests can be eroded. For example, in the early years of a market-driven conservation programme in Tanzania in the 1990s, the poor marketing of crocodile skins resulted in the a request to take off twice as many crocodiles from the wild - something that could have been avoided had the true value of the final product - the cured skin - been returned to the correct authorities (Hutton, 1992). Thus, there are sound reasons for regulatory authorities to embrace marketing as one of the variables associated with sustainability.

Marketing and technical knowledge has itself become a tradeable commodity in the crocodilian industry, with mixed results. Significant improvements in production efficiency have been gained from research, and in most cases investment in market research has resulted in better market prices, mostly due to improved quality and eliminating “middlemen” from the trading chain. However, in each case a recurrent problem has been the conflict between transparency and the protection of the intellectual property rights associated with market and technical research. In the early 1970s, research results tended to be available for all to use, but this has changed over time and it can be argued that secrecy has been a major impediment to progress in some countries, partly because it has constrained the ability of those receiving information to validate it. The impacts of poor or uninformed advice, or advice given by people who did not necessarily have the credentials to give it, is difficult to evaluate. There are clear cases where ‘expert’ advice has resulted in unrealistic expectations amongst both the government and private sector and, as a consequence, has been directly implicated in poor investment strategies. For example, ranching or captive breeding programmes were inappropriately developed for certain species or populations. As a result, a number of national programmes have shrunk dramatically, or closed altogether, and the whole concept of market-based conservation has suffered when unrealistic expectations, based on poor advice, have not been met.

In the absence of effective information allowing producers to influence the demand for traditional high-value crocodilian leather goods, producers commonly investigate value-added production, diversification and creating new markets. On the whole these are regarded as positive outcomes, but it has not proved easy to add value to the raw product in producer countries. Not only has there been strong opposition from vested interests, but the technology is expensive and expertise is not freely available. It has proved difficult for developing countries to produce the high quality required by a market specialising in luxury items. Attempts by government regulators to force value-adding have also had dubious results. For example, Indonesia insisted that skins be partly tanned before export, but the price was often higher for raw skins than for partly tanned ones (Jenkins, pers. comm.).

Most successes in value-adding have come from joint ventures between producers or groups of producers and established processing businesses. However, the principal result has not been penetration of the luxury market, but rather the creation of new markets, often of a domestic nature, providing goods of lesser distinction to ordinary consumers. In terms of diversification, crocodilian meat is an important by-product and in some species it may be worth as much, or more than the raw hide. Other by-products include curios and a variety of products made locally from low grade skins. These all generate income and stimulate secondary businesses, and are typically oriented towards domestic sales to tourists, who subsequently export the items.

It is not only tourist souvenirs that are moved across borders. The principal manufactured end-products of the crocodilian industry, luxury leather clothing and accessories, are commonly carried from country to country. Although CITES itself may exempt these legally-held personal possessions from inconvenient controls, such as permits and tags, many of the key consuming countries have adopted domestic trade control measures for wildlife products that are stricter than those under the Convention. It results in difficulties and inconveniences for the final consumer. Added to this, campaigns by NGOs and governments, such as those at many airports, often urge citizens to avoid buying any wildlife products, or at the very least, to exercise extreme caution. Travellers are urged to be aware of the strict regulatory requirements associated with any movement of wildlife products across international borders, and are often confronted with impressive penalties. While these exhortations and difficulties may be valid for some wildlife products, they rarely apply to crocodilians today - yet buyers are naturally discouraged from purchasing crocodilian products.

This situation persists, at least in part, because the commercial use of wildlife disturbs many conservationists, perhaps with considerable justification. History is littered with examples of where market forces have resulted in over-exploitation and declines in wild species. The widely held opinion that economically driven consumptive use of wildlife is incompatible with conservation lingers on, despite dramatic changes in our understanding of the reasons why this occurred so commonly in the past. Over-exploitation almost invariably occurred in situations of "open access" without appropriate institutional arrangements, and without any incentives to conserve or use sustainably. Thus, despite situations which rectify these problems today, wildlife trade is, at least in some cultures, now considered undesirable and even immoral.

DISCUSSION AND CONCLUSIONS

Markets have created economic incentives for crocodilian conservation in a diverse range of circumstances and contexts. There is no doubt that the most successful crocodilian programmes are those that have used a broad range of inputs during their preparation and implementation, and were flexible enough to adapt to changing circumstances. These are programmes that have been mindful of the socio-economic environment, and have ensured that the institutions of regulation could operate in an environment relatively free of perverse incentives.

It is also clear from the global experience that the development and maintenance of successful programmes requires effective partnerships between regulators and all other stakeholders. Not least to prevent the loss of institutional memory, which is the substance of building long-term partnerships. Policy and management are best developed cooperatively, so that all sides understand the conservation elements and the way business is expected to contribute to them. To ensure consistency with respect to conservation objectives, long-term management plans should be supported by precise and long term contracts to achieve the goals required. Management programmes should stipulate transparent procedures for developing and allocating quotas, to constrain the ease with which they can be manipulated. To avoid unrealistic expectations it is desirable to increase transparency in research, marketing and the provision of advice, even though there are important issues to tackle with respect to the balance between openness and the protection of commercially sensitive information.

CITES has always been the biggest international influence on the commercial use of crocodilians because most programmes were developed before Agenda 21 and the introduction of the Convention on Biological Diversity (CBD). As a result, there has been little attention paid to issues of equity and benefit-sharing which are important considerations with respect to sustainable use in the context of the CBD, but of lesser concern within CITES. In fact, experience suggests that it is difficult to extend benefit sharing beyond business and the government regulator, down to the landholder and others who live with crocodilians. One difficult issue to consider is how conservation benefits of the market can be maintained in the face of a seemingly inexorable drift towards the domestication of crocodilians in some countries: a trend which reduces the link between business investment and wild populations. The issue of long-term access to crocodilian resources is much more important and fundamental to business interests than would appear from most management programmes, and has often resulted in the pursuit of captive breeding. The ecology of wild crocodilians introduces significant variation in the numbers of eggs and hatchlings available from the wild each year, making life unpredictable for business interests. It is important to seek ways to ensure that supplementary production through captive breeding can add security to operations based on wild harvest without making captive breeding the most cost-effective option for obtaining stock.

While the market-driven conservation of crocodilians has its problems, many of these could have been predicted at the time of planning had there been any honest and objective assessment of the market environment. Far too much emphasis was placed on biological variables and far too little on economic factors. A large share of the responsibility for this lies with the biologists[17] who played a central role in the design of most programmes, as they typically sought little input and involvement from specialists in economics, business and marketing – a situation exacerbated by CITES. There is no doubt that CITES, which has been the most critically important instrument fostering the sustainable management of crocodilians, would benefit from the inclusion of standard economic issues in its deliberations. At the moment, it attempts to regulate trade in commodities without any detailed considerations of the market. As a result, it receives no warning of major economic problems, and its inflexible structure constrains its ability to respond to them when they arise. Unnecessary and burdensome regulation, often cosmetic and typically costly to implement, are of continual concern. CITES may have been the principal tool for change and improvement in the sustainable commercial use of crocodilians, but it has not been the driving force behind those changes. The impetus has been provided by strong national interests that have been supported by a strong constituency of voluntary crocodilian 'experts', particularly those under the auspices of the Crocodile Specialist Group which is part of the Species Survival Commission of IUCN – the World Conservation Union.

Price fluctuations cause major problems for businesses and ultimately threaten conservation of the resource. The question must be addressed as to whether or not there are any appropriate interventions that can be made to support the conservation premium where this exists? Producers, traders and some conservationists are calling for the endorsement of programmes of market-driven conservation by international conservation agencies and have suggested the introduction of certification and/or eco-labelling schemes. A number of initiatives endorse sustainably-harvested marine and forest products and these could, perhaps, be models for crocodilian harvesting regimes. In addition, given that Appendix II of CITES is supposed to act to prevent commercial international trade from threatening wild species, there may be potential for CITES itself to develop a certification role. These possibilities merit detailed investigation, though it is far from clear where the lead will come from. This is something that the IUCN Crocodile Specialist Group might consider further.

Of more importance, as far as the market is concerned, is the disincentive to business created by the burden of regulation imposed over recent years, regardless of the good intentions involved. Eco-labelling may be a far less important issue than removing restrictions on the movement of personal possessions, and amending information which discourages the public from buying products that are directly linked to better conservation. The practice of many OECD countries of adopting domestic control and regulation measures that are more restrictive than CITES adds a further tier of complexity. These issues must be addressed as a matter of urgency to ensure that the gains made from the market-driven conservation of crocodilians over the last decade or so are not lost over the next.

ACKNOWLEDGEMENTS

This review has been produced on behalf of a Working Group of the IUCN/SSC Crocodile Specialist Group (CSG) and we are grateful to all the members of the CSG who have given their time to contribute to the process. We would like to thank John Caldwell at UNEP-WCMC for his help with crocodile trade data and Don Ashley, Steve Broad, Rosie Cooney, Ruth Elsey, Richard Fergusson, Lee Fitzhugh, Dietrich Jelden, Hank Jenkins, James MacGregor, Alvaro Velasco and Allan "Woody" Woodward for their critical comments on earlier versions of this manuscript. Any remaining errors must be laid at our door. We are grateful to the ResourceAfrica and Wildlife Management International for their support to this project during its inception and throughout its implementation.

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[17] Possibly including some of those who have contributed to this paper.

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Accumulation of Radionuclide and Metal Contaminants in Flesh and Osteoderms of Estuarine Crocodiles (*Crocodylus Porosus*): Pathways and Histories of Catchment-Specific Exposure

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ABSTRACT: Flesh and osteoderms of estuarine crocodiles (*C. porosus*) from Kakadu National Park, Northern Australia were analysed for a range of metals, including uranium, to assess their capability for accumulation, in relation to their catchment-specific exposure to i) uranium mine effluents and mineralisation, and ii) Pb shot ammunition through their consumption of fauna shot by the traditional owners of the Park. Uranium in osteoderms was significantly ($P<0.05$) elevated in the East Alligator River catchment, that contains the Ranger and Jabiluka uranium mine sites, relative to two other adjacent catchments. The mean concentrations of various other elements in flesh and osteoderms were also significantly ($P<0.05$) different between catchments. Linear discriminant analysis was used demonstrate that multi-element signatures in both flesh and osteoderms could be used to classify individual crocodiles to their respective catchments. This approach may be useful for the identification of source catchments of itinerant 'nuisance crocodiles' that find their way into Darwin Harbour, close to dense human habitation. Pb concentrations were significantly ($P<0.05$) enhanced in both tissues of crocodiles sampled within areas hunted with Pb ammunition. Enhanced ratios of Pb:Ca in the annual laminations of their osteoderms are consistent with their history of continual exposure to elevated anthropogenic Pb sources. Subsequent experimental studies have demonstrated the ability of the crocodilian stomach to retain ingested Pb shot, that is readily solubilised and absorbed into the blood and then archived in the contemporary osteodermal lamination.

Molecular Cloning of Steroid Hormone Receptors of the American Alligator

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In all species of crocodilians, sex is determined not by genetic mechanisms alone, but also by the temperature at which the egg is incubated. In the American alligator (*Alligator mississippiensis*) the thermosensitive period (TSP) for sex determination is a 7- to 10-day window within stages 21-24 of development. Treating embryos with estrogen during the TSP produces female offspring, even at male incubation temperatures. Therefore, it has been suggested that estrogens play a role in determining sex in the alligator. However, the mechanisms of estrogen action on sex determination in the alligator are still uncertain. Further, studies of contaminant-exposed alligators have shown alterations in steroid action. Whether these abnormalities are due, in part, to alterations in steroid receptor expression is unknown. To begin to understand the mechanism of steroid action in alligators, we isolated cDNA encoding the estrogen receptors (ER) and the progesterone receptor (PR). Degenerated primers specific to ER were designed according to a comparison of nucleotide sequences of ERs from other species. Partial DNA fragments were amplified by PCR using alligator ovary RNA. Two DNA fragments (ER_a and ER_b) were obtained, and the RACE technique was utilized to clone full-length alligator ER_a cDNA in the 5' and 3' directions. Comparison of the amino acid sequence from the alligator ER_a with that of human, chicken and zebrafish ER shows that alligator ER is very similar to chicken ER (91 %). We also isolated a DNA fragment encoding a partial progesterone receptor (PR) of the alligator. We examined the expression levels of three steroid receptors (ER_a, ER_b and PR) in the ovary of juvenile alligators. Thirty hours after a single E_2 (270 mg/kg) injection, total RNA was extracted from the ovary. cDNA was synthesized, and the expression levels of each of the above receptors were analyzed with quantitative RT-PCR. Intriguingly, ER_a transcript decreased significantly with E_2 treatment. ER_b and PR transcripts were not changed. These results suggest that the expression of ER_a is sensitive to estrogen in the ovary of the juvenile alligator. However, in this study the expressions of ER_b and PR were not affected by estrogen treatment. Further study are underway to examine the expression of these receptors during embryonic development and reproductive cyclicity.

ACKNOWLEDGEMENTS

We thank Allan Woodward and other FL Fish and Wildlife Conservation Commission personnel for assistance in obtaining alligators as well as a host of undergraduate students at the University of Florida for laboratory assistance. This work was supported by Grants-in-Aid for Scientific Research on Priority Areas (A) from the Ministry of Education, Culture, Sports, Science and Technology of Japan, the Ministry of the Environment, Japan and the US Environmental Protection Agency (CR 826357-01-1).

Preliminary Surveys of American Alligators in Ephemeral Wetlands on Ichauway Plantation, Georgia, USA

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Ichauway Plantation, an 11,600 hectare private reserve located in southwest Georgia, is comprised primarily of longleaf pine-wiregrass uplands that are interspersed with numerous shallow ephemeral lime-sink wetlands. The property is bounded on the east by 20 kilometers of the Flint River and is bisected by 22 kilometers of the Ichawaynochaway Creek. Eyeshine counts of American alligator populations in 1994, 2000, and 2002 were higher in ponds than on the creek or river by at least 64%. The pond populations also had higher concentrations of juveniles, indicating that the ponds may provide important breeding habitat and refuge for juvenile alligators. Preliminary data indicate that alligators are more likely to use wetlands with emergent vegetation during wet years versus forested wetlands during times of drought. In spring 2002, we began a mark-recapture study that focused on a pond basin with a high concentration of juvenile alligators. Between 3/30/02 and 8/22/02 we marked 27 individuals within this pond basin (TL: 54.9 cm to 105 cm). We found that the alligators dispersed among the pools when they all had water, but concentrated in the deepest manmade pool during months of severe drought. Future work will include using radio telemetry to study the movements of alligators among wetlands. Ultimately we hope to study the role that alligators play in ephemeral wetlands in a seasonally fluctuating environment.

Present Range and Habitats of the American Alligator (*Alligator mississippiensis*) in Texas

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ABSTRACT: Survey results from a questionnaire circulated to area county biologist and from nuisance reports submitted by state wildlife staff and enforcement officers in Texas were used to document the current range and habitats utilized by the American alligator in the state of Texas. Range expansion from all-time population lows in the late 1970's is evaluated, and American alligator presence is reported for previously undocumented counties. Survey methods as used were found to have certain strengths and shortcomings that should serve as a basis in developing future surveys. Useful trends indicated by the survey aid in identifying areas with (1) increasing nuisance alligator problems, (2) American alligator populations from relocations outside of their historic range, (3) released exotic crocodilians, and (4) the ability to support an increased level of harvest.

Improved Field Techniques for Containing, Transporting and Estimating Body Mass of American Alligators

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ABSTRACT: Previously utilized methods of containing and transporting American alligators can be cumbersome, dangerous, extremely time consuming, and stressful to the animal. The use of baseball bags or army surplus style duffle bags for containment and transport of American alligators addresses some of these problems. Equipment for weighing American alligators in the field can be expensive and difficult to use. Morphometric measurements from wild-harvested, live nuisance, farm-reared, and live-captured American alligators were used in the development of an improved method to estimate the body mass of American alligators in Texas. Using total length to estimate the body mass of American alligators is generally less than optimal because of variations in body condition among years (e.g., drought versus wet years) or among habitat types. Preliminary results indicate that tail girth is a more accurate indicator of body mass than total length alone. Combining tail girth with other morphometric measurements may result in an even better indicator of body mass.

Status of the American Alligator (*Alligator mississippiensis*) in Southern Florida and its Role in Measuring Restoration Success in the Everglades

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ABSTRACT: The American alligator (*Alligator mississippiensis*) was abundant in the pre-drainage Everglades. The largest populations occurred in the broad marl prairies to the east and west of the southern ridge and slough and in the freshwater mangrove zone. Development and water management practices have reduced the spatial extent and changed the hydropatterns of these habitats. As a result of these activities, alligator populations have decreased. Currently, restoration of hydrologic pattern and ecological function is beginning in the Everglades. Due to the alligator's ecological importance and sensitivity to hydrology, salinity, habitat and system productivity, the species was chosen as an indicator of restoration success. A number of biological attributes (relative density, relative body condition, nesting effort, and nesting success) can be measured, standard methods for monitoring have been developed, and historical information exists for alligator populations in the Everglades. These attributes can be used as success criteria at different spatial and temporal scales and to construct ecological models used for predicting restoration effects. Here, we discuss Everglades alligator population status and its role in evaluating restoration success of the Southern Everglades.

An Evaluation of Follicular Quality for American Alligators in Contaminated Florida Lakes.

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ABSTRACT: Organochlorine pesticides (OCPs) in Florida lakes have been associated with decreased egg hatchability/quality and increased embryonic mortality in American Alligators (*Alligator mississippiensis*). Although levels in yolk and offspring do not correlate with hatchability, OCPs may decrease egg quality by altering maternal reproductive and ovarian function. To test this hypothesis, ovarian follicles and vitellogenin (Vtg) proteins were compared in female alligators collected during the peak follicular season from Lake Griffin, FL (n = 10) and Rockefeller Wildlife Refuge, LA (reference site, n = 10). Lake Griffin animals had two distinct follicular populations: 10-20cm and 21-35cm, with approximately 50 mature, pre-ovulatory follicles. Rockefeller animals had predominantly one population of follicles (16-25cm) with approximately 40 mature, pre-ovulatory follicles. SDS-PAGE of plasma revealed Vtg protein bands unique to follicular females at ~250, 300 & 350kD, which are similar to published molecular weights for Vtg or Vtg metabolites from other species. Two additional Vtg protein bands, ~150 & 230kD, were also identified and were more pronounced in Lake Griffin females. Follicular contents had similar protein profiles and showed similar site differences. These data suggest that there may be differences in the post-translational processing of Vtg in animals from Lake Griffin. (Funded by NIEHS-SFBRP).

Predicting Contaminant Body Burdens and Evidence of Maternal Transfer in *Alligator mississippiensis*

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ABSTRACT: Noninvasive methods for determining contaminant body burdens are useful in risk assessments for endangered crocodilian species. The present study's objective was to evaluate the use of eggs as a predictor of maternal body burdens in adult alligators. Adult female alligators (n = 7) and their eggs were collected from two contaminated lakes in central Florida during June 2001. Egg yolks from each clutch and maternal tissues were screened for 30 organochlorine pesticides (OCPs). Mean cumulative OCP burdens (ppb wet weight) for Lake Apopka females were 44,650 (fat), 15,108 (yolk), 2,134 (liver), 1,501 (muscle), 900 (bile), and 55 (blood). Mean cumulative OCP burdens for Lake Griffin females were 2,689 (fat), 616 (yolk), 208 (muscle), 153 (liver), 87 (bile), and 31 (blood). For all females, the tissue with the most linear correlations with yolk was fat in which 14 of 15 detected chemicals showed significant correlations (_ = 0.05), followed by liver (11/13), muscle (7/13), bile (6/12), and blood (1/9) with R2 values ranging from 0.67-0.99. We conclude that yolk burdens are predictive of maternal burdens for certain tissues and that selected OCPs are maternally transferred in the American alligator. (Funded by NIEHS-SFBRP).

Relationship between Egg Thiamine Concentrations and Embryo Mortality in the American Alligator.

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Thiamine deficiency has been linked to early mortality syndrome in salmonids in the Great Lakes. The present study was conducted to compare thiamine concentrations in alligator eggs from sites with high embryo mortality and high exposure to organochlorine pesticides (OCPs) (Apopka, Griffin, and Emeralda Marsh) to that from a site that has historically exhibited low embryo mortality and low OCPs (Orange/Lochloosa). During 2000 and 2001, a total of 120 clutches were collected from these sites, and artificially incubated. Clutches were monitored for embryo mortality and hatch rates, and thiamine measured in one egg/clutch. Eggs from the reference site had two times the amount of total thiamine compared to the impacted sites (1603 pmol/g vs. 847 pmol/g), and clutches with > 65% hatch rates had twice the amount of total thiamine compared to clutches with < 64% hatch rates (990 pmol/g vs. 485 pmol/g). These results suggest that thiamine deficiency might be playing an important role in alligator embryo survival and development. Causes for this deficiency are unknown at this time, but might be related to differences in the nutritional value of prey items across the sites studied. In addition, it is remains unknown what the role of OCPs are in the overall differences observed in egg nutritional quality across the sites studied (Funded by NIEHS-SFBRP).

Prehistoric Presence, Alligators and the American Landscape

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This proposal is to hang 20 to 30 large scale photographs (32” X 44”) in areas where speakers and attendees will frequent throughout the conference; and to have a poster presentation space where one photograph will hang, and a video monitor will present a video presentation which runs two hours and then can be rerun numerous times for continuing viewing. In this same space a copy of the book, Alligators, Prehistoric Presence in the American Landscape, Martha A. Strawn, The Johns Hopkins University Press, 1977, will be made available for review and sale.

The content of the presentation offers a selection of 151 photographs in a unique book, video, and exhibition that tells a story of America’s southern landscape and one of its most evocative creatures, the American alligator. The content combines art, science, history, folklore, land ethics, and literature to tell the story. Topics covered include mating and reproduction, hunting, loss of habitat, resource management, and the commercial meat and skin industries. The emphasis is on mutuality – when human beings and alligators live together in one habitat, each benefiting from the association -and the ethics involved.

Preliminary Study of an Identification Method by the Use of Natural Tail Marks in the Orinoco Crocodile

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Several artificial marking methods(tagging, cutting of scutes, ...) have been applied in the Orinoco Crocodile Conservation Program. A preliminary study was done to determine the feasibility of using a novel natural identification method in the Orinoco crocodile (*C. intermedius*). This method was developed by Swanepoel in the Nile crocodile (*C. niloticus*); it is based on the coding of natural marks located on a specific portion of both sides of the tail.
Tail sides were photographed and recorded from captive animals of Venezuelan breeding centers, ranging from hatchlings to adults.

Economic analysis of broad-snouted Caiman (Caiman latirostris) farming in Sao Paulo, Brazil

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ABSTRACT: Broad-snouted Caiman (*Caiman latirostris*) skin and meat present a considerable value at Brazilian markets. The natural distribution of the remnant wild populations of: broad-snouted Caiman in South-Eastern Brazil prevent the establishment of ranching and harvesting operations. Because populations are small and fragmented, they would not support hunting pressure or egg collection. Therefore, the only management option for this specie in South-Eastern Brazil is farming. The present study presents an economic evaluation of this system. The following indexes are presented: NPL, internal income rate, Payback period and analysis of sensitivity and risk.

Conservation Status and a Progress Report of the Re-introduction Program of the Siamese Crocodile in Thailand

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ABSTRACT: Since the latest comprehensive survey of *Crocodylus siamensis* in Thailand was in 1993, the wild population status has just been reevaluated. Surveys revealed few remnant populations of less than 10 individuals together in four remote habitats – Kaeng Krachan National Park (KKNP), Pang Sida National Park (PSNP), Khao Ang Ru Nai Wildlife Sanctuary (KARNWS), and Phu Khieo Wildlife Sanctuary (PKWS). Geographically isolated population of crocodiles in all four areas draws an urgent need for augmentation of viable population. Habitat of KKNP and PSNP were demonstrated to meet requirements for Crocodile Habitat Suitability Index. The other two areas are being surveyed. The schedule for pilot release and monitoring program is set for upcoming dry season. Two groups of local conservationists in KKNP and KARNWS areas have been fully supporting the re-introduction program. That suggests help for community outreach and education program in the areas. However, local sustainable development seems far away since most study areas are restricted and remote. The DNA analysis awaits DNA samples from wild-caught animals in study areas and from Cambodia for a comparative test. The main obstacle for Thailand program has been inadequate government support and insufficient funding.

INTRODUCTION

The Siamese crocodile has been widely distributed in the low altitude freshwater wetlands of central and eastern Thailand. They appeared to be reduced to non-breeding remnants in marginal habitats. The principal threats are habitat destruction, illegal hunting, and killing as vermin. They have been considered an endangered species based on the small number of specimens remaining in the wild. In IUCN Red List (1971), *C. siamensis* is categorized as CR: Critically Endangered, Criteria A.1.a. and c. severely decline in numbers and areas more than 80% decline in three generations (Ross, 1998). During a survey in November 1993, Ratanakorn *et al.* (1994) confirmed the presence of at least one wild adult *C. siamensis* in Pang Sida National Park and another in Ang Lue Nai Wildlife Sanctuary. Many sightings of *C. siamensis* in the wild were recorded at Pang Sida National Park. The most recent one was on April 25, 1993, which is an aerial photograph by M.L. Tossawan Tehwakul (Boonyakhajohn, 1999). In Yod-Dome area, a carcass of *C. siamensis* was discovered after fish bombing by fishermen. Platt et al. (in press) reported a recent photograph of a crocodile in Kaeng Krachan National Park. Historically, sightings of *C. siamensis* in the wild were common. In Me Yome, Me Ping, and Pasak rivers, it was fairly common, but it did not exist on the upper reaches of the Me Kong (Smith, 1919). Although wild populations are scarce, *C. siamensis* is abundant in captivity. Tens of thousands of captive populations of *C. siamensis* provide a significant resource for restoration (Temsiripong, 2001).

The ideal habitat proposed for restocking of endangered species must be within historical distribution of animals (IUCN, 1992). A limited number of papers describe the historical distribution of the species making it more difficult to locate potential release sites. It is apparent that this stage of survey is to locate any remaining crocodile populations in Thailand. A number of *C. siamensis* and *C. porosus* have been bred in captivity to provide a basis for recovery. However, the purity of captive-bred animals is questionable especially in hybrids. No genetic analysis exists for any of the captive populations; the degree of heterozygosity within populations and the degree of relatedness between isolated populations are completely unknown.

As the Siamese crocodile disappeared from people's immediate surrounding, so did this experience and tolerance (Dijk, 1999). It is suggested that the crocodile is not a threat to humans as long as he is given ample room to escape. In fact, a leading herpetologist told swimmers and fishermen that they would be safe from a crocodile attack unless they molest the reptile. During the first decade of the re-introduction effort, the chance that a crocodile will injure a human is exceedingly small, due to the low density of crocodiles in the areas and no one is allowed in the release areas (Temsiripong and Ratanakorn, 2001).

METHODS

Habitat Survey

Four protected areas within historical distribution of *C. siamensis* are visited and assessed the habitat suitability index (HSI) for crocodiles. The potential criteria are the food availability, basking ground, nesting area, protection, nursery pond, and survival index. The spoil or sub-optimum habitats are not considered.

Crocodile Survey

The technique involves a small team of observer who survey a section of waterway in one direction during the day, noting salient features and hazards, and then return over the same section in the reverse direction at night. The survey transect (the section of mainstream river or creek and any associated side creeks to be surveyed) has to be defined by a START POINT and a STOP POINT. Any side creeks off the mainstream, which are amenable to spotlight survey, must also have definitive stop points. Both banks of the mainstream and any side creeks are surveyed. Time of year and water level that is going to affect the number of crocodiles seen will be recorded. It is important to do surveys at the same time of year. For the best results, the cool dry season is the most suitable time to conduct surveys because the current is always too strong to conduct such survey. At this time of year crocodiles tend to be in the water at night because it is warm relative to the cool, night air. It is crucial to use the same type of light each time an area is surveyed. The choice of light used will be determined by the nature of the waterway to be surveyed. For small narrow creeks with thick vegetation fringing the water edge and a high frequency of bends, it is best to use a powerful hand torch as opposed to a 100W spotlight. Under these conditions, the area effectively scanned with the light is usually restricted to distances of 50 m or less. The use of a powerful spotlight creates a glare from light reflected off the vegetation. This may result in "eyeshines" going undetected as they tend to be obscured by the reflected light. Furthermore, crocodile eyes, like cat's eyes, close up in bright light. In wider, more open waterways, where the observer can scan 200-300 m ahead of the boat, a 100W spotlight is ideal. Locations in this study are reported in Universal Transmercator Units (UTM) Zone 47Q as eastings and northings.

DNA Analysis

Blood sample Collection: Blood (5 ml) was collected without injury to individuals from either an anterior dorsal sinus using a syringe rinsed with heparin. All samples were collected in icebox and sent to laboratory for DNA extraction.

DNA Extraction: For blood, the equivalent of 100 *u*l of crude blood was first suspended in ACK lysis buffer to a total volume of 1.5 ml. This was followed by a proteinase K digestion (62.5 U in 0.5 ml of 20 mM Tris-HCl pH 8.0) at 65^{o}C for at least 3 hrs or overnight follow by two extractions with equal volumes of phenol: chloroform (PC) in a ratio of 1:1 and one extraction with chloroform. The DNA was then precipitated with 95% ethanol, rinsed with 75% ethanol and redissolved in 200 *u*l, TE buffer.

Quantity and quality' of DNA: The quantity of DNA recovered from an extraction was determined from the absorbance of the sample at 260 nm. The estimate was refined by comparing the intensity of the fluorescence produced by the sample and by a standard sample of known DNA concentration running on a agarose electrophoretic gel containing 1 *u*g ethidium bromide/ml, and visualized under shortwave UV light. These gels also allowed us to estimate the size range of the DNA fragments in the samples.

DNA analysis: PCR amplifications had final concentrations of 50 mM KCl, 10 mM Tris-HCl pH 8, 1% Triton X-100, 1.5-2.5 mM $MgCI_2$, 150 μM of each dNTP, 0.5 μM of specific primer, 1 unit *Taq* DNA polymerase and 50 ng of DNA. During optimization, annealing temperature was varied and/or bovine serum albumin (BSA; 250 μg/ml) was added. Thermocycling parameters must be $94^{o}C$ for 2 mm, follow by 30 cycles of $94^{o}C$ for 1 mm, annealing temperature for 30 sec, and $72^{o}C$ for 30 sec.

We tested the ability of the primers to produce specific PCR products from DNA of Siamese crocodiles. PCR conditions were identical to those used *C. siamensis*. Products were assayed 1.5-2% agarose gels. Tests were considered positive when one or two bands of similar size and intensity to those from *C. siamensis* are produced. Decreasing stringency of PCR increased taxonomic breadth of taxa amplified, but it also tended to increase presence of extra nonspecific bands and smearing.

STUDY AREAS

Kaeng Krachan National Park (KKNP) is located in the Tenasserim Mountains along the Thai-Myanmar border in Petchburi and Prachuab Khiri Khan Provinces of southwestern Thailand (Fig. 1). Encompassing 2,915 km^2, Kaeng Krachan is Thailand's largest national park. The topography is characterized by steep mountain ridges with swift-flowing rivers in restricted valleys. Khao Phanoen Thung (1,207 m) is the highest point in the park. The steep topography and lack of roads make access to the crocodile habitat difficult. Semi-evergreen forest is the dominant vegetation with hill evergreen forest above 1,000 m. Surrounding lands are largely deforested, and KKNP protects the Petchburi River watershed, which supplies Kaeng Krachan Reservoir. The Petchburi River is swift flowing with numerous rapids with small number of Siamese crocodiles recently discovered.

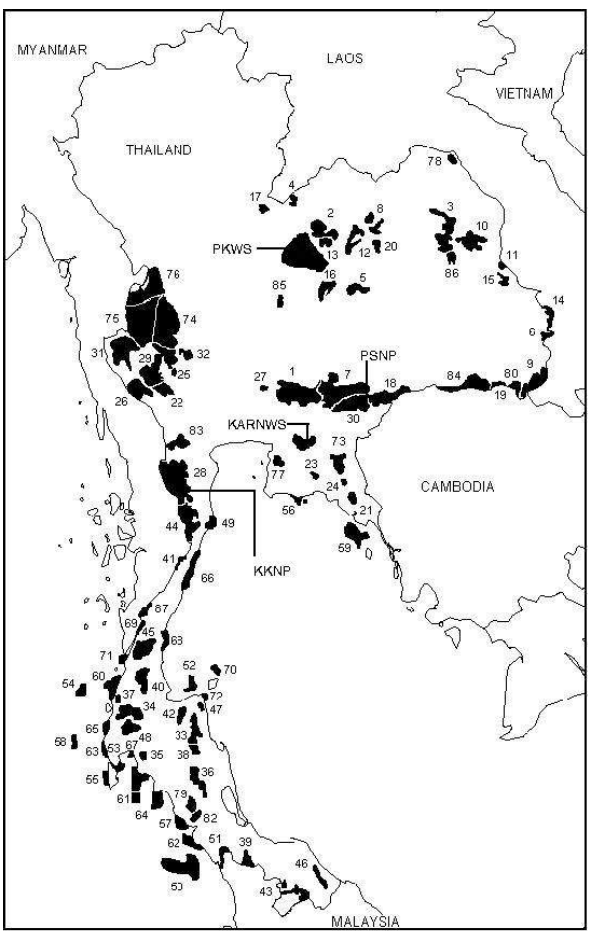

Figure 1. Study areas – KKNP, PSNP, KARNWS, and PKNP

Pang Sida National Park (PSNP) is located by The Khorat Hills in Srakaew Province, eastern Thailand (Fig. 1). With 845 km^2, the park is dominated by deciduous and evergreen rain forest as well as lowland scrub and open grasslands at the foothills, which reflects past logging activities. Surrounding lands are deforested with agricultural use. The Houy Nam Yen Creek was selected as the survey site due to many evidences of *C. siamensis*. For example, a crocodile was sighted and photographed from a helicopter there in 1992. And poachers claimed that they used to harvest hatchling crocodiles from the creek as well. The creek located in the western part of the park flows out of the western boundary of the park into surrounding lowland country.

Khao Ang Rue Nai Wildlife Sanctuary (KARNWS) comprises of 108 km^2 and encompasses hills covered in evergreen and dry deciduous forests, with open grasslands in the lowlands. In most of the sanctuary, there are several watersheds that eventually flow into river systems well outside the sanctuary. Most creeks dry and break up to form series of small pools in dry season. Klong Ta Kraw Creek was surveyed once in 1993 by Ratanakorn et. al. (1994). The creek is shallow and narrow and superficially seems to be sub-optimum habitats for *C. siamensis*.

Phu Khieo Wildlife Sanctuary (PKWS) encompasses an area of 1,560 km^2 in Chaiyaphum Province, northeastern Thailand, approximately 550 km from Bangkok. The sanctuary comprises a steep-sided plateau ranging from 540 m at its base to 1,310 m at the highest peak. The plateau is drained by five watersheds: Lam Saphung, Lam Nam Chi, Lam Dok, Huai Sang, and Huai Nam Phrom Creek. The latter is the river reported to have a remnant crocodile population. Hill and dry evergreen and dry deciduous forests with open grasslands in lowlands are major types of forest.

RESULTS

Habitat and Crocodile Survey

Kaeng Krachan National Park (KKNP)

A series of survey carried out in the Petchburi River, Kaeng Krachan National Park from dry season 2001 to wet season 2002. The 30 km stretch of river from the watershed to a reservoir is a rapid flow system with couple deep pools. The sighting of *C. siamensis* in this river has been reported. Two animals were caught there some thirty years ago and put into a farm. However, no reliably positive identification has ever made until recently. A photograph of a 2-m crocodile was recovered from a camera trap. We are able to confirm three locations where signs of crocodiles were discovered.

First of all, the first camera-trap photograph of a Siamese crocodile from Thailand was taken in March 2001 by a field team from Royal Forest Department and WCS, in the course of a tiger survey. We visited and surveyed the area in early 2002 and found an old footprint at UTM coordinate 0531939 1425677. Next, the fresh sign of a crocodile is a drag mark and a footprint of approximately 2m crocodile at UTM coordinate 0533145 1416876. The size of the footprint is similar to the one previously reported by Platt et al. (in press). The location is approximately 13 km upstream from the site of the photo record. The footprint measures 175 x 125 mm. It was a right rear foot. It situated at the edge of the sandbar where sand is tiny grain. The left rear footprint was not shown distinctly because the substrate is the coarse grained sand. Tail drag lies next to the footprint with 40-mm width. This indicates that the animal is approximately 2m. The crocodile was observed a week before by a helicopter pilot and a wildlife photographer. Several efforts to try to capture a crocodile that was camera-trapped were carried out, but due to the fact that there was no fresh track found at the location. We got a water monitor in one of the live traps (Fig. 2). The species is extremely common in the area and its sign could confuse an inexperienced observer. We also used a combination of snare, rope trap and baited snare.

Figure 2. Live trap used in Kaeng Krachan National Park

From the surveys, we were able to verify the photo observation and to visit a fresh track spotted a week before. We could not capture one and that may be because a recent rain that obscure all tail drag and foot print. Observation and sampling of potential prey item prove that this area can support a population of *C. siamensis*. Protection is above average according to a large number of carnivore species. And the last but not least, a remnant population lives here. KKNP is, therefore, considered as a re-introduction site.

Pang Sida National Park (PSNP)

The first set of surveys provided an update information of a remnant population of *C. siamensis* in PSNP. The surveys on the main section (16.7 km) of Houy Nam Yen Creek was repeated several times. The whole section of the creek was walked, paddled, and some time just drift away on bamboo raft. Several basking sites were spotted, three of which could have been made by moderate-sized crocodiles or monitor lizards. With the size of 2 m^2, these basking grounds are located between Wang Yao and Wang Mon (Start and stop point of line transects). Unfortunately, 72-hour observation failed to locate a positive sign of crocodiles. Two helicopter surveys for nesting activities in dry season were not able to locate a nest.

The surveys for hatchling crocodiles in wet season were carried out during July – August 2002 in the same area and beyond Wang Mon where never been surveyed before by any research team. We located a hatchling drift across the creek at UTM coordinate 0191145 1553582, but due to dense vegetation we were not able to capture it. We also located a footprint measured at 125 x 105 mm. The footprint could belong to a 1.2-m crocodile. We estimated that there is at least a breeding pair, a juvenile, and a pod of hatchling crocodiles. Habitat and food availability is sufficient to support a small population of crocodiles. Through out the entire creek, there are several deep pools, plus the water is running all year round. The depth of the bottom reaches 3.5 m while the range of the width is 2.5-30 m. The slope of the bank is minimum with abundant aquatic vegetation such as *Cyperus* sp.and *Sagittaria* sp.

Figure 3. A 2.8-m wild Siamese crocodile in KARNWS

Khao Ang Rue Nai Wildlife Sanctuary (KARNWS)

Several visits were paid to the basking sites (the location is confidential) which belong to one individual (Fig. 3) in Klong Ta Kraw Creek, KARNWS. We almost always find the animal by one of the basking areas. From 120-hour observation during both day and night, the animal usually surfaces quietly and does not panic when he realizes the presence of humans. He, then, submerges upon arrival and leaves only bubble trails on the surface. Twenty minutes thereafter, he comes back up to breathe for 2 minutes and submerges again for another 20 minutes. Water level appeared low and seemed to be lower till the rain falls. In wet season vegetation on the basking ground is dense, which suggests that the animal had not used the site for a while or he basks only in the dry season. Line transects reveal two more basking sites normally used by the crocodile. A number of scatters collected from these sites proved that the animal has sought a much more secluded site to bask and hide away from us. Later analysis of the scatter uncovers the taxons, which normally being preyed upon by a wild crocodile. The majority of preys are freshwater fish such as *Probarbus* spp., *Channa* spp., and *Clarias* spp. Small mammals' fur is accounted for only 5% w/w of the scatter. A skull of Pig-tailed macaque was discovered by a sanctuary ranger near the creek seemed surprised but not impossible that it was taken by *C. siamensis*. Upper stream is broken in dry season with only two small pools. Downstream the creek runs toward sanctuary border and end at the Si-Yad Dam near park border.

Observation data show that the crocodile lives mostly under water. He is highly secretive. He basks only in the morning after a cold night. Amidst breeding season, the minimum activity suggested that there is only one crocodile in the area. The sex is therefore unknown because in captivity the size of some females does exceed 2.5 m, while this individual is estimated to attain 2.8 m. Habitat suitability for a small crocodile population looks promising, provided that illegal hunting is under control. A few pools in dry season can accommodate just less than 10 crocodiles. Later relocation of crocodiles to other stretches in the sanctuary is an alternative if there is a severe drought. Although intraspecific competition can be high, interspecific competition is minimal due to small number of salvators and other large reptiles.

Phu Khieo Wildlife Sanctuary (PKWS)

Kreetiyutanon and Khumsuk (2002) photographed a footprint with a measurement 220 x 170 mm for a fore foot track and 210 x 190 mm for a rear foot track. Three basking sites were located near Huai Nam Phrom Creek as well. From the measurement, the animal may have a total length of up to 3.5 m. Two more footprints were reported in a different section of the creek. Therefore, at least 3 crocodiles live separately in PKWS. The plan to conduct more surveys in PKWS is set for this dry season. Currently, the current is strong and unpredictable.

DNA UPDATED RESULTS

We were able to distinguish *C. siamensis* from *C. porosus*. We applied the American alligator microsatellite markers to differentiate both species. It is now in the process of cloning a specific microsatellite marker for the Thailand Siamese crocodile. The DNA samples are from captive animals. We expect to capture a wild crocodile in each study area to represent geographical variation in genetic material, in order to check genetic diversity and the range of heterozygosity of potential release stocks. A few groups of captive-bred crocodiles were selected from CMAT members' crocodile farms. Most were tested for purity of gene.

Interview surveys

From interviews of 38 park rangers from KKNP and PSNP, 14 sanctuary rangers from KARNWS and PKWS, and 145 local conservationists near KKNP, PSNP, and KARNWS, the results show a significant increase in the number of supporter. Figure 4 could be summarized that people tend to support the project if they are well educated by a project coordinator. Although they are reluctant to welcome crocodiles into their vicinity, half of them think that crocodiles may bring no harm to humans. The need for community outreach and education to create a suitable social climate for accepting wild crocodiles is part of the project (Fig. 5). Social work with education program for schoolchildren and community was considered a major strategy. In KARNWS, local people form a group of conservationists. They campaign against construction of pavement road leading to the crocodile site, since they are afraid the poaching pressure would be out of control.

CONSERVATION STATUS AND POSSIBILITY FOR RE-INTRODUCTION

Threats from poachers and aloewood (*Aquilaria* spp.) collectors with fishing and hunting activities have always been a major problem of wildlife conservation in developing country. Further natural threats such as flooding and interspecific competition are also major problems. Although most areas have suitable habitat, threat to crocodile may hinder the success.

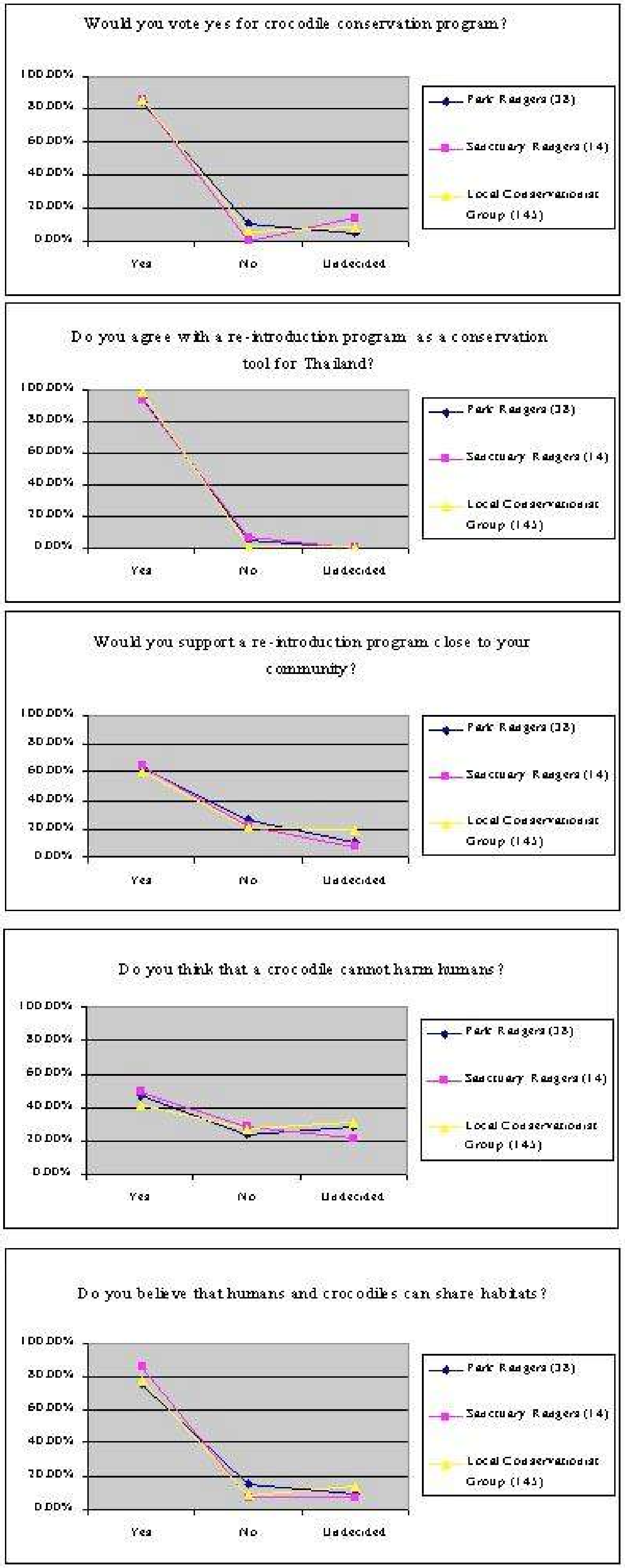

Figure 4. Poll results from crocodile education program

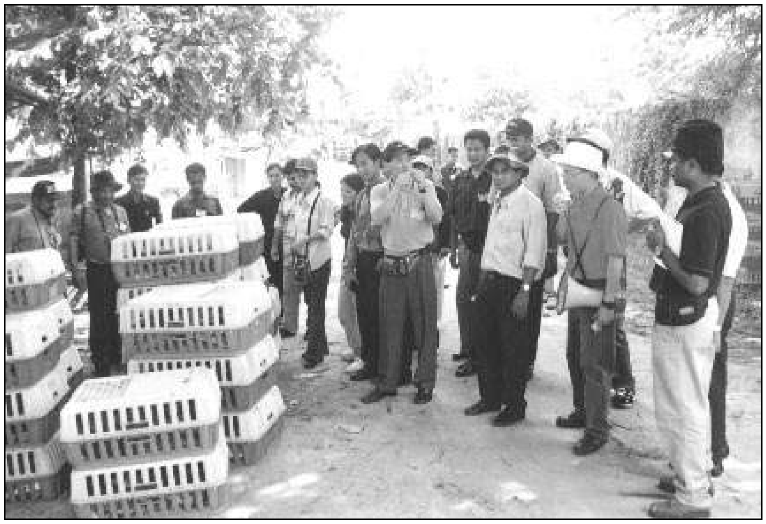

Figure 5. Community outreach program for local conservationists, park and sanctuary rangers

Together with the Royal Forest Department, we plan to minimize threats to the species such as poaching and fishing, and restore or adjust environment to make it suitable for released animals. We emphasize on monitoring the core not the edge habitat of release areas. We also plan to release the genetic pool that is as similar as possible to the existing wild population. The release of juveniles is in a cause of several years within designated areas. In each area, crocodiles will be released together to make certain that they will not disperse to the distance that make social gathering, mating, and monitoring almost impossible.

Every precaution has been taken to make this re-introduction program the best conservation tool for Thailand Siamese crocodile. Everything that goes into this program has been checked and rechecked to insure long-term survival. We, therefore, sincerely hope that every step of the program will be successful. It is evident that this is going to be a long term and quite slow process, but we agree that the careful and cautious approach is likely to address some of the deep institutional and cultural issues around crocodile re-introduction in a successful way.

MANAGEMENT AND CONSERVATION RECOMMENDATIONS

1. Continue promoting sustainable use of captive-bred crocodile products, which is part of "wildlife trade campaign" by WWF-Thailand to stop illegal trade of wild fauna and flora.
2. Royal Forest Department and Thai government must enforce protection to minimize poaching and fishing pressure. Today, National Park Division is budgeting the tourist infrastructure to promote many pristine tourist spots in most parks. This could bring an end to poaching behavior.
3. Expand an already established market-driven conservation program to the greater extent
4. Risk assessment must be conducted to evaluate the risk involved within project and from local communities, in order to increase public awareness.
5. A re-introduction workshop needs to be set up with representatives from the Royal Forest Department, Fisheries Department, Mahidol University, NGO, breeders, producers, and leather industry to discuss the following issues: wild population status, in-situ management, effort of market-driven conservation for Thailand program, and local sustainable development.

ACKNOWLEDGMENTS

We wish to thank Dr. Plodprasop Suratsawadi, DG Royal Forest Department, for the research permit to conduct a study in protected areas. Dr. Napawan Nopparatnaraporn's help with DNA analysis is greatly appreciated. Special thanks go to Sriracha Farm Group for technical support and training for sanctuary rangers. We further want to thank all park and sanctuary rangers who assisted in series of surveys. FFI 100% Fund no. 02/21/06FLAG, YAP, NGTV, and CMAT grant no. 4401 and 4501 were sources of funding for the research. Finally, we would like to thank Dr. Robert Mather, WWF-Thailand for pioneering "The Wildlife Certification Scheme" to help prevent illegal trade of wildlife and promoting sustainable use of captive-bred animals that leads to market driven conservation.

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Incidence of Umbilical Scaring in Hatchling American Alligators

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ABSTRACT: Umbilical scaring is the presence of excess scar tissue deposited between pectoral dermal layers at the site of yolk sac absorption in hatchling American Alligators (*Alligator mississippiensis*). The presence of this dermal condition plays a key evaluatory role in the overall quality and subsequent selling value for various commercial leather products. This stated, we have begun to quantify the extent and occurrence of this condition during the 2001 egg laying season. Eggs were incubated in two separate incubators (FCSC and CCF) at 31.5E C (the median temperature for a 1:1 sex ratio) to examine the relationship between artificial incubation of eggs and the subsequent occurrence of umbilical scaring. In addition, we developed a means to quantify umbilical scaring at two days and ten days post hatch to examine whether this technique can be utilized as a predictor management tool of future skin quality. Though umbilical scaring was noted to decrease from day two to day ten post hatch at both sites, no significant differences in the incidence of umbilical scaring were observed at either FCSC and CCF. These data suggest the need for additional research and management in the areas of incubation temperature regimes as well as the relationship between site and incidence of umbilical scaring.

Key Words: umbilical scaring, American Alligator, egg quality, leather goods, management

Alligator Embryo and Hatchling Growth from Contaminated and Clean Lakes in Florida.

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ABSTRACT: Research from our laboratory has shown increased alligator embryo mortality in eggs collected from sites contaminated with organochlorine pesticides (OCPs). It is not known, however, if hatchling growth and survival is equally affected. The objective of this study was to evaluate embryo and hatchling growth and survival from lakes with different degree of OCP exposure. During 2001, 40 clutches were collected from the following lakes: Apopka (total average egg OCPs = 12.4 mg/kg), Griffin (1.3 mg/kg), and Lochloosa (0.3 mg/kg). Eggs were incubated and monitored for embryo survival and hatch rates. A subset of hatchlings (10 from 5 clutches/site) was raised for 6 months, and survival and growth (body measurements and thyroid hormones) measured once a month. Although there were no differences in embryo growth between lakes, total embryo mortality was highest in eggs from Lake Griffin (57%, vs. 17% for the other lakes). Hatchling growth rates were highest for Apopka (0.7 g/day vs. 0.5 g/day for the other lakes), whereas hatchling survival was higher in animals

from Apopka and Lochloosa (80%) compared to Griffin (50%). Although these data does not rule out a possible role of OCPs in the development of alligator embryos and hatchlings, it at least suggests the involvement of additional factors. In this respect, our laboratory is currently examining differences in the nutritional quality of eggs among these sites (Funded by NIEHS-SFBRP).

A Management Plan for Crocodiles in Belize

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Although the status of *C. acutus* and *C. moreletii* in Belize are different, both species share the common concern of human-crocodile interactions as the primary driving force for conservation and management programs. In the absence of hunting and habitat loss *C. moreletii* appears to be secure, especially in northern Belize. The same is not true for *C. acutus* whose continued survival in Belize is tenuous. For both species, residential development in wetland habitats is the root cause of increasing contacts between humans and crocodiles. The common practice of feeding crocodiles in these areas exacerbates the problem. Hence, for both species a common solution is educational programs for residents and tourists. Beyond educational programs, the recommendations for management of both species differ and are related to their different status. Since *C. moreletii* are more secure there is a potential for a problem crocodile program similar to the nuisance alligator program in Florida where potentially dangerous crocodiles can be removed, perhaps even for commercial use. In any case, there will be more pressure to commercially exploit *C. moreletii* and a management plan will have to be developed to deal with this pressure. The primary threat to *C. acutus* is development of nesting and nursery habitat. For *C. acutus* a habitat conservation plan to insure the ecological sustainability of crocodiles and the economic sustainability of humans will have to be developed. The development of an ecotourism attraction based on wild populations of *C. acutus* will be an important component of a conservation plan. Taken together these steps can conserve crocodiles in Belize while providing benefits and security for humans.

Causes of Low Egg Viability in Florida Alligators

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Alligator egg viability (the proportion of eggs hatching from a clutch) has been chronically depressed on a majority of Florida lakes. Severe declines in egg viability (<0.05) were observed during the late-1980s on Lake Apopka and during the mid-1990s on Lake Griffin. In recent years, egg viability on lakes Apopka and Griffin has improved, but egg viability on lakes Apopka and Griffin is still depressed relative to egg viability on lakes Orange and Woodruff, which have high (0.70-0.80) egg viability. We hypothesized that depressed egg viability could be caused by several agents, including pesticide residues, fatty acid imbalances, and nest material. Organochlorine pesticides, DDE (a metabolite of DDT) and toxaphene were found in high levels on Lake Apopka relative to eggs from other areas in 2000. Both of these compounds have been found to reduce reproductive success in birds and fishes. However, preliminary analyses have not found a significant association between egg viability and concentrations of DDE and toxaphene, either for individual lakes (Apopka, Griffin, Orange, Woodruff) or for all lakes combined. Preliminary examination of fatty acid composition of alligator egg yolks collected during 1998-2001 indicates no discernible differences between lakes with depressed egg viability (Apopka and Griffin) and lakes with elevated egg viability (Orange and Woodruff). No discernible pattern was observed between nest material and egg viability on any lake. Thus, no consistent patterns have been detected in the possible causes of depressed egg viability. Further investigations will be undertaken to examine whether endocrine disruption, hypereutrophication, algal toxins, vitamins deficiencies, and thiamin deficiencies are associated with poor egg viability.