CROCODILES

Proceedings of the 12th Working Meeting of the Crocodile Specialist Group

of the Species Survival Commission of IUCN - The World Conservation Union

convened at

Pattaya, Thailand, 2 - 6 May 1994

(Unedited and Unreviewed)

Volume 1

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Cover. *Tomistoma Schlegelii*, one of a captive group held at Samutprakan crocodile farm, Thailand. This species remains one of the most urgent priorities for conservation action.

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Table of Contents (Vol. 1)

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* Paper not presented at the meeting.

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FOREWORD

The two volumes of this PROCEEDINGS are a record of the presentations and discussions that occurred at the 12th Working Meeting of the Crocodile Specialist Group (CSG) in Pattaya, Thailand, 2 - 6 May 1994. These volumes represent the latest in a series which has been published since 1971 by the CSG, reporting on the CSG Working Meetings. To facilitate the rapid dissemination of these materials the manuscripts are unreviewed and unedited. The papers are published just the way they were submitted and for this reason, they appear in a variety of formats and typefaces. Some retain original page numbering but the volume page numbers appear centered at the bottom of each page. A number of papers that were submitted for presentation and publication, but were not presented at the meeting, are also published here. This includes *Harvesting Wild Crocodilians: Guidelines for Developing a Sustainable Use Program*, prepared by Dennis David for CSG, published in Volume 1. Dr. James Perran Ross was the managing editor. These PROCEEDINGS were produced and distributed with a grant from Mr. M. Temsiriphong, Sriracha, Thailand.

Copies of the PROCEEDINGS can be obtained from the the Crocodile Specialist Group or from the IUCN Publication Unit. Copies of individual papers and *Harvesting Wild Crocodilians: Guidelines for Developing a Sustainable Use Program*, should be requested from the authors directly.

The opinions expressed herein are those of the individual authors and are not necessarily the opinions of CSG, IUCN - The World Conservation Union, or its Species Survival Commission.

SUMMARY OF THE MEETING

The 12th Working Meeting of the Crocodile Specialist Group was hosted by the Crocodile Management Association of Thailand (CMAT), the Royal Forest Department, the Department of Fisheries, Kasetsart University and the Thai Association for Trade in Reptiles and Amphibians (TATRA). Between 2 and 6 May 1994, 96 members of the CSG from outside Thailand, as well as an additional 100 participants from within Thailand, gathered at the Royal Cliff Beach Hotel in Pattaya for the meeting.

The meeting was most ably organized by Dr. Parntep Ratanakorn, assisted by Kriengkrai (Ken) Chaimongkoltrakul, and Mr. Leslie George and his staff. Dr. Amara Thongpan acted as Moderator throughout the meeting. Uthen Youngprapakorn provided extensive assistance to participants on behalf of Mr. Utai Youngprapakorn and Charoon Youngprapakorn. Numerous assistants and volunteers from the host organizations contributed to the smooth running of the meeting. These PROCEEDINGS were produced with financial aid from Mr. M. Temsiriphong.

The assistance of the above named individuals and organizations, the participants, and all the many people who contributed to the success of the meeting, is gratefully acknowleged here.

The meeting was honored by an opening address from H.E. Mr. Sawadi Suebsaiprom, Deputy Minister of the Agriculture and Cooperatives Ministry. Forty two papers were presented in sessions covering Conservation in S.E. Asia, Taxonomy and Systematics, The Status of Priority Species for Conservation, Captive Breeding and Conservation, Stress in Farmed Crocodilians, Monitoring populations, and General papers. Particularly interesting reports were received from the S.E. Asian region indicating both the high diversity of crocodile populations in this region and the precarious nature of their status. The very great interest in sustainable use of crocodile resources in the region as a conservation mechanism was presented. Of special interest was the new information revealed about the distribution of wild populations of Siamese crocodile in Thailand and Cambodia and Tomistoma in Indonesia. Conservation of these species is a priority of the CSG.

The Meeting also provided a forum for discussion of the relative conservation merits of different forms of crocodile use. It is evident from the papers presented and subsequent discussion that each of the different methods of crocodilian use (cropping-hunting, ranching, captive breeding-farming) can have conservation value and the key element in sustainable use programs is ensuring that the link to the conservation of wild populations is established and maintained.

Field trips to several crocodile farms were arranged by the hosts and there was the intense discussion and exchange of ideas between sessions for which CSG Working Meetings are known. The CSG Steering Committee met for two days before the Working Meeting and the CSG-CITES Review Committee for Thailand Crocodile Management met immediately following. The CSG would like to express again our grateful thanks to all the many people who made the meeting such a success, and particularly to our Thai hosts who made us so welcome.

IUCN - The World Conservation Union

Founded in 1948, The World Conservation Union brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership: over 800 member organizations in all, spread across some 125 countries.

As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. A central Secretariat coordinates the IUCN program and serves the Union membership, representing their views on the world stage and providing them with the strategies, services, scientific knowledge and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 6,000 expert volunteers in specialist groups, project teams and action groups, focusing in particular on species and biodiversity conservation and the management of habitats and natural resources. The Union has helped many countries to prepare National Conservation Strategies, and demonstrates the application of its knowledge through the field projects it supervises. Operations are increasingly decentralized and are carried forward by an expanding network of regional and country offices, located principally in developing countries.

The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

CROCODILE SPECIALIST GROUP

The Crocodile Specialist Group (CSG) is a worldwide network of biologists, 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, Caimans 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 CSG works closely with CITES to promote sustainable use and international trade that benefits the conservation of crocodilians. The Group is headed by its chairman, Professor Harry Messel, and maintains offices in Gainesville, FL USA. Working Meetings of the CSG are held every two years.

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SPEECH
BY
H.E. MR. SAWADI SUEBSAIPROM
Deputy Minister of Agriculture and Cooperatives Ministry
at the Opening Ceremony of the
12TH WORKING MEETING CROCODILE SPECIALIST GROUP
2-6 May 1994
Pattaya, THAILAND

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Professor Harry Messel
Members of Crocodile Specialist Group
Distinguished Delegates
Ladies and Gentlemen :

On behalf of the Royal Thai Government and Thai people as the host country of the 12th Working Meeting Crocodile Specialist Group, I would like to take this opportunity to welcome you all to Thailand and hope that you have received a warm welcome from the organizer of the Meeting. I firmly believe that this gathering will provide a useful forum for the delegations to discuss with one another to share knowledge and to exchange ideas about the conservation and utilization of crocodile.

Ladies and Gentlemen :

Most Thai people familiar with crocodile for a long period of time due to the abundant distribution of crocodile in the wild in Thailand previously. The distribution of crocodile in Thailand diverses from freshwater to estuarine. With that, there are many stories about crocodile in various Thai folk literatures. The famous crocodile from Thai folk literature is Chalawan which is wellknown to all Thai people. Recently, however, the number of crocodile in the wild in Thailand has been decreasing. Some species almost become extinct, for example, <u>Tomistoma schlegelii</u>. This is due to the fact that crocodile has been seriously threatening from human activities. The most serious threat is the hunt for crocodile skin and crocodile meat. The other factors are the degradation of environment; the damaging of crocodile habitat, spawning ground and nursery ground; the loss of food supply form the wild; etc.,.

In Thailand, previously the private sector was actively play an important role for the conservation and utilization of crocodile with some supports from the government. Currently, the Thai government has taken serious measures to conserve crocodile. This can be proved from the attempting to amend the Wildlife Law and the new Wildlife Reservation and Protection Act, B.E. 2535 has come into the force in 1992. According to this Act, all species listed in the List of Protected Species shall be prohibited from hunting, trading, possessing, breeding, exporting, importing, etc.,. There are three indigenous species of crocodile listed in the List of Protected Species. Those species include <u>Crocodylus porosus</u>, <u>Crocodylus siamensis</u> and <u>Tomistoma schlegelii</u>. However, if any species in the List of Protected Species can be bred in captivity for commercial purposes such species will be listed as Species for Breeding Purposes which will be permitted for breeding, possessing, and trading under some conditions setforth by the Ministerial Notification of this Act. In addition, Thailand has strictly complied with the CITES regulations for controlling crocodile utilization as well. By doing so, the Crocodile Specialist Group (CSG) has given a very useful and constructive advises for us.

Apart from amending the Wildlife Legistation, there is also a change in governmental agency responsible for crocodile matters. The authority of competent official for crocodile matters has been transferred from the Royal Forest Department to the Department of Fisheries. From now on, the Department of Fisheries is empowered to control all crocodile farms, regulate crocodile registration system, issue CITES Export Permit for crocodile and their products, enforce the law and regulation concerning crocodile matters. However, for scientific research and study of crocodile the researchers of Royal Forest Department, Department of Fisheries and other academic institutions can do research and study for the purposes of crocodile conservation and utilization.

For the management of crocodile conservation, the Ministry of Agriculture and Cooperatives has given the policies for the Department of Fisheries to conduct the research on Biology of pure bred Thai crocodile both freshwater species and estuarine species for artificial breeding purposes. In addition, there will be many conservation programs for Thai indigenous crocodile species to implement such as releasing pure bred of Thai crocodiles back to their original habitat, rehabilitation of crocodiles habitat,etc.,. The same programs are applied to Tomistoma schlegelii as well. For the crocodile farmers and other people interested in crocodile farming, there will be the programs providing information about crocodile farming, technique of breeding, nutrition, diseases, etc. in order to improve the quality of crocodile for sustainable utilization and conservation purposes.

The 12th Working Meeting Crocodile Specialist Group has been organized in collaboration with both private sector and government sector. The organizing committee of this meeting are Kasetsart University, Department of Fisheries, Royal Forest Department, Crocodile Management Association of Thailand (CMAT) and Thai Association on Trading of Reptiles and Amphibians (TATRA).

Distinguished Delegates, Ladies and Gentlemen, permit me to hope that in spite of your tight schedule, you will have some time to relax and enjoy your stay in Pattaya, Thailand.

With that, I am pleased to declare open the 12th Working Meeting Crocodile Specialist Group. I wish you have a very fruitful and constructive meeting.

Thank you very much.

COUNTRY REPORT

ON

CROCODILE CONSERVATION IN CAMBODIA

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(This paper is prepared for presenting in the 12th working meeting on Crocodile conservation held in Pattaya, Thailand from 2 to 6 May, 1994)

1. Introduction

Cambodia is one of the home range of two crocodilian species, the fresh water or Siamense crocodile (C. siamensis) and the salt water or estuarine crocodile (C.porosus). Both endemic species remained in the rivers, lakes, streams, wetland, swamp and estuarine areas. The former one is still presenting in the wild and in captivity while the latter is reportedly existed some in estuarine areas where no human settlement is taken place. One less populated coastal province (Koh Kong) is considered to have a peaceful habitat of this remaining species population. Beside this 4 heads of them ageing 4-5 years were brought from the Mekong Delta in Vietnam and are now bred in captivity in a country largest crocodile farm in Siem Reap province.

Conservation and management of crocodile is subject of the Department of Fisheries since it is an aquatic animal and it became more and more concern since this animal was domesticated in the farm by the people in around the French colonial period.

Even crocodile is a dangerous animal for most of Cambodian people, the recent crocodile trade value was led this wild animal population dwindled year after year due to over hunting for export . This was caused many concern to the concept of wild life conservation of the authority which was later promulgated a regulation as a part of the fisheries law for the purpose of wild crocodile conservation and crocodile farming management.

2. Background

The fresh water or Siamese crocodile (C. siamensis) and the salt water crocodile (C.porosus) are the two endemic species to Cambodia. They were very abundant in the past in every water bodies. The ancient Khmer artists carved them on the Angkor Wat and Angkor Thom temples (constructed in 11-12th Century) as a legacy.

As the human settlement being developed, they compete with crocodiles for usable space and resources, as well as hunting them for foods and hides. When human convert forest into farms, marshes into rice fields, mangroves swamps into aquaculture projects and rivers into human settlement, they displaced the animals from their habitats, driving them to the periphery of their range, where they may, ultimately, never breed successfully (Angel and Maria 1989). As a result of the direct and indirect assaults on habitats from exploitation, colonisation, settlement, exploration and habitat conservation, crocodiles are steadily loosing ground and some species may be heading for extinction. Reportedly, the wild crocodile population is mainly existing in the hinter land and unaccessible swampy areas.

Concept of Crocodile conservation

Because of the decline of crocodile species as mentioned above, crocodile was becoming an endangered species. To protect this wild animal from extinction, the ban for hunting was promulgated along with the fishery law in around 1945 during the French colonial, then later the ban was still legalized during the king Sihanouk and Soramarith rule.

The enforcement of the above ban was ineffectively done during the civil war period from 1970 to 1975 then it seemed to be abolished during the khker rouge rule from 1975 to 1979. The latter situation was continued until there was a promulgation of the new fishery law in 1987.

Very recent, concerning to the environment degradation and wild life depletion, the decree of creation and designition of protected areas was issued by the King and came into effect in late of 1993 (see Figure 1).

How ever, through information collected from many local key persons during recent mailing survey conducted throughout the country, number existing wild crocodile habitats were detected that number of them are located out of the precinct of the protected areas created and designated by the the above decree. So the effort of crocodile conservation is assumed that it requires to tackling of those where location is isolated from the defined areas.

3- Present Status of Crocodile Conservation

a-Distribution and Population

Even human activity hampers the population growth of the wild crocodile, the presence of these species is reportedly found in many remote areas of about 14 provinces of Cambodia (see Figure 2).

Table 1 is indicated the location of existing wild crocodile habitats and its populations.

Table 1. Distribution of wild crocodile in Cambodia.

No.	Provinces	Estimated No.(head)	Habitats
1	Stung Treng	3-4000	Sekong and Sesan region
2	Battambang	1500-2000	Flooded forest in lot No.1-2-3-4
3	Siem Reap	1000-1500	Flooded forest in lot No.1-2-3-4-6-7 & Srey Snam
4	Kg Chhnang	200-300	Flooded forest in lot No.1-2-3
5	Kg Thom	150-200	Region of the Seine stream
6	Kg Speu	150-200	Triangle region of three provinces Pursat, Kg Speu & Koh Kong
7	Pursat	200-300	
8	Kg Cham	80-100	Fishing lot No.2
9	Kampot	50-100	Anlong Vil, Prek Krieng & Stung Kach
10	Koh Kong	300-500	Mondol Sayma district, Kbal chay
11	Svay Rieng	10-20	Kg Trach river
12	Kandal	10-20	Prek Phnouv
13	Kratie	80-100	Chhlong
14	Preach Vihea	2-3000	Swamp area near Tbeng Meanchey district

b- Enforcement of Crocodile Conservation

Article No. 18 of the fishery law issued in 1987 is mentioning that "It is strictly forbidden the catching, selling and transportation of fingerlings, fish eggs, crocodiles, Giant catfish....; and All the above activities can be taken place on the contingency that special permission is available", but the ban enforcement, even it was thoroughly done through control system, is still facing to many difficulties since the location of wild crocodile habitat are mainly in the remote and unaccessible areas. On the other hand, widespread of unsecurity in many part of the country especially remote areas is subject of having gap in the law enforcement. While the decree of creation and designation of protected areas, even the demarcated areas are not covering all the existing wild crocodile habitat, but at least it can be an additional form of the legal aspect to enhance the enforcement of the wild crocodile conservation in Cambodia.

c- Present status of Crocodile farming

After the free market economy of the country was settled down in around 1988, the privatization of the production sector was promoted in incredible speed, inwhich all scales of crocodile farming began to boom in the private sector. In 1989 and 1990, the market demand increased very high which was led the crocodile business to a very lucrative business that just one single baby crocodile of one month old priced up to about US$ 200-300. Because of it feasibility and profitability, farming of crocodile was became very popular in many different communities especially the communities surounding the Great Lake area. So about 172 private and government farms including one country largest government farm were recorded in 1993. Table 2 below is shown the distribution of crocodile farm and its cultured population in the overall of Cambodia.

Table 2. Distribution of Crocodile farms and number of breeding stocks in Cambodia 1994

			No. of Crocodiles (heads)			
No.	Provinces	No.of farms	Female	Male	Sub-adults	Total
1	P.Penh, Private farms	6	50	20	40	110
2	Siem Reap, gvt & pvt farms	76	354	164	1,445	1,963
3	B.Bang, gvt & pvt farms	71	307	230	496	1,033
4	Kg Chhnang, gvt & pvt farms	5	75	30	10	115
5	Pursat, pvt farms	5	15	8	20	43
6	Kg Thom, gvt & pvt farms	4	20	11	20	51
7	B.Meanchey, pvt farms	3	20	10	30	60
8	Kandal, pvt farms	1	2	1	12	15
9	Kg Som, gvt farms	1	0	0	7	7
10	Total	172	843	474	2,080	3,397

4- Domestication of Crocodiles

History :

Cambodia . is known to have started crocodile farming since 1945 when the country was colonized by France. Farmers especially fishermen in the surrounds of the Great Lake Tonle Sap began domesticating by catching them from the wild and raise them in their backyard since they learned that crocodile are economically viable and important for skin export.

In 1975, when the Lon Nol Government was collapsed, the Pol Pot government came to power. They then collected all crocodiles from private farms together and put them in to two farms. One farm in Siem Reap province is the largest farm with around 100 heads of breeding stocks. Another is located in Kampong Chhnang province with around 70 broodstocks.

In 1979 , after the country had been liberated from the genocidal regime of Khmer Rouge, these farm were turned back to be real crocodile farms again . In addition to this , 3 more farms were also created in 3 provinces Battambang , Kampong Thom and Kampong Som.

As crocodiles have been considered as a valuable resource for export , many farms especially fishermen who were aware that this business was economically viable and important ,recommenced the raising of crocodiles by catching them from the wild and raised them as backyard animals since the beginning of the 1980's.

Farming System in Cambodia.

Ratanakorn (1992) classified the crocodile farming in Cambodia into 3 classes , according to number of crocodile kept , the area and management .

Class 1: small scale ,small number of crocodiles , 2- 20 head kept in earthen or concrete ponds or wooden cage. This class is the majority and may be called"family farming "because of the small size and small number of crocodile . There were around 142 small scale farms in Cambodia which scattered on the river banks or near and even in the lake .Cambodian villagers living on the river bank used to keep 1-2 pairs of breeders in an area at the back of their houses . The natural fishes from the rive and lake is a good source of natural food supply .They used their family labour to catch fishes or purchased them at low price. Some fishermen who live on floating house or boats preferred to keep crocodiles in wooden cages that could float around their houses or boats .They brought their breeders to the river bank only during the eggs -laying season when water has receded.

Class 2: Medium scale 20 -70 head, kept in collective concrete ponds .These farms were generally on the bank of river or stream. The farms were constructed by concrete pond and concrete or wooden fence .Crocodiles were put together in social pond with 1:2 to 1:3 male - female ratio. Nesting materials of sod brought from the natural habitat were provided for breeding purposes- there were 25 farms of this class.

Class 3 : large scale Farms which were big in area and number of crocodile were usually more than 100 head . The breeding stocks were kept in concrete ponds and nesting material and pens were provided with sod and rotted vegetation brought from the natural habitat. They used to hatch crocodile eggs in artificial nest imitating the natural condition .Eggs were collected early the day after laying and re-burying in artificial nest. There were only 5 farms of this class.

All crocodile farms in Cambodia produced and sold hatchling to other farmers who want to growout or fattening and also to the Cambodian Fishery Import Export Company or to brokers for export .The number of hatchings produced in 1993 was 10,322 head. Siem Reap province was the highest producer of baby crocodiles and Battambang and Kampong Chhnang were the second and the third most productive, respectively (Table3) .

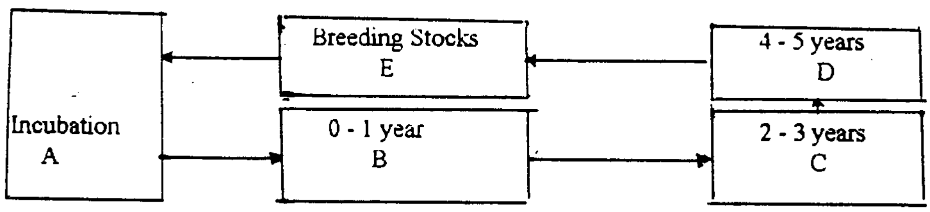
Table3 .Number of hatchling produced in 1993 and the expected number for 1994

		Number of hatchling (heads)	
No.	**Provinces**	**1993**	**Expected 1994**
1	Phnom Penh	450	830
2	Siem Reap	3.850	5.664
3	Battambang	3,350	4,912
4	Kg Chhnang	1,700	1.900
5	B.Meanchey	350	410
6	Kg Thom	310	380
7	Pursat	300	384
8	Kandal	12	36
9	Total	**10,322**	**14,506**

Farm Management:

Crocodile farming in Cambodia was a close cycle farming which produced hatching, nursing and breeding stocks. All crocodiles were put in social ponds which were in very restricted spaces and poor sanitation . Some farmers had no drainage at all.
Since 1989 an effort has been made to develop the Siem Reap Provincial Crocodile Farm into a modern one. This modernisation consisted of building new pens , new rearing pens , pens for juvenile and an upgrading for the hatchery . However, the farm could not be developed so much due to limitted budget allocations provided by the provincial authorities. Nevertheless, some primary data on crocodile weight, size, eggs number and incubation techniques have been able to be collected since then.

The structure of farm management could be presented as follows:



After hatching, offspring were brought to rear in nursing pens B where they remain for one year . The mortality was 5 - 10 % (7.5% in 1990) during this period.
During the second and third year, the young breeding stocks, remaining from sale, was reared in the juvenile pens, pen C, where the mortality was very low and generally nil.
The 4 - 5 year old sub adults were kept in pen D, until they were mature and were further

transferred to the pen E, to become breeding stocks.

Breeding technology

The breeding stock were kept in social ponds for breeding . The male, female ratio was 1 to 3 while some farmers kept one pair of animals separately in concrete or wooden ponds . The water depth of each ponds varied from o.5 to 1.5 m. The animals began courting from early january to late March or April . The female crocodiles began laying their first clutch from the end of the fourth week of February or early March until the end of May or June .

Production

In a study collected from the Siem Reap provincial crocodile farms , from 1989 to 1993, an average of 77.33% to 85 .35% of females laid eggs every year with an average mean clutch of around 30 eggs (table 4). The hatching percentage varied from 60 : 00 to 76.30 . The average number of hatchlings produced per female varied from 18.10 to 23.01 (table5)

Table 4. Average mean clutch of Siamese crocodile bred in Captivity in Siem Reap provincial farm.

Year	Total No.of female	Total females laids	% Female laid/Total	No.of eggs	Average mean clutch (eggs)
1989	123	105	85.36	3,203	30.50
1990	129	106	82.17	3,209	30.37
1991	133	107	80.45	3,243	30.37
1992	134	111	82.83	3,416	30.30
1993	150	116	77.33	3,401	29.31

Table 5. Number of hatchlings , hatching percentages and Average number of hatchlings per female Siamese crocodile , recorded from 1999- 1993 in Siem Reap provincial farm .

Year	No.Females laid eggs	Number of eggs	Number of hatchlings	Hatching%	Hatchlings/ Female
1989	105	3,203	1,922	60.00	18.30
1990	106	3,209	2,440	76.00	23.01
1991	107	3,243	2,247	69.28	21.00
1992	111	3,416	2,183	63.90	19.66
1993	116	3,401	2,100	61.74	18.10

Incubation of Eggs

Eggs were incubated by Semi- artificial incubation, imitating their natural condition. Usually , in the early morning ,after eggs were laid ,the female crocodile were transferred to another pen and eggs were collected carefully, without changing their initial position from the nest, to incubate in the artificial hatchery. Eggs of one female were placed into 2 - 3 piles, in the same position in which they were laid, in a hole dug about 25 - 30 cm wide, 30 deep. Before piling, a handful of dried leaves and grass was placed at the bottom of the hole, and before covering, dried leaves and grass mixed with soil were added, and a small 15 - 20 cm high compact mount was made. Each artificial nest was located about 0.5 m from each other.

The artificial hatchery was about 0.5 m higher than the soil level and filled with sod and rotted vegetation brought from the crocodile habitat near the Great Lake. It was fenced with barbed wire to a height of 1.6 m. A 0.5 m wide and 0.3 m deep canal was dug around the hatchery to retain water during dry season.

The hatchery was left to open sunlight from morning to noon when it was too hot, coconut tree leaves were brought in, to shade the nest and lessen the heat. It was also exposed to the rainfall during the whole incubation period. During the dry season (especially in April) if there was no rain , water was sprinkled over the nest and around the hatchery, filling up the surrounding canal. The sprinkling of water was intended to add moisture to the rotted vegetation, to help in the decomposition of these materials. Temperature was monitored every day (every two hours in Siem Reap Provincial Farm) by permanently inserting a ground thermometer at the egg-layer. The temperature varied between 28,5 C° during the first month of incubation (March) to 33 C° in April and May.

Hatching

At the time of hatching, 68-75 day of incubation, sound from the hatchlings could be heard when one approached the nest. At that time, eggs were excavated and offspring could come out, by using their egg teeth to slice the shell membrane and then puncture the hard shell from the inside. If the offspring could not puncture the shell and come out by themselves, they were helped manually. After hatching, if the umbilical cord was not yet broken, it was cut with a pair of clean scissors.

Nursing

After hatching, offspring were brought to the nursing pen, washed and placed in separate wooden cages, about 15-20 head in each 30 x 60 Cm compartment. If there were any abnormalities, e.g. the yolk was not completely absorbed, it was reasonable to keep them separate from the others and to expose them to adequate sunlight at about 31 C, which helped them to absorb the remaining yolk. During the first year, especially the first 2 months, young baby crocodiles of about 28 Cm were, very difficult to look after. They suffered stress or shock when exposed to loud noise or sharp light, or changes of food or variation of temperature and would not eat for many days which led to stunting on some cases. During the cool weather from December to February, they were unwilling to take any food because of lowered body temperature. Therefore, farmers used to keep their offspring in a warm environment by heating them with charcoal fire stoves or electric lamps, where available.

Feeding

Hatchlings fed with small whole fish (sometimes live) mixed with shrimps, grew very fast. The fishes were caught from the stream, and fed to crocodiles right after catching. Farmers used to feed hatchlings with small whole fish mixed with shrimps in the first few months. They increased the size of fish gradually, as the animals grew up. During the second and third year they kept providing fishes daily, as much as the animals could eat. By practising this feeding technique they have recorded a considerably fast growth rate. The animals could grow from 28 to 120 Cm during the 1st year, and reached 140-1`50 Cm by the end of the second year. At the end of the third year, the animals measured 160 to 180 Cm. Some specimens recorded 2m or more.

In the state farms, the growth rate was lower, the animals reached 1,5 m in 4 yeas. This low growth rate may be because of large number of crocodile and restricted areas.

Mortality

Depending on market demand, hatchlings were sold within 1-6 months of hatching. Farmers used to sell all hatchlings and keep only a small number for breeding purposes. Therefore, the mortality was low ranging from 0-7.5% during the first year. Some farmers kept 50-100 head of hatchlings for fattening without any mortality. Among 200 heads kept in the Siem Reap state farm, 15 heads died during the 1st year, corresponding to 7.5% mortality.

Diseases

Diseases were frequent in crocodiles, from hatching to 1 year of age, and especially during the cold months, from November to February. From the second year onwards, crocodiles were rarely found sick, if food was available. The following diseases were usually frequent on the Siem Reap provincial farm :

(1)- **Pox Virus** : the animals had grayish-white circular skin lesions scattered over the body surface and particularly on the jaw, eyelids and ear drums.

(2)- **Runt** : from a few weeks to a few months after hatching some individuals remain small and weak and could not grow, even though they received identical treatment to the others.

(3)- **Limbs paralysis** : the disease appeared to effect to hatchlings during the cold weather months. The animals could not move its four limbs and died some times later.

(4)- **Gout** : This disease occurred generally in the small and medium scale private farms which was caused by over feeding.

Disease had been very rare for all small and medium scale farms, due to their small scale which made management and cleaning very easy.

5- Marketing of Crocodile

The hatchlings produced every year were sold to the Kampuchea Fishery Import Export Company (KAMFIMEX. Co), the state fishery products import export enterprise, for export, or to farmer and fishermen, for raising as broodstocks, or for further sale when market price were good. Depending on market demand, hatchlings aged from one to six months were sold at the farm gate price, which was very cheap. For private farmers, they used to raise their hatchlings until they were big enough. They were only sold when the price had peaked. They generally sold them to brokers who would smuggle the animals to Thailand. These brokers offered higher prices.

The largest market was Thailand. Therefore, the value of crocodiles was dependant on the demand for crocodiles in Thailand. Each hatchling could be sold from US$ 40-60 except in 1989 + 1990 during which the market peaked very high (between $ 200 and 300). The export of baby crocodiles was channelled through two routes: through Kampong Som to Trat and Poipet to Arunvaprathet.

6- Constraints in culture and Conservation

Cambodia has been in war for more than 2 decades. Information on crocodiles farming, management and conservation around the world is lacking. The crocodile farming is still considered illegal from the international point of view.

Political constraints: the country has been torn by the civil war and until now the political situation is still unstable. The K.R guerrillas are still disturbing in some areas. Thus, the conservation of crocodile can not be undertaken.

Technological constraints: any international cooperation with the international community except a short training course in Cuba of 2 gvt staff. National park and reserves had just created. No technical staff available to use in this field.

Economical constraints: because of war the country had not enough money allocated for the conservation of this species. Furthermore, most people are poor and they use to do gathering, fishing and also hunting for wild life as well as crocodile if it is profitable even these are restricted or banned by the natonal law.

Social and culturaral constraints:

Crocodiles have been and still are considered to be one of the most dangerous animals to human beings and domestic stocks, comparable to lions, tigers etc. and people tend to kill them whenever they meet them, either to use as food or simply out of fear.

Legal constraints:

Long run civil war and its adoption for national politique in the past led the country failed to link with external cooperations. Furthermore, the previous regime had no management policy. In addition, when the country was liberated from the Khmer Rouge regime, no conservation law was settled down until 1987. And even the law was enacted, the enforcement of the law was roughly done due to unsecurity in many parts of the country. More over, Cambodia had not been acceeded to join any international crocodile organisations as well as CITES, so neither information nor assistance had been taken place for developing the crocodile conservation in the country.

7- Priorities for dealing with crocodile conservation problems

- To promote conservation activities by the direct agreement and participation of local people by providing them economic incentives for crocodile conservation.

- To join CITES and other international crocodile conservation in order to request legal commercialisation of the resource and to participate in any international activities related to world crocodile farming, management and conservation.

- To cooperate with developed farms in neighbouring country such as Thailand to seek its technical assistance in the transference of modern technology.

- To conduct a wild crocodile population survey in order to assess the detail stocks and the expected outcomes related to the conservation in the future. This might need financial assistance from international organisation.

- To promote crocodile extension programmes

- To monitor the farming system for sustainable development.

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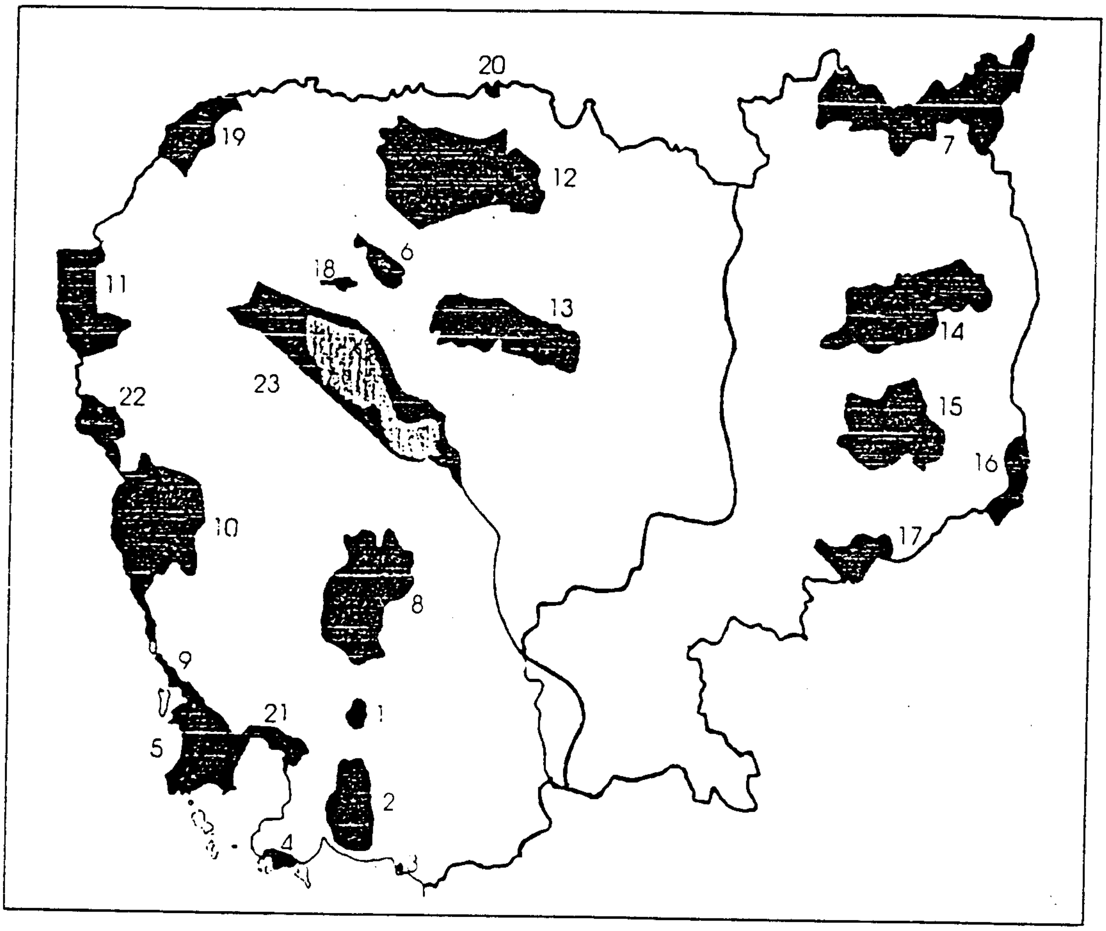
AREAS DESIGNATED AS PROTECTED AREAS



NATIONAL PARKS
1. Kirirom
2. Phnom Bokor
3. Kep
4. Ream
5. Botum - Sakor
6. Phnom Kulen
7. Virachey

WILDLIFE SANCTUARIES
8. Aural
9. Peam Krasop
10. Phnom Samkos
11. Roniem Daun Sam
12. Kulen - Promtep
13. Beng Per
14. Lomphat
15. Phnom Prich
16. Phnom Nam Lyr
17. Snoul

PROTECTED LANDSCAPES
18. Angkor
19. Banteay Chmar
20. Preah Vihear

MULTIPLE-USE AREAS
21. Dong Peng
22. Samlaut
23. Tonle Sap

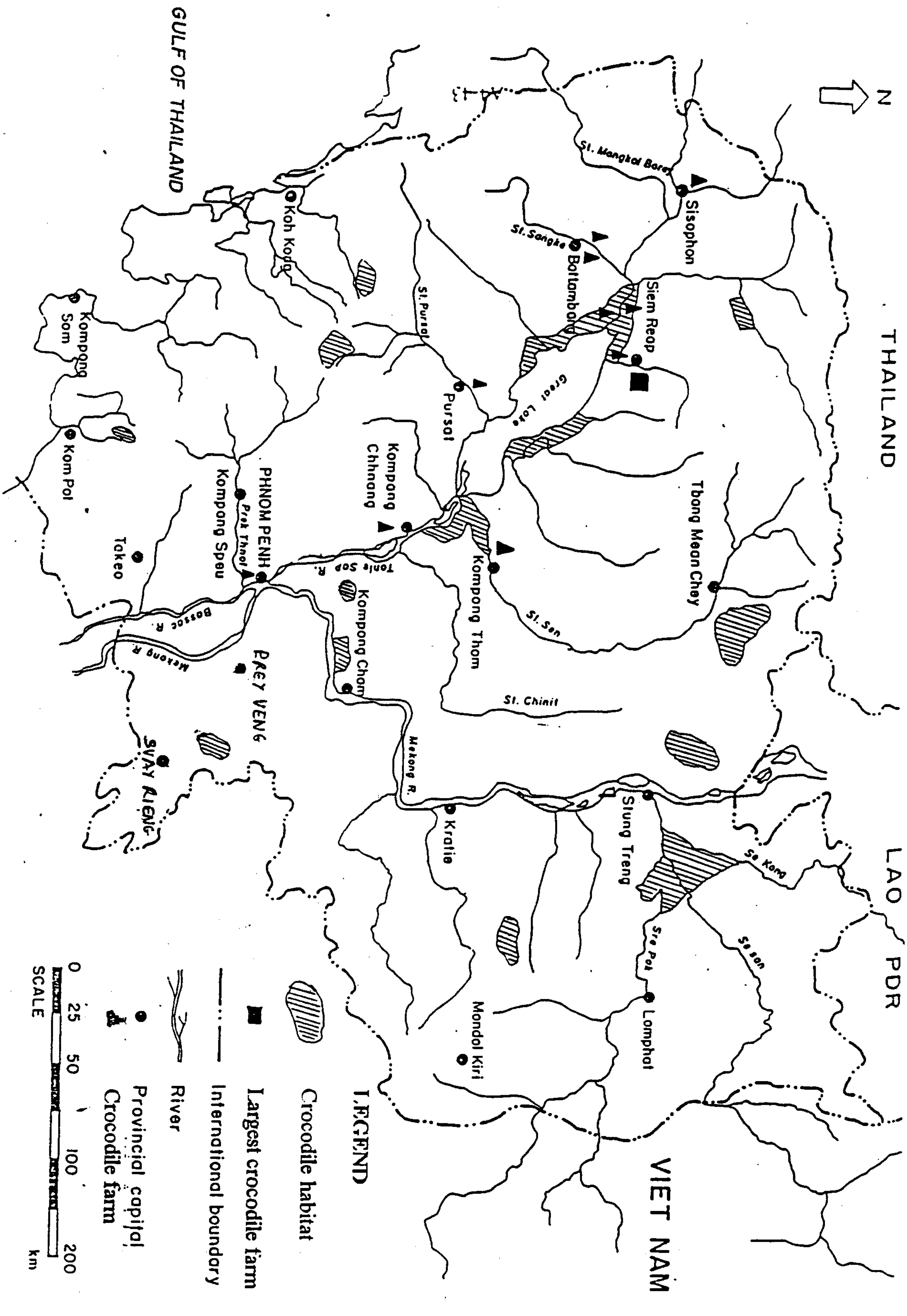


Fig. 2 Map of Cambodia indicating the distribution of wild crocodile and crocodile farms

Sivannavong Sawathvong, Wildlife Inventory & Research, National Office for Nature Conservation.

THE STATUS OF CROCODILE OF THE LAO P.D.R.

GENERAL INFORMATION

The Lao P.D.R is a land-locked counrty in SouthEast Asia bordered by China to the North, Vietnam to the East,Cambodia to the South,Thailand to the West and the Union of Mynmar to the North West.The total land area is 236800 square kilometres.

The Lao P.D.R is a mountainous country,only 20% represents the lowlands.The Mekong river and its tributaries flow from north to south through the country.

The population is small and comprises of 68 ethenic groups with different cultural backgrounds,sparsely dispersed through out the country.The population in 1990 was estimate to be 4.2 millions.About 1.7 million live in upland area and 2.5 million on the lowlands formed by plains of the Mekong river.

The level of culture,education and public health of the Lao people is not well developed yet.The communication and transport networks still remain inadequate.Economic production is still at the subsistance level,output is at low level.Gross Domestic Product is only US$220 per capita.

A national reconnaissance survey indicates that the total forest cover was about 49% in 1982 and 47% in1989 .About 70000 Ha of forest have been lost each year during 1982-1989. The main causes of deforestation are shifting cultivation,forest encroachment,forest fire,inapproppriate forest management,inadequate law enforcement,inadequate public care for the forest and an increased demand for timber and fuelwood.

Lao P.D.R issituated in the Indochinese of the Indo-Malayan Realm.Laos contains parts of four Biogeographic Units:Annam;consisting of the Anamite Range and extanding across Vietnam to the south china sea;and tropical lowlands,tropical montane and sub tropical transition zone subunits of central Indochina shared with Cambodia,Thailand,Burma,Vietnam and China.The Anamite range and the Mekong river are the main natural barriers in the area,forming the limits of the range of a numbeeer of species and subspecies.

THREATS TO THE SURVIVAL OF CROCODILES

There problably is some trade in Siamese Crocodile skins, and of hatchling destined for thai crocodile farms. However;it is now being considered by other parties in combination with a tourist development near Vientiane . A crocodile ranching operation that would collect hatchlings from the wild and raise them for skins and meat has also been proposed by N.A.F PtyLtd,Canbera;Australia and has been approved by government but has not yet been established because of funding problem.The proposal for a crocodile ranch is of particular concern as it was based on an incomplete feasibility study in which there was no attempt to determine current level of crocodile population in project area. Although it includes provisions for returning crocodiles to the wild to maintain breeding stock.

EXISTING LAW \PROVISIONS

At present Wildlife Management and Conservation in Lao P.D.R are governed by the following executive decrees and instructions for their implementation:

1./ Decree of the Council of ministers No 185/CCM in relation to the Prohibition of Wildlife Trade(21 October 1986).
This decree specifically prohibits all kinds of wildlife trade(trade in live or dead specimens,in trophies,or in articles produced from wild animals).

2./ Decree of the Coucil of Ministers No 118/PCM, on the Management and Protection of Wildlife and on Hunting (5 October 1989).
This decree prohibits hunting using military weapons,grenades,poison or other equipment of a" mass-destruction"character.It is also prohibited tohunt protected or endangered species (not specify),pregnant or nursinganimals.Import or Export of wildlife (living or dead) or parts thereof requires specified forms of documentation.Protected species may be cayght or killed in defence of human life but ownership of such animals reverts to the state.

3./ Instructions on the Execution of Council of Minister's Decree No 118/PCM dated 5 Otober 1989 on the Management and Protection of Wildlife and on hunting.
These instructions require the registration of all firearms used for hunting,and prohibit the use of firearms modified from war weapons.They prohibit hunting,catching,killing,damaging, transporting,selling,exchanging or having in possession without authorization alive or dead animals or parts such as horns,hides,bones,ivory,gall-bladders,skins,scales etc. They also specify that import or export of wildlife should comply with international principles regarding certificates of origin,certificates of health,and import-export licences;These can be issued by the National Office for Nature Conservation (Protected Areas snd Wildlife Division) not by any local administrative committees. They also define management categories for wildlife species ,as follows:

Prohibited Category_ (1) : valuable and nearly extinct species . Hunting is banned in all seasons except with the approval from the Council of Ministers. Individual animals may be killed in defence of human life or property but become the property of the State.

Controlled Category (2): rare species, which may be threatened with extinction if hunting is not controlled.Hunting is permitted only during the off (non-breeding) season,and only for food and not for sale or exchange.The breedingseason is taken to coincide with the Buddhist Lent or fasting period,from the beginning of August to the end of October.

General Category : species that are not included in Catergories 1 or 2.

Provinces may increase the level of protection for individual species (eg., by placing general Catergory species in the Controlled Catergory,or Controlled Catergory species in the Prohibited Catergory) but can not decrease the level of protection withoutauthorization from the Ministry ofAgriculture and Forestry.

4./ Hunting Ban during the Buddhist Lent (30 July 1993).

This notice, sent to all ministries, provinces,municipality, special zones and districts in the country,reiterates the need to enforce the provisions of Decree No118 and the subsequent instructions for its implementation, and specifically to :

- stop the hunting, capture or export of all wild animals cited in the lists of prohibited and controlled species.
- prohibit the selling,service in restaurants,and consumption of wild meat.
- prohibit the transport of live or dead wildlife including trophies.

5./ Penalties.

Penalties for violation of these decrees and instructions are outlined in the Penal Code of the Lao PDR (23 October 1989).

CURRENT STATUS OF CROCODILE

Crocodiles still occur in a number of the tributary drainages of the Mekong primarily inhabiting perennial rivers, oxbow lakes and freshwater lakes and ponds,but also swamps ,marshes,seasonally flooded grassland,permanent reservoirs and (transiting through) rain fed paddies.They apparently are absent from NorthEastern Laos and the Anamites.

Population level are problably very low through out the range of this specie in Laos,and it has recently disappeared from a number of areas.

Virtually all remaining populations are threatened by hunting and habitat destruction. Although most villagers reported that they do not purposely persue crocodiles;they are occasionally captured accidentally in fishing nets and there is some eggs collecting and purposeful hunting of adults for skins. Wildlife traders from thailand currently are the major byer of both live animals and skins. There also is an active trade in live animals and skins of this specie from Cambodia through Southern Laos in to Thailand.

The distribution of Siamese Crocodile as reported during village interviews 1988-1993 are as follows:

1. **Nam Ma** *:A 1.5m long individual reportedly was shot at the mouth of the Nam Ma in 1990,and its skin sold.(previous occurrence problably extralimital).*
2. **Nam Poui PA:** *Formerly occured in the Nam Poui and Nam Gnam drainages but dis appeared,atleast from the upper reaches,about 20-30 years ago;occasional individuals may still occur in the adjacent lower Nam Gnam and main Mekong.(probably extirpated).*

3.Nam Gnum Reservoir : *Small crocodiles have occasionally been caught in fishing nets in the reservoir,and whenever captured are sold.Villagers at the northern edge of Phou Khao Khouy PA reported that crocodiles occur in the Nam Xan,which drains into the Nam Ngum reservoir.(Probably on the verge of extirpation).*

4.Phou Khao Khouy PA : *Crocodiles are reported from the area's peripheral drainage the Nam Xan and its main drainages the Nam Leuk,the NamGnang and the Nam Mang and its tributary the Nam Pa.(Endangered,probably on the verge of extirpation).*

5. Nong Ngom Wetland : *A population of 100 or more crocodiles reportedly occupied this area,a small freshwater lake at the northern edge of the Vientiane plain,up until about 30 yaers ago.According to some villagers crocodiles are still occasionally seen in inaccessible,heavily vegetated parts of the wetland.(On the verge of extirpation if not already gone).*

6.Khammouane Limestone PA : *Currently report only from location,a small wetland at the western edge of the area,near Nam Hinboun.*

7.Phou Xang He PA : *Reported from the upper Xe Champhon during the rainy season,the Xe Kang and the Xe Xangxoy;previously occurred in the Xe Noi and the Xe Thamouak but now have disappeared from these rivers.*

8. Xe Banghiang : *Reported by villagers to be common in the Xe Banghiang River and its tributary the Houei Namkhan.They are reportedly seen baskingevery year and sometime are caught in fishing nets.*

9. Xe Champhon Wetland : *Crocodiles occur throughout the southern part of this wetland complex,with Kout Xelat and Kout Chiak,and perhaps other small oxbow lakes and ponds along the xe Champhon,having resident breeding populations.Calling and presumably matinf takes place during May,the early part of the rainy season.Part of the area has been declared a protected area by villagers but eggs,hatchlings and adults all are at leat occasionally harvested and sold to itinerant thai traders or in the market in Savannaket.(Major threats include invasion by the aquatic weed Mimosa,flooding of breeding habitat if currently planned irrigation projects go ahead,and illegal harvest of eggs,hatchlings and adults).*

10. Nong Luang Wetland Group : *Crocodiles occur in several wetlands in this area,with Kout Bakkok and Kout Koang,two small oxbow lakes south of the Xe Xangxoy,probably providing the best habitat .Crocodiles also occur in Nong Luang,where they are occasionally seen moving overland through rice paddies and are sometime accidentally caught in fishinf nets.In addition to incidental caprye in fishingnets there is evidence that crocodiles in this are have been and probably still are hunted for their skins.(Available information suggests that crocodiles were much more common in this area prior to the mid-1980,although a small population and some excellent habitat still remains).*

11.Xe Bang Nouane PA : *Crocodiles are reported to occur virtually all along the Xe BangNuane,which rises at the eastern end of the protected area.(Widely distributed along the river but probably uncommon).*

12.Phou Xieng Thong PA: *Crocodiles reportedly occur in deep pools in one or more of the stream draining this low plateau.(A small and spatially limited population possibility remains).*

13. Houei Khamouane: *Villagers in the area reported that there is a population of crocodiles in the Houei Khamuoane,its tributaries the Houei Khala and others,and possibly associated seasonally flooded wetlands.*
14.Nam Lepou: *Villagers in the area reported crocodiles in the Nam Lepou,which flows into yhe Mekong and forms the border between Laos and Cambodia.*
15.Seephandon Wetlands: *Two villages at the southeastern edge of this wetland(a widening of the Mekong river with numerous islands,channels and rapids) reported that crocodiles are often seen in the river channels in this area.*
16.Dong Hua Sao PA: *Crocodiles apparently stil occur in a number of streams and ponds in the lowland section of th PA.*
17.Xe Khampho: *Crocodiles are frequently seen in the middle section of the Xe Khampho,which flows from the southeastern corner of the Dong Hua Sao PA across a flat plain to the northeastern of the XePiane PA.*
18. Xe Piane PA: *Crocodiles reportd from Bung Gnai-Kiatngong ,a large ,swampy wetland complex at the northen edge of the area.*
19.Nathongsomlong/Nong Houei Soymong Wetlands: *Local residents reported that crocodiles occur in the small lakes and ponds of this wetland complex year-round,basking on rocks in the wet season and staying in the heavy grass cover during the dry season.*
20.Mid and Upper Xekong Drainage: *Crocodiles appear to be widely distributed in the Xekong river and its left bank tributaries arising in the anamites and along theLao-Cambodia border.Villagers report frequent sightings and consider crocodiles to be common in some areas.*

CONSERVATION MEASURES

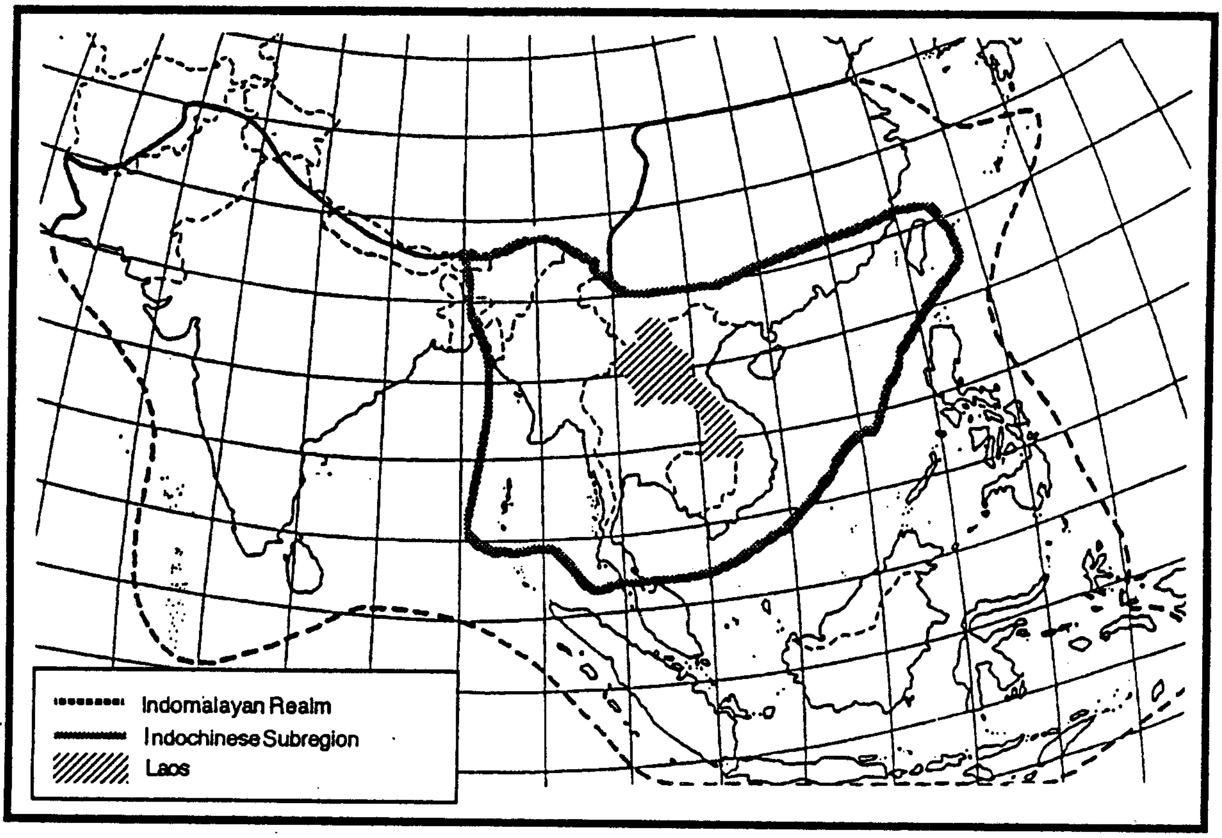
The historic range of Siamese crocodile encompassesThailand,Indonesia,Malaysia, Cambodia,Vietnam and Laos, It is currently known from only few locations within this range.It is listed in the SSC Crocodile Action Plan as extremely endangered and is considered to have the highest priority specie for conservation action and the specie for which the least and poorest quality population survey data are available.So in Lao PDR , i would like to suggest that :

1.The status survey is the highest conservation priority for this specie.

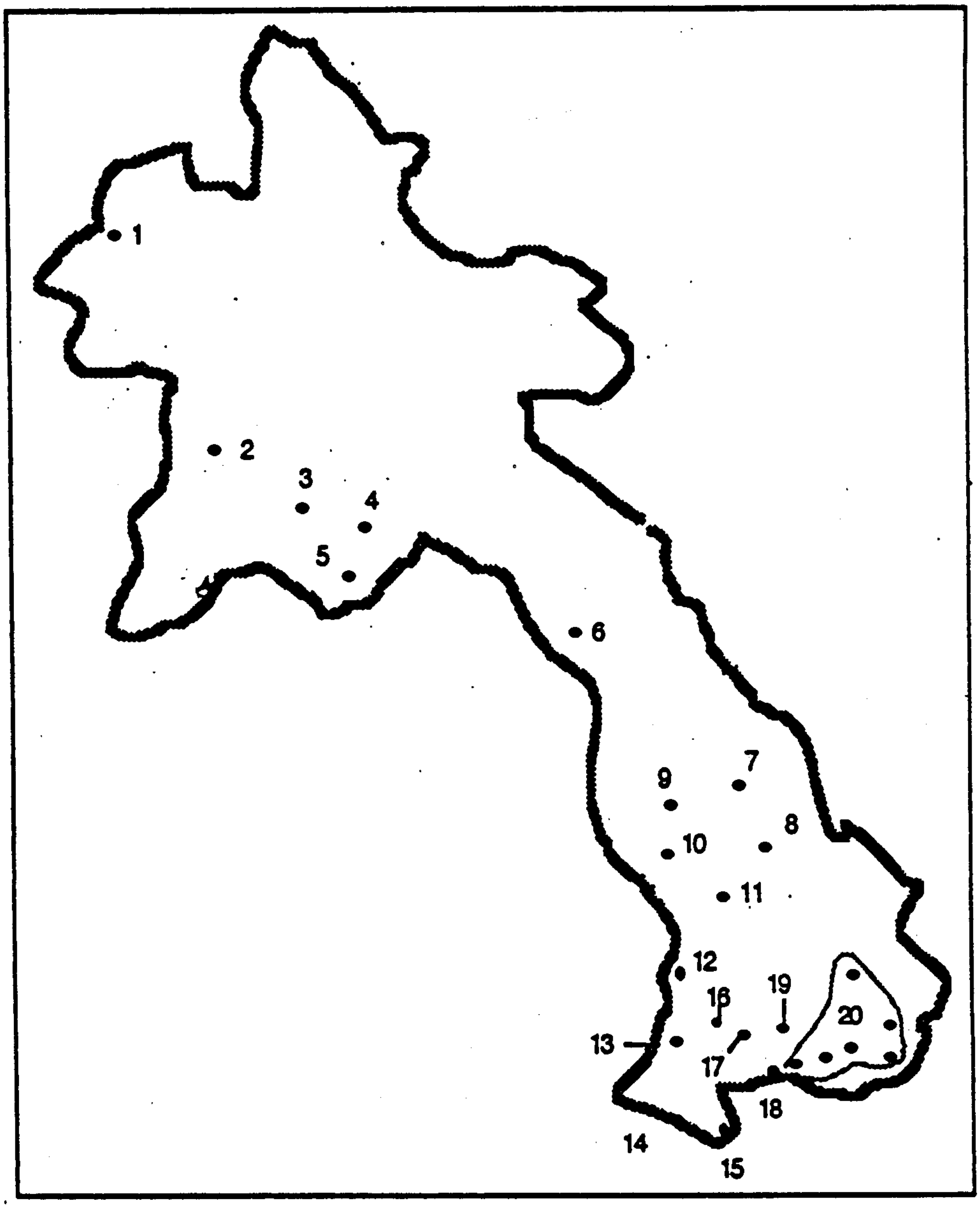
2.Establishment of wetlands protected areas.

3. Accession to CITES to help control illegal trade..

4. Develop of an educatinal program regarding values of crocodile conservation aimed at local people to ensure their input and participation in crocodile management.



Biogeographic units.



Distribution of Siamese crocodiles, as reported during village interviews 1988-93, and from other sources.

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THE STATUS OF CROCODILIANS IN MYANMAR

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Manager
Myanma Fisheries Enterprise
2 - 5 - 1994.

Mr president, CSG members, distinguished guests and participants-

First of all, please allow me to express my sincere thanks and appreciation to Dr. Parntep Ratanakorn, Secretariat General of the 12th CSG Working meeting for inviting me to this gathering in order to present a paper on " The Status of Crocodilians in Myanmar"

Introduction

Myanmar is the largest country in mainland Southeast Asia with a total land area of 676,577 sq.km. It has a coastline of 2,832 km.

Myanmar could be taken as a forest clad mountaineous country. Three parallel "Chains of mountains ranges run from north to south, the Western Yoma or Rakhine Yoma,the Bago Yoma and the Shan plataue.They begin from the eastern extremity of the Himalayan mountain range. These mountain chains divide the country into three river systems, the Ayeyarwaddy, is the Sittaung and the Thanlwin, of which the Ayeyarwaddy is the most important river whole length is about 2,170 km. As it enters the sea, the Ayeyarwaddy forms a vast delta area of 240 km x 210 km.

As it is mainly in the Tropical region, Myanmar has a tropical climate with three seasons:- the rainy season from mid May to mid October and the cool season from mid February to mid May. Annual rain fall vary from 500 cm in the coastal regions to 75 cm and less in the central Dry Zone. Mean temperature ranges from 32° C in the coastal and delta areas and 21° C in the northern low lands.

Myanmar's population is estimated at 40.03 million in 1989-90,an increase of 1.88 % over the previous year. The area under cultivation is 8.0 million hectares, Forest covers about 57 % of the total land area.

The Crocodilians in Myanmar

Crocodiles are quite familiar to Myanmar people for ages. They are found in the old paintings, drawings, carvings of the ancient pagodas and monestaries of Myanmar. In the great legendaries of Myanmar crocodiles play a great role as the main character.

Myanmar kings usually dug up moats around his palace and reared crocodiles to fend off enemies.

Myanmar Species

According to the past records, it seems that there were four species of crocodiles in Myanmar. But at present only Crocodylus porosus species remain.

i. Crocodylus porosus is found in tidal Ayeyarwaddy waters at delta regions of Bogale Township.

ii. Crocodylus palustris were found in fresh water ponds. At present the existence of this species in not known yet.

iii. Crocodylus siamensis is also not known for the present. But Peacock in his book known as the " Game book of Burma " stated that both G. gangeticus and C. palustris (or possibly Crocodylus siamensis rarely occur in the Ayeyawaddy river.

iv. Gavialis gangeticus were found existed in the past but there is no evidence whether existing now.

Present wild population

There is no surveys made as to the existence of C. palustris, C. siamensis and G. gangeticus in Myanmar.

In 1980 Mr. Caughley made his survey at Bogale township in the delta area. I was one of the members of that Survey Group.Only 16 crocokiles were seen and according to his survey it was found that the isolated population, i.e. the largest remaining population is about 4,000. There is a decline in population on account of illegal hunting, destroying of nests and habitat destrucrtions.

No specific legal protection is enforced for crocodilians. But protection by the general way is normally made for illegal catching, hunting and farming. During the year 1993 the farm made a purchase of 177 hatchlings from the Ayeyawaddy delta area at the rate of ks 2000/- each.

Açcording to the information received from Kowthoung and Sittway, crocodiles are still existing there. But it is not possible to estimate their population. At the border area, illegal businesses are carried out. In the year 1992 a Navy Boat while on duty recovered 12 crocodiles (2 of them breeder size), from an abandoned ship, which were later handed over to there crocodile farm.

The Forest department is planning to nurture a crocodile Sanctuary on Meinma Hla Kyun Island (in the Ayeyawaddy Delta) and the area is declared as a reserve forest. The Department of Fisheries has also declared this area as a reserved fishery area.

Legislation

The present government enacted three Laws in respect to the conservation of natural resources including crocodilians. They are: Myanma Marine Fisheries Law 1990, Freshwater fisheries Law 1991 and Forest Law 1992. The laws protect crocodilians. No one can hunt or catch or farm without Licence. When any one is found guilty of violation any of the prohibitions shall be liable to be punished with fine which may be extended to Kyats 300,000 or with imprisonment which may be extended to 10 year or both.
Crocodile farming is being conducted by the government only. There is no private farm in Myanmar.

Conservation & Farming

The present Government is well acquainted with the economic value of the crocodilians and that is why some Laws were made for conservation and farming. There were three main objects for crocodile farming:-

1. For conservation and research.
2. For sustainable use.
3. To develop the farm as a Tourist centre.

Tharketa Crocodile Farm.

This farm was established in the year 1979 by the Myanma Fisheries Enterprise, under the Ministry of Livestock Breeding and Fisheries.

At the beginning, wild crocodiles were bought and reared at the farm. Since 1982 egg laying had been started in the farm. In the year 1992 26 nests and 1076 eggs was obtained.

At present there are nearly 830 crocodiles of all sizes reared at the farm. Big crocodiles are being fed with fish and hatchlings are fed with small prawns. Rearing ponds are made of concretes. The Breeder pond is of 450 ft x 350 ft in size. There are altogether 46 male and 69 famale breeders. Eggs are incubated by man-made nest and rearing is being done under natural environment. The mortality rate is still high in hatchlings.

From 1983 to 1989 a total number of 1830 live crocodiles were exported to Thailand and Singapore by the farm, at on F.O.B price of US$ 1,62,689.

Discussion

There is a National Commission for Environmental Affairs to preserve the natural resources of Myanmar. The Government is very keen in conservation and interested in sustainable use of crocodiles. There is a possibility to develop a sanctuary in Ayeyawaddy delta area and to develop the farm as a Tourist Centre. For this, new information techniques are needed to develop our current crocodile research and farming.

STATUS AND CONSERVATION OF CROCODILES IN VIETNAM

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Institute of Ecology & Biological Resources, NCNST VIETNAM

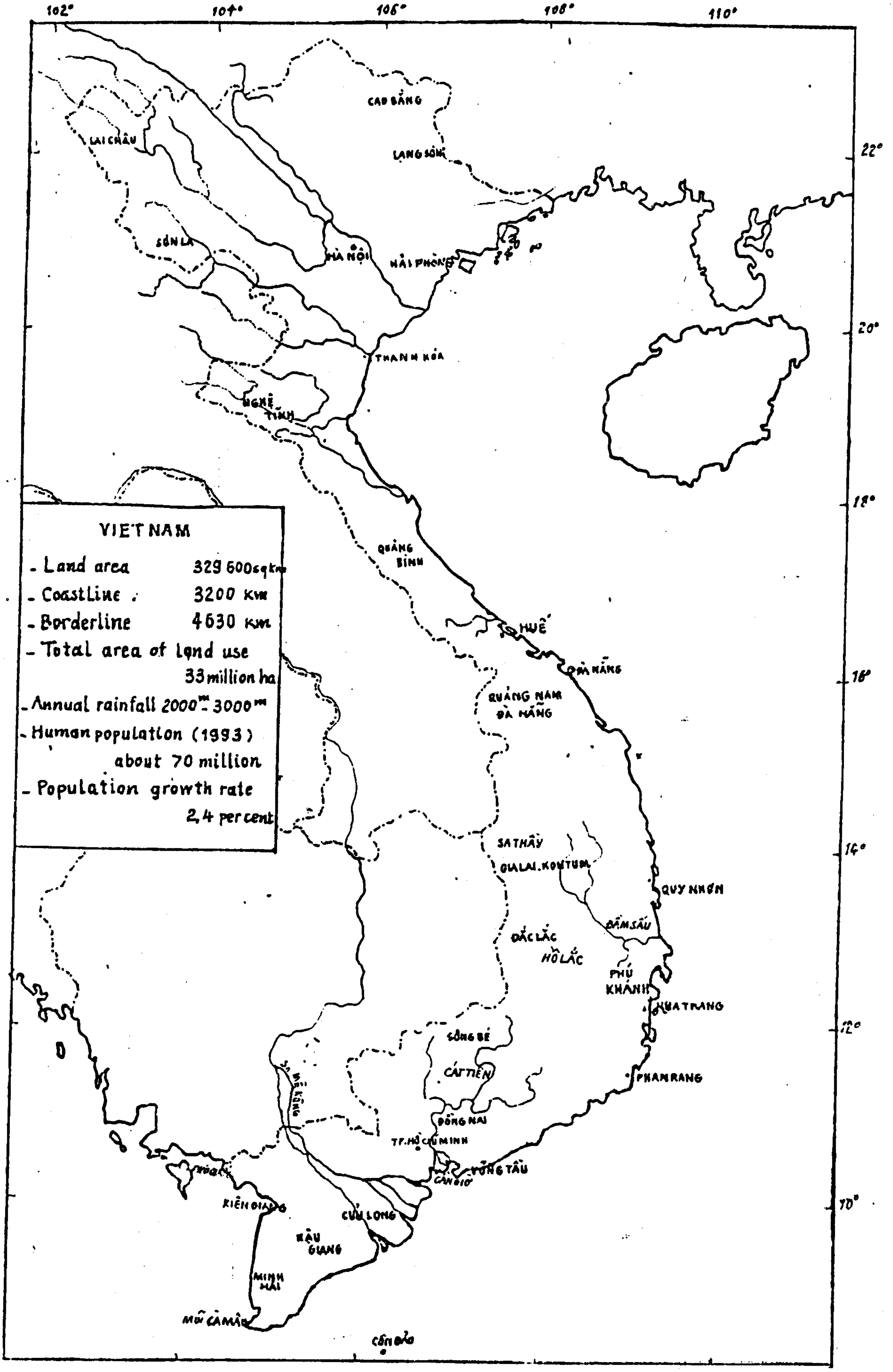
I. NATURAL AND SOCIAL CONDITIONS OF VIETNAM

Vietnam situates along the southeast margin of the Indochinese Peninsula. It stretches from latitude 8°N to 24°N. Total coastline is about 3 200km and total land area is 329 600km². The main mountain range - Truong Son range - forms the natural boundary with China, Lao and Cambodia. The mainland borderline is 4 630km (1 430km with China, 2 067km with Lao and 1 100km with Cambodia).

The country is S-shaped, broader in the Northern and Southern parts, where it is swelled by the Red river and Mekong Delta and very narrow in the middle, where in the Binh Tri Thien province it is only 50km wide at the narrowest point. So, the country has its length much longer than its width. A broad, shallow continental shelf follows the shape of the land, wide in the North and South and narrow in the middle.

Three-quarter of the country consists of mountains and hills. The highest peak - Fanshipan - reaches 3 144m in Northwestern Vietnam, where they form an extension of great Himalayan range. The land suitable for agriculture reclamation covers about 100 000km². It is situated mostly in the large fertile plain of Nambo and Bacbo, which include the Mekong and Red river deltas, respectively. Total area of all current patterns of land use is 33 million ha. Of it 6.9 million ha for agriculture, 11.8 million ha for forestry, 1. 4 million ha for towns and other special use and 12.9 million ha of very poor or unproductive land.

Vietnam shows a variety in climate condition on account of it wide range in latitude and altitude. Although, the entire country lies in the intertropical zone, climate varies from humid tropical condition in the southern lowland to bracing temperate condition in the northern hills. Mean annual sea level temperatures correspondingly decline from 27°C in the South to 21°C in the extreme North. The mean annual rainfall is 2 000mm, but this increases in the narrow central mountainous region to 3 000mm, sufficiently heavy to support tropical rain forests. There are three monsoon seasons, namely the northeast winter monsoon, and the southeast and western summer monsoons. Destructive typhoons sometimes develop over the East sea during hot weather.


VIETNAM
- Land area 329 600 sq km
- Coastline 3200 Km
- Borderline 4630 Km
- Total area of land use 33 million ha
- Annual rainfall 2000 - 3000 mm
- Human population (1993) about 70 million
- Population growth rate 2,4 percent
102°
104°
106°
108°
110°
22°
20°
18°
16°
14°
12°
10°
CAO BẰNG
LAI CHÂU
LANG SƠN
SƠN LA
HÀ NỘI
HẢI PHÒNG
THANH HÓA
NGHỆ TĨNH
QUẢNG BÌNH
HUẾ
ĐÀ NẴNG
QUẢNG NAM ĐÀ NẴNG
SA THẦY
GIA LAI. KONTUM
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VŨNG TÀU
CẦN GIỜ
KIÊN GIANG
CỬU LONG
HẬU GIANG
MINH HẢI
MŨI CÀ MAU
CÔN ĐẢO

The river network of Vietnam is mazy and varied. The North alone has 1 083 rivers and water ways of all sizes. In Nambo, there is a big river every 10km along the road, and a river estuary every 20km along coast.

The very rich lake, swamp system in conjunction with 3 200km of coastline and islands provides Vietnam with large wetland area as favourite habitats for water fauna, including crocodiles.

Vietnam is the most densely populated country in Southeast Asia with about 70 million residents in 1993 and a mean annual growth rate of 2.4 per cent. This gives a mean density of about 200 persons per square kilometer, the highest density for any agricultural country in the world.

The high population growth rate, together with severe destruction during the recent war has brought great negative affects to the habitats of wildlife, including crocodile: forest loss for agriculture land use and new villages, towns, forest logging and fires etc...

II. STATUS OF CROCODILES IN VIETNAM

1. Status in the wild

There are 2 species of crocodiles in Vietnam:

- Siamese crocodile or freshwater crocodile (Crocodylus siamensis)
- Saltwater crocodile (Crocodylus porosus)

Both species has distribution range only in South Vietnam . The siamese crocodile is freshwater one. They inhabit big rivers, lakes, swamps in Tay Nguyen plateau and Cuu Long delta, such as Sa Thay river (Kon Tum province) , Ba river (Gia Lai province), Lac lake, Krongpach thuong lake, Easup river, Krongana river (Dac Lac province), Dam Sau Tay Son (Khanh Hoa province), Bau Sau in Nam bai Cat Tien Reserve (Song Be province), Dong Nai river (Dong Nai province) , La Nga river (Lam Dong province) and Cuu Long river.

In the past, freshwater crocodile was relatively abundant in Vietnam. Pham Mong Giao, 1981 informed of 200 crocodiles in 80-hectared Tay Son "Crocodile lake" (Khanh Hoa province). Hunter and local people oftenly caught the crocodiles in Lac lake (Dac Lac province), uper part of La Nga river for sale and for meat, they also collected crocodile eggs in "Crocodile swamp" of Nam Bai Cat Tien Reserve for food. It was informed that the crocodiles were captured in large number in Krongpach lake and Easup river.

Saltwater crocodile (Crocodylus porosus) had inhabited mangrove swamps, river estuary in Vung Tau, Can Gio, west to Kien Giang Bay, Phu Quoc Island and Con Dao Island. But it was decades of years ago and now they probably extinct in the wild, there are some of them now are keeping in Sai Gon Zoo.

The forest logging and conversion of hundreds hectares of riverain, lakes, swamps into agriculture land have seriously decreased the habitats of wildlife, in general, and crocodiles, in particular. Meanwhile, agressive hunt has also seriously decimated the number of crocodiles in the wild. The crocodiles were captured by different ways, such as shooting by guns, traping, explossive mines. The using mines for capture of crocodiles is very dangerous due to mines can kill not only adult but also young crocodiles and severely destroy their habitats. At the present, according to the hunters and local people not more than 100 crocodiles still survive in the nature.

2. Captive propogation of crocodile

There are several crocodile farm in Vietnam (The Vietnam-Cuba Friendship Crocodile farm, Hanoi Zoo, Saigon Zoo, Centre for Forestry Science Application, etc...) , but mostly for economical purposes and zoo servises, not for conservation, properly.

Before 1960, Hanoi Zoo kept some individuals of crocodile provided by China, which lived for 10 years in the Zoo. In 1979 Sai Gon Zoo have received 7 siamese crocodiles from Siem Rep province of Cambodia (as present), wich have very good status and successfully breeding in captivity.

In October 1985, a group of 100 crocodiles (Crocodylus rhombifer) was imported from Cuba. These crocodiles have been distributed to several provinces for captive breeding: 5 in Hanoi Zoo, 10 in Sai Gon Zoo, others in Da Nang, Nha Trang and Minh Hai. Of them, at present only 26 individuals still survive (Sai Gon Zoo: 4, Vietnam- Cuban Friendship Crocodile Farm: 10 and Centre for Forestry Science Application: 12). Others died or have been sold to private farms. Recently, in 8 March 1994 one crocodile of Hanoi Zoo died due to swallowed a resin tube givenby a visitor. The keeping facilities here, were also not suitable for the crocodiles.

Due to budgetary investment shortage all these governmental farms could not provide the crocodile populations with relevant conditions for their development. The farm even have to cooperate with private farmers for the animal keeping. SaiGon Zoo, for example, cooperated with farmer Bui Van Do in An Giang province for breeding of 31 crocodiles. They now are of 3 years old, weight about 12kg each, with costs about $700 each.

Except for the governmental farms there are some private crocodile farm in Vietnam. Mr. Nguyen Thanh Thuan in Thu Duc province (for example) have invested $170 000 to set up his crocodile farm of area 31 000m². The farm is keeping 170 young crocodiles (of about 20kg each). He expects that by 1997 his farm will have 150 breeding fimales and 50 breeding male.

The private farmer understand well the economic value of crocodiles. They are pure bloodline and have high reproductive capacity and now become very rare in the wild.

Some farms (Saigon Zoo, Vietnam- Cuba friendship crocodile farm. . .) have been successful in breeding crocodiles. Saigon Zoo, for example, got the first result of crocodile breeding in captivity in July 1989, and present percentage of hatching sometimes reach to 80-90%. Especially the Zoo has been successful in hybridization of 2 species crocodylus siamensis (female) and crocodylus porosus (male). Their hybrid has given 20 eggs, 17 of which hatched successfully. But, in general, crocodile farming in Vietnam is not developed and the achieved results are very limited. The main reasons are shortage of knowlegde on techniques of husbandary and limitation of fund.

III. CONSERVATION

Inspite of small number of crocodiles remained in the wild the crocodiles in Vietnam are still intensively hunted for meat, eggs and for skin. Morever, illegal crocodile trade also becomes more intensive during recent years. The crocodiles (adult and young) are captured and skins are collected for illegal export to Cambodia, Thailand and other countries. In Vietnam, a crocodile is sold for about $100 - $2000 depending on their status. The crocodile are sold in animal market of big city (Ho Chi Minh City. . .). Some brokers collect crocodiles captured by local people keep them for short period of time until they meet the customers who willingly pays high price.

The conservation of crocodiles in Vietnam is of government interest. The government has adopted a number of regulations for habitat protection, stop of hunting and animal trade of endangered species, including crocodiles.

Recently, a national workshop on protection and restoration of crocodiles was held in Ho Chi Minh city in 31

March 1994 which pointed out that the number of crocodiles in Ho Chi Minh city alone has increased from several tens to 500 heads for recent 3 years, mainly in private farms. However, the death rate of youngs is still high (25 - 30%) due to deficiency of nutrition and unproper keeping facilities. The workshop called for close cooperation between scientists and farmers for protection and captive breeding of crocodiles in Vietnam.

Both species of crocodile in Vietnam are enlisted in the "Red Data Book of Vietnam" in highest category - " E" , "Endangered" for urgent conservation measures.

A network of 87 national parks and nature reserves has been gazetted by Vietnam's Government in 1986 for nature conservation. Of them there are 3 reserves with crocodile occupation:

- Nam Bai Cat Tien National park (36 000 ha) in Dong Nai province. Coordinates: 11°25 N, 107°26 E. The park has a swampy area, where the crocodiles concentrate in high density, so that it is named "Bau Sau" - "Crocodile swamp".
- Suoi Trai Nature Reserve (80 ha) in Tay Son district, Khanh Hoa province. Coordinates: 13°20 N, 106°45 E. There is named "Dam Sau" - "Crocodile Lake" - with high density of crocodile in the Reserve.
- Lac Lake (540 ha) in Dac Lac province. Coordinate: 15°25 N, 108°11 E.

Due to many reasons the management of these reserves is not strict enough and crocodiles are still poached occasionally.

IV. CONCLUSION AND PROPOSALS

In Vietnam, both species of crocodile survive in very small number and face with threats of extinction in near future. Several conservation measures have been conducted but not effectively enough. As the result, crocodile habitats are being destroyed and disturbed, hunting pressure is still considerable.

Meanwhile, very little is known about the natural history of the crocodiles and study on crocodiles in Vietnam is very unsufficient.

All these make the conservation of crocodiles in Vietnam a very urgent and difficult problem. In order to ensure survival of the last remained populations of crocodiles in

Vietnam, restor them in future an action plan for conservation of crocodiles in Vietnam should be developed and implemented as soon as possible. The following activities should be included in the action plan:

- To strengthen the effectiveness of extant policy and measures of crocodile conservation, aware people of the government policy and regulations for crocodile conservation and interest of crocodile conservation by radio broadcasting and TV programmes, video, posters etc...

- To conduct fieldsurveys to determine exact status and distribution of crocodiles in the wild to elaborate relevant recommendation for their management and conservation.

- To carry out crocodile farming project for conservation (not for economical) purposes, to ensure their survival, increase their number, and study their biology and ecology.

- To train Vietnamese officers on techniques of crocodile management and breeding.

- The conservation of crocodiles requests large manpower, experience and budget, so that the international cooperation for crocodile conservation in Vietnam is utmost important. We are seeking for international support and collaboration on the crocodile conservation in Vietnam.

PRELIMINARY SURVEYS OF CROCODILES IN THAILAND

by

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INTRODUCTION

The Siamese Freshwater Crocodile (Crocodylus siamensis) was once widespread within the freshwater wetlands of Thailand (Ratanakorn1994). However, its status in terms of both distribution and abundance has declined dramatically over the last 50 years, due to: use of natural habitats for agriculture and aquaculture; hunting for skins; collection of wild stock over many years for sale to crocodile farms [which started in the 1930's (Webb and Jenkins 1991)]; and, the destruction of crocodiles as vermin (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992; Ratanakorn 1994).

Saltwater Crocodiles (Crocodylus porosus) also occurred in the coastal areas of the southern peninsula and Gulf of Thailand (Webb and Jenkins 1991). Their status has also declined dramatically, probably for the same reasons as C. siamensis (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992). The Malayan False Gharial (Tomistoma schlegelii), now almost certainly extinct in Thailand, was known historically from near the southern border with Malaysia (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992; Ratanakorn 1994).

A recent review of the status of crocodiles in Thailand (Ratanakorn 1994) revealed two locations within which remnant populations of C. siamensis may still exist (Pang Sida National Park and Ang Lue Nai Wildlife Sanctuary; Fig. 1). An additional area was identified on the Island of Phuket where C. porosus may still exist.

The primary aim of the present study, undertaken by the Royal Forestry Department (RFD) and the Crocodile Management Association of Thailand (CMAT), with financial asisstance from the Asian Conservation and Sustainable Use Group (ACSUG) and the

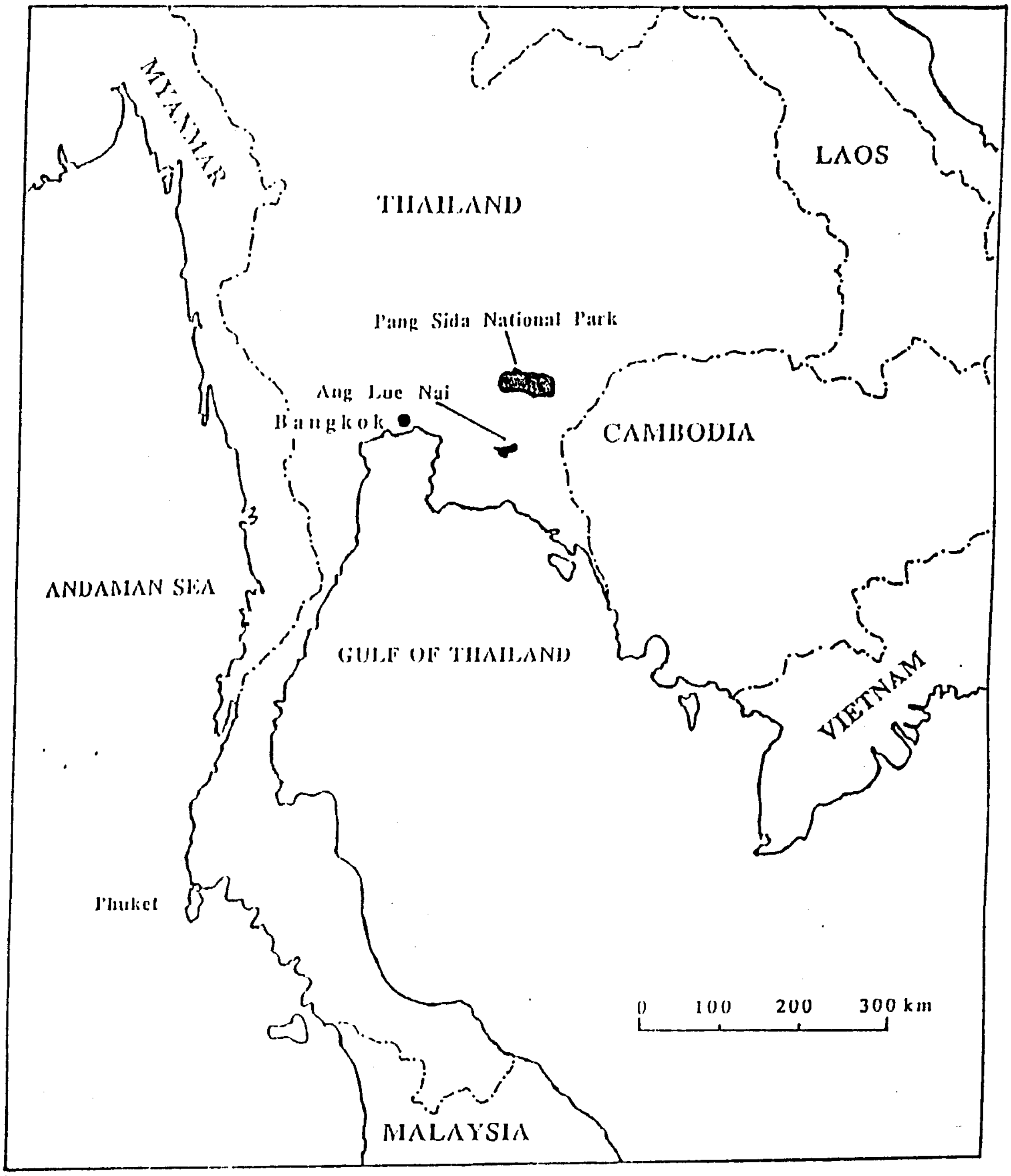

Figure 1. Location of Pang Sida National Park, Ang Lue Nai Wildlife Sanctuary and Phuket Island in Thailand.

German reptile leather associations ("Internationaler Reptillederverband-IRV" and "Reptil-Artenschultz e.V.-RA"), was to confirm the presence of crocodiles in these three areas. Secondary aims were to: establish baseline survey data that could be used for monitoring future status: assess the suitablity of the remaining habitats for the re-establishment of crocodiles; familiarise RFD staff with survey methodology and provide some guidelines for them (Appendix 1).

METHODS

Pang Sida National Park

Location

Pang Sida National Park comprises 845 km^2 of predominantly natural forest in in the Khorat Hills, in Prachinburi Province, eastern Thailand (Fig. 2). The vegetation is dominated by deciduous and evergreen rainforest (Grey et al. 1991), and there are areas of lowland scrub and open grasslands at the foothills, which reflect past logging and clearing for agriculture. Rainfall occurs throughout the year, but there is a distinct "wet" season between May and mid-October, when water levels rise appreciably. The cool dry season usually extends from mid-October to mid-February (Grey et al. 1991).

Houa Nam Yen Creek (Fig. 2) was selected as the survey site because a crocodile was sighted and photographed from a helicopter there in 1992. It is located in the western part of the Park, formed by drainage lines from the hills, and flows out of the western boundary of the Park into surrounding lowland country (Fig. 2). Agricultural use of lowlands on the edge of the Park is intense, with all viable areas under cultivation with tapioca and rice.

The creek is characterised by steep banks, high sinuosity and numerous sections of shallow water and rapids separating deeper more permanent bodies of water. Heavily vegetated banks are dominated by dry deciduous forest and bamboo thickets. Areas which have previously been logged, cleared and burned are now dominated by open vegetation consisting of tall grasses, vine thickets and shrubs (e.g. Calamis spp.).

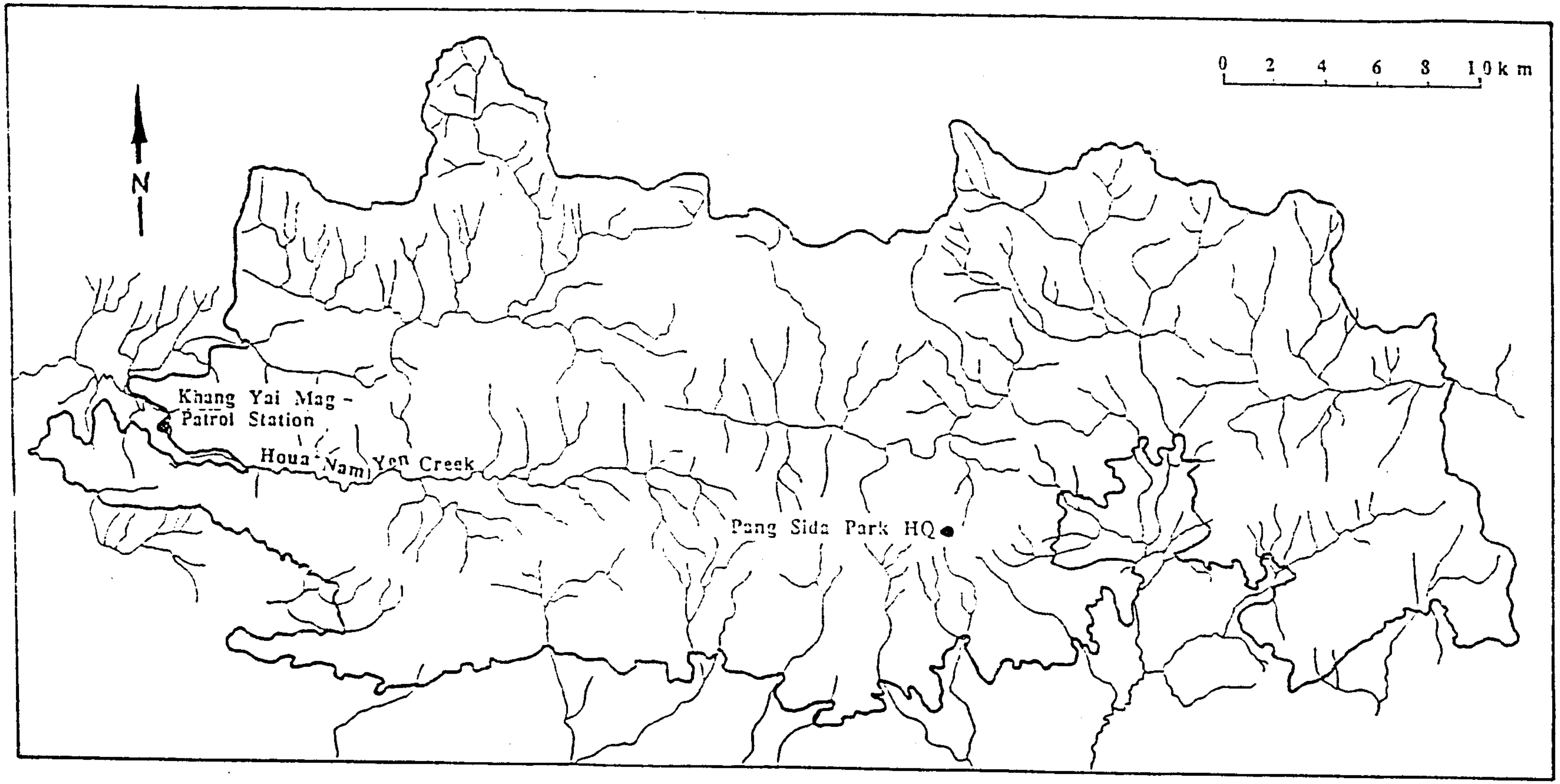

Figure 2. Location of Houa Nam Yen Creek in Pang Sida National Park.

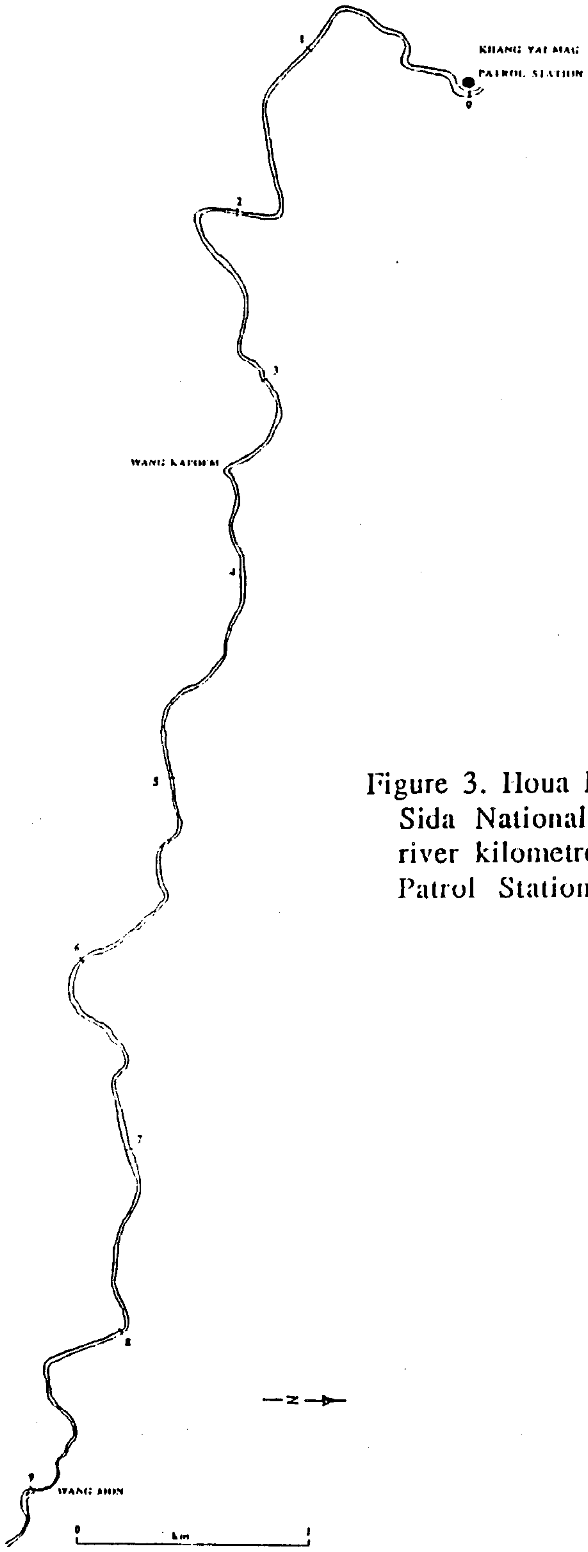

Figure 3. Houa Nam Yen Creek in Pang Sida National Park. Numbers indicate river kilometres (0= Khang Yai Mag Patrol Station).

Survey Transect

The survey transect was defined by the Park boundary near Kang Yai Mag Patrol Station and extended upstream for 9.3 km to rapids at Wang Mon (Fig. 3). A section of rapids (0.8 km) extending downstream from Wang Kapoem was not surveyed for logistic reasons. Upstream of Wang Mon the creek is too narrow and shallow to survey by boat.

During the day, sections of bank were walked and observations on habitat and other information were recorded. Particular attention was paid to any signs that may reveal the presence of crocodiles (e.g. slides, old nest sites, basking sites). The section of the river to be surveyed each night was paddled during the day to familiarise the observer with the creek course and to note habitat type.

Mapping the Water Course

Prior to the surveys being undertaken, a working map of Houa Nam Yen Creek was prepared from aerial photograghs (scale 1: 10,000) as described by Messel et al. (1981). The creek course was traced and a geared-wheel map measurer used to define midstream distances upstream (in units of 0.1 km) from the boundary of the park to Wang Mon (Fig. 3).

Spotlight Survey

The mainstream of Houa Nam Yen Creek was spotlight surveyed on 24-26 November 1993, using a small (2.3 m long) fibreglass boat. Access to the creek upstream of the Patrol Station was by foot, with all equipment being carried some 5 km over hills to Wang Kapoem, approximately halfway along the length of the survey transect. The survey team consisted of a spotter and a boat paddler. To the extent possible, the boat was paddled in the middle of the creek and the banks scanned with a 100W spotlight.

Ang Lue Nai Wildlife Sanctuary

Location

Ang Lue Nai Wildlife Sanctuary is located in Chachoengsao Province, south-eastern Thailand (Fig. 4). It comprises 108 km^2 of land, and encompasses hills covered in evergreen and dry deciduous forests, with open grasslands in the lowlands. There are numerous creeks draining the hills within the Sanctuary, and these

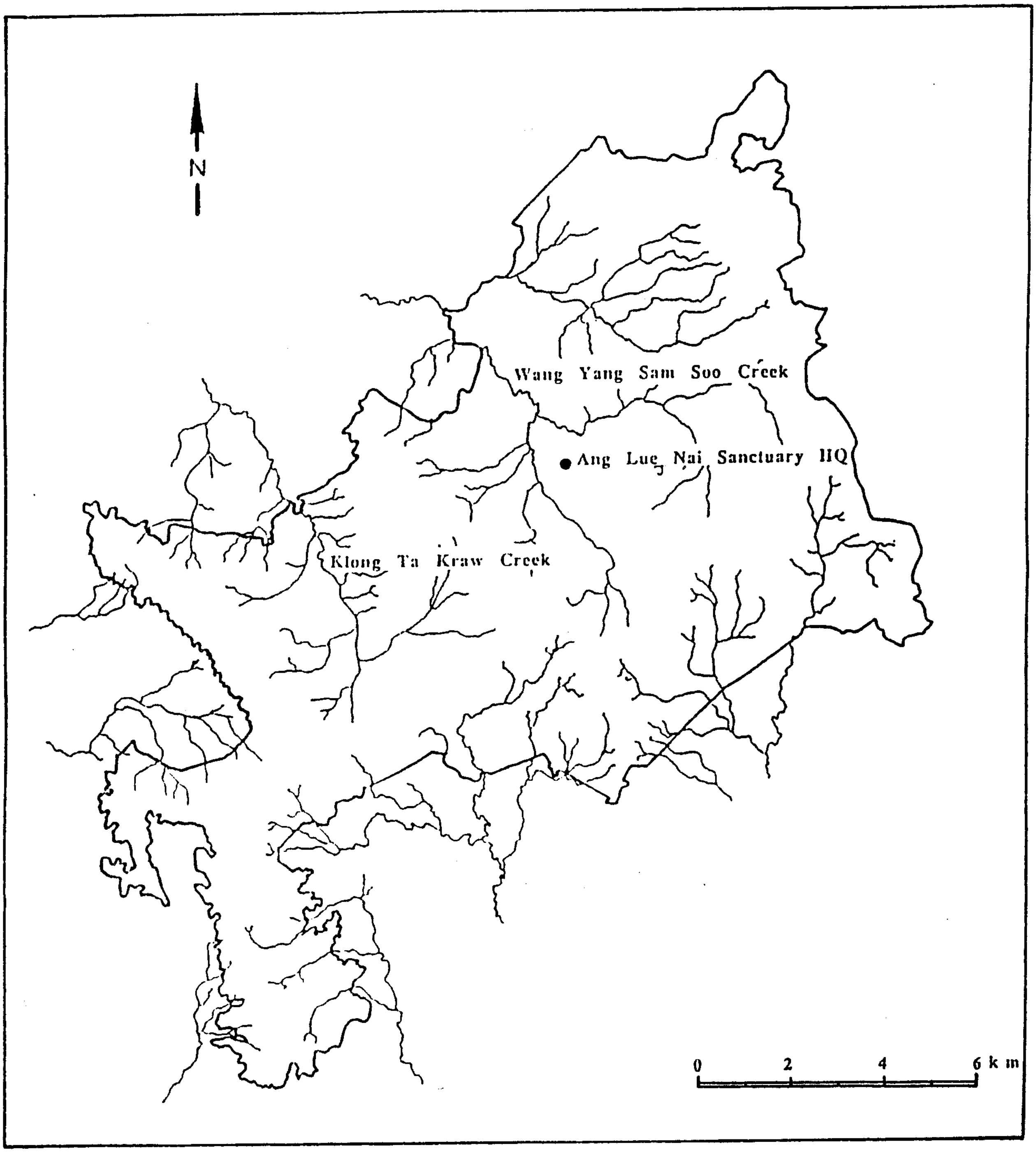

Figure 4. Ang Lue Nai Wildlife Sanctuary.

coalesce to form larger creeks which eventually flow into river systems well outside the Sanctuary. During the dry season, most of these small creeks dry into series of small pools.

Two small creeks were selected for the survey: Klong Ta Kraw Creek, where there has been a recent sighting and photogragh of a 2.5 m C. siamensis, and Wang Yang Sam Soo Creek, where crocodile tracks were recently photograghed by RFD staff. Both creeks are on the western side of the sanctuary (Fig. 4).

Klong Ta Kraw Creek is very narrow (3-5 m wide) and dries to a series of shallow pools less than 1.5 m deep during the peak of the dry season (according to RFD rangers). Banks are covered in secondary growth dry decidious forest with a dense understorey dominated by bamboo and ratan cane palm. These conditions made the use of a boat for the spotlight surveys impractical. After a trail was cut through the understorey, approximately 200 m of the creek was walked during the day to familiarise the observer with conditions and to evaluate the habitat.

On the night of the 28 November 1993, a survey was carried out by walking the bank, and, wherever tracks into the creek had been cut (determined by thickness of vegetation) scanning the water surface with a "Magna-lite" torch. Six observation sites were used, each allowing the spotter to view some 10-20 m of the creek. At each site, there was an initial scan with the light, and then it was switched off. The spotter remained silent for 15-20 minutes before quickly scanning the area again. Three scans were carried out at each site.

Wang Yang Sam Soo Creek is north-east of Klong Ta Kraw Creek (Fig. 4) and flows from hills to the south-east and out onto lowland country. Access to most of the creek is restricted by thick vegetation and the lack of any tracks. During the dry season, water flow in the creek ceases, and it dries to a series of deep waterholes separated by shallow gravel beds. Stream width was approximately 15 m and maximum water depth in the deepest holes about 2 m. Bank vegetation consisted of fringing scrub and tall grasses, the result of past clearing for agriculture.

Only 1 km of the creek was accessible by foot. A spotlight survey was not conducted during this visit. Observations on the availablity of suitable habitat for crocodiles were made and the logistics assessed so that a future spotlight survey could be conducted in an efficient manner.

Phuket Island

Phuket Island is situated off the west coast of the southern peninsula of Thailand, in the Andaman Sea (Fig. 1). The hottest period of the year is from February to May and the coolest from September to December (Grey et al. 1991).

The survey area is located at the northern end of the island, at Ban Mai Khao (Fig. 5), a remnant peat swamp and coastal lagoon complex. Historically, the total area was some 3 km in length, but most of it has been altered through draining and clearing of vegetation. The lagoons and associated swamps lie behind coastal sand dunes (about 100-500 m inland from the sea), and form a chain connected by shallow canals. The swamps are formed in depressions bordering the lagoons and are characterised by a dense understorey of sedges, hanguana, climbing fern and cane grasses (Phragmites spp.). There is an overstorey of low Melaleuca spp. Local villagers have cultivated all suitable areas to the water's edge, and the lagoons are intensively fished. It is estimated that less than 1.5 km of lagoon and swamp remain.

Of the three small remaining swamps, two were walked, for signs of nesting and crocodiles. A small boat was used to spotlight survey those parts of the lagoons and swamp edge that were accessible. The remaining open water was surveyed by walking the bank and scanning with a 6V handtorch. Surveys were conducted on 2-3 December 1993.

RESULTS

Pang Sida National Park

One eyeshine was located at km 5.5 on Houa Nam Yen Creek (Fig. 3). The animal surfaced some 40 m in front of the boat and swam away from the boat before diving. The angle of the animal's head relative to the spotlight beam resulted in a weak eyeshine, and it dived before it could be approached. No positive identification could be made.

No other evidence of crocodiles was found during daytime searches of the banks by boat or walking. Although 8 basking sites were located on the banks, none could be attributed definitively to crocodiles. Otters (Lutra perspicillata or Aonyx cinerea) and water monitors (Varanus salvator) could also be responsible. Tracks and tail grooves at three of these sites matched the track patterns of

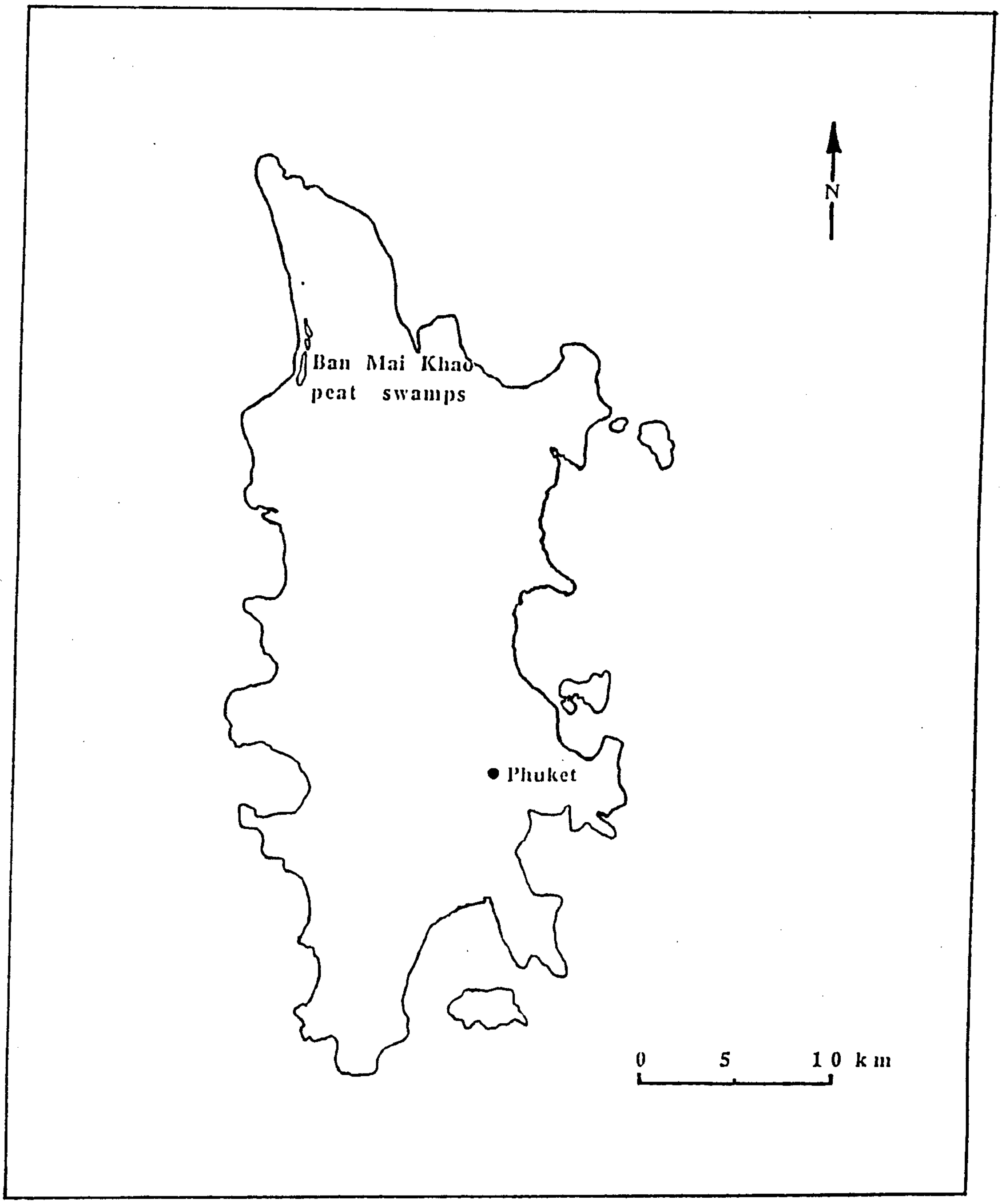

Figure 5. Phuket Island. See Fig. 1 for location in relation to mainland.

V. salvator. Only one slide found at Wang Mon could possibly have been made by a small crocodile. However, even here, the tracks were not distinct, and the possiblity that they were made by a large V. salvator cannot be rejected. In gereral, basking sites are limited due to the steep banks and tall, thick vegetation.

Observations made at night in the clear water suggest that there is a paucity of large fish species and turtles in the creek, which may reflect a generally limited food supply for crocodiles. Potential nesting habitat is limited to some patches of thick grassy bank, although nesting may be possible in leaf litter under bamboo thickets. The overall impression was that Houa Nam Yen Creek provides only marginal crocodile habitat in terms of area, nesting habitat and food availability. Historically, upstream sections of such creeks may never have provided anything but marginal habitat. The recent photogragh of a large crocodile near Wang Mon remains the only definitive record that one crocodile still exists in the river.

Ang Lue Nai Wildlife Sanctuary

Daytime searches of the banks and the torchlight survey of Klong Ta Kraw Creek revealed no evidence of crocodiles. A 2.5 m C. siamensis was photographed there in November 1992, after 3 days observation from a blind. The narrow, highly sinuous nature of the creek, and the thick vegetation which obscures the water's edge, make this system unsuitable for spotlight surveys (Bayliss et al. 1986). Sightable portions of the creek at any point are restricted to 5-6 m in length. Any nesting would be restricted to the floor of the dense forest, and the only basking sites were partially submerged tree trunks. There was no evidence of large fish or other potential prey species in the creek, again suggesting limited food availablity.

Wang Yang Sam Soo Creek was more suitable for spotlight surveying, but logistics did not allow the survey to be carried out. There are limited basking sites and potential nesting sites are restricted to the levy bank where vegetation is predominantly tall grasses (a result of extensive clearing in the past). A photograph of crocodile tracks (by RFD rangers) at the creek indicates that at least one animal is present.

Both Wang Yang Sam Soo and Klong Ta Kraw Creeks appear to be marginal habitat for C. siamensis, and probably never contained significant densities of crocodiles.

Phuket Island

Spotlight surveys of Ban Mai Khao peat swamps by foot (using a hand held torch) and by boat (with a spotlight) did not result in any crocodile sightings. Over the last three years there have been 3 records of C. porosus in these lagoons: a medium sized (2 m) crocodile was caught in a lagoon after it was drained; a small crocodile (possible a hatchling) was caught in a fishing net; and, a small to medium crocodile (1-2 m) was seen crossing a road separating a lagoon from a canal (information from local villagers and fishermen). With the exception of the small crocodile, these records probably reflect animals entering the swamp from the sea (possibly originating from Myanmar or Malaysia).

Up until 20 years ago crocodiles were common in the lagoons, and villagers never entered the water for fear of being attacked. Fishermen regulary saw crocodiles and they remember a buffalo being bitten. However, the intensive use of the area by people and the recent destruction of a large proportion of the remaining habitat make it difficult to avoid the conclusion that the area is now totally unsuitable for C. porosus. They are probably extinct in the area today. The daily use of the area by villagers, the large size of mature Saltwater Crocodiles, and the small area of habitat left (about 0.75 km^2) would make it near impossible for crocodiles to exist there without being sighted.

The coastline of Phuket Island has a number of mangrove-lined creeks, which until recently were relatively undisturbed, and may have provided some remnant refuges for C. porosus. Crocodiles from these creeks may have used the lagoons during the nesting season, and as a source of fresh water. Similar use of freshwater swamps by C. porosus occurs in the Northern Territory of Australia, where animals cross from the sea to the swamps (Messel et al. 1979).

DISCUSSION

The surveys did not provide evidence of a remnant population of C. siamensis in Thailand, although photographs taken recently do indicate that a few C. siamensis still exist in the wild. However, the extremely wary nature of any existing crocodiles and type of habitats they are restricted to (thick fringing vegetation at the water's edge; narrow, sinuous creeks) greatly reduced the chances of them being sighted using conventional spotlight survey techniques (Messel et al. 1981; Webb et al. 1989).

All areas investigated are considered to be marginal habitat for crocodiles. They consisted of narrow creeks that are fast flowing in the wet season, with limited deep water in the dry season, limited nesting sites; and possibly a limited food supply. They may never have supported high densities of crocodiles.

On Phuket Island the remaining peat swamp has no potential for maintaining even a small population of C. porosus. There is intensive use of the area by people who cannot afford to tolerate a large dangerous animal in such close proximity. In addition, the remaining habitat has been extensively degraded and reduced in size. Tidal creeks along the coastline, where mangroves have not been cleared for aquaculture, may still contain some C. porosus. Such areas would be more amenable to spotlight surveys.

Recommendations

1. Resurvey all areas by spotlight during the next cool-dry season (October to February).

2. Fly all areas by helicopter during the next dry season. This may prove to be a more appropriate survey method for wary crocodiles in such habitats.

3. Prepare working maps for Wang Yang Sam Soo Creek, in Ang Lue Nai Wildlife Sanctuary. The length of the creek within the Sanctuary needs to be mapped and ground surveys conducted to determine the feasiblity of using a small boat to spotlight survey the creek. Information on the extent of deep waterholes and the type of habitat along the creek should be collected for assessment.

4. Identify from topographic maps, aerial photos and ideally by helicopter survey, any other creeks which may be suitable for crocodiles in Ang Lue Nai Wildlife Sanctuary. Groundchecks of these areas would indicate whether spotlight surveys can be carried out there.

5. Fly all areas during the nesting season, searching the banks for signs of nests and/or nesting activity.

6. Conduct spotlight surveys of the Phuket Island coastline and tidal creeks.

ACKNOWLEDGEMENTS

We would like to thank all of the Royal Forestry Department staff for assistance in the field. This report represents part of the crocodile research program being undertaken in Thailand by Dr. Parntep Ratanakorn under the auspices of the Asian Conservation and Sustainable Use Group and the Crocodile Management Association of Thailand. Additional technical support was provided by the Royal Forestry Department. The involvment of Brett Ottley and Dr. Grahame Webb was made possible through financial support from the German leather industry associations ("Internationaler Reptillederverband-IRV" and "Reptil-Artenschutz e.V.-RA").

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APPENDIX 1

SURVEY METHODS USED TO MONITOR CROCODILE POPULATIONS

A Report to the Royal Forestry Department and the Crocodile Management Association of Thailand

GENERAL

When designing a monitoring program, it is important that the managment "problem" that requires monitoring is clearly defined. It will influence the type of monitoring program instigated. If the main objectives are to monitor changes in the total population, the survey program will need to be designed to sample discrete units of crocodile habitat across the known range of the species. Monitoring at this level of resolution is concerned primarily with whether the population is increasing, decreasing or stable. It may not be sensitive enough to detect changes within local populations (i.e. within any one survey unit): for example, the population in one unit may be declining, while the total population is increasing.

A separate problem may be to assess changes in one segment of the total population or one area over time- perhaps in one river system. This may require an intensive survey program designed to provide data on basic population parameters such as annual hatchling recruitment and size class distributions within the population (Webb and Smith 1987).

These two levels of monitoring are not necessarily exclusive, but they are quite different and need to be considered independently.

The Royal Forestry Department (RFD) and the Crocodile Management Association of Thailand (CMAT) need to determine what the managment questions are that need to be answered by surveys. It would appear that the first priority at this stage is to locate any remaining crocodile populations in Thailand. The monitoring program needs to be designed to provide presence or absence information in the first instance. This maybe followed by surveys designed to provide information on populations in individual river systems: establishment of more systematic survey programs, within each river, may be warranted. These will provide data on the numbers present, annual recruitment and long-term changes in the populations. Such a program could form the basis of a total population survey program in the future.

The two main techniques used to survey crocodile populations are spotlight surveys and helicopter surveys. Spotlight surveys are best suited to monitoring in areas were the sightability of crocodiles is high. Such areas are characterised by a low sinuosity and a waters edge which is not obscured by vegetation. In areas with thick vegetation along the waters edge and/or a high degree of sinuosity the sightability of crocodiles is reduced and the accurracy of spotlight counts is accordingly reduced (Bayliss et al. 1986). In areas suitable to spotlight surveys, the results will give precise estimates for annual changes in hatchling recruitment and size class distribution within the one population (Bayliss 1987; Webb et al. 1990). Helicopter surveys tend to be less sensitive to subtle changes within a population as this method does not readily detect the hatchling and juvenile size classes. This survey method is best suited to sampling extensive sections of crocodile habitat cheaply and quickly (Bayliss et al. 1986; Webb et al. 1986).

To meet the aims of the present management program in Thailand, both survey techniques can and should be used. The primary aim at this stage is to confirm the presence of crocodiles in the wild. Where the animals are particularly wary after a long history of exploitation, and have learnt to avoid man [which is the case in Thailand (Ratanakorn. 1994)] helicopter surveys are probably more likely to locate animals. However, where it is desirable to monitor changes in any remnant populations, spotlight surveys may be the best to use.

For a survey program to be of use in the long term, it must be designed to be REPEATABLE over time. This is achieved by reducing the sources of variation in the methods used to conduct surveys, so that a standarised procedure can be followed each time a survey is done.

SPOTLIGHT SURVEYS

The basic method for conducting spotlight counts has been described by Messel et al. (1981). The critical elements of that description, as they relate to the method and principles used to design and conduct spotlight surveys, are:

1. The survey transect (the section of mainstream river or creek and any associated sidecreeks to be surveyed) has to be defined by a START POINT and a STOP POINT. Any sidecreeks off the mainstream which are amenable to spotlight survey must also

have definitive stop points. Both banks of the mainstream and any sidecreeks are surveyed. This ensures that the exact same area is surveyed each time, which means that the data collected from year to year is related and can be assessed for changes over time. It is useful to measure the survey distance in units of 0.1 km, as this allows the location of each animal to be recorded reasonably accurately. It allows the distribution of animals within the survey transect, to be mapped over time.

2. Time of year and water level will affect the number of crocodiles seen. 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. At this time of year crocodiles tend to be in the water at night because it is warm relative to the cool, night air.

3. Changing the strength of the spotlight or torch used on different surveys may affect the number of crocodiles seen, and thus bias the results. It is important 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 waters 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.

4. When using the spotlight it should be held so that the observer's eye is positioned behind the light so they are looking along the beam of the light. The light is swept in an arc of 180 degrees, so as to cover the waters edge along both banks and the water ahead of the boat. The eyeshines are most easily detected from a distance, especially the eyeshines of hatchlings and those of crocodiles hidden in thick vegetation. The boat should be kept in the middle of the river while seaching for eyeshines. When an eyeshine is picked up in the light the spotter directs the boat driver to approach the eyeshine until close enough to see the crocodile, determine species and make a size estimate. If the animal dives before it can be identified and "sized" it is recorded as an "eyeshine". The boat should then be moved back into the middle of the river.

5. A common fault when spotlighting is the tendency for some spotters to hold the light on a eyeshine as they are approaching it, until the crocodile is sighted and sized, and thus fail to continue searching the area for other eyeshines. This will result in some crocodiles not being detected if they dive at the approach of the boat or the boat passes them. The best technique is to give the boat driver the direction of the eyeshine then continue to search the area as the boat approaches it.

6. The observer should be the same for all surveys. If spotters are changed then the new spotter should be checked against the original one, to ensure that they are equivalent. Some observers just seem unable to detect crocodile eyeshines in the distance.

HELICOPTER SURVEYS

The methods used for helicopter counting of crocodiles has been described by Bayliss et al. (1986). The same principles apply to setting up the survey transect as for spotlight surveys. In areas that are spotlight surveyed the same transect should be flown. When conducting a survey the helicopter is flown at a height of 100 feet, a speed of 60 knots and is positioned out from the bank toward the middle of the river. Usually only one bank is flown and the best time of year is the cool dry season, when crocodiles bask and are more easily seen. Each crocodile sighted is identified to species, placed in a size category, and its location along the survey transect recorded. If the crocodile cannot be identified to species it is recorded as "unknown".

AIMS

The current survey program has three main aims. The first is to determine if crocodiles are present. The second is to determine how many are present and where they are. The third is to set up a long-term monitoring program so that accurate data on numbers and size classes can be collected. This information will give estimates of the population growth and changes in the size structure of the population over time.

RECOMMENDATIONS

General

1. Accurate work maps of the creeks to be surveyed need to be prepared.

2. The survey team needs to be trained to identify crocodile eyeshines from those of spiders, frogs and mammals.

3. Drawings of the crocodile hind foot print should be made from the photogragh taken in Ang Lue Nai Sanctuary. This drawing can then be distributed to ranger staff, to aid them in distinguishing crocodile tracks from those of Varanus salvator and otters.

4. Post-hatching time is a good time to spotlight survey all areas, as the hatchlings will be close to the nest site and still in clutch groups. Location of these hatchlings will give some indication of the nesting effort and indicates the presence of adult crocodiles, which may have been too wary to be sighted during surveys.

5. A short workshop on crocodile survey techniques would be useful.

Pang Sida National Park

1. It would be worthwhile surveying Houa Nam Yen Creek again this dry season.

2. Any sections of the creek where tracks and belly slides are found, should be closely monitored. These may be regularly used basking sites, which can be observed from hides built near these sites. Baits could be hung near the sites to encourage the crocodiles to show themselves.

3. Helicopter surveys of this creek will probably be more likely to find crocodiles than the spotlight surveys. The crocodiles are extremely wary and have learned to avoid man, boats and spotlights. However, they have not been subject to interference by helicopter.

4. Over the nesting season the creek banks should be searched for nests, both by boat and by helicopter. Female crocodiles visit the

nest sites regularly and create well defined paths through the vegetation to the nest. Careful searches of the bank from a boat, may locate these paths. Nest mounds can often be seen from the air if the helicopter is flown slowly along the bank.

Ang Lue Nai Wildlife Sanctuary

1. Maps of the creeks to be surveyed need to be drawn. The maps need to be of a scale that will show the creek in detail (1: 10 000 would be suitable).

2. An assessment of other creeks in the sanctuary which may be suitable for crocodiles needs to be made. Factors such as the presence of deep water, especially during the dry season, bank vegetation, availability of basking sites and food supply can be used to form an assessment of the potential of each creek for crocodiles.

3. If possible Wang Yang Sam Soo Creek should be spotlight surveyed this dry season.

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CLASSIC IDENTIFICATION OF SOUTHEAST ASIAN CROCODILES

TAXONOMY AND SYSTEMATIC PROBLEMS OF CROCODILES IN S.E. ASIA.

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A REVIEW OF THE HISTORY OF SOUTHEAST ASIAN CROCODILE TAXONOMY WILL BE PRESENTED INCLUDING THE CLASSIC CHARACTERS HISTORICALLY USED TO IDENTIFY SPECIES SPECIFIC POPULATIONS. DIAGNOSTIC CHARACTERS FOR IDENTIFICATION OF POPULATIONS WILL BE PRESENTED. EXAMPLES OF INDIVIDUALS WHICH DO NOT FIT CURRENT CHARACTERIZATIONS OF RECOGNIZED POPULATIONS WILL BE DISCUSSED.

Karyotypes of 5 species of crocodile kept in Samutprakan Crocodile Farm and Zoo

*Vivat chavananikul**
*Sumitra Wattanodorn**
*Panya Youngprapakorn***

Abstract

Five species of crocodile bred in Samutprakan Crocodile Farm and Zoo were used in this study. They were 8 Siamese freshwater *(C. siamensis)*. 7 saltwater *(C. porosus)*. 12 crossbreds produced by these two species, 3 Cuban *(C. rhombifer)*. 2 New Guinea *(C. novaeguineae)* and 4 Nile crocodiles *(C. niloticus)*. Lymphocyte cultures from heparinized blood were performed using Amphibian medium and incubated at 29 °c for 3 days. Well spread metaphase cells were examined under light microscope and photographed. The results from karyotype analysis were show in the following table.

Keyword : chromosome karyotype crocodile

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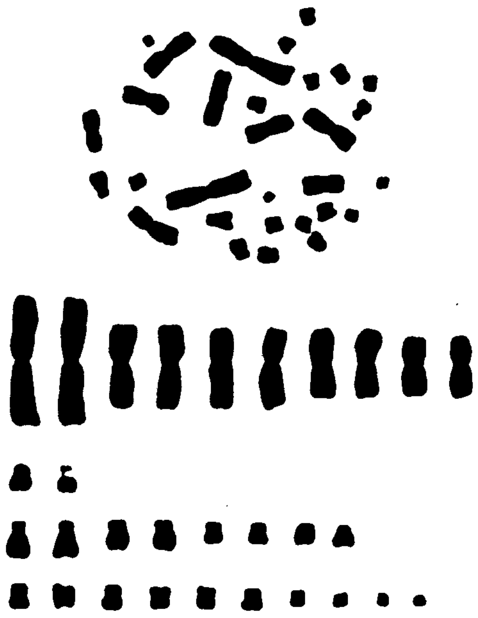
Karyotype analysis of five species of crocodile

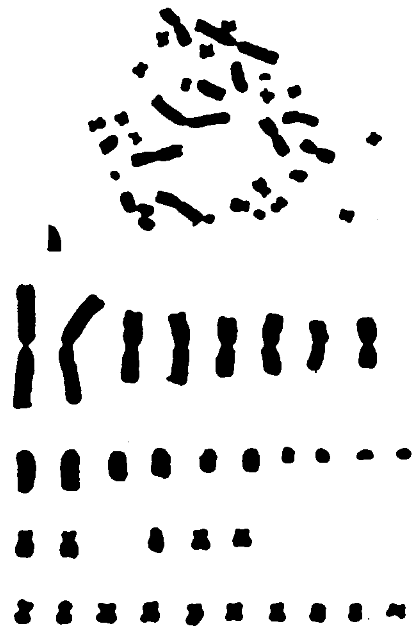
Species of crocodile	Number studied	2n =* (NF)**	Meta- large	Acro	Submeta small	Meta- small
1. Siamese freshwater croc. (*Crocodylus siamensis*)	8	30 (58)	10	2	8	10
2. Saltwater croc. (*Crocodylus porosus*)	7	34 (58)	8	10	6	10
3. Crossbred F1 (*C. siamensis* x *C.porosus*)	8	32 (58)	9	6	7	10
4. Crossbred F1-freshwater (F1 x *C. siamensis*)	1	31 (58)	9	4	8	10
5. Crossbred F1-saltwater (F1 x *C. porosus*)	2	33 (58)	9	8	6	10
6. Crossbred F2-*Inter se* (F1 x F1)	1	32 (58)	10	6	6	10
7. Cuban crocodile (*C. rhombifer*)	3	30 (58)	10	2	8	10
8. New Guinea crocodile (*C. novaeguineae*)	2	32 (58)	8	6	6	12
9. Nile crocodile (*C. niloticus*)	4	32 (58)	8	6	6	12

2n* = Diploid number NF** = Fundamental number
Meta- = metacentric Acro- = Acrocentric Submeta = Submetacentric



FRESHWATER CROCODILE 2n=30

C. siamensis จระเข้น้ำจืดไทย

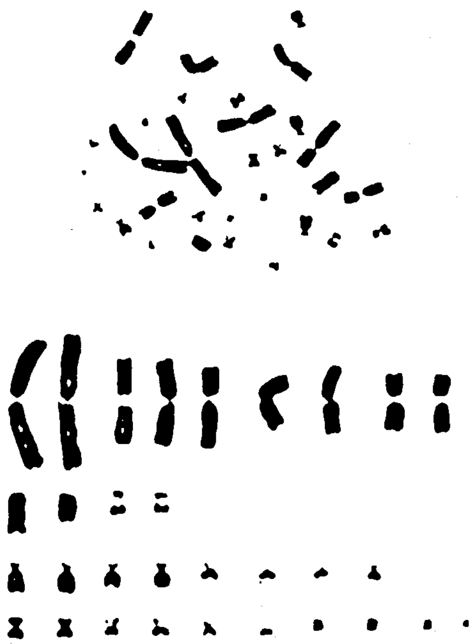


SALTWATER CROCODILE 2n= 34

Crocodylus porosus จระเข้พันธุ์น้ำเค็ม

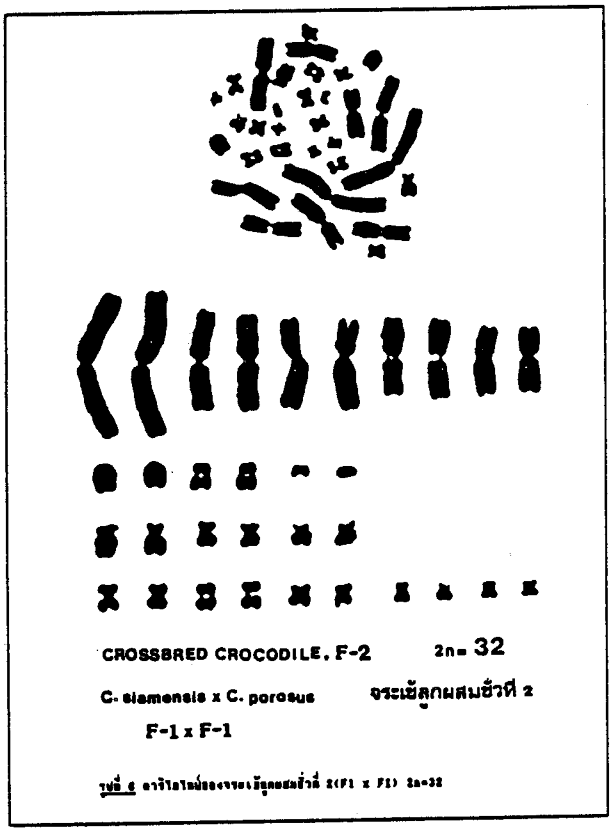
CROSSBRED CROCODILE, F1 2n=32

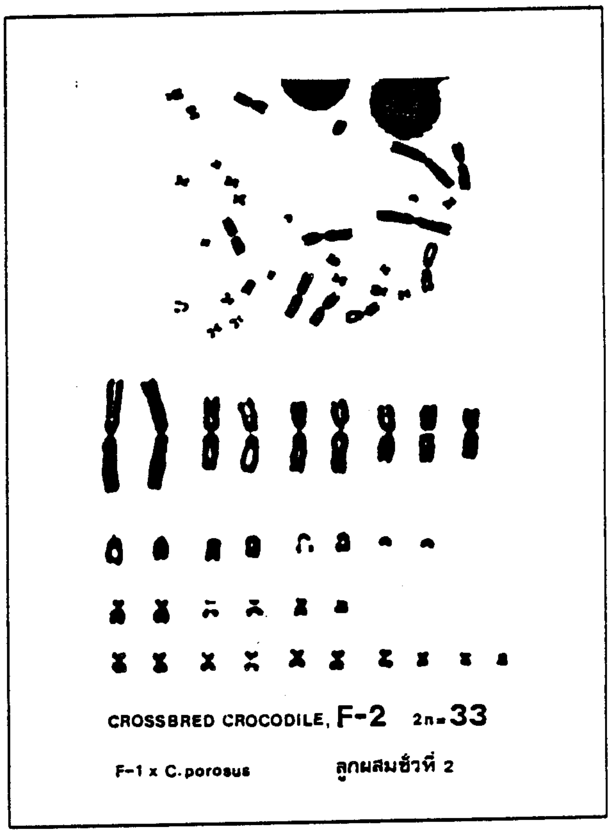
C. siamensis x C. porosus ลูกผสมชั่วที่ 1

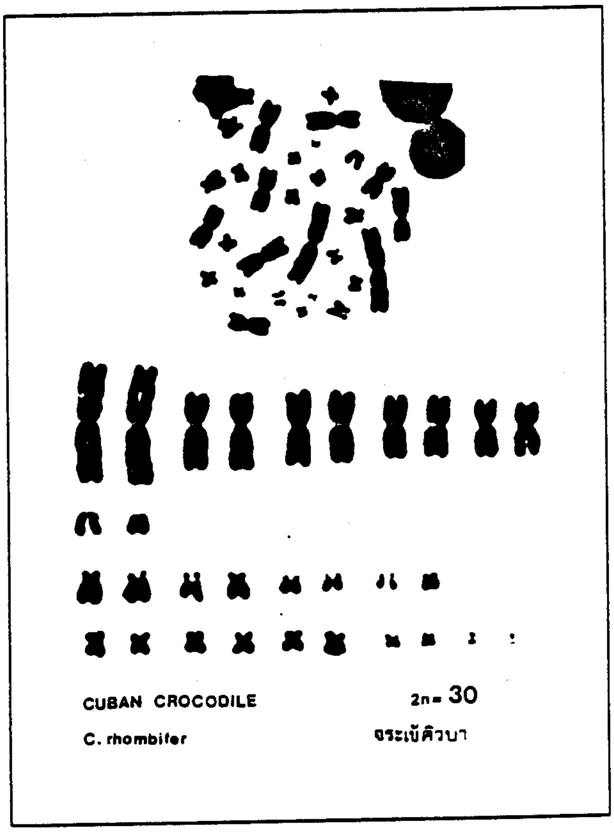


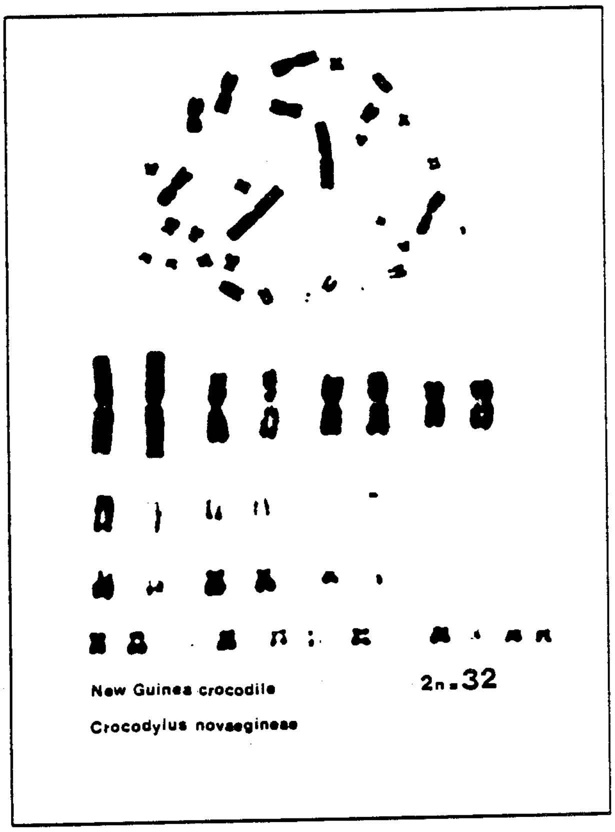
Crossbred crocodile, F2 2n= 31

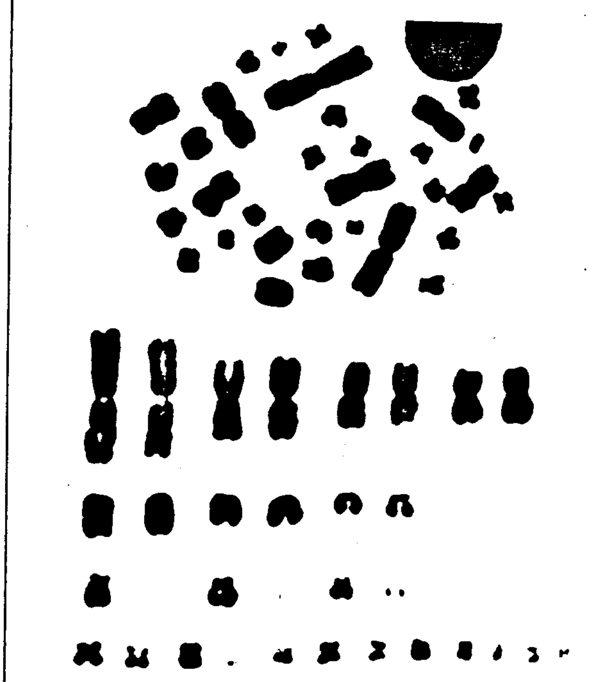
C. siamensis x F-1 จระเข้ลูกผสมชั่วที่ 2


CROSSBRED CROCODILE. F-2
2n= 32
C. siamensis x C. porosus
จระเข้ลูกผสมชั่วที่ 2
F-1 x F-1


CROSSBRED CROCODILE. F-2
2n=33
F-1 x C. porosus
ลูกผสมชั่วที่ 2


CUBAN CROCODILE
2n= 30
C. rhombifer
จระเข้คิวบา


New Guinea crocodile
2n=32
Crocodylus novaeginese



NILE CROCODILE $2n=32$

Crocodylus niloticus

Differential Morphology of Crocodilian Leucocytes

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Abstract

Blood smear from 50 crocodiles of three breeds (Crocodilus siamensis, C. porosus and crossbreds) are examined after Wright-Giemsa stainning.Three types of granulocytes are distinguished: heterophil, eosinophil and basophil. In addition, 2 types of agranulocytes are characterized: lymphocyte and monocyte. Heterophil with the size of 8-10 um has spiculate pink granules with oval eccentric light blue nucleus. With the mixing of round, rod and tear drop-shaped acidophilic granules, the eosinophil is 8-9 um., its pale blue nucleus is also at the periphery. Basophil is the largest(9-12 um) among the granulocytes. Granules are of various sizes and stained purple. Nucleus is rounded and surrounded by pale blue cytoplasm. Granules of the heterophils and basophils are dissolved in methanol. Moreover, it is possible that the basophilic granules are also dissolved in water. Lymphocyte's diameter is 7-9 um with eccentric or centrally located round nucleus. Its fine basophilic granules are evenly distributed in the cytoplasm. Monocyte (8-10 um) is few, mostly with kidney-shaped, eccentric nucleus and vacuolated blue cytoplasm. Crocodile has nucleated thrombocyte which is very much like lymphocyte but of smaller size (6 um). The small thin rim cytoplasm surrrounds the rounded nucleus. In addition, the unknown cell is also reported and discussed. It is possible that the unknown cell is another white cell type, "the azurophil".

Introduction

Addition information concerning the morphological and physiological characteristics of crocodilian blood are needed to make a successful differential diagnosis and disease monitoring. Examination of a stained blood film is integral and very helpful in routine hematological examination. Apart from differences in the form and size of the nucleus and cytoplasm, staining characteristics of the cell constituents are essential in classsification of the white blood cells . Confusion and contradictory interpretations on nomenclature of the reptilian blood cells have been an interesting controversy for a long time (5,6,7). Moreover, different staining techniques, type of anticoagulants and whether or not are used all have various effects on blood cell morphological interpretations(4).

The present study is to provide informations on morphological differences (size, shape, nuclear-cytoplasmic ratio and cytoplasmic granules) of the crocodilian leucocytes. In addition, details and results of fixative used in blood smear preparation are also discussed.

Material and methods

Blood samples are collected from blood sinus located behind the base of the skull of 50 crocodiles of 3 types (Crocodilus siamensis, C. porosus and hybrid type). Heparin coated venoject tubes are of tremendous convenience in blood collection. Blood samples are centrifuged at 2,500 rpm for 20 mins. to obtain the buffy coats. One drop of buffy coat is smeared on the slide and 4 slides are prepared from each sample. Two slides of each sample are fixed in methanol for 1 mins. The fixed and nonfixed buffy coat smears are stained with Wright-Giemsa (Clinical diagnostic Ltd.part. , Thailand).

Observations

Examination of the buffy coat smears with Wright-Giemsa stained under the light microscope reveals the following leucocytes:

Granulocytes

1. Heterophils are abundant (Fig 1) .The slightly oval cell of 8-10 um has oval eccentric light blue nucleus with spiculate pink granules densely packed in the cytoplasm. As expected examination of the ruptured heterophil exhibits acidophilic needle-liked granules. The nuclear-cytoplasmic ratio(N:C) is 1:2-2.5.
2. Eosinophils is round, 8-9 um in size (Fig.2) .The nucleus is round or oval and located at the cell periphery. Dark acidophilic, rod and round granules are closely packed in the cytoplasm. However, some of the eosinophilic granules are sparse in the nuclear area. Studies of the disrupted eosinophils reveal a few tear drop-shaped granules mixing with the numerous round and rod shaped granules. The N:C ratio of the eosinophil is 1:2.5-2.8.
3. Basophils (Fig.3) are not as numerous as heterophils and eosinophils. The cell is the largest (9-12 um) among granulocytes with N :C ratio of 12:1 . Granules are mostly round of various sizes and stained dark purple. The nucleus is round and situated in the middle of the cell.

Agranulocyte

1. Lymphocytes are small (7-9 um), round cells with round eccentric or centrally located nuclei(Fig.4). In some instant, very fine basophilic granules are observed in the cytoplasm. The N:C ratio is 5:1.
2. Monocytes (Fig.5) are large (8-10 um) round cells with N:C ratio of 1-2.5:1. The kidney-shaped or oval nuclei are eccentric with vacuolated (ground-glass) blue cytoplasm on one side. Some monocyte has prominent halo areas imprint in the cytoplasm.

Thrombocytes

The thrombocytes (Fig. 6) are nucleated and very similar to lymphocytes but are smaller (6 um). The round nucleus has a thin rim cytoplasm all around. Thrombocytes always appear as clusters or clumps.

Unknown leucocytes

Few unknown leucocytes (Fig.7) are observed in the buffy-coat smears. The cell is round, about the size of lymphocyte (8 um) with various sizes of basophilic granules dispersing in the cytoplasm. It is possible that this unknown leucocyte is azurophil.

Additional reports from the present study are on solubility of the leucocyte granules. Buffy-coat smears that are fixed with methanol display disintegration of basophilic granules (Fig. 7) and granules of the heterophil (Fig. 7 and 8). Whereas, eosinophils remain intact (Fig. 8).

Discussion

Three types of granulocyte are distinguished in the blood of brids and reptiles and these cells probably have the same functions similar to those of mammals. The difference is that cells of brids and reptiles which are generally assumed to be homologous with mammalian neutrophils have cytoplasm containing a large number of strongly eosinophilic spiculate granules.Therefore, the term "neutrophil" is not appropriate and these cells are named as heterophils (6,9).

Heterophils and eosinophils of the crocodile have round or oval eccentric nucleus. Spiculate eosinophilic granules in the heterophils give rise to problems in distinguishing between these cells and true eosinophils. Especially when the granules are densely packed and no single granule can be examined. To add more confusion, ruptured eosinophils always contain a few tear drop-liked granules which sometimes appear very much like the spiculate granules in the heterophils.

Neutrophils/heterophils are the most numerous granulocytes found in normal mammals, birds and reptiles.Their primary function is bacterial killing through phagocytosis, ingestion and lysis (2,6). Some investigator (5) has reported the presence of alkaline phosphatase and peroxidase in reptilian neutrophils while the others(1,3,8) found that both positive and negative alkaline phosphatase and peroxidase reactions in the heterophils. Further investigation on histochemistry of the crocodilian hetrophils would answer this ambigity.

The unknown leucocytes of 8 um diameter display similar characteristics as basophils but are smaller. Two possible interpretations may apply: 1) The questionable cells are degranulated basophils. This is based on the report that in adequate fixation would results in degranulation of the heterophils and basophils(6). 2) These cells are another white cell type, "the azurophil". An outstandingfeature of azurophils is the metachromatic reaction of their cytoplasmic constituent with Romanowsky stains. Little is known about azurophils and they have been considered as allied to the granulocyte or monocyte series.This is due to their roles in the inflammatory response(6).

In addition to degranulation of the heterophils and basophils causes by inadequate fixation(6). Granules of the heterophils and basophils are dissolved when using an alcoholic fixative (methanol).In contrast, the eosinophils remain intact. In addition, degranulation of heterophil is not observed in the nonfixed buffy coat smears.

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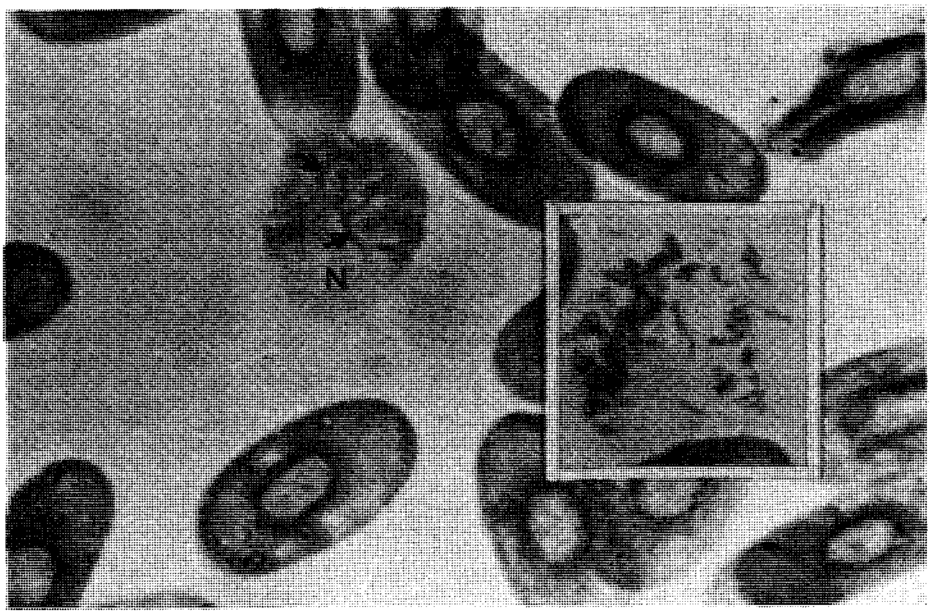

Fig.1 An intact heterophil(8-10 um) with spiculate pink granules (arrows). Inset is a smashed heterophil, the pointed, needle-liked granules are scattered around. (N = nucleus). (Wright-Giemsa x3,600)

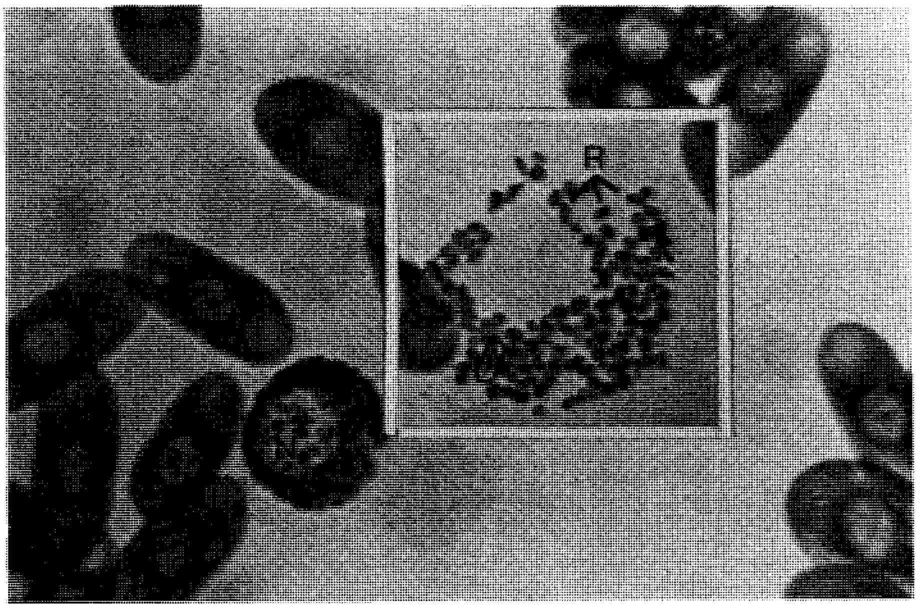

Fig.2 Eosinophil has 8-9 um diameter with eccentric nucleus(N). Round, rod and fusiform granules are found in the cytoplasm. Inset is the disrupted eosinophil with round (arrow), rod(R) and tear drop-liked (oval) granules. (Wright-Giemsa x3,600)

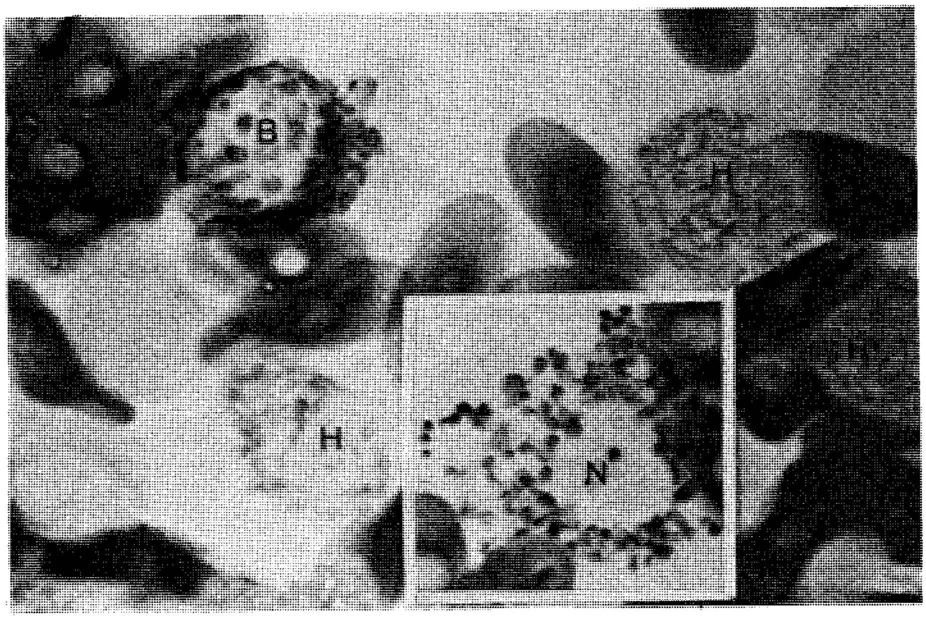

Fig.3 Basophil (B,9-12 um) with round, big basophilic granules are scattered in the cytoplasm. Three heterophils(H) are also observed. The disrupted basophil in the inset displays various sizes and basophilic intensity of the granules. (N= nucleus) (Wright-Giemsa x3,600)

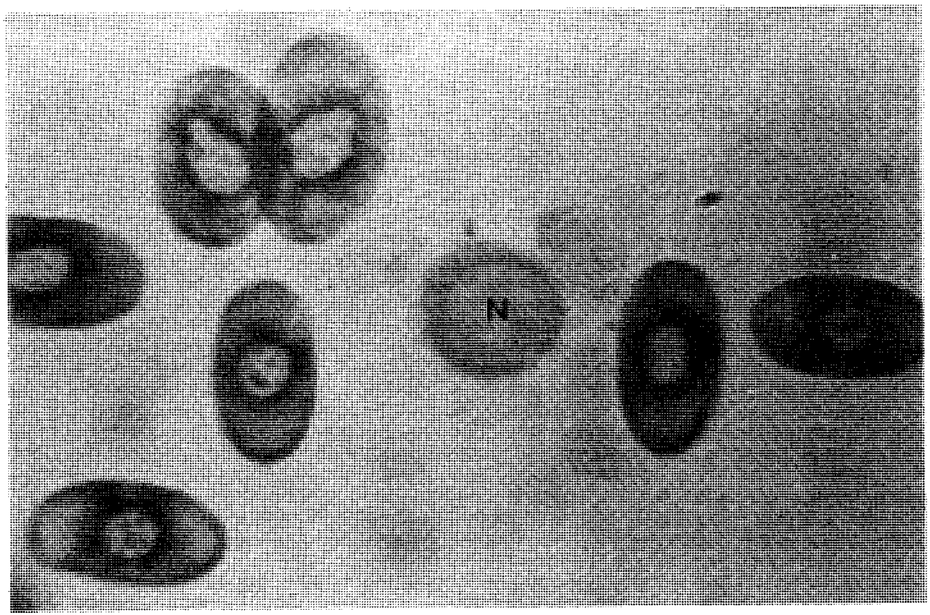

Fig.4 Lymphocyte (7-9 um) is one of the agranulocytes. This lymphocyte has eccentric, round nucleus(N) surrounded by a small amount of basophilic cytoplasm. (Wright-Giemsa x3,600)

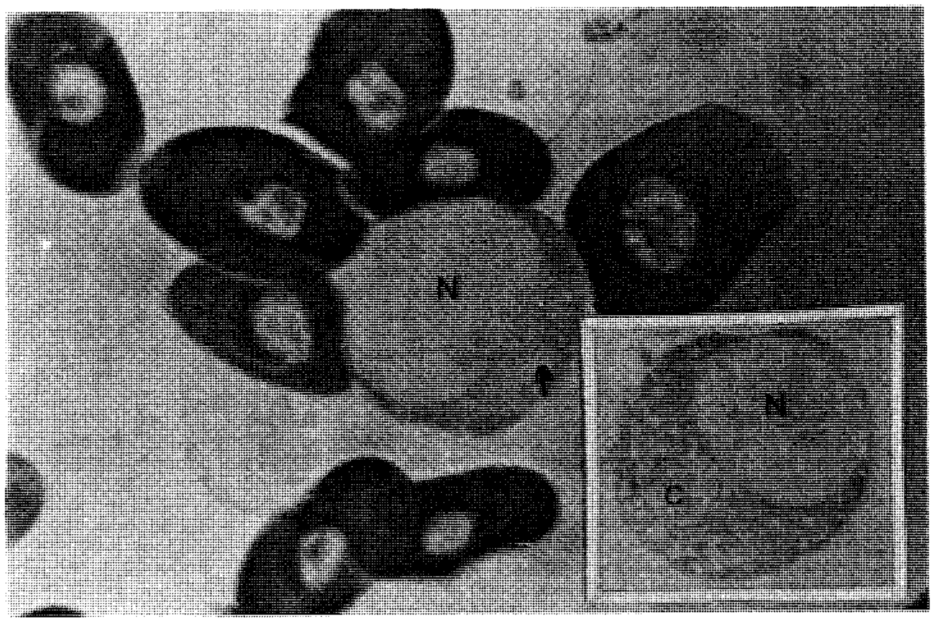

Fig.5 The monocyte (8-10 um) has eccentric nucleus(N). A large amount of pale blue cytoplasm surrounds on one side of the nucleus and halo area(arrow) is also observed. Monocyte in the inset has a prominent foamy cytoplasm(C). (Wright-Giemsa x3,600)

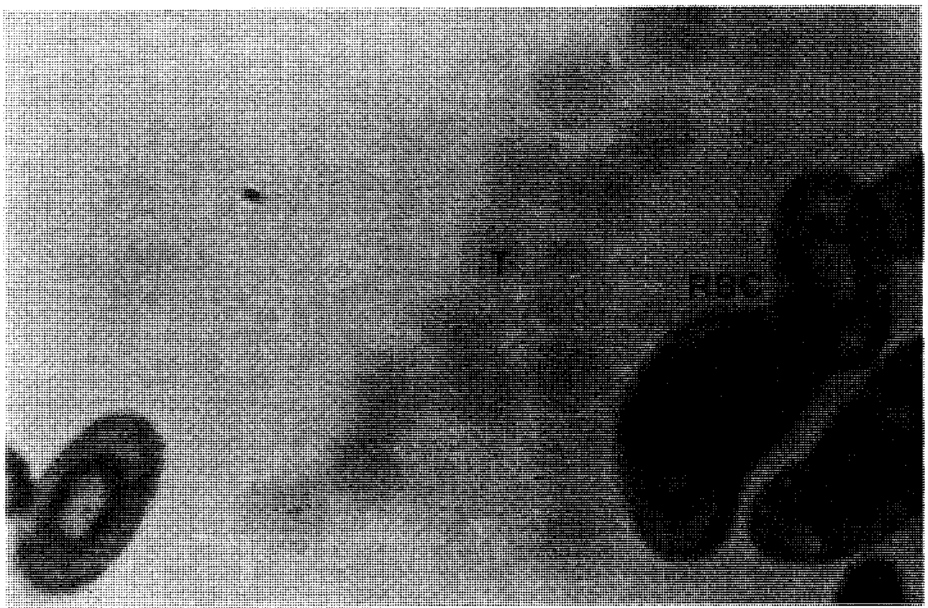

Fig 6 Clump of thrombocytes(T) is displayed along with the nucleated red blood cells (RBC) on the lower right corner. (Wright-Giemsa x3,600)

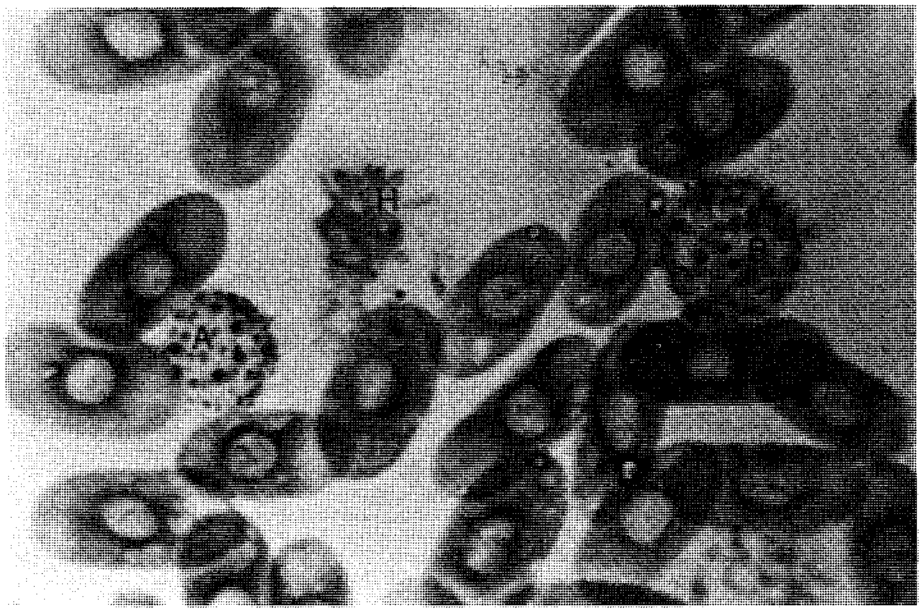

Fig. 7 An unknown leucocyte which could possibly be an azurophil (A) is on the far left. The granulated cell is round with 8 um diameter. The basophilic granules are of various sizes and dispersed in the cytoplasm. Ruptured heterophil (H) is in the middle. (B=basophil)(Wright-Giemsa x 3,600)

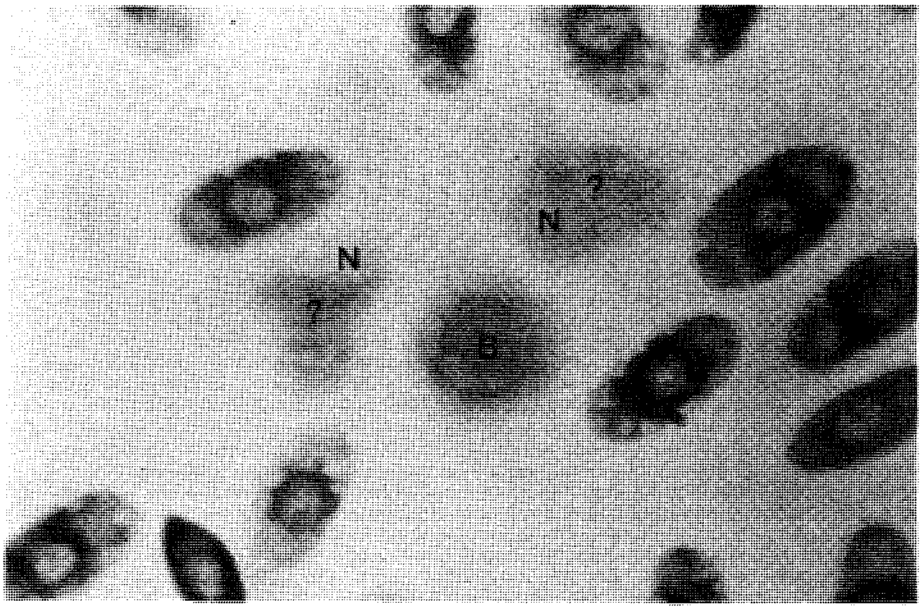

Fig. 8 Blurred basophilic cytoplasm of the basophil (B) is observed after the granules are dissolved away. The upper two cells (?) have eccentric nuclei (N) and fainted remnant of spiculate granules. Disintegrated heterophils are suspected.(Methanol fixed, Wright-Giemsa x3,600)

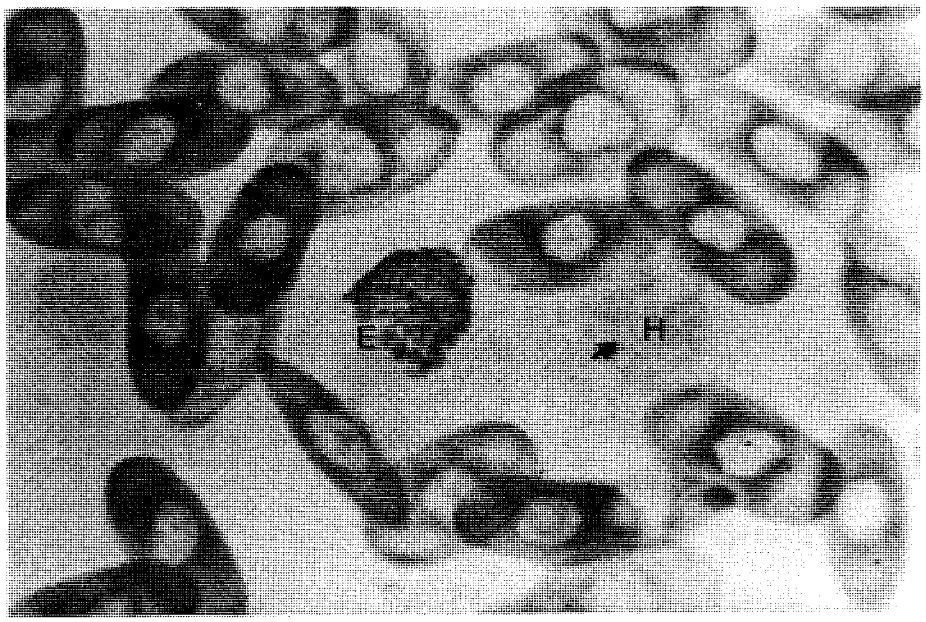

Fig.9 Some spiculate granules (arrow) remain distinct giving an impression that granules of the heterophil (H) are dissolving. Interestingly, eosinophil(E) appears intact and normal with densely packed round granules. (Methanol fixed, Wright-Giemsa x3,600)

Allozyme Variation in the Nile Crocodile *Crocodylus niloticus* from Southern Africa

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INTRODUCTION

The Nile crocodile in South Africa is under severe pressure due to increased human activity and habitat destruction (Blake and Jacobsen, 1992). This could possibly explain the fact that almost 6000 (75%) of the estimated 8000 animals in the wild are at present found in National Parks. Although the remaining animals are protected by local conservation legislation (Marais and Smith, 1991), their numbers are rapidly decreasing.

Crocodiles are also commercially bred on several farms located throughout the country, mainly in the provinces of the Transvaal, Natal and the Cape. The total number of crocodiles involved here are unknown, but is estimated to be in the thousands. Most farmers obtained their breeding stocks from other countries such as Zimbabwe, Botswana, Namibia and also Zambia, mainly because it is illegal to utilize animals from local wild populations. However, the lack of suitable broodstock and hatchlings have lately become a major problem for the crocodile industry (Smith and Marais, 1990) and most farmers now rely on captive-bred breeding stock.

Conservation authorities are understandably concerned that the present inadequate control and coordination between crocodile farmers and various authorities may lead to interbreeding and a loss of genetic variation in local Nile crocodile populations. Although the re-introduction of crocodiles into the wild is not taking place at present (Smith and Marais, 1990a), restocking of river systems did occur in the Transvaal during the 1970's. Reasons for, and possible implications of such mass releases were discussed by Loveridge (1980).

Little is known about the genetic structure (amount, distribution and pattern of allelic variation) of natural as well as domesticated populations of the Nile crocodile in South Africa. This information is of vital importance for the formulation and implementation of coordinated management strategies (Adams *et al.*, 1980).

The purposes of this study were therefor (i) to determine the genetic variation within and between natural and captive breeding populations and (ii) to compare these results with those obtained for other crocodile populations as well as for closely related crocodilian species. This information will undoubtedly contribute to our knowledge of existing genetic resources and phylogenetic relationships within the order Crocodilia.

MATERIAL AND METHODS

Nile crocodiles were sampled from a captive-bred population from Rustenburg, Transvaal (originating from Zimbabwe) and a natural population from St. Lucia Crocodile Centre (originating from the St. Lucia Estuary: 27°51'S; 28°25'S; 32°27'E).

During a routine slaughtering operation at the Rustenburg farm, tissue samples (blood, eye-fluid fat-organ, heart, kidney, liver, muscle and testis) were obtained from 100 two to three year old individuals. The samples were stored in liquid nitrogen (-196°C) and transported to the laboratory.

At the St. Lucia Crocodile Centre blood samples were obtained from 50 young adults. Samples were immediately centrifuged to separate the cellular fraction from the serum. Muscle samples were also collected from 20 individuals by performing biopsies. Crocodiles are not slaughtered at St. Lucia and it was therefor not possible to obtain any other tissues from this population. Samples were kept frozen (-20°C) until used.

Tissue samples were prepared and analyzed in the laboratory by horizontal starch-gel electrophoresis using standard electrophoretic procedures. Histochemical methods of Harris and Hopkinson (1976) were used in staining for protein activity. Interpretation of gel banding patterns was done as described by Grant (1989), and genetic nomenclature as described by Shaklee *et al.* (1990) was used. Statistical analysis of allozyme variation was executed using a biochemical systematics computer program (Swofford and Selander, 1989).

RESULTS AND DISCUSSION

A total of 51 protein coding loci were detected with 23 in all specimens and an additional 28 in those individuals from which heart, liver and kidney tissue were used. The larger number of presumed loci surveyed should provide a more accurate estimate of heterozygosity compared to studies in which fewer loci were studied (Van der Bank *et al.*, 1992).

The mean number of alleles per locus was 1,12 ($\pm$0,06) for the Rustenburg population and 1,22 ($\pm$0,05) for the St. Lucia population. Similar allelic frequencies were found in related crocodilian species.

Allozyme variation was detected at only five of the 51 protein coding loci (9,8 %). The percentage polymorphic loci were 7,84 % for the Rustenburg population and 17,39 % for the St. Lucia population. Chi-square (X^2) values for polymorphic loci showed significant ($P > 0{,}05$) deviations of alleles from expected Hardy-Weinberg proportions at three loci (MPI-1, PGD-1, PROT-1) in the Rustenburg population and at two loci (MPI-1, PGD-1) in the St. Lucia population. These deviations from the Hardy-Weinberg proportions could be the result of a sampling error, or it might reflect non-random mating during breeding and/or the consequence of using limited brooding stock which might lead to interbreeding. Genetic frequencies at one locus (MPI-2) in the Rustenburg population closely approximated Hardy-Weinberg expectations and at two loci (GPI-1, MPI-2) in the St. Lucia population. Heterozygotes at the GPI-1 and PGD-1 loci were triple-banded, as expected for dimeric enzymes, and they were double-banded for the monomeric enzymes PROT-1, MPI-1 and MPI-2.

The mean heterozygosities per locus were 0,035 and 0,042 for the Rustenburg and St. Lucia crocodile population, respectively. Heterozygosity usually ranges from 0,05 to 0,18 with proportions of polymorphic loci between 0,20 and 0,86 in most animal populations (Gartside *et al.* 1976). Particularly low heterozygosity values have also been obtained in other reptile populations (e.g. Gartside *et al.* 1976; Menzies *et al.*, 1979; Adams *et al.* 1980; Lawson *et al.*, 1989).

Low genetic variability could be attributed to various factors, such as genetic drift where population size is small (as found at St. Lucia). Fixation of loci would be inevitable where neither migration nor mutation takes place. Certain breeding practises at some farms could reduce variability which might lead to interbreeding.

Gartside *et al.* (1976) indicated that fixation of genes could be the result of long periods of environmental stability. Selection for homozygosity might have taken place and the high level of homozygosity could be advantageous if it is an approach to optimal adaptation. Due to the protected status of the Nile crocodile, it is unlikely that a reduction in numbers will take place. However, habitat destruction might cause a decrease in numbers.

CONCLUSIONS

This preliminary study of two Nile crocodile populations indicated general low genetic variability, yet revealed distinct differences between the populations. These differences imply that uncontrolled release into the wild should be avoided. The random mixing of broodstock from different populations is therefore also not advisable.

One major goal of the crocodile industry should be to find a compromise between the short-term need to achieve high-performance consistency, and the long-term need to conserve genetic variability.

To conserve the Nile crocodile, it will have to be managed as a resource and the routine implementation of genetic management programs on crocodile farms could play a major role.

(NOTE: A list of all loci assayed is available from the senior author on request).

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STATUS AND CONSERVATION OF GHARIAL IN NEPAL

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STATUS AND CONSERVATION OF GHARIAL IN NEPAL

Abstract

A field study of the gharial, Gavialis gangeticus, was conducted in the Royal Chitwan National Park and Royal Bardia National Park during 1993 to determine the status of gharial in the Narayani, Kali, Karnali, and Babai river systems of Nepal. Systematic survey conducted in December and May revealed that a minimum of 58 wild gharials and about 70 released gharials survived in the Narayani, Kali, Babai, and Karnali rivers. the sex ratio of wild gharials 1 male to 10 females, was at a critical stage. The low number of males were tributed to the heavy poaching of males in the past. The population may be sustained by releasing captive-reared gharials

Introduction

The gharial, a large crocodilian with a long,slender snout, is the only surviving member of a once well represented family, Gavialidae. The adult male gharial develops a large, cartilaginous protuberance on the end of ist snout, and in fact, the name gharial originated from the resemblance of the protuberance to a ghara or earthenware pot common in India and Nepal (Smith 1931). Mystical beliefs have been attributed to the ghara in Nepal. Local tribesmen (specially the Tharu) believed that a ghara placed under a pillow of expectant women relieved and speeded labor (Mishra and Maskey 1981). They also believed that when the ghara is made into incense and burned in their fields, crops are freed of insects and other pests.

Gharial eggs were believed to have medicinal value in parts of India and Nepal. In Nepal, the local Tharu people believed that gharial eggs had aphrodisiacal and medicinal value. For example, the dry powder of the egg is considered to be effective as a cough medicine (Maskey 1989). Because the eggs do not taste good, they were mixed with flour and prepared as bread (Bika Ram and Nathu Ram, pers. comm.). Eggs were sold for Rs. 30-40 (US $0.60-0.80) on both sides of the Nepali-Indian border.

Until the early 1960s, gharials were found in all the major river systems of Nepal, including the Mahakali, Karnali, Babai, and Rapti rivers in western Nepal, the Kali Gandaki and Narayani Rivers in central Nepal and the Koshi river in eastern Nepal (Fig. 1) By the late 1970s, there had been a drastic depletion in their abundance and distribution; in fact, the wild gharial had become extinct in the Mahakali and Rapti rivers in western Nepal and Koshi River in eastern Nepal. The gharial population in Nepal would probably be on the verge of extinction were it not for the present gharial conservation program.

Many factors contributed to the decline of the gharial population: habitat loss and disturbances, lack of strict enforcement of existing laws, entrapment in nylon gill nets introduced for fishing construction of reservoirs and dams in suitable habitat, and poaching of eggs by the local people for medicine and food. Collectively, these factors have resulted in the gharial becoming one of the rarest and most endangered crocodilians in Nepal. A high priority was given to this species by the IUCN/SSC Crocodile specialist Group during its working meetings in different countries. Gharials in Nepal are fully protected under the National Parks and Wildlife Conservation Act 1973, and are listed as "endangered species" in the IUCN Red Data Book(1975).

Study Area

The study was conducted in the Karnali and Babai rivers of Royal Bardia National park and the Narayani and Kali rivers of the central Nepal. The Narayani Nepal's third largest river, flows through a relatively low gradient and is fed principally by two major rivers, the kali and Trisuli, which originate in the Himalayan region. The Narayani River has a maximum width of a kilometer and consists of many channels and islands. It swells to a maximum level during the monsoon of June-Septemder, and carries a high sediment load. During the dry season (December-March) the river recedes to the center of the flood plain, and is fed by snow-melt water from the Himalayas. the river is flanked by open sand banks, rocks, and stands of phragmites (Phragmites Karka) and other grasses.

The Mugu Karnali River, originating in the Ladakh Himal, joins the Humla Karnali which originates in China (Tibet), giving rise to the Karnali River (Fig. 2). The Karnali, which flows for 507 km., is characterized by many gorges. One of the area that provided habited for gharials was the Chisapani Gorge, which lies in the Royal Bardia National Park in western Nepal.This habitat was severely degraded by the construction of a bridge over the Karnali River at the Chisapani gorge.

Mathods

Surveys of gharial were conducted in the Karnali and Babai rivers of Royal Bardia National Park and the Narayani and Kali river of the Royal Chitwan National Park. Surveys were conducted from dugout canoes with the help of the members of the local ethnic culture, the Bote. The main livelihood of the Bote is derived from fishing in the rivers, and consequently, they are very familiar with the habits and natural history of the gharial. During the study period, the entire lenghth of the Narayani, Kanali, and Babai rivers within the park area, and Kali River outside the park was surveyed and the estimated size, sex, and location of sighted animals were recorded. The number of gharials in the Koshi River was recorded on the basis of the Warden report.

Results

Approximately minimum of 58 wild and about 70 released gharials were extant in Nepal in 1993. The largest single population of wold gharial, consisting of minimum 39 adults, was found on the Narayani and Kali rivers. The smllest number of minimum five wild gharials were recorded from Karnali River (Tabel 1). Similarly among the released ghariais, 22 were recorded from the Narayani and Kali rivers, 36 from the Babai River, 10 from the Karnali River and two in the Koshi River (Table 2).

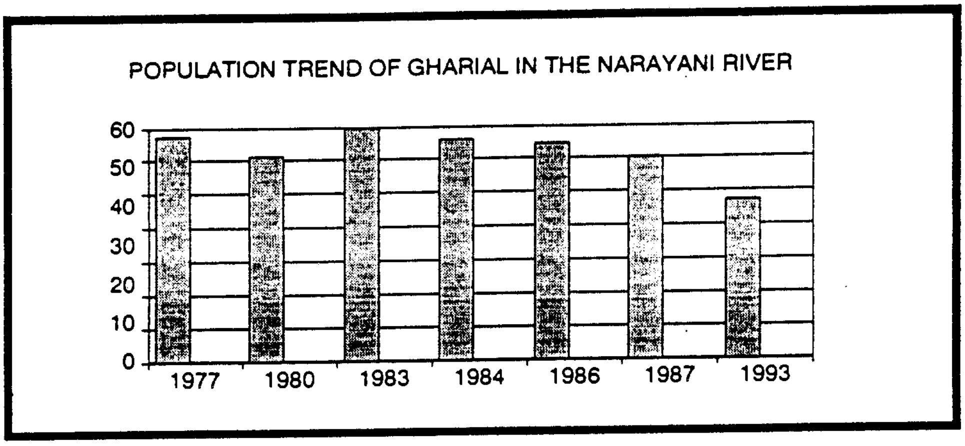
TABLE 1: Present status of Wild Gharial in Nepal

RIVER	MINIMUM NUMBER OF WILD GHARIAL SIGHTED
Babai	12
Kali	9
Karnali	5
Koshi	0
Mahakali	0
Narayani	30
Rapti (west)	2
TOTAL	58

TABLE 2: Number of relesed gharials and their survival to 1993

RIVER	NO.OF GHARLAL RELEASED	NO.OF GHARIAL SIGHTED	SURVIVAL PERCENTAGE
Narayani	273	20	7%
Koshi	84	2	2%
Babai	50	38	76%
Karnali	20	10	50%
Rapti (Chitwan)	5	3	60%
TOTAL	432	75	17%

In chitwan Shrma (1977) reported a population of 58 wild gharials in the Kali and Narayani rivers. Minimum popoulation estimates of 53, 60, 57, 56, and 51 wild gharials were calculated from 1980, 1983, 1984, 1986, and 1987 surveys, respectively, in the Narayani and Kali rivers.



Hundreds of gharials were observed on the lower Narayani River prior to the constrution of the dam on the river near the indo-Nepalese border in 1964 (pers. comm. with local people). In the early 1950s, about 235 gharials occured along the river between Narayanghat and Tribeni (Juthe Ram pers. comm.). These gharial had been extirpated by poachers and dam construction (Jung Prasad pers. comm.)

Many gharials and muggars were observed on the upper and lower Karnali River prior to the survey of Karnali dam site in 1970s (Pers. comm. Krishna Man), but at present the population of gharial in the Karnali River is highly uncertain. The local people living near Kuinae reported that earlier in 1960s, they observed as many as 20 gharials in one spot of the kachali area (Shrestha 1990). Shrestha (1990) also reported 9 muggars, 11 gharials in the various spot of Karnali River, whereas 10 gharials were detected in both 1978 and 1979 (Bhim Gurung, pers. comm.). In 1987 Krishna Man (Former Senior Warden, Royal Bardia National Park) reported the occurence of seven adult and two juvenile gharials in the Karnali River, seven in Babai River, and three (or less) in the Rapti River of western Nepal. During the field survey in the Karnali River, only 5 adult gharials all females were observed in the upper Karnali River (Chisapani Gorge area), whereas not one gharial was observed in the lower Karnali area Among the released gharials, the survival rate in the Babai River is 10 times more than in the Narayani River (7% survival in 1993) and about twice more than in the Karnali River (50% survival in 1992). The main reason of high survival rate in the Babai River is because of less disturbance by the people and less fishing activities, whereas these activities are high in the Karnali and Narayani River.

During the monsoon season, wild gharials enter tributares to avoid the increase force of waterflow in the Narayani River A maximum of five wild gharials were counted in the Rapti River of Royal Chitwan National park Three of the five young gharials that escaped from captivity into the Rapti River in 1986 were observed regularly near Dudhaura in Rapti River.

The visually observed sex ratio of the gharial in the Narayani, Karnali and Babai rivers strongly favors females, represent a problem. The highest sex ratio of the gharial 1 male to 6 females was recorded in 1984, 1 male to 9 females in 1987 and 1 male to 10 females in 1993. The low numbers of males can be attributed directly to (a) heavy poaching of the male in the past for the "ghara" and, (b) temperature effects on incubation/hatching in the hatchery, because earlier superstitious beliefs about the ghara have diminished, modern poaching may not be selective. In the future the number of male gharial might be increased by releasing more captive reared males, however, that strategy does not lessen the severity of the current situation.

Conservation Strategy

The surviival of the gharial in Nepal is threatened primirily by continuous haditat destruction that is related to increasing human pressure on the environment due to extensive agriculture, firewood collection cattle grazing, grass cutting, and heavy traffic in the river course. Since the gharial population has continued to decline, conservation measures are necessary to protect the surviving population. Fewer than 1% of all ghrials hatched in nature reach a length of 2m, a length at which they are generally secure from nature predation (Singh 1978) One breeding female may lay from 14 to 62 eggs in a clutch (Maskey 1989), but the eggs generally fall vicitm to predators, to poachers, and particularly to flooding. To protect this animal from extinction, His Majesty's Government of Nepal strongly supported by the Frankfurt Zoological Society, launched its Gharial Conservation Project in Royal Chitwan National park in March 1978. The objectives of the Chitwan rehabilitation project are to protect natural nest sites, to carefully collect and incubate will eggs, and to rear hatchlings to a length of 2m for re-stocking the major river systems in Nepal. A similar project was initiated at Royal Bardia National Park Headquarter, but later it was abandoned because of heavy flooding in the rearing facilities

The gharial conservation Project released the first lot of 50 3-year old animals in to the Narayani River on March 2, 1981; subsequent releases were made in the Narayani River in 1982, 1983, 1984, 1987 and 1989, in the Kali river in 1983, in the Koshi River in 1983 and 1986, in Rapti River in 1985 (escaped from the enclosure), in the Babai River in 1990, and 1991, and in the Karnali River in 1992.

Since 1981, the Gharial Conservation Project adopted several strategies. It included updating the status of wild and released gharials in Nepal, identifying suitable habitat for reintroduction and protection, collection of wild eggs from the Kali, and Narayani rivers. The strategy also includes incubation, and reaing at Kasara, reintroduction of captive-reared stock, and long term monitoring of the effectiveness of the reintrodution.

The Nepal Gharial Conservation project has successfully produced over two thousand gharials and reintroduced 432 into the Narayani, Kali, Koshi, Karnali and Babai rivers. Until now, budgets and extreme logistical difficulties have prevented the development of an expanded program of this project.

Recently a crocodile Project was initiated in Nepal under the auspices of the local IUCN office in collaboration with the Department of National parks and Wildlife Conservation. The main objectives of the project are:

- Creation of gharial and muggar sancturies outside the protected areas
- Continue of control hatching of wild eggs of both species
- Continue of restocking of both species in different river systems
- Initiation of a country wide surver of both gharial and muggar
- Creation of data base to centralize crocodile information

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STATUS AND CONSERVATION OF THE GHARIAL IN INDIA

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ABSTRACT

The Government of India has taken up a long-term conservation programme for three species of Indian crocodiles. Due to hunting and habitat destruction, the gharial population was reduced significantly. Its range is limited to few rivers in North India. Massive fishing activities in the rivers where gharial occur have caused mortalities of gharial. To save the species along with other crocodiles, the Govt. of India in collaboration with FAO/UNDP has developed a National conservation management plan for the gharial and its habitat. Under this plan gharial habitats have been declared as protected areas. There are 7 existing gharial sanctuaries in 5 States with a total area of about 2986 sq. Km. In addition to these special sanctuaries about 520 sq. Km. of protected area in Uttar Pradesh is also available for gharial protection. To give more protection to the gharial habitat some of the protected areas, especially the National Chambal Sanctuary has been proposed for National Park status. At present 3 gharial rehabilitation centers are under operation where 'grow and release' programs are being taken up. Three capitve breeding centers have been established where gharial is successfully breeding. Monitoring of gharial populations in different protected areas revealed that the gharial population has been recovered, particularly in the National Chambal Sanctuary where more than 64 gharials are breeding in the wild. The total population is estimated to be more than 1500 animals in the wild. Although the speceis is recovered it is not suitable for commercial exploitation as the Government laws are against wildlife exploitation in the Country.

INTRODUCTION

The gharial. *Gavialis gangeticus*, one of the three crocodilian species in India suffered from a long period of habitat degradation and to certain extent exploitation for skins (FAO, 1974). Gharial population dwindled down in many of its distributional ranges. However, due to conservation programmes taken up since 1975, population in different areas has been recovered (Singh, *et al.*, 1984; Rao, 1990). This paper deals with the historical background, conservation aspects and current status of gharial in India.

DISTRIBUTION

The gharial orginally occured in the river systems of India, Pakistan, Bangladesh, Nepal, Burma and Bhutan (Smith, 1931), According to Steel (1989) occurence of an extinct fossil species in Sumatra that is allegedly referable to Gavialis indicates that the genus probably had a much more extensive range in South-eastern Asia in geologic times than is the case today. The gharial inhabits major northern river systems particularly Ganges, Indus, Brahmaputra and also Mahanadi (FAO, 1974). It occur in Madhya Pradesh, Rajasthan, Uttar Pradesh, Bihar and Orissa. Its occurrence in the Godavari in the South India (Andhra Pradesh) was reported by Bustard and Choudhury (1982).

HISTORICAL BACKGROUND

Old records indicate that the gharial abounded in all the great rivers of Northern India (Shortt, 1921, I.A.K. 1921, Rao, 1933). According to Adam (1867), ten to twenty gharial may be frequently seen together in different rivers. Hornaday (1885) reported seeing 22 gharial in two hours on the Yamuna river.

The gharial has been illegally hunted throughout its range for hides, meat, and medicine. This "harvet", the loss of habitat from alteration and human settlement, and the use of nylon set nets for fishing may have been significant in regulating some local populations. By the end of 1960's the gharial dwindled to a trace of its former abundance (Biswas, 1970, Whitaker *et al.*, 1974). According to Whitaker and Basu (1982), during mid 1970's the largest known wild concentration was 34 animals including adult and juveniles in 5-6 km, of river at

Katerniaghat, U.P. , 50 adults and 100 smaller animals in 600 Km. of the Chambal river and 14 adults in Rapti-Narayani River in Chitawan National Park, Nepal. They reported that an estimated 100 wild gharial survived in India in 1975, which was half of the estimated world populaition.

CONSERVATION STATUS

Gavialis gangeticus, is listed on Appendix I of CITES. Under the National legislation, the species is protected through Wildlife (Protection) Act, 1972. The gharial is considered as endangered in IUCN Red Data Book.

CONSERVATION MANAGEMENT

A Nation-wide crocodile conservation project was initiated in the Country by the Govt. of India during 1975 in technical collaboration with FAO/UNDP (FAO, 1974). Under this crocodile project many corcodile habitats were identified and protected by declaring thirteen of them as crocodile sanctuaries where captive reared crocodiles are released since 1977. Wild gharial eggs are being collected for artificial hatching in different rehabilitation centres. The important captive rearing centres for gharial in India are shown in table 1.

Table No. 1. Gharial captive rearing centres in India.

Sl. No.	Centre	State
1.	Kukrail Crocodile Rehabilitation Centre, Lucknow	Uttar Pradesh
2.	Katerniaghat Centre	Uttar pradesh
3.	Deori Gharial Rearing Centre, Morena	Madhya Pradesh
4.	Gharial Research and Conservation Unit, Tikerpada	Orissa
5.	Nehru Zoological Park, Hyderabad	Andhra Pradesh
6.	Madras Crocodile Bank, Madras	Tamil Nadu.

The captive reared gharial from these centres are released in many protected rivers in North India and Mahanadi in the east and also released in

Pakisthan (Fig. 1). The number of gharial released in different rivers in India are shown in table 2. So far a total of 3342 captive reared gharial have been released in these rivers.

Table No. 2. Year wise gharial releases in Indian rivers.
(Source : M.P. and U.P. Forest Departments)

Year	River	State	No. of Gharials
1979-93	Chambal	M.P./Raj./U.P.	1718
1985-93	Son	M.P./U.P.	106
1986	Rapti	U.P.	10
1979-94	Girwa	U.P.	172
1986-92	Ghaghra	U.P.	45
1982-94	Ramganga	U.P.	257
1986-92	Sharada	U.P.	105
1985-93	Ken	M.P.	35
1977-89	Mahanadi	Orissa	609
1990-93	Betwa	U.P.	55
1990-91	Dudhwa	U.P.	5
1990-93	Ganga	U.P.	225

The protected areas where gharial receives active protection are given in table 3 (Fig. 2).

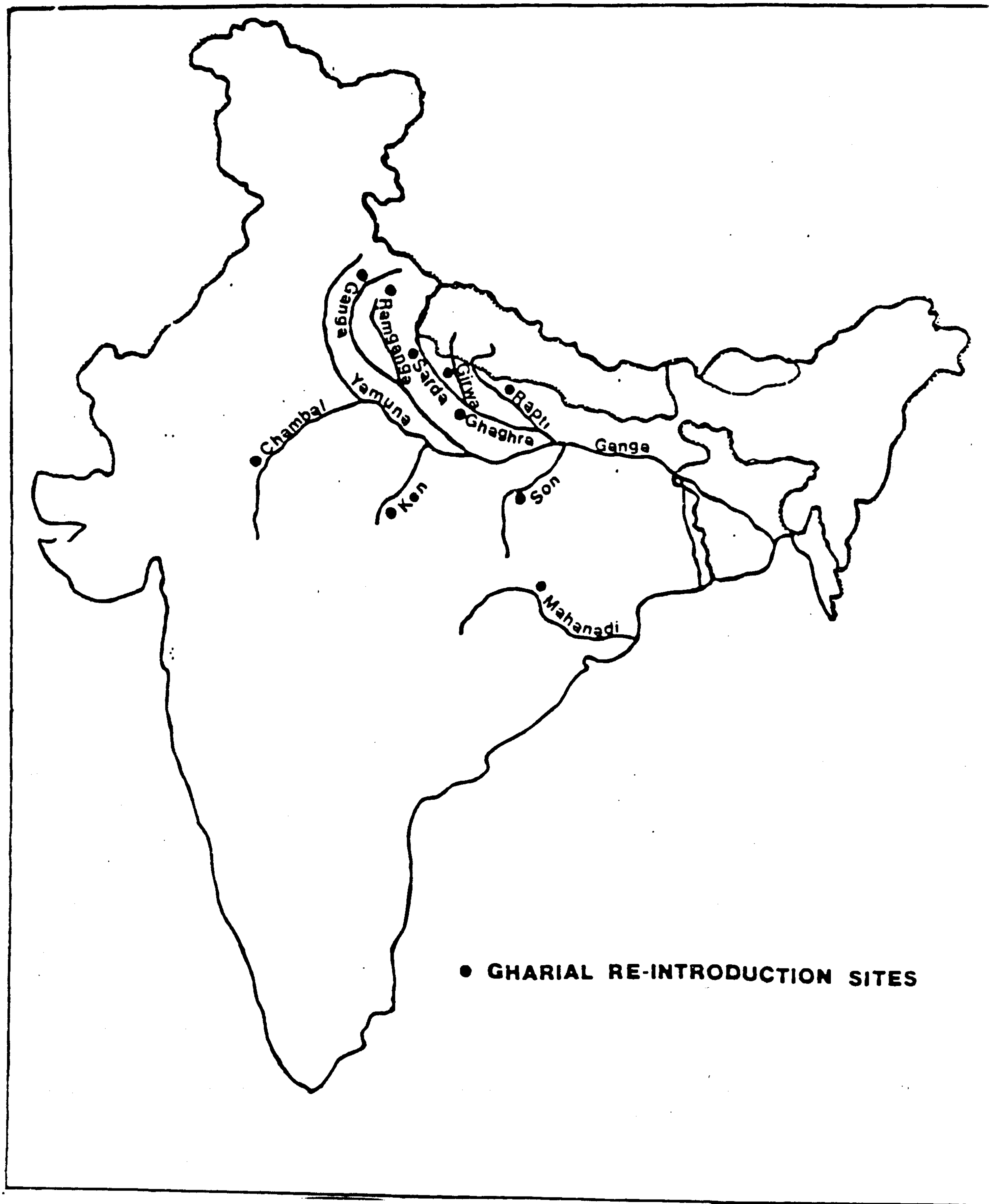

Fig.1 Gharial re-introduction sites in different rivers in India

Table No. 3. List of protected areas for gharial protection.

Sl. No.	Protected Areas	River	State
1.	National Chambal Sanctuary	Chambal	M.P./U.P./Raj.
2.	Jawahar Sagar Sanctuary	Chambal	Rajasthan
3.	Katernia ghat Sanctuary	Girwa	U.P.
4.	Ken Gharial sanctuary	Ken	M.P.
5.	Son Gharial sanctuary	Son	M.P.
6.	Satkoshia Gorge Sanctuary	Mahanadi	Orissa
7.	Papikonda Sanctuary	Godavari	A.P.
Other Protected Areas			
8.	Corbett National Park	Ramganga	U.P.
9.	Dudhwa National Park		U.P.

PRESENT STATUS

Population estimates and counts have been made sporadically by various investigators. Among the 34 protected areas in India where all three crocodilian species are protected (Singh. *et al.*, 1984) gharial receives protection in 9 (3%) areas. In a total of 13 crocodile sanctuaries in India 7(54%) sanctuaries with an area of 2986 Sq. Km. are specially created for the protection of gharial. In U.P. an area of 520 sq. Km. of Corbett National Park is offering protected area for gharial in the Ramganga River. Successful captive breeding of gharial has been reported for the first time from Nandankan Biological Park, Orissa (1981) followed by Kukrail Crocodile Rehabilitation Centre, U.P. (1989) and Madras Crocodile Bank, Tamil Nadu (1989) (Fig. 2).

The monitoring studies conducted in different parts of the Country revealed that the numbers and distribution of gharial have changed markedly over the last 15 years. Presently, the important rivers where large number of gharial can be seen are Chambal, Ramganga and Girwa. According to Singh *et al* (1984) the gharial population in the Country, before releasing any animal, was 230 including 72+ adults and by 1984 the population has been increased to 2518 including wild, released and captive animals. The status surveys conducted in different rivers indicated that the gharial population have recovered due to conservation

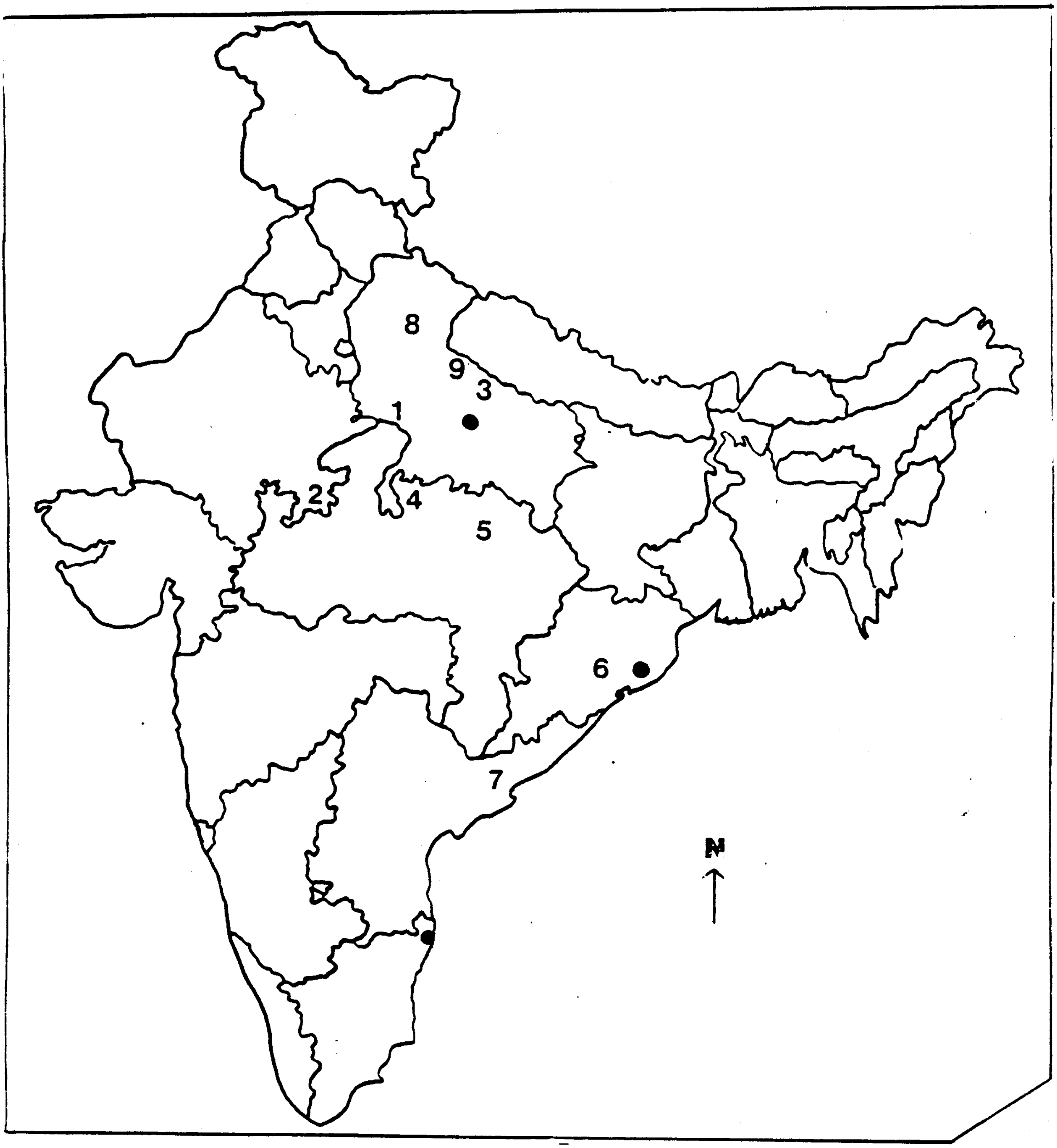

Fig.2 Gharial protected areas and captive breeding centres in India. See text and table 3 for area names.

managment programmes. But Mahanadi river requires a fresh effort for management (Singh, 1991).

Out of 609 gharials released in Mahanadi only about 25 including 10 in the Satkoshia Gorge, are seen today (Sharma, S.S. in the Samaja, Cuttak, Orissa, 26.11.91). Similarly, in both Ken and Son rivers less number of gharial are seen than released. Intensive population surveys and studies were continued in the Chambal river. Population monitoring was also continued in the Katerniaghat Sanctuary by the Uttar Pradesh Forest Department. These studies indicated that more than 1100 gharial are present in the Chambal river and over 50 individuals in Girwa river. No data is available on population figures in other rivers, as systematic census has not been carried out. Out of all rivers inhabited by Gharial maximum number of gharial are found in the Chambal river. The total population in India is estimated to be more than 1500 animals in the wild. The census figures from the Chambal river are shown in Table 4.

Table No. 4. Census of estimated population of gharial and No. of nests in the Chambal river.

Year	No. of Animals (all sizes)	No. of Nests	No. of Nesting Sites
1978	107	12	6
1984	451	28	?
1985	605	33	7
1986	628	37	10
1987	-	45	12
1988	804	50	15
1989	-	57	15
1990	982	-	-
1991	-	60	15
1992	-	-	-
1993	-	64	15
1994	1100+	64+(?)	15(?)

Gharial were seen in large groups (more than 20) in different areas in the Chambal river (Singh, 1985). The nesting population was also greatly increased in the Chambal river. According to Rao (1988) 12 nests were located during 1978. Every year the figure have increased and during the 1993 nesting period around 64 nests were located from the Chambal river (Table 4). The breeding records in the Chambal river revealed that number of nests and nesting sites in early 1990's have greatly increased over the figures in late 1970's. Although number of nests increased in 5 years period from 50 in 1988 to 64 in 1993 the nesting sites have not been increased (Fig. 3). This shows that there is a saturation of suitable nesting sites for the increased breeding population in the Sanctuary. Gharials were also successfully breeding in Girwa and Ramganga Rivers (Basu, 1991).

These results show that the crocodile conservation programme in India is a great success. The gharial population are increasing, particularly in the Chambal river, due to release of captive reared animals, highly protected habitat with security against possible dangers (Rao, 1990).

CURRENT PROBLEMS:

a. Rehabilitation of gharial

The problem identified in India for gharial conservation is that the cost for operation of rehabilitation centres is very high. There are not sufficient protected areas identified for releasing of captive reared animals. All rehabilitation centres have reduced their activities by collecting very few eggs from wild. At present emphasis is only given to protect the wild animals, there by reducing the expenditure for captive rearing programme.

b. Human-gharial Conflict

There is an increase of human population in the bank-side villages along most of the gharial inhabited rivers which resulted a conflict between crocodiles and people. The impact of human activities like agriculture, sand mining and fishing on gharial population and its habitat is very high. With the increase of human encrochment in the gharial habitat, there is a loss of suitable habitat which made the gharial to live in few isolated small stretches of the rivers.

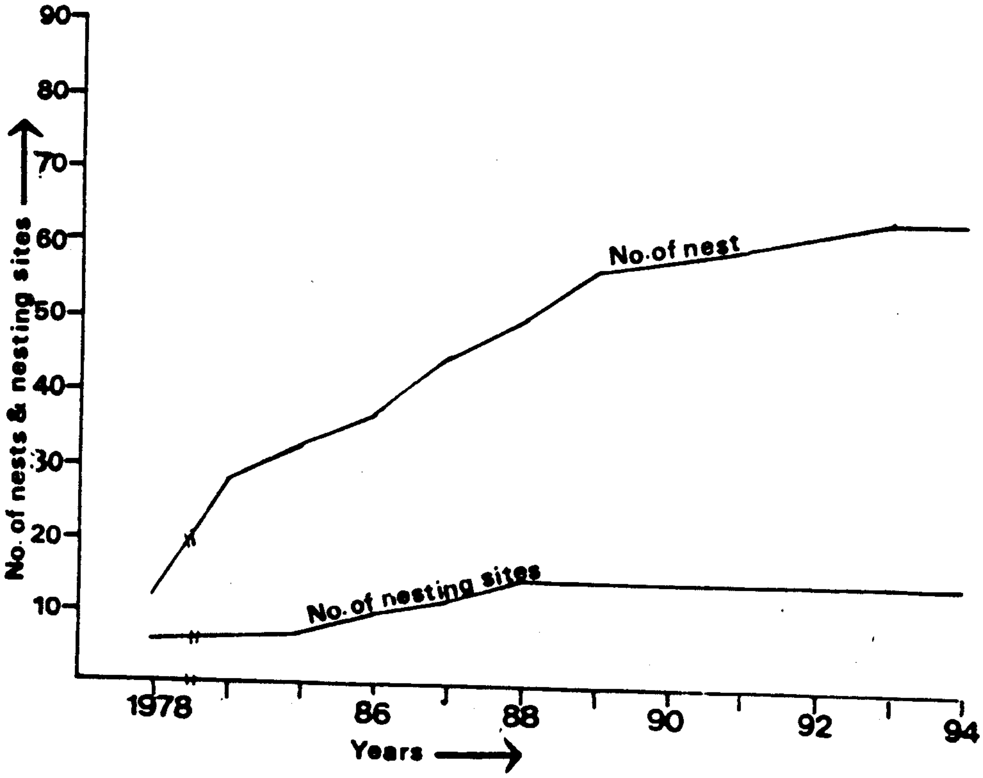

Fig.3 Number of nests in different nesting sites along Chambal river during 1978-1994

FUTURE GHARIAL MANAGEMENT

The continued survival of gharial in different rivers will depend increasingly on the Govt.'s capacity to manage population in the protected areas. The protected areas like National Chambal Sanctuary and Katerniaghat Sanctuary should be considered as core areas and other gharial sanctuaries act as buffer for introduction of the species. The Chambal river has the capacity to produce more than two thousand hatchlings every year. but post-monsoon survival of the young ones is estimated to be 6% only. It is necessary to control this high loss by collecting maximum number of eggs, hatch them in captivity and release them after monsoon to assist mortality in monsoon floods. It is very essential for protection of key breeding sites in the most productive gharial habitats.

The decline and/or non-survival of gharial population in the Mahanadi needs to manage human-crocodile interface with sensitivity. It is a challenging proposition to manage community attitudes towards gharial conservation. The locals will support proposals for crocodile conservation only after fulfilling their demands.

SUSTAINABLE USE

Conservation through sustainable use has proven to be very sucessful for a number of crocodilian species, when carried out under carefully planned and rigorously controlled management programmes (Messel & King, 1992). Instead of harvest of commercial sized animals directly from the wild, use of captive reared crocodilian product from wild laid eggs, which have high mortality rate, is recommended. This practice of ranching is economically feasible for sustainable use projects for crocodilians (Messel & King, 1992). Since gharial breeds in large semi-natural enclosures, cost for captive breeding for commercial exploitation is very high. It is much cheaper to collect the wild laid eggs, incubate in controlled temperatures and use the young ones after releasing some percentage of animals in the wild.

The nesting population in the National Chambal Sanctuary is around 64. Considering the clutch size as 38.4 (Rao, 1988) and hatching success at gharial rehabilitation centre as 87% the annual production of gharial in captivity will be around 2000 if we collect and incubate all wild laid eggs. Rearing success upto sub adult stage at different centres is more than 50%. If this figure is also taken in consideration then 1000 gharial (Sub-adult stage) per year can be raised every year. In future if Govt. laws have some relaxation, then gharial ranching can be initiated for sustainable use of the resource.

TOURISM

Eco-tourism in crocodile sanctuaries is identified as a tool for public support for the conservation programmes of gharial. At present tourists visitation is only restricted to tiger areas in India. Tourist developments have to be initated in the crocodile sanctuaries without disturbing the animals and their habitats to attract more tourists whose participation will help in the crocodile management.

CONCLUSION

The available information on crocodile population in India indicate that population of gharial has increased in some habitats where they were formerely very low in number. In India large number of captive gharial are yet to be released. It is suggested to conduct surveys in the Brahmaputra river system to identify suitable areas to release the captive gharial. There is a need for monitoring gharial populations in the country and to extend the programmes to the neighbouring countries like Bangladesh, Nepal and Pakistan to bring the population to its former distributional range in the Indian sub-continent.

Although gharial are protected in India, growing human interests are a constant threat. There is a need to educate people on the biological and commercial value of gharial to get proper support for gharial conservation.

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The Tomistoma *Tomistoma schlegelii* in Southeast Asia, a Status Review and Priorities for its Conservation

by

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INTRODUCTION

The Tomistoma or False Gharial *Tomistoma schlegelii* is one of the least known and most endangered crocodilians in South-east Asia. Placed in a genus of its own, the Tomistoma was formerly thought to be more closely related to the true crocodiles rather than the Indian Gharial *Gavialis gangeticus* (Tarsitano et al. 1989). Recent evidence, however, seems to suggest closer ties to this ancient *Gavialis* genus, Family Gavialidae (Densmore & Owen 1989).

Gharials are primitive reptiles, dating back to the Eocene of Africa and Asia. They have poorly developed limbs making them less mobile on land than most other crocodilians. They are easily distinguished from true crocodiles by their long slender snouts. Adult male Gharials develop a bulbous growth at the end of the snout. Adult male Tomistomas do not develop the bulbous nose and are distinctly marked with dark bands on the tail and snout. They can attain lengths of over five meters and their modified jaw structure suggests an adaptation for feeding primarily on fish. Juveniles are bright yellow with oblique dark bands on the sides of the body and tail.

The Tomistoma is an elusive reptile, occurring in slow-flowing waters along the upper reaches of small rivers, peat and freshwater swamps and lakes. These areas are often overgrown with aquatic and riverine vegetation, usually species such as *Pandanus*, *Baringtonia* and *Hanguana*. This species is thought to naturally occur in low densities and therefore can often be inadvertently overlooked in survey records of an area.

The Tomistoma is a mould nester and requires extensive areas of undisturbed riverine habitat to breed. The extensive conversion of wetlands to agriculture and urban development in recent years has resulted in a huge loss of this habitat. The subsequent fragmentation of suitable habitat and the isolation of populations have also resulted in a reduction in breeding success and a loss of their long term viability.

Tomistoma have been in captivity at crocodile farms throughout the region and have recently been the focus of attention as stock for reintroduction programmes and also as genetic pools. However, all attempts to breed Tomistomas in captivity have been unsuccessful to date. It is increasingly clear that more information on the nesting habits in the wild is necessary to be able to breed this species successfully in captivity.

The large numbers of captive Tomistoma in these farms, presently of value only as exhibits, could form the base for reintroduction programmes. However, a possible restriction on this is that information on collection localities are usually absent, creating potential problems.

Known to range from south-eastern China, west to Burma and throughout southeast Asia and Indonesia, this species has now been confirmed only in Malaysia, and Indonesia (Sumatra, Kalimantan). The Tomistoma is probably extinct in Thailand. The species may also occur in Sulawesi and Vietnam. This restricted range is emphasized further by the limited availability of suitable habitat.

STATUS OF WILD POPULATIONS

The Tomistoma today occurs in the wild in only two countries; Malaysia and Indonesia. Confirmed populations are known only from Malaysia and Indonesia with the Thai population possibly extirpated over the last decade. The countries of the region are dealt with separately below, describing the status of Tomistoma as known from existing literature. Appendix One presents the records of Tomistoma in the region from the wild while Appendix Two indicates, based on sightings and records, potential concentrations (hotspots) of Tomistoma populations throughout its present range.

Thailand

No recent information exists on the status of populations in the wild. Last records of Tomistoma were in the 70s from southern Thailand (Taylor, 1970) and the species may have already gone extinct. The species exists in captivity at Samutprakarn Crocodile Farm but claims of successful breeding are doubtful. Bain and Humphrey (1980) state that if surviving, the Thai population probably numbers fewer than 20 individuals. Fourteen years later, there have still been no records.

Malaysia

No recent information exists on the status of this species in West Malaysia. Known to occur in the Pahang River basin, Tasek Bera in Pahang and the North Selangor Peat Swamp Forest, no recent surveys have been conducted to confirm the presence of this species. There have been recent unconfirmed records of a crocodilian fitting the description of a Tomistoma from the North Selangor Peat Swamp Forest. A Tomistoma was caught here in the late 70s close to the Bernam river (Marsh, 1982). The Setiu River basin in Trengganu, also provides an ideal habitat for crocodiles and regular Crocodile Safaris are conducted for tourists. The identity of the crocodilian here is unknown. Although *C. porosus* is more likely along the lower reaches, the possibility of Tomistoma occurring in the dense riverine and swamp forests along the upper reaches is high.

In 1983, a survey done in Sarawak (East Malaysia, Borneo) recorded Tomistoma in almost all the inland river systems and freshwater swamps (Whitaker, 1984). A subsequent survey in 1985 in Sarawak recorded the Tomistoma only once; two adults and one juvenile in the Upper Ensengai Baki River in western Sarawak (Cox & Gombek, 1985). The most recent records from Sarawak National Parks and Wildlife Office (NPWO) are from an animal confiscated in late 1992 from Simunjan, First Division (Gombek, pers comm). This animal is presently housed at the Semmenggok Rehabilitation Centre outside Kuching. Interestingly, Sg. Simunjan (where this animal was most likely caught) flows into the Sg. Sadong, as does Sg. Ensengai, where the 1985 sighting was recorded. This suggests the Sg. Sadong basin may support a population of Tomistoma, possibly a viable one.

Another record is of an animal described as Tomistoma which was observed basking on a mudbank of Sg. Maludam in the Third Division in 1993 (Ramli Ahmad, pers comm). That this animal was seen in the same location on two separate days appears to fit more with *C. porosus*, for two reasons; the animal has a particular basking spot and the habitat was mangrove and Nipa swamp. The most recent record is that of a 20 inch Tomistoma bought by Johnson Jong in December 1993, from a fisherman in Serian, apparently caught in a fishing net (Johnson Jong, pers comm). This animal was very likely from Sg. Ensengai although the fisherman was reluctant to confirm this.

In April 1994, a survey in the ninth Division of Bintulu heard from natives (Punans) that both species of crocodiles were common along the Kakus and Mayeng rivers, up-stream tributaries of the Sg. Tatau (Elizabeth Bennett, pers. comm). Descriptions fit *T. schlegelii* and *C. porosus*. This is an interesting isolated wetland separated from the huge Third Division Peat Swamp Forest by a high range of mountains. The habitat is, however, degraded freshwater swampforest and fishing activity is intense and includes electro-fishing and *Tuba* poisoning.

Further surveys are required in Sarawak to determine the current status of this species. The greatest number of Tomistoma in captivity is at Johnson Jong's Crocodile Farm, Kuching. There are twenty-nine juveniles and ten adults in his farm but all attempts to breed have been unsuccessful.

The species has never been recorded in Sabah, north-east Borneo (Whitaker & Whitaker, 1989) and is probably excluded from this corner of Borneo due to geographic topography.

Indonesia

Evidently the last stronghold of this species, the Indonesian populations of Tomistoma occur only on the islands of Sumatra and Borneo (Kalimantan). There is little evidence to indicate that the Tomistoma used to occur anywhere else in the archipelago. A report from Sulawesi (reported from the Marisa river, north Sulawesi) has not been investigated to date (IUCN, 1992). If confirmed, this would be the furthest east its range extends.

The most recent surveys conducted in Indonesia were in 1990 by FAO-PHPA in Sumatra and Kalimantan. The Sumatran populations appear to be restricted to the extensive swamp habitat on the eastern and south-eastern part of the island. The northern most records come from Buaya Bukit Batu, the lakes and swampforests along the Siak river (Giam-Siak Kecil, where the species has been confirmed in 1992) and Pulau Padang (where a lake, Danau Tanjung Padang, supports populations), all within the Riau province. The nearby wetlands of Danau Belat, Besar Sekak, Sarang Burung, Danau Bawah and Pulau Besar also support Tomistoma but these areas have not been surveyed since 1982.

A second concentration comes from the southern region where the Strict Nature Reserve of Kerumutan Baru has been recently confirmed to support Tomistoma (Martin Keith, 1992 unpublished data). Pulau Bakung, a mangrove island with a lake and some swampforest has also been found to have Tomistoma in 1990. The Berbak National Park, Indonesia's first Ramsar Site, has been known to support populations since 1981 and can be considered for a base for ecological studies on this species. Nearby Sg. Lalan and the Ogan-Komering Lebaks in the south are other confirmed sites, including Way Kambas National Park in the extreme south of the island.

In Kalimantan, the National Parks of Kutai (in the northeast), Tanjung Puting (in the extreme south) and Gunung Palung (in the west) all support significant populations. The Tanjung Puting National Park also provides the base for ecological research. The Danau Sentarum Wildlife Reserve, an extensive inland floodplain 700km upstream of the Kapuas river also supports Tomistoma, as does the Kahayan Production Forest and the lake of Muara Along. Frazier and Martubongs (1990) provides a complete listing for Kalimantan.

Singapore

Historically, there have never been records of Tomistoma in the wild on this island. This is perhaps not surprising due to the small size of the island and the absence of any area of swampforest of significant size. Tomistoma are kept in captivity in farms and as collections and the Singapore Zoological Gardens have had eleven adults for many years. A lack of suitable holding areas have prevented any attempts to nest though gravid females releasing eggs into the water have been observed for many years.

Brunei Darussalam

There have been no records of Tomistoma here to date. However, due to its close proximity to the Baram River basin which has historically been prime crocodilian habitat, it is likely that this species may occur in some areas of suitable habitat. The lake of Tasek Merimbun with its surrounding swamp forests is a possible site to direct investigatations.

Vietnam

In 1992, an Asian Wetland Bureau (AWB) scientist on a visit to a crocodile farm in the town of Ca Mau, Minh Hai Province, South Vietnam noticed five young crocodiles in a concrete enclosure, all with very thin, long snouts. The descriptions fit closely with those of Tomistoma. The scientist was informed by the park officials that with the exception of the *C. rhombifer* (gifts to the Govt. of Vietnam), all other crocodiles there were caught from the surrounding areas. Subsequent attempts to communicate with the park authorities came up with photographs of various animals at the farm (*C. siamensis*, *C. porosus* & *C. rhombifer*) but none of these five young animals.

If these were indeed wild-caught Tomistoma, this would be a significant extension to the existing known range of this species. Tomistoma used to occur in Indochina in the past.

STATUS OF ITS PROTECTION

Appendix Three provides a listing of the records of the species in the wild throughout Southeast Asia. It must be noted that some of the sites listed encompass larger areas within which more than one sighting/record/report of wild Tomistoma exist. As seen from the table, a total of nine sites are presently not under any known legislative protection (Production Forest is not considered a designation which provides any form of protection to wildlife within). This would encouragingly indicate that 65% of wetland sites where Tomistoma have been recorded are under some form of protection. This tends to differ from the true picture.

Most of the known threats (and those yet unknown) to Tomistoma continue to affect populations even within protected areas. Even the threat of habitat loss is only slightly dampened by these protective legislations. It is therefore clear that while protection is essential, much more is required in terms of enforcement and implementation of on-the-ground management practices. The glaring fact then rises that although general basic concepts apply, little is known regarding how to manage a wetland for the conservation of this species.

THE NEED FOR CONSERVATION

Of the seven species of crocodilians identified as deserving the highest priority in the CSG Action Plan, five are Asian. With substantial progress made in initiating conservation of the Gharial *Gavialis gangeticus*, the Chinese Alligator *Alligator sinensis* and the Philippine Crocodile *Crocodylus mindorensis*, two species remain unaddressed, the Siamese Crocodile *Crocodylus siamensis* and the Tomistoma. This species is now becoming an urgent priority (CSG Steering Committee, 1992). The Tomistoma is listed as Endangered in the IUCN Red List 1990 and is an Appendix I species under CITES.

Natural wild populations are thought to have been reduced to dangerously low levels, mainly due to habitat loss. Restricted to slow-flowing rivers with dense riverine and floating vegetation, freshwater and peat swamp forests and lakes, the natural habitat of the Tomistoma is undergoing conversion at an increasingly rapid rate. It is crucial to locate viable populations of Tomistomas now, so as to be able to justify and acquire legal protection for their habitats.

The fragility of freshwater wetlands used by this species requires the protection and management of entire ecosystems and not representative parts of the habitat. The effort and cost required to maintain an area as a sanctuary for Tomistoma is likely to be higher the smaller the area is. It is therefore important to identify suitable areas of sufficient size to be gazetted as sanctuaries for Tomistoma.

In the event that no viable populations are located in Thailand or West Malaysia, the option of captive breeding centres with the purpose of scientific studies and reintroduction programmes must be examined.

Surveys should be conducted in West Malaysia, especially in the Pahang River basin, concentrating on the freshwater lake systems of Tasek Bera, Tasek Chini and Ulu Lepar, to establish the presence of this species and identify potential habitats.

Indonesia still retains vast areas of peat and freshwater swampforests in Sumatra and Kalimantan. The presence of Tomistoma within protected areas has recently been confirmed. These are probably the only areas supporting such populations of the Tomistoma in the world and present good opportunities for detailed ecological studies of the species in the wild.

The urgency for the design of proposals and the allocation of funds for the conservation of this species cannot be emphasized. Efforts should be made now to save this ancient reptile from extinction.

THREATS TO WILD POPULATIONS

Crocodilian populations in general, and the Tomistoma in particular, are threatened globally by a series of factors. All these threats have one thing in common, the devastating influence of the rapidly growing human population and its increasing demand on land and its resources. Discussed below are the most serious threats to Tomistoma populations throughout its natural range.

1. Habitat Loss

Whenever species specifically adapted and dependent on wetlands are discussed in terms of threats to their survival, the loss of habitat invariably takes the foremost position. Both coastal and freshwater wetlands throughout the region have been decimated at an alarming rate over the past two decades. This conversion of riparian habitat through flood mitigation schemes, channelling of rivers for irrigation and the damming of rivers for water supply and power generation has been by far the most influencing factor on the decline of freshwater aquatic species, in particular the larger and more conspicious species.

A further consequence of the loss of habitat for Tomistoma is the fragmentation of remaining habitats and the resulting isolation of populations. The small pockets of riparian vegetation left relatively intact are more often than not insufficient to support a population of large reptiles, thus forcing these animals to wander off in search of a better refuge or to die. This displacement is becoming more apparent in recent years, supported by the increasing number of sightings of Tomistoma in irrigation ditches, canals and flood by-passes where the virtual absence of riparian vegetation could not possibly support viable populations of these reptiles.

This loss of habitat also translates into a lack of suitable sites to nest. This has serious repercussions on the ability of the population to reproduce and hence sustain itself in the long term.

2. Depletion of Food Supply

This factor is often overlooked or not given due attention. Fish have constituted a major source of protein and income to the rural people of the region. Today, it is evident among local communities living along the rivers and lakes of Southeast Asia that fish catches have declined and continue to decline every year. The reason for this is the ever increasing populations dependent on this wetland resource.

The result of this decline is the intensification of effort into fishing. "Improved" fishing techniques and equipment begin to weigh a heavy toll on the fisheries of these wetlands and, in some areas, result in fish populations being depleted, to the extent that the prey base for large fish-eating species such as crocodiles and otters have reached non-sustainable levels. This leads to either the death or emigration. The effect is emphasised in the more specialist species, i.e. those which are dependent on particular species for food or, in the case of Tomistoma, sufficient fish of a certain minimum size.

Another destructive form of fishing is the use of poisons. Traditional use of root-poisons still continue in many areas but this form of fishing has been expanded to include the indiscriminate use of chemical poisons such as rotenone. These pesticides completely wipe out aquatic life along stretches of rivers and streams when used. Their use in first-order streams leave little chance of recolonisation of fish populations and restocking from migratory movements are seasonal, thus leaving these streams "empty" for long periods of time. Crocodiles inhabiting these rivers die out or move upstream/downstream in search of food.

3. Hunting for Skins and Trade

Crocodile skin does not have the same value it used to command in past years. Strict protection laws have ensured the virtual eradication of this market. Occasional hunting continues, especially in Kalimantan Borneo but skin sought is mainly that of *C. porosus* as Tomistoma skin has little commercial value.

Capture of live animals, usually young, is done on an opportunistic basis. These animals go mostly to farms which today, are increasingly reluctant to buy Tomistomas. Other than being of value as exhibits, they present a drain on resources.

4. Incidental Capture of Young

In areas where the wetland dependent human population is high, crocodiles suffer from getting caught in fishing nets. Larger animals are known to destroy the nets and anger fishermen, while younger animals are caught and either killed or sold. In some areas where fishing activity is intense, the regular removal of young from the population can compromise the ability of the population to sustain itself.

PRIORITIES FOR CONSERVATION

In view of the known threats to Tomistoma populations throughout its range, attention must be directed towards ensuring this species continues to exist in the wild. There have been well-documented cases of man's efforts to bring back species on the brink of extinction by artificially breeding them in captivity. It is recognised today that the Tomistoma may be headed towards extinction in the near future, maybe sooner if current influencing factors continue to operate unabated. If this were to happen, captive breeding may become a missed opportunity especially because there has been no success in getting this species to breed in captivity so far. This stems mainly from the fact that the natural breeding ecology and biology of the Tomistoma remains a mystery to science.

The concept of preserving areas solely for certain species of wildlife is a dying one. There are few important protected areas which do not have human populations intrinsically dependent on the ecosystem for their survival. In fact, ethnic tribes today can be regarded as being an indivisible part of that ecosystem. The approach therefore must be an integrated one, combining the sustainable utilisation of the earth's resources with the conservation of all life-forms, while attempting to include representatives of as many of the diverse environments and species as possible. The presence and dependence (on the areas) of local communities in the process of the management of reserves, parks, sanctuaries and wildlife cannot be ignored any longer.

In the case of the Tomistoma, many are of the belief that because the major cause of its decline has been the loss of habitat, preserving suitable habitat within protected areas should be sufficient to ensure the species' survival. This may not necessarily be true as other factors which threaten Tomistoma populations could continue to operate even within protected areas. The depletion of food resources, for example, is difficult to resolve if the management of the fisheries cannot be effected.

The fact remains that there are too many gaps and guesses where Tomistoma is concerned. The case here is not only to immediately protect but to protect and learn as well. Management can only be effective if scientific information moulds the process. In order to focus conservation efforts towards the most important and urgent requirements for this species, a listing of the highest priorities for the conservation of the Tomistoma is provided below.

1. Location of Viable Populations throughout its Range and the Design of Survey Techniques

While the past two years have contributed greatly to our present knowledge of the range and distribution of the Tomistoma, much more information is required. Kalimantan Borneo and Sumatra in Indonesia have been covered superficially between 1990 and 1992, while Malaysian Borneo and the peninsula have not been investigated since 1985. There have been no surveys for Tomistoma in Thailand in recent years and even if carried out, may prove to be an exercise in futility. No attempts have been made to investigate reports of Tomistoma from Sulawesi (Indonesia) in 1982 and Ca Mau (Vietnam) in 1993.

Comprehensive surveys involving the accurate assessment of habitats is an essential step towards understanding this species. It must be emphasised that without combining habitat assessment with actual animal counts, the data is not particularly useful. It is the relation of habitat and population density which is significant in terms of the conservation and management of the species.

Although much can be said about the accuracy of present survey techniques, no field-tested alternative exists. Perhaps a different methodology specifically to survey for Tomistoma can be designed. While an ecological study of Tomistoma would undoubtedly provide clues for a superior survey technique, a viable population must first be located (using standard techniques) in order to conduct this investigation.

Factors which influence the accuracy of standard surveys include time of day, weather conditions, tidal influence, water levels, river traffic volume, hunting intensity, availability of prey, riparian vegetation and suitable natural cover. A single survey on a river therefore, yields to a great number of variable parameters. More useful data can be obtained by surveying each site (or river stretch) regularly over an extended period.

It therefore remains that comprehensive field surveys to assess and locate populations in the wild in Peninsular and East Malaysia, Kalimantan Borneo and Sumatra in Indonesia are the highest priority. Investigative surveys should also be conducted in Sulawesi, southern Thailand and southern Vietnam.

2. The Ecology and Biology of the Tomistoma

In order for us to conserve this species, we must understand its ecology. A long term study must be conducted on an identified viable wild population. Ideally, this population should exist within a protected area. The study should address the following:

- Habitat requirements and preferences of the Tomistoma in the wild.
- Dietary requirements and preferences of the Tomistoma.
- Breeding ecology of the Tomistoma, especially nest-site requirements and preferences.
- Ranging behaviour of the species in the wild.

Identified protected areas in Indonesia with on-site research facilities include Berbak National Park (Sumatra), Siak Kecil Hunting Reserve (Sumatra), Danau Sentarum Wildlife Reserve (Borneo) and Tanjung Puting National Park (Borneo).

3. The Gazetting of New-found Areas with Viable Populations for Legislative Protection

Sites where Tomistoma are recorded must be re-surveyed more comprehensively to determine the size of the population. If the population is viable and the area is of sufficient habitat to support such a population, then immediate steps must be taken through the relevant government agencies and departments to afford the site legislative protection.

Justification for recommendations made regarding affording protection for new areas can be easily argued in the case of Tomistoma. The species is totally protected in all the countries it is likely to occur today. Furthermore, its endangered status (Red Data Book listing), demands appropriate attention to its protection, in particular, its habitat.

4. Effective Management of Protected Areas for the Species

In the short term, steps must be taken to ensure that existing Tomistoma populations occurring within protected areas have the necessary conditions to maintain their viability. A population within a protected area is not necessarily protected from all threats. These reserves require careful management such as:

- No clearing of riparian zones throughout the reserve. This will ensure sufficient shelter and potential nesting sites for the animals.
- Along stretches of rivers where dense rooted/floating vegetation obstructs navigation, removal to maintain a navigable channel should be supervised to prevent unnecessary clearance or damage to the habitat.
- Regulation of the fishing regimes and operations to prevent over-fishing and loss of fry-stock. Poison fishing should be banned.

- Awareness campaigns among local communities regarding the species. Accidentally caught animals (in nets) should either be released or handed over to the authorities (such specimens are useful for tagging or radio-telemetry experiments)

5. Control over Fishing Regimes (in non-protected areas) to Ensure Sustainable Prey-Base

Government agencies concerned with the regulation of fishing laws and operations within the countries should be urged to table and enforce laws regarding non-sustainable fishing practices, particularly with regards to freshwater fisheries. Some suggestions are;

- Ban all use of poisons for fishing.

- Limit the mesh-size of gill nets which can be legally used.

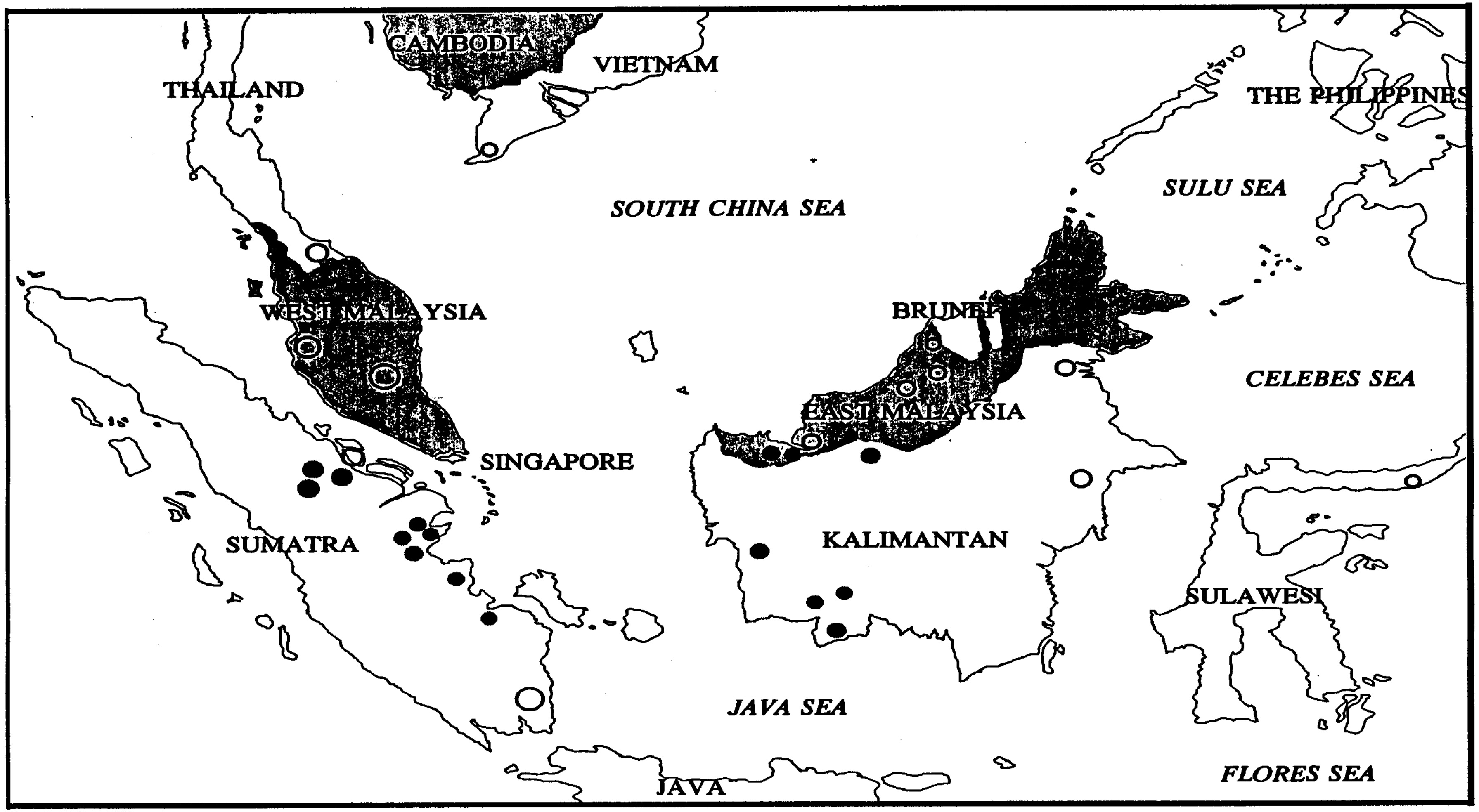
- Enforce guidelines regading the use of "Jermals", which dam a river completely and catch everything that comes down with the current.

6. Availability of Funds

The management of wetlands which acts as a foundation to their wise use is constrained by the lack of funds. However, it must be remembered that increases in funding alone will not solve the problems. Action is required at a number of levels and many of these processes do not rely on increases in funding. Government budget allocations for wetland (and species) conservation is usually very low and consequently, little gets done.

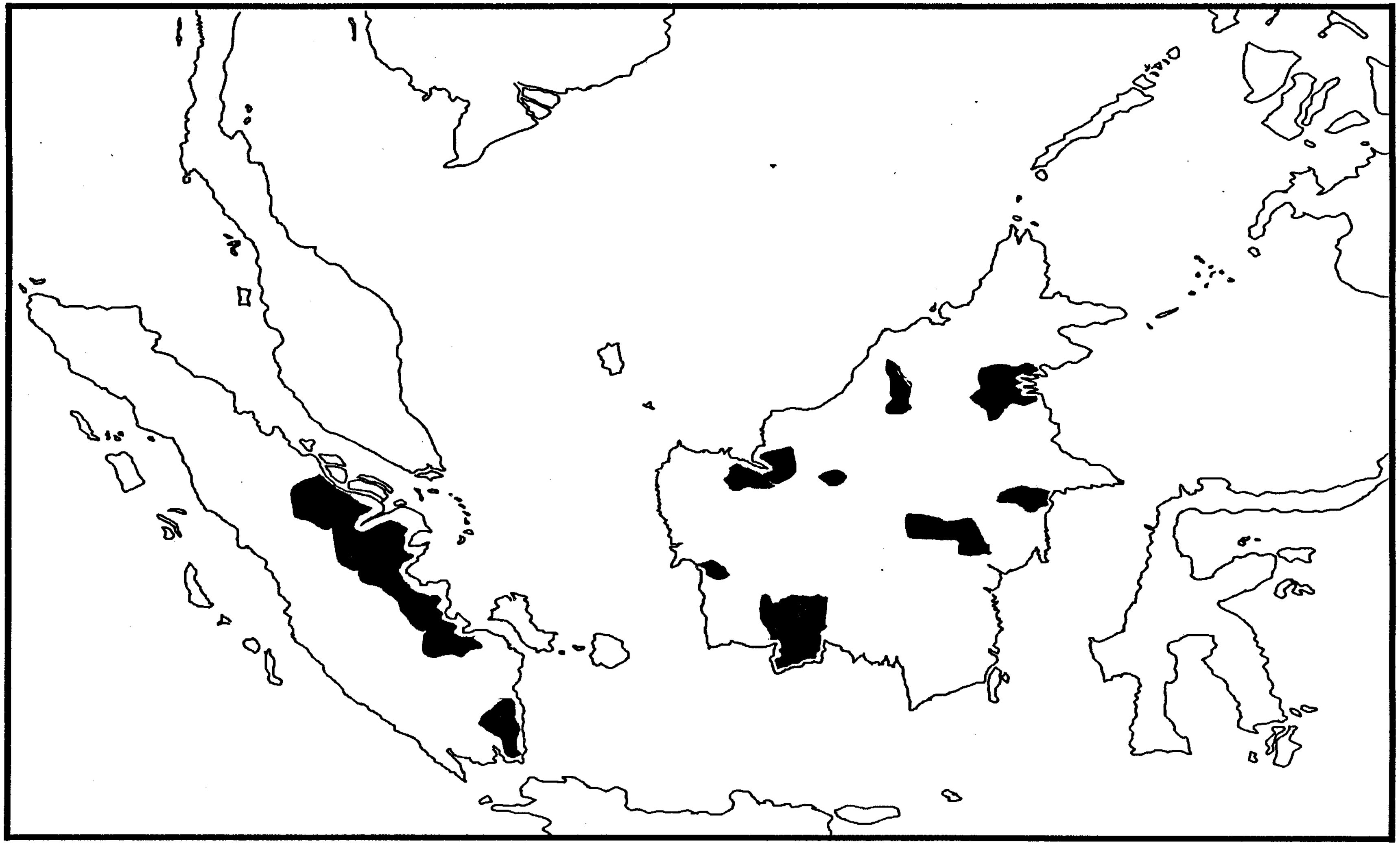
Development assistance aid from developed countries has had mixed results in the past. Today, guidelines ensure the efficient channelling of aid in developing countries. In terms of species conservation, the role of NGOs is becoming increasingly important. The provision of technical expertise associated with aid is vital to the development and implementation of species action plans.

APPENDIX ONE PAST AND PRESENT DISTRIBUTION OF TOMISTOMA IN SOUTHEAST ASIA



Confirmed Sites for Tomistoma (since 1990) *All Site Records of Tomistoma to date*

APPENDIX TWO KNOWN CONCENTRATIONS OF TOMISTOMA POPULATIONS



APPENDIX THREE RECORDS OF TOMISTOMA FROM WETLAND SITES IN SOUTHEAST ASIA

[Compiled and adapted from Wetland Database, 1994]

NO	LOCATION	NAME OF SITE	COORDINATES	LAST OBS	HABITAT	PROTECTION
1	Sumatra, Indonesia	Giam-Siak Kecil	N001°10', E101°35'	'87, 1992	L / F / P	Wildlife Reserve
2	Sumatra, Indonesia	Danau Belat/Besar Sekak/Sarang Burung	N000°37', E102°40'	1987	L / P	No Protection
3	Sumatra, Indonesia	Danau Bawah and Pulau Besar	N000°40', E102°15'	1987	L / F / P	Strict Nature Reserve
4	Sumatra, Indonesia	Pulau Padang and Danau Tanjung Padang	N001°08', E102°20'	1987	L / P	Production Forest
5	Sumatra, Indonesia	Kerumutan Baru	S000°05', E102°29'	1992	P	Strict Nature Reserve
6	Sumatra, Indonesia	Pulau Bakung, including Tanjung Bakung	S000°20', E103°40'	1990	L / P	Protected area, Production Forest
7	Sumatra, Indonesia	Taman Nasional Berbak	S001°23', E104°20'	'81, '84, '87, '91, 1992	R / F / P	National Park, Ramsar Site
8	Sumatra, Indonesia	Sungai Lalan	S002°15', E104°15'	1987	F / P	No Protection
9	Sumatra, Indonesia	Ogan-Komering Lebaks	S003°35', E104°45'	1990	L / R / P	No Protection
10	Sumatra, Indonesia	Way Kambas	S004°50', E105°43'	1987	F / V	National Park
11	Sumatra, Indonesia	Buaya Bukit Batu	N001°23', E101°53'	1987	R / P	No Protection
12	Kalimantan, Indonesia	Danau Sentarum Wildlife Reserve	N000°51', E112°06'	'86, '87, 1993	L / R / F / P	Wildlife Reserve, proposed Ramsar Site
13	Kalimantan, Indonesia	Gunung Palung National Park & surrounding swamps	S001°15', E110°15'	1987	R / F/ P	National Park

APPENDIX THREE RECORDS OF TOMISTOMA FROM WETLAND SITES IN SOUTHEAST ASIA (Cont'd)

NO	LOCATION	NAME OF SITE	COORDINATES	LAST OBS	HABITAT	PROTECTION
14	Kalimantan, Indonesia	Tanjung Puting National Park	S002°55', E112°00'	1990 (2)	R / P / V	National Park
15	Kalimantan, Indonesia	Kelompok Hutan Kahayan	S003°18', E113°55'	1984	F / P	Production Forest
16	Kalimantan, Indonesia	Muara Along	N000°26', E116°41'	1990	L / R	No Protection
17	Kalimantan, Indonesia	Kutai National Park	N000°22', E117°17'	1987	L / R / F / P / V	National Park
18	Sulawesi, Indonesia	Marisa River	N000°28', E121°55'	1986?	R	No Protection
19	Selangor, Malaysia	North Selangor Peat Swamp Forest	N003°33', E101°16'	1986	R / P	Forest Reserve
20	Pahang, Malaysia	Tasek Bera	N002°58', E102°35'	1982?	L / F / V	Wildlife Reserve
21	Sarawak, Malaysia	Loagan Bunut National Park	N003°47', E114°14'	1985	L / F / P	National Park
22	Sarawak, Malaysia	Sg. Mayeng Swamp Forest	N002°39', E113°06'	1994	R / F	Protected Forest
23	Sarawak, Malaysia	Maludam Swamp Forest	N001°28', E110°45'	1986	R / P	Protected Forest, Forest Reserve
24	Sarawak, Malaysia	Sadong Swamp Forest	N001°18', E110°45'	1993	R / P	Forest Reserve
25	Sarawak, Malaysia	Sg. Ensengai Baki	N001°15', E110°35'	1985	R / F / V	Forest Reserve
26	Minh Hai, Viet Nam	Ca Mau Peninsula	N009°20', E105°00'	1993		No Protection

*Habitat Codes : **L** - Floodplain/oxbow lakes; **R** - Perennial riverine forest; **F** - Freshwater swampforest/non-peat swampforest; **P** - Peat swampforest; **V** - Floating vegetation*

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CURRENT STATUS OF THE CUBAN CROCODILE, *CROCODYLUS RHOMBIFER*, IN THE WILD.

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INTRODUCTION & BACKGROUND

The situation of crocodilians in Cuba was reviewed by a CITES team in 1991 (Ottenwalder and Ross 1991). Three species of crocodilian are currently found in Cuba. *Crocodylus rhombifer*, the 'Cocodrilo' or 'Cocodrilo Criollo' (Cuban crocodile), is endemic to Cuba and is found in a very restricted number of fresh water habitats; *Crocodylus acutus*, 'Caiman' (American crocodile), is found widely distributed in coastal areas, mangroves and offshore cays around the island; and *Caiman crocodilus fuscus*, 'Babilla de Colombia' (spectacled caiman), has been introduced to fresh water habitats on the Isla de Juventud (Varona 1966, 1976, 1986a, 1986b, 1987). Detailed information on the present status and distribution of these crocodilians in Cuba is lacking. Two of these, *C. rhombifer* and *C. acutus* are being raised in captivity in Cuba for commercial use and export. *C. rhombifer* and *C. acutus* are on CITES Appendix I and *C. c. fuscus* is on CITES Appendix II.

Crocodilians in Cuba are viewed as a resource with the potential for valuable export earnings. The farm at Laguna de Tesoro (Zapata Swamp) has been raising captive-born crocodiles for meat and skins and the intention is to produce skins for the international market.

The Cuban crocodile has the smallest known natural distribution of any crocodilian. Its present distribution is restricted to the Zapata Swamp in southwestern Cuba and a small remnant population may still be found in the Lanier swamp on the Isle of Pines (Isla de Juventud). However, in the recent past this species was more widely distributed on the main island of Cuba (Varona 1966). Skeletal material shows that this species was found on the Cayman Islands (Morgan, Franz & Crombie 1993). A sub-fossil crocodile skeleton in the Florida Museum of Natural History recently recovered from an underwater marine cave on Abaco Island in the Bahamas appears to *C. rhombifer* (G. Morgan pers comm.).

The Cuban crocodile is without doubt the most threatened species of New World crocodilian. Wild populations have been greatly reduced and little or no work has been done on surveys of wild populations, or this species behavior and ecology. A large number of the wild animals were collected and placed in pens during the 1950's and 60's. The largest farm at Laguna del Tesoro has about 800 adults. Some of the farmed animals are harvested for meat which is used locally.

Following the recommendations of Ottenwalder & Ross (1991) a proposal to undertake the recommended surveys was developed in conjunction with the Cuban authorities and the CITES Secretariat and submitted to CITES. At the same time, preliminary field work by Cuban biologists in Zapata Swamp was expanded to become the base for a detailed survey. In refining these plans it was decided to place priority on the Zapata Swamp area which was thought to be the primary refuge of any remaining wild population of *C. rhombifer.*

The present survey was undertaken under the auspices of CITES, with support from the European Community, to determine baseline data on the distribution and abundance of the wild *C. rhombifer* population of the Zapata swamp and make recommendations to develop a suitable management plan.

METHODS

Information on crocodile numbers and distribution was collected during field work undertaken by the CITES coordinators between 27 September 1993 and 26 October 1993. Additional information collected on prior visits by JPR was also included. A significant body of information has also been collected by R. Ramos and the MIP field team during periodic site visits to the Zapata swamp since 1988 and data from this work is included.

Three basic techniques were used to estimate crocodile densities; aerial surveys, night spotlight counts and mark and recapture studies. We used topographic maps of 1:25,000 (1990 edition), 1: 50,000 (1974 edition) and 1:100,000 (1983 edition) scales covering the entire Zapata Peninsula, constructed by the Instituto Cubano de Geodesia y Cartographia. Positions and straight line distances between them were determined with a Magellan NAV 5000 Global Positioning System (GPS) operated by battery power. The GPS receives information from polar orbiting satellites to calculate its position on the earth's surface. The unit is rated at an accuracy of 100m when used under standard conditions without differential correction (Magellan reference manual, 1993). Only readings with a satellite signal strength of 7/9 or greater and a geometric accuracy rating of 5/9 or better were used to determine positions. Empirical estimation of GPS accuracy was obtained by recording the position of the same point on numerous occasions over several days and noting the variation of indicated position. These tests confirmed that the variation in Latitude or Longitude at one point was no more than one second (i.e. about 80m at this latitude). For the purposes of the study, positions were accepted with an uncertainty of 100m.

Quantitative aerial transect surveys were conducted from an MI8 PS helicopter flying a fixed transect route at 70 m altitude and 100 km/hr velocity. Two observers on each side of the aircraft (four observers total) kept independent records of the transect section, time and crocodiles observed. Two additional observers maintained a record of position and time, coordinated navigation with the aircraft crew and made subsidiary observations of terrain and crocodiles. Observers rotated positions and side of the aircraft each day to try and distribute sighting biases due to aircraft configuration. The transect strip width was estimated by each observer and confirmed by geometrical calculations based on the aircraft window aperture, altitude and field of view. Aerial reconnaissance overflights were conducted by conventional biplane (ANDO AN-2) on 3 August 1993 and by helicopter on 30 September 1993 prior to beginning field work, to gain familiarity with the terrain and to train observers. The quantitative aerial surveys were flown on three consecutive mornings 21-23 October 1993. The transect route was chosen to be representative of the main area of distribution of *C. rhombifer*, but was constrained by the lack of electronic navigation apparatus available to the aircrew and the subsequent need to navigate by dead reckoning between the few visible reference points in this largely uniform terrain. Actual transect routes were determined from regular GPS positions obtained at section endpoints and intermediate positions. Observers on right and left sides of the aircraft had nonoverlapping fields of view and thus the transect sample consisted of two parallel strips of known width and length. The independent observations of two observers on the same side of the aircraft allowed the application of the dual observer technique developed by Magnusson et al. (1978) and described by Graham (1988, 1989) and Bayliss 1987 for analysis and calculation of crocodile density. Care was taken to avoid the observers cueing each other to sightings.

Night spotlight surveys were conducted in Laguna Tesoro on two nights. This is the one location where the terrain allowed the use of standard night spotlight techniques. The lake was circumnavigated in the early evening in a 4 m outboard powered boat and crocodiles were located with a one million candle power (Brinkman Q-beam) spotlight powered by a 12 volt battery. Crocodiles sighted were approached as closely as possible, identified to species and their total length estimated if possible.

Attempts to modify this technique for application at other localities in the Zapata area were unsuccessful for several reasons. Foremost of these was the heavily wooded terrain and complex, shallow waterways of much of the area which made passage by outboard motor boat impossible. Average water depth varied from 10 - 35 cm with many impassable shallow areas. Visibility was usually restricted to between 5 - 10 m by the standing vegetation and passage in a straight line was rarely possible for more than 30 m. We tried to conduct spotlight surveys from small (3m) boats powered by a push pole but considerations of personnel safety and the very real difficulty of navigating in the swamp at night, even along previously marked routes, made this unsuccessful.

Mark and recapture studies were conducted for 21 days at a site in the South-western part of the Zapata swamp accessible from the sea via a hand dug canal, Zanja (Canal) Diez. We operated from small boats powered by hand and push-pole. Within the swamp, campsites are restricted to occasional areas of a few square meters of slightly higher ground amid the muck and water. Many of these were traditionally used by crocodile hunters and have been rediscovered and utilized by the MIP team.

Three of the more accessible of these camps were chosen as the centers of operation for the mark and recapture study. They are named 'Jamon', 'Emetario' and 'Rinconada del Canal Diez' and are located approximately 4 km distance from each other in the southwestern part of the Zapata swamp (Figure 3). At each of these camps three 'radial' transects were established of approximately 1 km length. The actual direction and length of the transects was determined by the terrain and accessibility by small boat. Along each of the transects a series of 6 bait stations was established. At these locations baits consisting of offal and carcasses of either cows or Hutias (*Capromys* sp.) were suspended 1-2 m above the water. The positions of camps, transect routes and bait stations were established to the nearest 100m using the GPS. Routes were established and baits placed on the first day at each camp and then the transects patrolled each morning and crocodiles captured on the three subsequent days.

Crocodiles were captured by hand using a rope noose (lasso) during the day. Crocodiles in the

Zapata swamp are remarkably tolerant of close approach in daylight and the field teams were very skilled at capturing the crocodiles in this manner. Crocodiles were also captured using a spring-noose trap modified from the designs described by Murphy & Fendley (1975) and Mazzotti & Brandt (1988). We utilized the basic trap conformation and gravity trigger bar described by Mazzotti & Brandt but modified the elastic spring for the noose to use a stretched length of surgical rubber, similar to the Murphy trap. Four traps were baited and set along each transect on two nights. The sample of crocodiles caught by hand and in traps were combined for the calculation of population data and numbers.

Captured crocodiles were measured (total length) to the nearest whole cm, their sex determined by manual probe and the animals marked by removing a series of the double caudal scales to code a unique number for each individual. Additionally, crocodiles were painted with white quick drying spray paint so that marked individuals could be identified by sight at a distance. Tests conducted on six captive crocodiles at the Laguna Tesoro crocodile farm indicated that such paint marks remain readily visible for one week and have completely disappeared by the end of two weeks. Paint marks were applied to a different location on the crocodile at each different campsite so that exchanges of crocodiles between campsites could be noted visually. An important uncertainty in the use of bait stations is the distance from which crocodiles are attracted to the bait. We noted movements of crocodiles between stations and between transects, and the absence of exchange between campsites, to calculate minimum and maximum attractive distances.

Air and water temperatures were determined with mercury in glass thermometers accurate to 0.5 C°. Wind speeds were determined from a hand held "Wind Wizard" field anemometer. Salinity of water was measured to the nearest part per thousand using a Zeiss Salinity Refractometer. Crocodile lengths and water depths were measured to the nearest cm using steel tape measures.

One of the important considerations of this study was the presence of sympatric populations of *C. rhombifer* and *C. acutus* and the possible presence of hybrids in the wild population. To identify crocodiles in the field we constructed a table of externally visible characteristics that differentiate these two species (Table 1). These characters were developed from published sources, particularly Varona (1966, 1986a, 1986b) but were significantly augmented by the experience of the field team who are very familiar with both species and who have arguably seen and handled more specimens of these two species than any other workers. Captured crocodiles were usually unambiguously assignable to either *C. rhombifer* or *C. acutus*. A small number of individuals demonstrated a mixture of characters beyond the normal range of variation and these we term "Mixed phenotype" without making any comment about the possible genetic origin of these individuals (see discussion below).

To further clarify crocodile identifications we collected blood samples and preserved them for future genetic analysis. Blood samples of approximately 1 ml were collected from the cervical sinus, or by cardiac puncture, into unheparinised sterile syringes and immediately decanted into DNA Lysis buffer (White & Densmore 1992). This material preserves DNA for up to one year at room temperature.

Table 1. Differentiation of *Crocodylus rhombifer* and *Crocodylus acutus* in the field. External characters based upon observations of 693 wild *C. rhombifer* and several thousand captive bred individuals. Scale counts overlap completely in these two species. See Varona 1966 and 1986b for detailed skeletal descriptions.

	C. rhombifer	*C. acutus*
Strong and reliable characters Obvious in all sizes, including hatchlings, and showing little variation.		
■ Form of the rostrum	broad and robust length/width = 1.4 -- 1.6	long and narrow length/width = 1.8 -- 2.5
■ Cranial table (squamosal) Posterior-lateral margin	raised, forming distinct crest or knob in specimens over 1 m	flat or slightly raised
■ Color of the lateral mandible	Cream or yellow with prominent black patches	Grey with small, obscure black spots
Strong characters Usually well distinguished but some individual variation		
■ Dorsal scalation	Usually completely regular 6 scales/row	Usually irregular with several scales offset from their rows, variable 2-6 scales/row.
■ Nuchal scales	Very regular	Often irregular in number and placement
■ Body color	Always bright yellow with black 'checkerboard' pattern	Usually grey and banded, rather than spotted, but some individuals yellow
■ Scalation of the limbs	Notably rugose, each scale with a distinct central ridge	Not rugose, scales flat
■ Longest maxillary tooth	Usually M5 (i.e 10th tooth)	Usually M6 (i.e. 11th tooth)
Characters of larger individuals over 180 cm total length		
■ General body form	Distinctly robust, short robust limbs and erect posture	Relatively more slender, gracile, posture rarely erect.
■ First mandibular teeth	Rarely/never penetrate upper external premaxilla	Often one or both penetrate the premaxilla and are visible externally from above.
■ Eye color	Usually deep brown in adults but subadults vary yellow-green-brown	Usually greenish with blue or grey tinge in adults

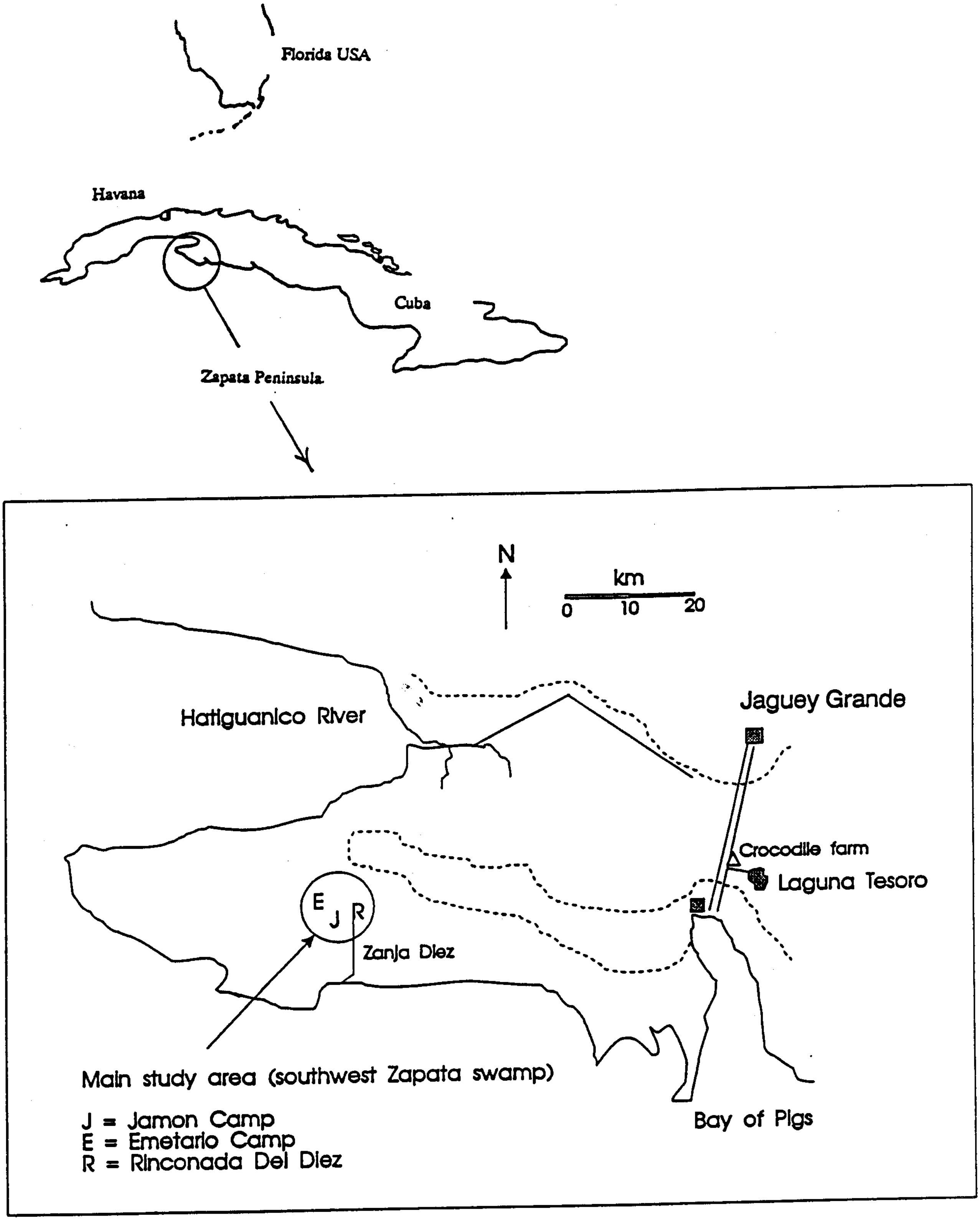

Figure 1. Location of the Zapata Peninsula and the study area. Dotted lines are approximate 10 m contour.

RESULTS

The Zapata peninsula is located on the south coast of Cuba at approximately 22° South latitude and 81° West longitude. The peninsula is approximately 175 km East to West and varies from 14 km to a maximum of 58 km North to South encompassing an area of 4,520 km^2. Approximately 2,600 km^2, or 57% of this area, is permanent wetland, Figure 1.

The whole peninsula, with its low relief and poor drainage, forms a huge area of shallow wetlands, marshes, swamps and woodland. Rainfall averages 1,200 - 1,600 mm/year, falling in distinct wet seasons associated with summer storm activity and winter cold fronts. Soils and sediments are generally saturated and form a muddy layer 1-2 m deep over the underlying limestone rock. The fresh water of the interior is heavily stained with plant tannins and has a low pH. Annual temperatures vary from 15 °C - 35° C with a median of 24.5° C.

The whole peninsula is quite heavily vegetated with shrubs and small trees. The coastal regions in the reach of tidal and ocean influences are dominated by Red and Black mangroves (*Rhizophora mangle* and *Avicennia germicans*). In fresher water, buttonwood (*Conocarpus erecta*) 2-4 m high is the dominant tree and sawgrass (*Cladium jamaicensis*) and rushes (*Typha domingensis*) form dense stands. Trees form an almost continuous canopy over much of the area. A large variety of aquatic and emergent plants grow in the wet areas. Prominent among these are the floating waterlilies, *Nymphea ampla* and *Nuphar luteum*. Two kinds of tree islands are common. Slightly higher ground is dominated by the palm, *Sabal parviflora*, while areas around deeper pools and freshwater seeps support *Conocarpus* and a variety of other trees. In the eastern portion of the peninsula significant stands of introduced Australian pine (*Casuarina* sp.) and paperbark tree (*Melaleuca* sp.) occur.

The swamp presents a complex, heavily vegetated appearance with almost no natural open water areas of any size or coherence. Instead, the area is characterized by complex networks of channels, a patchwork of isolated pools and large areas where shallow water, unconsolidated sediments and vegetation impede access by boat, vehicle or foot.

Significant wildlife of the area, in addition to the endemic crocodile (*Crocodylus rhombifer*), includes several endemic plants and birds, large populations of Hutias (*Capromys pilorides*), several fish species including an endemic garfish (*Lepisosteus tristochus*), numbers of the Cuban parrot (*Amazona leucocephala*), numerous waterbirds, the Cuban boa (*Epicrates angulifer*) and the Cuban freshwater turtle (*Trachemys decussata*). The area is a significant wintering area for many waterfowl and migratory passerine birds from North America. Feral pigs (*Sus scrofa*) and introduced white-tailed deer (*Odocoileus virginianus*) are also common. Manatees (*Trichechus manatus*) and the American crocodile (*Crocodylus acutus*) are found in the surrounding coastal waters and mangroves.

Human influence in the peninsula is concentrated along the road running to the head of the Bahia de las Cochinos and westward along the slightly higher (and dryer) ground separating the southwest and northwest portions. A number of small villages support a permanent population of several thousand people. Traditional land use in the area has been extraction of hardwoods and production of charcoal, fishing, beekeeping, and small scale garden agriculture, augmented by hunting wild game, including crocodiles. This area was one of the poorest in Cuba and a program of civic improvement was initiated after 1959. Currently fishing and tourism provide significant economic benefits to the area. A master plan for the orderly and sustainable development of the area (Plan de Victoria Giron) guides the coordination of various sectors and interests in the region. Part of this plan has been the designation of an area in the central part of the peninsula as the Zapata National Park.

AERIAL SURVEY

Aerial reconnaissance was flown over a large part of the southeastern portion of the Zapata Swamp on 3 August 1993. A single crocodile was seen. On 30 September 1993, a similar reconnaissance was flown using the MI-8 helicopter. We experimented with velocity and altitude and practiced observing and recording observations. Five crocodiles were seen enabling all observers to gain confidence that crocodiles could be seen from the air. Based on the results of these two preliminary flights a quantitative aerial survey was designed and conducted 21-23 October using the double (or tandem) observer technique.

The quantitative survey route varied from 70 to 80 km due to variations in the wind and the consequent divergence from straight line transects. Transect routes are shown in Figure 2. All observers agreed that they were viewing a strip of approximately 100 m width and this was confirmed by geometric calculations.

A total of 43 crocodiles were seen during the quantitative survey. Observations on the two sides of the aircraft constitute independent samples and Table 2 indicates that most observers saw between 20% and 50% of the crocodiles apparently visible. The counts can therefore be corrected upwards by a factor of 2-5 times to account for differences between observers. It was not possible to identify species from the air in every case although in about half the observations observers were prepared to offer an opinion. Many of the large crocodiles seen from the air were unmistakably *C. rhombifer*. We have adopted the more conservative position of considering aerial observations to be just "crocodiles" and calculating the actual proportion of different species from the mark and recapture study. The crocodiles seen from the air appeared to be larger individuals and most were seen in similar circumstances, lying in or at the edge of open water pools. Much of the terrain observed is covered by thick vegetation and it was not likely that crocodiles would be seen there, although our mark-recapture work indicates that crocodiles are abundant in such heavily vegetated areas. The field work on the ground also indicated that smaller crocodiles (below about 1.5 m total length) are quite cryptic and easily overlooked even when approached closely. We are therefore very confident that the density calculated from aerial surveys is only a small proportion of the number of crocodiles present.

Observers on the left side of the aircraft consistently saw more crocodiles than observers on the right side even though observers rotated positions between flights to attempt to control any "position bias". This may be due to the orientation of the sun and shadows relative to the transect directions which were the same on each flight.

The aerial survey results provide two very valuable pieces of information. The distribution of sightings confirmed the results of earlier field work on the ground and our subjective impression, that there is a well defined core area of the southwestern Zapata swamp where crocodiles have a high density and where many of the crocodiles are *C. rhombifer*. We further confirmed this impression by observing that the density of tracks which are made by crocodiles through the vegetation, and are readily visible from the air, are dense within the general area of aerial sightings and rare or absent elsewhere in the Zapata swamp. An exception was a small area of drainage canals at the eastern end of the Zanja de los Patos where a small concentration of tracks indicated crocodile presence. An

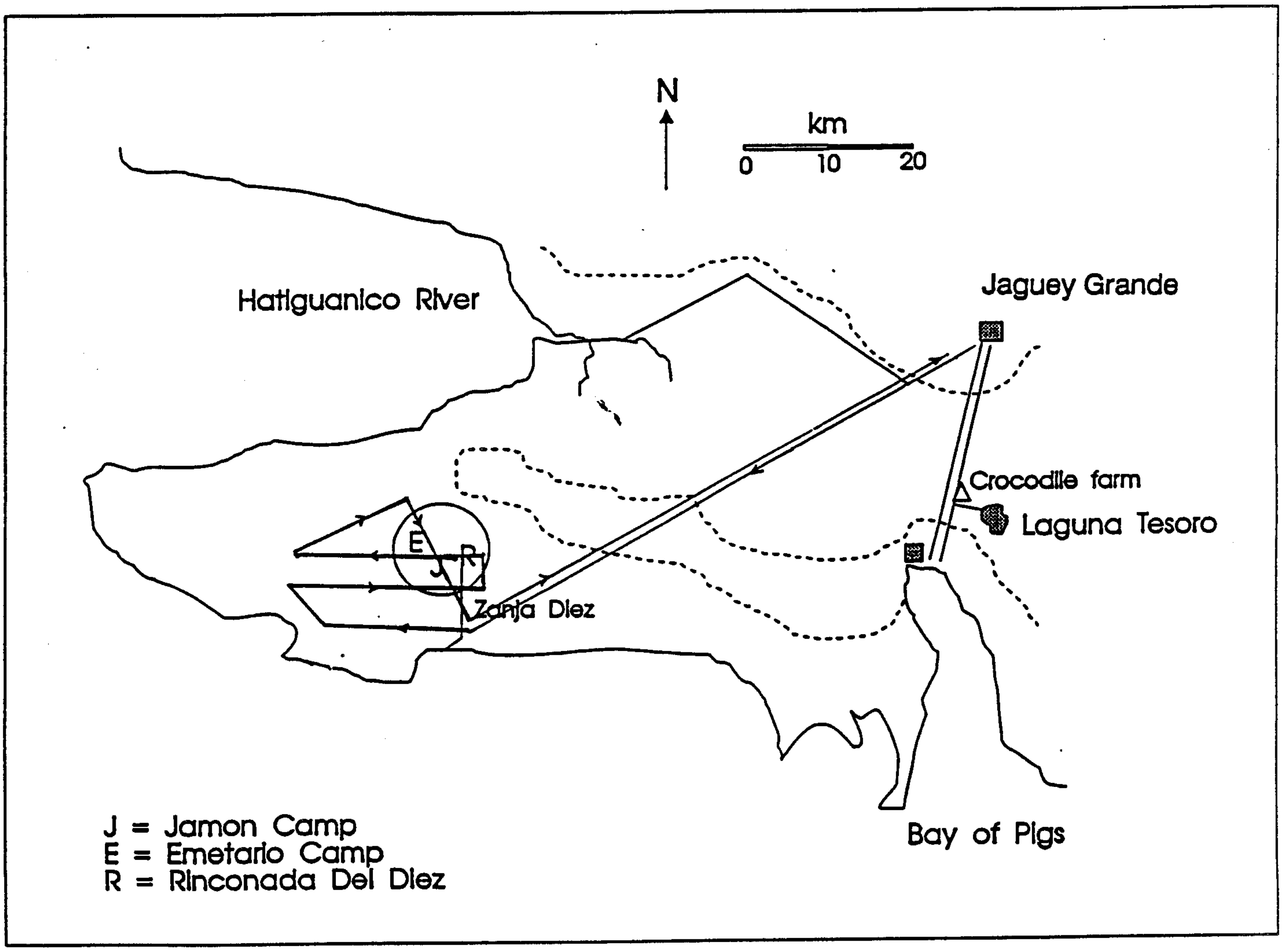

Figure 2. Position of aerial transect lines. General observations were made from Jaguay Grande to Zanja Diez and quantitative surveys were conducted from Zanja Diez onward.

experienced local observer commented that these were thought to be *C. rhombifer* and this possibility should be confirmed.

The density estimates generated are a severe underestimate of the actual numbers present but provide a clear and potentially repeatable index for the monitoring of the numbers and distribution of this population.

Table 2. Aerial survey results: Zapata Swamp, Cuba

FLIGHT	DATE	AREA [1]	SIGHTED [2]	ESTIMATED [3]	DENSITY [4]
Recon. 1	3 Aug.	approx. 16 km^2	1	-	-
Recon. 2	30 Sept.	8.12 km^2	5	-	-
Survey 1 right side	21 Oct.	8.0 km^2	3	5.0 (CV=28%)	0.63/km^2
left side		8.0 km^2	9	23.0 (CV=27%)	2.88/km^2
Survey 2 rt side	22 Oct.	7.025 km^2	6	17.7 (CV=32%)	2.51/km^2
lft side		7.025 km	10	24.7 (CV=34%)	3.51/km^2
Survey 3 rt side	23 Oct.	7.108 km^2	6	13.0 (CV=37%)	1.83/km^2
lft side		7.108 km^2	9	17.0 (CV=38%)	2.39/km^2
			Average density		2.29/km^2
			Standard error		0.40

1. Distance flown (km) x mean strip width
2. Number of individual crocodiles seen by two observers.
3. Estimated number of crocodiles calculated by the double observer method of Magnusson et al. 1978. see Table 3.
4. Estimated density = Estimated number (3) / Area (1) crocodiles /km.
5. CV = Coefficient of variation = Standard Error of the Estimate/ Estimate expressed as a percentage.

SPOTLIGHT COUNTS

Standard spotlight counts were conducted on Laguna Tesoro on the nights of 30 September and 21 October 1993. The distance surveyed in both cases was 4.0 km around the eastern, northern and western shore of the lake and an additional 4.5 km along the canal from Boca del Laguna to the lake. On 30 September we also surveyed an additional 1 km of the canals running east of Guama on the east side of the Lake. Conditions were suitable during both surveys with air temperatures 28° - 31°C, water temperatures of 29°- 30° and modest winds of up to 5 m/sec. The moon was full on 30 September and in its last quarter on 21 October.

On 30 September we saw five crocodiles. One of these was a *C. rhombifer* of 1.5 m length. The other four were very wary and recorded as eyes only (E O). Of these, one was a large individual that was alleged by our guide to be a *C. acutus* of about 4 m that is a regular inhabitant of the locality. The other three all appeared to be in the 1-2 m size class. All the sightings were made around the margins of the lagoon and none in the surrounding canals. On 21 October no crocodiles were sighted.

We concluded from these rather unsatisfactory surveys that crocodiles are present in Laguna Tesoro but in low density (less than 1/km, all species). Both species of crocodile occur at this location but, these crocodiles are remarkably wary and hard to approach compared to the very tolerant behavior of the wild crocodiles of both species that we encountered deep within the Zapata swamp.

MARK AND RECAPTURE STUDIES; HAND CAPTURES

During the mark and recapture survey 184 *C. rhombifer* and 38 *C. acutus* were first captured by hand and an additional 27 crocodiles (23 *C. rhombifer* and 4 *C. acutus*) were seen but not captured during twelve working days. Overall, approximately 90% of the crocodiles seen were captured. Two of the three capture teams had success rates of 95% while the third team had a success rate of 83%. This lower rate was largely due to two days when a very large number of crocodiles were encountered by this team and it was not possible to capture all the crocodiles seen. Capture success was 89% for *C. rhombifer* and 91% for *C. acutus* and this difference is not considered significant.

TRAPPING.

Crocodiles were captured in modified Murphy/Mazzotti & Brandt snare traps. A total of 67 trap nights resulted in the capture of 8 *C. rhombifer* and 7 *C. acutus* (Table 3) with an overall trap success rate of 22%. None of the animals first captured in a trap were subsequently recaptured in a trap or by hand, but 4 crocodiles captured in traps had been first caught by hand during this study. Four of the trapped crocodiles had been caught by hand and marked on previous field trips in 1991-92. *C acutus* were caught significantly more often in traps (47% of captures) than their presence in the population as indicated by hand captures (17%) or crocodiles observed but not caught (18%). [Chi squared = 7.76, 1 degree of freedom]. Sizes and sexes of trapped crocodiles did not appear to be different from the general population given the small sample size. One crocodile, *C. acutus* # 502, a female 201 cm total length, was found dead in a trap, having apparently been killed by other crocodiles. This was the only mortality or injury suffered by crocodiles or the research team during the survey.

Table 3. Trap success: Zapata Swamp, Cuba. Traps were baited snare traps activated by stretched surgical rubber springs and a gravity trigger.

LOCATION	DATE	TRAPS SET	*C. rhombifer* CAUGHT	*C. acutus* CAUGHT	% SUCCESS
Jamon	5 Oct	12	2	1	25%
	7 Oct	12	2	3	42%
Emetario	10 Oct	12	1	1	17%
	11 Oct	12	1	1	17%
R. del Diez	14 Oct	10	0	0	0%
	15 Oct	9	2	1	33%
TOTALS		67 trap nights	8 (12% success)	7 (10% success)	22%

CROCODILE MOVEMENTS.

A total of 503 *C. rhombifer* and 176 *C. acutus* in Zapata swamp were marked during 1989 -1992 by the Cuban field team prior to the present study. Of these, 225 *C. rhombifer* and 53 *C. acutus* were marked near the three camp sites used in 1993. Not one of these was recaptured at a camp site other than its original capture location. We captured 30 *C. rhombifer* and 3 *C. acutus* from this previously marked set, all near their original locations.

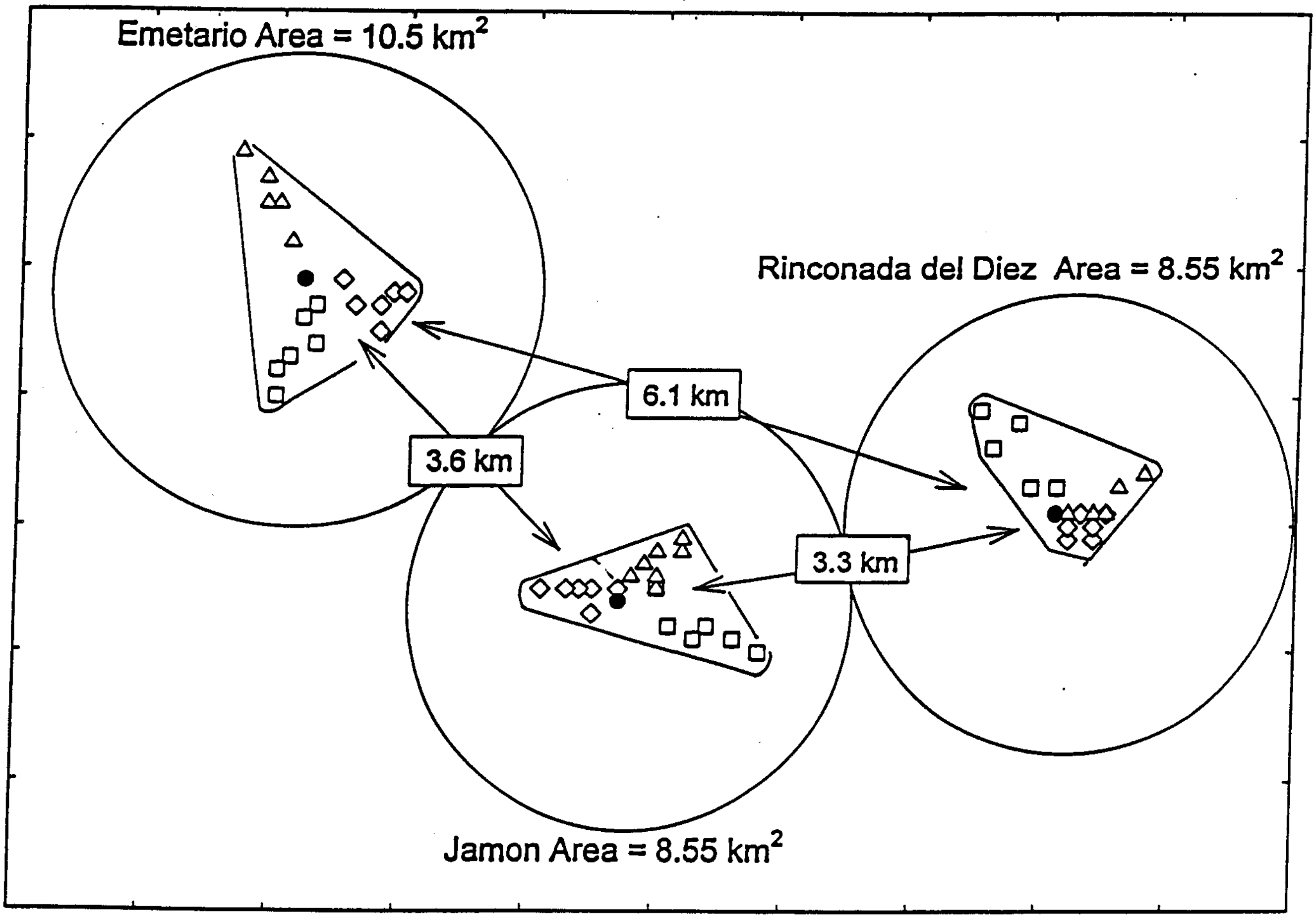

Figure 3. Relative positions and areas of the study area. Scale and direction are accurate. Solid circles represent central campsites and open symbols represent bait station positions. Inner polygon represents minimum study area, circles represent maximum study area (see text).

During our study we noted the movements of 14 crocodiles that were captured more than once, all within three days of first capture. The mean distance of movement was 162 m and five were recaptured at the same location as their first capture. The greatest distances of movement were 390 m, 340m and 340m. Because the uncertainty of our positions generated by GPS was in the order of 100m it is possible that both positions recorded for each crocodile are as much as 100 m further from the other than we estimated. We therefore have accepted the distance of 500m as the greatest documented movement of marked crocodiles during our study.

During the study 223 crocodiles were painted with a distinctive mark to enable us to recognize marked animals, and to identify the location where they were marked (10 small juveniles were not painted as we feared this would subject them to additional predation pressure). None of the crocodiles marked during this study were observed to move as far as the other campsites we used, although we took care to observe crocodiles during our movements between camps to test this possibility.

We infer from these observations that crocodiles in the Zapata swamp are relatively sedentary and do not normally move as far as the median distance between our camps (3.5 km). This enables us to make some important assumptions about the attractive distance of our bait stations and the area from which crocodiles were drawn for our mark and recapture study. These in turn allow us to calculate densities based upon reasonable estimations of the actual area of the study sites. The assumptions are these:

1) There was no interchange of crocodiles between the three campsites of this study. Each campsite can therefore be treated as an independent unit for the purposes of calculating population and density estimations.

2) The smallest reasonable area of study at each of our camps is the polygon enclosing a radius of 500m from each point of our transects. This area is shown in Figure 3. We assume that crocodiles can and did move freely through this area during the study. We estimate the **minimum** area of each of our capture sites to be Jamon 1.7 km^2, Rinconada del Diez 1.5 km^2 and Emetario 2.4 km^2 or a total of 5.6 km^2 for the three sites combined.

3) The largest reasonable area of study at each campsite is the radius of half the distance to the closest adjacent camp. There is no evidence that crocodiles have moved further than this either during this study or in the prolonged period of up to 36 months since some of these crocodiles were originally marked. This area is shown in Figure 3. We estimate the **maximum** area of each of our capture sites to be; Jamon 8.55 km^2, Emetario 10.17 km^2, Rinconada del Diez 8.55 km^2, or a total of 27.27 km^2 for the three sites combined.

SIZE DISTRIBUTION.

Measurements of the straight line distance from the tip of the snout to the tip of the tail (Total length TL) were taken for 179 *C. rhombifer* and 40 *C. acutus*. Measurements were not taken for several crocodiles that had a portion of the tail missing. These measurements were made with a steel measuring tape under field conditions in small and unstable boats. For this reason we did not attempt to make measurements more accurately than the nearest whole cm and an uncertainty of $\pm$ 1 cm is likely with these measurements. The distribution of TL is shown in Figure 4.

The largest proportion of both species in our sample was greater than 120 cm TL and smaller individuals appear under-represented in our sample. We suspect that this is a reflection of the capture

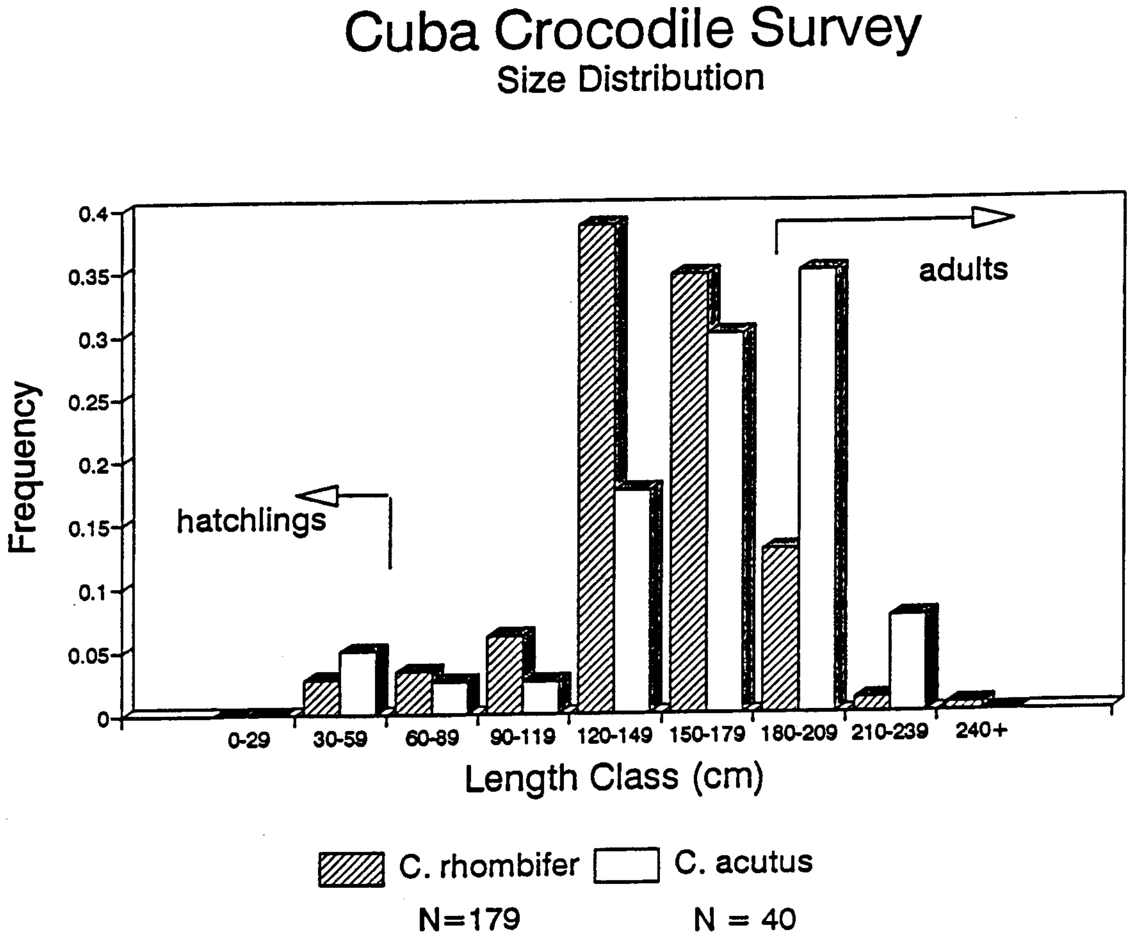

Figure 4. Size distribution of crocodiles in Zapata Swamp, Total length of *C. rhombifer* (hatched bars) and *C. acutus* (open bars).

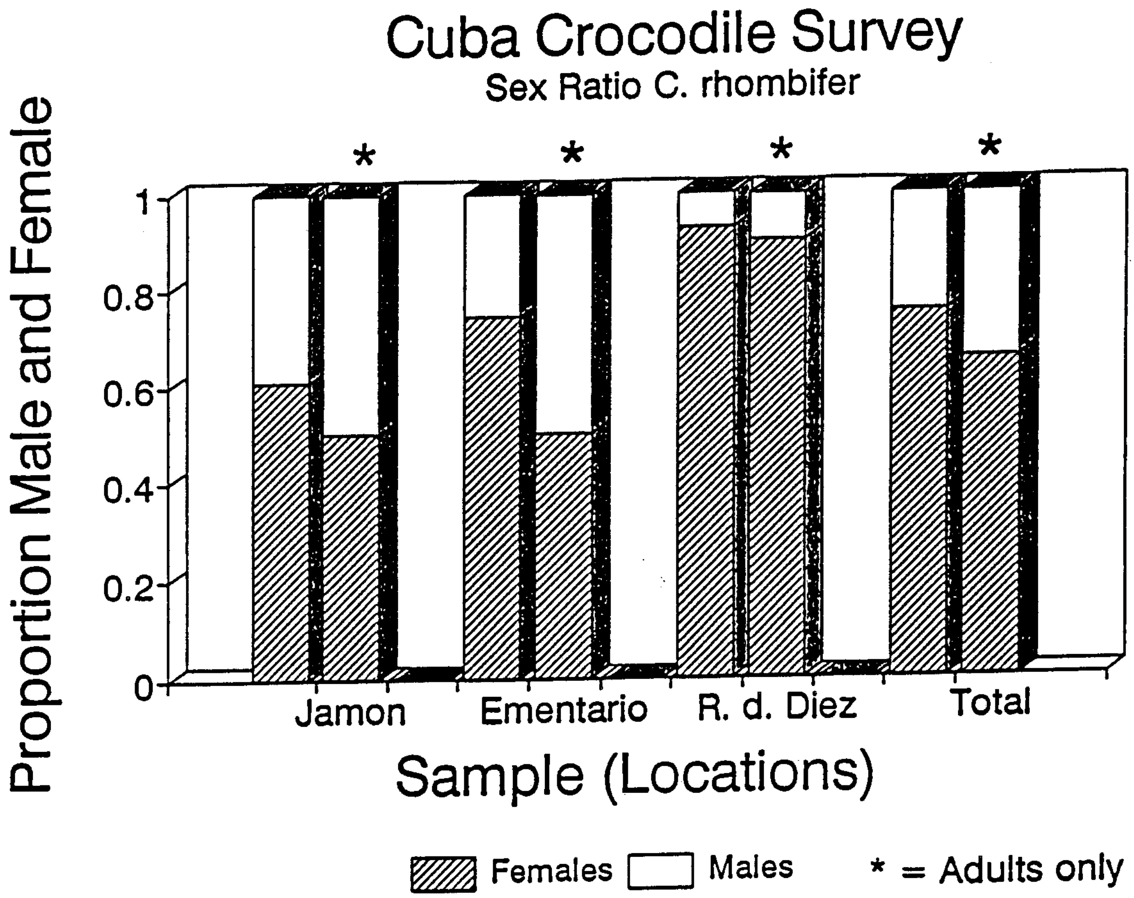

Figure 6. Sex ratio of *C. rhombifer* at different locations. Bars beneath the asterix represent sexes in the sample of individuals of 180 cm TL and greater.

techniques we used and also of the cryptic behavior of smaller crocodiles and the heavily vegetated nature of their habitat.

Studies of growth rates of captive crocodiles at the Laguna de Tesoro farm (R. Ramos pers. obs..) suggest that crocodiles up to 40 cm TL are young hatched this year (1993). Crocodiles up to 60 cm probably represent the previous year's (1992) age class. The presence of animals of this size class confirms that both species nest and successfully produce young in the Zapata Swamp. At the farm crocodiles of both species reach sexual maturity at around 180 cm TL. Crocodiles of 180 cm TL and greater were presumed to be adults in the field. The largest *C. rhombifer* (and the largest crocodile) captured in this study measured 246 cm TL. Several *C. rhombifer* exceeding 3m length have been captured in the wild by the Cuban field team and several captive *C. rhombifer* at the farm approach 4m TL. *C. acutus* achieve greater length in the wild (up to 7 m, Medem 1981), but animals of this size have not been reported recently in Cuba.

The proportion of adult crocodiles in larger size classes was greater in *C. acutus* than *C. rhombifer* although the absolute number of crocodiles represented was less. This may reflect the larger maximum body size achieved by *C. acutus* or may alternatively be an indication of a differing age structure in the two species. The largest individuals of either species seen in the Zapata swamp are considerably smaller than the maximum size for the species.

SEX RATIO.

The proportion of females in the sample of *C. rhombifer* greater than 60 cm is 0.75 (N=168). Gender was not determined for crocodiles smaller than 60 cm TL. In the sample of adult *C. rhombifer* (TL 180 cm and greater) the proportion of females is 0.65 (N= 26) which is not significantly different from the expectation of equal sex ratio. Adult females make up 10% of the sampled *C. rhombifer* population. Sex ratio varied quite dramatically between locations (Figure 5). For two locations, Jamon and Emetario, the proportion of males to females among adults was almost exactly 0.50 while the Rinconada del Diez sample showed a strong bias in favour of females in both the adult (0.90) and total samples (0.92).

For *C. acutus* the ratio of females for all locations combined was 0.52. The small number of individuals in the samples precludes meaningful analysis of sex ratio in the adult population or between locations.

POPULATION ESTIMATION.

To calculate the number of crocodiles apparently present in the study area we combined the samples from hand capture and traps and used Schumacher's Method (Bayliss 1987)

$$N = \frac{\text{SUM } Mi^2 ni}{\text{SUM } Mi\ mi}$$

Where N is the Estimated Population
Mi is the number of marked animals in the population immediately preceding the ith captures
ni is number of animals captured on the ith occasion
mi is the number of previously marked animals captured on the ith occasion

The assumptions of this method, in common with other similar mark and recapture indices, are:

a. No animals are born or immigrate into the study area.

b. Marked and unmarked animals die or leave the study area at the same rate.

c. All animals are equally likely to be caught.

d. No marks are lost.

Given the short duration, limited movement of marked animals and the marking methods used we consider assumptions a. and d. to be secure. Violations of assumptions b. and c. are considered in Discussion below.

Table 4. Calculated number of crocodiles from mark and recapture studies at three locations in the Zapata Swamp, Cuba. $N = \text{SUM } Mi^2\, ni/\text{SUM } Mi\, mi$, Standard Error from the equation in Bayliss 1987: 174.

Location	Date	Mi	ni	mi	Estimated population	2 Standard errors
C. rhombifer						
Jamon Camp	5 Oct.	0	50	0		
	6 Oct.	50	17	8	106.3	59.1
	7 Oct.	58	12	6	116.0	27.7
Emetario Camp	9 Oct.	0	29	0		
	10 Oct.	29	24	4	174.0	53.3
	11 Oct.	49	18	6	147.0	41.9
Rinconada del	14 Oct.	0	43	0		
Diez	15 Oct.	43	20	4	215.0	58.9
	16 Oct.	56	16	3	298.7	35.8
C. acutus						
Jamon Camp	5 Oct.	0	12	0		
	6 Oct.	12	3	1	24	12.0
	7 Oct	14	3	1	28	6.0
Emetario	9 Oct	0	9	0		
	10 Oct	9	13	1	63	21.8
	11 Oct	20	5	3	30	16.3
Rinconada del	14 Oct	0	1	0		
Diez	15 Oct	1	3	0	insufficient recaptures for calculation	
	16 Oct	4	4	0		

This method allows a check on the assumption of equal catchability (c. above). If the

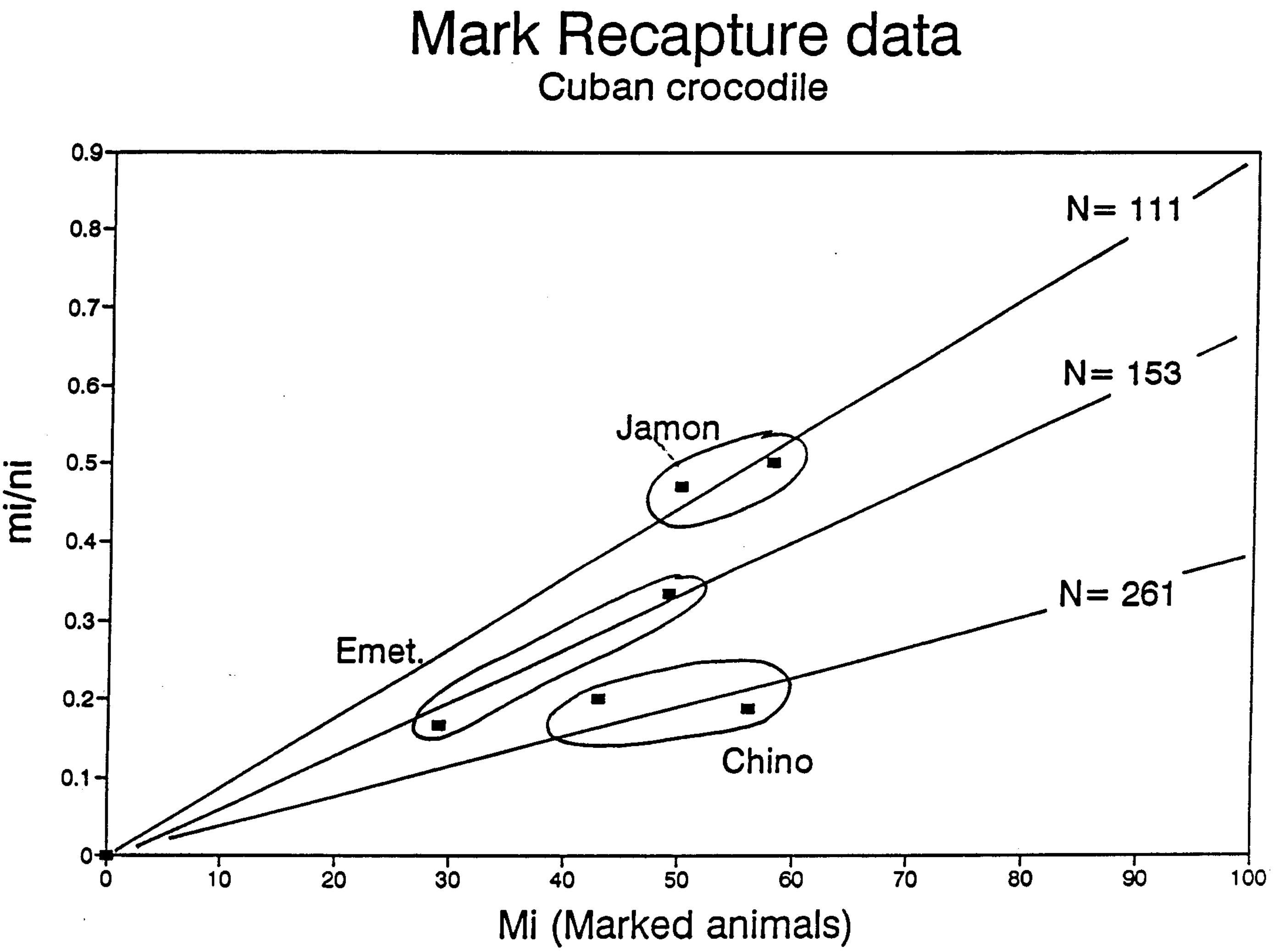

Figure 7. Regression of mi/ni against Mi to test for equal catchability. Slope of the lines estimates 1/N

assumption is not violated a regression of mi/ni on Mi is linear through the origin and the slope of these regressions is equal to 1/N. These regressions are shown in figure 7. The estimates of population size at the three locations are very close to, and well within the confidence limits of, the estimates derived above. (Jamon N = 111, Emetario N = 153 and Rinconada del Diez N = 261).

We calculated the estimated number of crocodiles of each species at each of the camps, combining the data from the three transects at each camp. We captured and marked crocodiles for three days and can calculate population estimates for the second and third day at each location. The results of this calculation are given in Table 4. Ninety five percent confidence limits for these estimates (plus and minus 2 Standard Errors of the estimate) were calculated and the extreme high and low values at each location summed to estimate the total number of crocodiles in the three sampling areas, shown in Table 5.

Table 5. Population estimates and 95% confidence limits for *Crocodylus rhombifer* mark and recapture studies at three locations in Zapata Swamp, Cuba.

Location	Mean estimated population		95% range
Jamon Camp	111		63 -165
Emetario Camp	160		105 - 227
Rinconada del Diez	256		156 - 333
Summed totals	527	Min - Max	324 - 725

We also calculated populations using the sample of crocodiles marked at each camp by the Cuban field team in preceding years. In this case we used the modified Petersen estimate (symbols as above):

$$N = \frac{M \cdot n + 1}{m + 1}$$

In this case the total number of previously marked animals is M and the total of all such previously marked animals captured during the present study is m. One animal is added to both samples and recaptures to compensate for small recapture numbers. Again, we calculated estimated populations for each of the three camp sites separately. In this estimator there is a significant probability that some animals have been born or entered the area (assumption a.) which would lead to an overestimate of the population, however, the greater time period for distribution of animals makes this estimator perhaps more indicative of the larger scale situation.

Table 6. Population estimations using the sample of crocodiles marked in 1989 -1992 by the Cuban field team and recaptured during the present study. Method of Petersen as described by Bayliss 1987.

	Number marked (year)	Recaptured October 1993	Estimated N ($\pm$ 2SE)
C. rhombifer			
Jamon	75 (1990)	16/65	291 ($\pm$ 118)
Emetario	72 (1992)	4/59	864 ($\pm$ 675)
Rinconada Del 10	78 (1990)	8/65	572 ($\pm$ 336)
Total Sum of three separate locations (with 95% confidence limits)			1,727 (598 - 2,856)
C. acutus			
Jamon	23 (1990)	2/16	130 ($\pm$ 118)
Emetario	18 (1992)	3/24	112 ($\pm$ 92)
Rinconada Del 10	12 (1990)	1/6	42 ($\pm$ 40)
Total Sum of three separate locations (with 95% confidence limits)			284 (34 - 534)

DENSITY

By combining the estimates of population size with the minimum and maximum estimated areas of the study sites we can calculate the density of crocodiles(Table 7). In the interests of obtaining the most conservative estimates of density we choose to use the greater estimate of study area derived from the absence of movement between our study sites.

Table 7. Calculated density of crocodile populations in the Zapata Swamp.

Estimated population	Area of study	minimum calculated density (95% confidence range)
C. rhombifer		
Schumaker estimate this study Table 5.		
527 (324 - 725)	27.27 km ^{2}	19.3 (11.9 - 26.6) individuals/km ^{2}
Petersen estimate, this study and earlier marking, Table 7		
1,727 (598-2,856)	27.27 km ^{2}	63.3 (21.9 - 104.7) individuals/km ^{2}
C. acutus		
Schumaker estimate this study Table 5. (Jamon & Emetario only)		
70 (38 - 98)	18.62 km ^{2}	3.8 (2.0 - 5.3) individuals/km ^{2}
Petersen estimate this study and earlier marking, Table 7.		
284 (34 -534)	27.27 km ^{2}	10.4 (1.2 - 19.6) individuals/km ^{2}

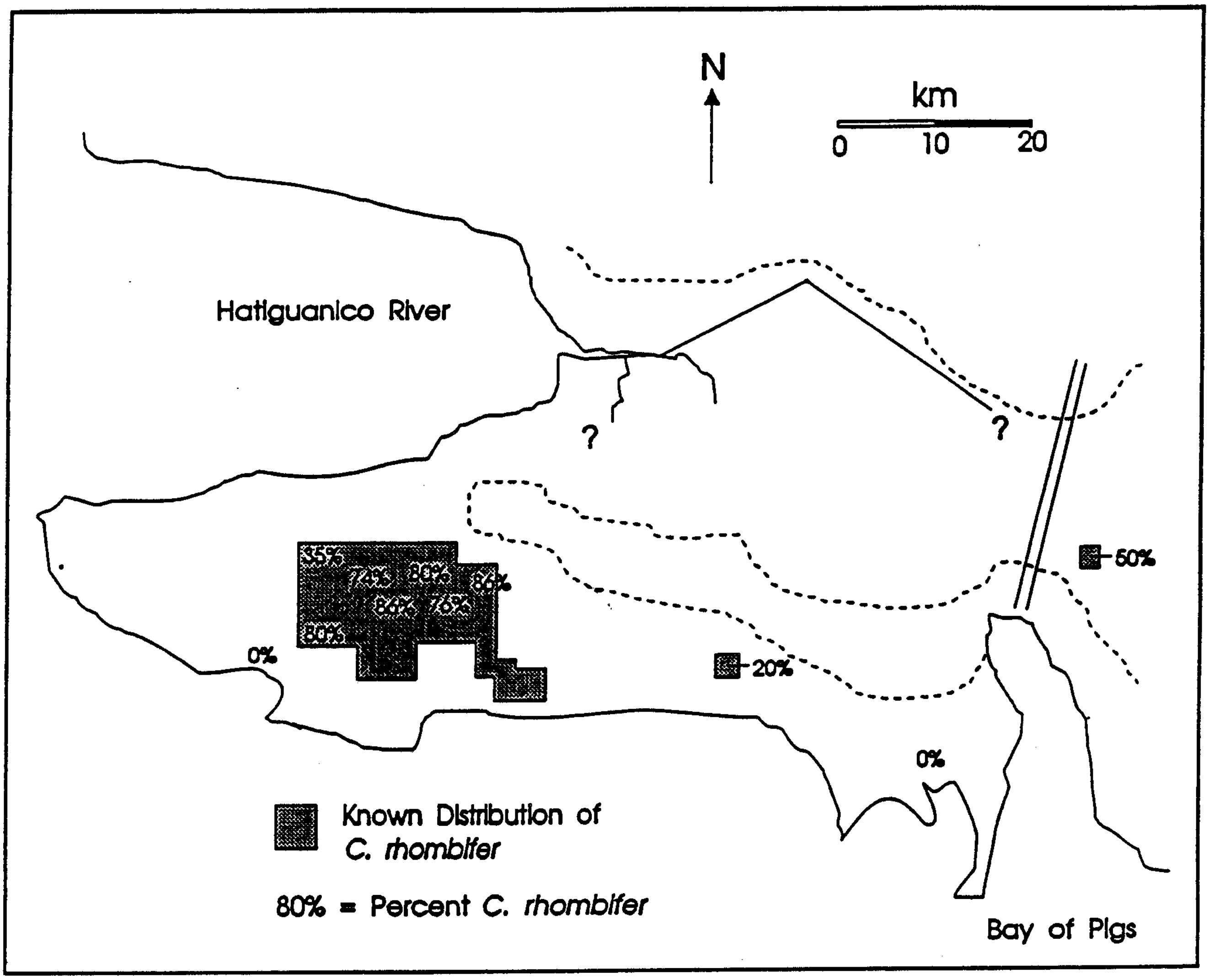

Figure 8. Known distribution of *C. rhombifer* in the wild. Data were combined from previous field studies (Table 9.), aerial surveys (Figure 2.) and field data. Percentages indicate the percentage of *C. rhombifer* in the total of *C. rhombifer* and *C. acutus* at each locality estimated from frequency of captures. Area estimated from the number of 4 km^2 grid squares on the 1: 100,000 scale map where *C. rhombifer* are confirmed present.

Table 9. Summary of crocodiles captured and marked at various localities within the SW Zapata Swamp, Cuba, by R. Ramos and the MIP field team 1989 - 1992. Technique used was hand capture identical to the present study. Species, size class and effort (days worked) are shown. RB = *C. rhombifer*, AC = *C. acutus*. Localities Jamon, R. del 10 and Emetario are the same as the present study. Other localities are indicated on fig. 8. Data from R. Ramos unpublished MS used with permission.

Area	Deleitosa		El Jamon		R. del 10		Castro		R. del Pino		La Perra		Emetario	
Date	Aug-Sep 89		Oct 90		Oct 90		Sep 91		Oct 91		Sept 92		Aug 92	
Species	RB	AC	RB	AC	RB	AC	RB	AC	RB	AC	RB	AC	RB	AC
< 60 cm	-	-	20	-	15	-	-	-	35	-	11	-	15	-
60 - 150 cm	4	8	12	-	37	3	12	4	42	5	17	-	14	4
151 - 180 cm	12	18	31	19	20	9	27	6	10	15	25	6	20	9
> 180 cm	17	36	12	4	6	-	31	15	5	3	30	7	23	5
Total	33	62	75	23	78	12	70	25	92	23	83	13	72	18
Days capture	13		15		15		12		12		14		15	

Distribution and Total Population

The area occupied by *C. rhombifer* in the wild is indicated in Figure 7. This distribution is derived in part from the aerial survey results (Figure 2), in part from the field work of this study, and (the majority of information) from field work conducted between 1988 and 1993 by the Cuban field team. Table 8 indicates numbers and species caught and marked by the Cuban team at a variety of locations including the three sites that we studied intensively. It is evident from the ratio of *C. rhombifer* and *C. acutus* that there is a core area where *C. rhombifer* is more abundant, a transitional area, and an extensive coastal region of the peninsula where *C. acutus* is found exclusively. We used the 1: 100,000 map of the region and characterized the number of 4 km^2 quadrats on this map where *C. rhombifer* is known to be present (the shaded area on Figure 7). This area comprises just over 300 km^2 which is the present known distributional area of this species in the wild.

The lowest estimate of this population we calculate is to use the density of crocodiles seen from the air (2.29/km^2) corrected for the average proportion of *C. rhombifer* in the core area (about 74% from Table 9) and extrapolate to a total population of 508 individuals, but this is smaller than the total number of *C. rhombifer* caught and marked to date (692)! This is most certainly an underestimate.

Extrapolation of our estimates of mean density of between 19.3 - 63.3 individuals/km^2 to the 300 km^2 area, suggests the wild population of *C. rhombifer* is in the order of 5,790 - 18,990 individuals. Our sample indicating 10% of the population are adult females extrapolates to an adult female breeding population of between 579 and 1,899. The statistical uncertainties associated with these estimates are around plus and minus 40% of the estimate. However such extrapolations are perilous. For the purposes of management we recommend the cautious approach of using the lower confidence limits of these estimates. We can therefore say with confidence that there are a minimum of around 3,000 *C. rhombifer* in the Zapata swamp and likely around 5,000-6,000.

Hybridization.

The two species, *C. acutus* and *C. rhombifer*, are completely sympatric in the Zapata Swamp and can be captured literally side by side. Hybrids are well known to occur in captivity, although the Tesoro farm reports that only crosses between male *C. acutus* and female *C. rhombifer* normally occur. This would appear to be a result of the non-synchronous breeding seasons reported. The hybrids are reported to be most similar to *C. acutus* in appearance and in temperament, differing only in their regular *C. rhombifer*-like scalation and a tendency toward an intermediate form of head shape. Hybrids are reported to have normal behavior and normal appearing gonads, but their fertility in captivity has not been established (R. Ramos pers. obs.).

Among the 233 crocodiles we handled during field work we identified six (2.5%) that appeared to have external characters similar to the hybrids described above. These animals were most similar to *C. acutus*, and were treated as such for the purposes of estimating population data and numbers, but had intermediate head shape and regular scalation. We also recognized seven other crocodiles that appeared to be *C. rhombifer* but showed some irregularity of dorsal scalation, however we interpret these to be indicative of a degree of natural variability in the normal *rhombifer* phenotype. We cannot say that any of these animals are natural hybrids, only that they show intermediate external characters. What is much more striking is that even though each study site contained both species in significant numbers, the great majority of individuals were clearly assignable to one species or the other. This suggests to us that hybridization in the wild, if it occurs at all, is not a common event and in particular that *C. rhombifer* is maintaining its species integrity even though it is constantly in contact with *C. acutus*. Genetic testing will clarify this situation and we have begun to collect tissue (blood) samples which are now lodged with the Cuban authorities, to accomplish this.

DISCUSSION

Our conclusions rest heavily upon the mark and recapture results, although they are supported by other aspects of our data. It appears from inspection of Table 4 that the number of crocodiles captured (ni) was reduced progressively from day to day at each site. At the same time the proportion of marked animals in the daily sample generally increased. This suggests the crocodiles may be responding to capture by being more wary, but that marked animals are not preferentially leaving the site. Numerous studies and abundant anecdotal information report the rapid response of crocodiles to disturbance and this forms one of the most predictable biases in all kinds of survey techniques. In this case, as marked and unmarked animals seem equally affected, no distortion of the calculated population size will result.

We remain cautious that our calculation of the area from which crocodiles are attracted to the bait stations may be incorrect and this remains the most serious source of bias in our results. The one possibility that we cannot entirely refute is that these crocodiles range widely over the whole 300 km^2 of their distribution and that most of them were attracted to our study sites during our study. This would cause our estimate of population to be too high. The absence, in our sample, of crocodiles marked in previous years at distant locations tends to refute this concern. Some species of crocodiles are reported to move over long distances while others remain sedentary (Joanen & McNease 1972, Hutton 1989, Webb & Messel 1978). Studies of the movement of *C. rhombifer* involving both additional tagging and radio tracking would help resolve this point.

The spotlight survey of Laguna Tesoro indicated a surprising paucity of crocodiles and those that were present were very wary. It seems likely to us, although unproven, that crocodiles in Laguna Tesoro originated in the nearby crocodile farm. The behavior of these animals strongly suggests that they have been persecuted recently. Laguna Tesoro is the location of an important tourist center and sport fishing industry. A population of large crocodile would be incompatible with this use and a management plan for crocodiles should consider the aspects of control of nuisance crocodiles at this public location.

The aerial survey results indicate the presence and distribution of crocodiles but resolution of the actual numbers, species and biological data requires additional study on the ground. The extremely high cost of aircraft charter in Cuba makes the use of this technique difficult at present, but if a source of cheaper air time could be identified (perhaps military or police aircraft) then aerial surveys provide a rapid and repeatable index of crocodile populations. It is less important to measure the actual number of crocodiles than it is to identify the trends in numbers. Graham (1988) suggests that in order to detect a population trend of 50% from one survey to the next, survey coefficient of variation (the Standard Error as a percentage of the Mean value) needs to be reduced to 5- 15%. Coefficients of variation for our surveys varied from 27% - 38% (Table 2.). Improved coefficients of variation would likely result from additional observer training and experience and the application of appropriate stratification to the sample area. For the time being it seems that ground survey techniques will continue to be the most effective indicators of crocodile population trends in the Zapata Swamp.

In order to achieve comparable results in successive surveys it is mandatory that a standardized methodology be used. The present study provides a base line for future evaluation, but this will only be valid if the same sample areas and methods are used. The technique of hand capture over bait stations appears to have provided an adequate survey with minimal sample biases. In the future it will be useful to utilize the same transects. A problem that may arise is if the crocodiles become more wary as a result of repeated disturbance and capture. It seems likely that the present approachability of the crocodiles results from them only seeing people every two or three years. There is therefore a necessary trade off between sample frequency and maintaining capture efficiency close to its present 90% value. In anticipation of likely changes in crocodile behavior it would be advisable to develop alternative capture methods and apply them in parallel with hand capture so that future comparisons between methods can be calibrated.

CONCLUSIONS

In the absence of any data, several recent reports expressed concern that the combination of heavy hunting in the period prior to 1959 and the removal of a large number of wild animals to stock the Laguna Tesoro crocodile farm in the early 1960's might have severely reduced, or even eliminated, the wild population (e.g. CSG 1992). It now seems clear that survivors remained in the wild and that in the ensuing 30 years, and benefiting from complete protection from human persecution extended by the Cuban authorities, this population is making a substantial recovery.

This study has demonstrated that a significant wild population of *C. rhombifer* occurs in the wild in the Zapata Swamp. Even if the most conservative and pessimistic interpretation of our data is adopted, it seems certain that the wild population numbers in the thousands and includes over a thousand adults. Consideration of the size distribution, sex ratio and demonstrated breeding activity all suggest that this is a vigorous and self-sustaining population. Our study further shows that this population is restricted to a rather small area. Prior uncertainty about the existence of the wild population can be laid to rest and the primary remaining concern can be focussed on ensuring this population's persistence.

The restricted distribution of this population remains a serious concern. It is evident that small numbers of *C. rhombifer* occur outside the core area, for example in Laguna Tesoro and possibly in the Zanja de los Patos. All of these areas are outside the designated Zapata National Park. The area is currently buffered from human impacts by the extreme difficulty of access and the unsuitability of the area for agriculture, industry, habitation or any other current use. However, this is a tenuous level of protection for such a unique crocodile population. It is easy to imagine a future in which some unanticipated new use, for example newly discovered mineral wealth (oil ?) or the requirements for military training areas, might quickly change the present situation. The present Cuban system of land management and development requires a formal consultation process between all interested government entities prior to changes in land use. It is therefore unlikely that the area will come under any threat that would affect the persistence of the crocodile population without the opportunity for consideration of the crocodiles. Nevertheless, formal protection for the area where the crocodiles actually live is highly recommended.

Beyond protecting the present crocodile population it would be advisable to ensure that some other viable natural populations exist. Uncertainty remains about the status of *C. rhombifer* in its reported range on the Isla de Juventud. The existence of another population would be of great value as insurance against natural disaster. Several suitable wetland areas, including Lanier Swamp on Isla de Juventud, could be the location of restocking programs and there is an abundant source of stock from the farm, and now from the Zapata swamp. However, prior to restocking a careful evaluation of the species habitat needs and the causes of its disappearance from its earlier range should be assessed. It would be a waste of time to restock without this information only to have the restocked populations fail. There is also need for caution that any restocking uses the purest possible stock of *C. rhombifer* and includes adequate genetic variability.

Cuba presents a very favorable situation for the development of sustainable use programs that ensure both national economic benefit and the long-term conservation of crocodiles and their habitats. In the present phase the production of products of *C. rhombifer* from closed cycle breeding farms is justified by the very endangered status of the wild population. The possibility of products (skins) from the wild population reaching international trade is virtually zero given the well organized regulatory and enforcement capacity of the Cuban authorities and the strong government control of export trade. Similar use of other species in Cuba, particularly, *C. acutus*, requires population surveys of the type reported here. For the longer term it would be beneficial to recognize the intrinsic merits of ranching crocodiles by collecting eggs and hatchlings from self sustaining wild populations.

Recommendations to meet these needs have been presented to CITES and the Cuban authorities. These are divided into recommendations to ensure the protection of the wild *C. rhombifer* population, recommendations for future study and monitoring and recommendations for the management of captive production in the farm to ensure conservation benefit to the wild population.

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STATUS OF CROCODILES IN THE PHILIPPINES. AN UPDATE. 1994.

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Since the 1982 SI/WWF report on crocodiles in the Philippines the status of crocodiles in the wild has changed little except we suspect a deterioration caused in part by harvest, but mostly owing to continued loss of habitat. Future rate of habitat loss will likely increase as under the Ramos regime, peace and order throughout the country is improving and some lowland areas, previously dangerous for agricultural use, are now becoming available. The immediate future of crocodiles in the wild continues to be bleak. As such, emphasis on captive management continues to form the principle component of crocodile conservation in the Philippines.

Since 1982, survey work conducted by CFI staff and Smithsonian Institution fauna inventory studies has revealed three additional wild crocodile populations. These are <u>Crocodylus mindorensis</u> on Busuanga, an island where they had previously been assumed extinct, <u>Crocodylus porosus</u> on

Siargao island, and a yet unidentified population (likely _C. porosus_) on Dalupiri Id., north of Luzon (R. I. Crombie, pers obs.). Also the existence of _C. mindorensis_ in the Agusan river basin, previously a matter of conjecture, has been confirmed (J. Diaz, pers. obs.).

Captive management of crocodile resources in the Philippines is best addressed in three categories: the two legal farms at Silliman University in the central islands and the Crocodile Farming Institute, non-sanctioned farms, and, foreign breeding programs.

SILLIMAN UNIVERSITY (SU)

Owing to space and food restraints the SU project will remain small. Currently they have 23 _C. mindorensis_ which include a single breeding pair, several adult males, and young. They are interested in obtaining one or two more adult females for breeding.

CROCODILE FARMING INSTITUTE (CFI)

CFI started operations in 1987. Since that time they have accumulated 281 _C. porosus_ and 202 _C. mindorensis_ from private captive sources and the wild. Active acquisition of crocodiles ceased in 1992. Successful captive breeding started in 1989 and has increased dramatically with 1046 _C. porosus_ and 564 _C. mindorensis_ produced during the 1993 breeding season. The total number of crocodiles at CFI as of Dec 1993 was 2074. If the increased rate of successful breeding continues, CFI will soon have to cull stock or exceed their original goal of 200 adult breeders and 5000 young.

CFI was initially started as a research institute and training center. To date their accomplishments along these lines have been limited. However as excess stock of *C. porosus* become available, CFI will likely assist several private corporations in the Philippines develop crocodile breeding/rearing projects integrated with poultry or livestock enterprises. Only after several such projects are initiated will CFI as a CITES registered farm for *C. porosus* start culling crocodiles for their skin.

UNSANCTIONED FARMS:

The number of unsanctioned farms cannot be accurately determined. We suspect that there are less than half a dozen of consequence, or holding 50 or more crocodiles. In addition there are a seemingly endless number of small local zoos and private landowners with one to several crocodiles in their possession. The ultimate status of these enterprises is indeterminate but likely will have little influence on the potential crocodile industry in the Philippines.

FOREIGN FARMS:

Gladys Porter Zoo, Brownsville, Texas, has a breeding pair and two excess male *C. mindorensis*. The breeding pair are successfully producing young on an annual basis. During 1993, 5 progeny from this project were returned to the

Philippines for disposition by Silliman University and the Department of Environment and Natural Resources. It is anticipated that young from this project will continue to be returned to the Philippines for release in secure sanctuary areas.

Melbourne Zoo (Australia) recently received a pair of *C. mindorensis* from the Silliman University project noted above.

Few other *C. mindorensis* exist in foreign zoos and most are without known provenience.

The Atagawa Tropical Gardens, Japan, has sought *C. mindorensis* from the Silliman University project for several years but has not been able to obtain the requisite CITES import permit from MITI even with support from the Philippine government and CSG. The controlled export of *C. mindorensis* to foreign zoological parks is an important component of the conservation plan for this species and in this instance application of CITES regulations appear to be working against the conservation of the species instead of for it.

CONSERVATION BENEFITS OF CAPTIVE BREEDING - A CITES PERSPECTIVE

Prepared for the 12th Working Meeting of the
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Background

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was concluded at an international conference held in Washington DC in February/March 1973. It wa a direct result of the United Nations Conference on the Environment and Development (UNCED), held in Stockholm the previous year. Countries represented at the 1972 UNCED identified inadequate regulation of international trade in wildlife as a major factor contributing to the decline and extinction of many species of wild animals and plants. Accordingly, UNCED resolved to develop an international treaty to address and correct the problem. Twenty-one years later, with more than 120 countries as Parties to the Convention, CITES is one of the most important multilateral legal instruments operating to enhance, through international cooperation and appropriate regulation of trade, the sustainable use of certain wildlife.

When CITES was formulated, the participating countries established two principal categories of wild plants and animals - Appendix I and Appendix II based on the perceived threat of extinction and/or level of international trade. Appendix I contains those species which are considered to be in imminent danger of extinction and for which international trade must only be authorised in exceptional circumstances. Appendix II was for the much larger number of species which, although not necessarily threatened with extinction, may become so unless international trade was subject to appropriate regulation. Appendix II also contains species which closely resemble those in Appendix I.

CITES does permit commercial trade in Appendix I species under certain circumstances. Article VII paragraphs 4 states:

> "Specimens of an animal species included in Appendix I bred in captivity for commercial purposes, or of a plant species included in Appendix I artificially propagated for commercial purposes shall be deemed to be specimens of species included in Appendix II."

and Article VII, paragraph states:

> "Where a Management Authority of the State of export is satisfied that any specimens of an animal species was bred in captivity or any specimen of a plant species was artificially propagated or is part of such an animal or plant or was derived therefrom, a certificate by the Management Authority to that effect shall be accepted in lieu of any of the permits or certificates required under the provisions of Article III, IV or V."

Thus, the Convention provides an avenue by which international trade in Appendix I-listed species may be undertaken; namely where they have been derived from closed-cycle captive breeding or artificial propagation. In this case, they are considered as Appendix II species and traded according to the regulatory requirements applying to Appendix II species.

The rationale for this provision was recognition that the captive production of critically endangered species of plants and animals in isolation from the wild populations, for the purposes of trading in products derived from them, was unlikely to impact adversely on the conservation of the wild resource if appropriate controls were in place. In fact it may benefit conservation by removing pressure from the wild resource.

The situation with Appendix II species is quite different. Parties can apply any form of sustainable management to Appendix II-listed species. There is no requirement to restrict trade to captive bred specimens (as for Appendix I species) and in fact, the sustainable use of wild populations is often encouraged. Mechanisms are provided by the Convention (eg Article IV.3) that require the Scientific Authority of an exporting country to monitor export levels and ensure that use is not excessive and detrimental to the species concerned.

Captive breeding of Appendix I species for commercial purposes has been problematical for CITES and has been the subject of numerous resolutions to interpret the text of the Convention and guide effective implementation of the provisions of Article VII.4 and 5.

The first effort occurred in 1979 at the second meeting of the Conference of the Parties. *Resolution Conf. 2.12* (San Jose, 1979) provides an interpretation of "bred in captivity", "artificial propagation" and other related terms contained in Article VII.4 of the Convention. The sustainability of captive breeding was identified as an important element and operations were required to demonstrate a capability of "reliably producing second generation offspring in a controlled environment". Furthermore, captive breeding operations were required to demonstrate that they had been "established in a manner not detrimental to the survival of the species in the wild". By incorporating this requirement into the resolution, it is clear that the Parties to CITES were directing their attention to the application of captive breeding as a means of trading in specimens of Appendix I species which were critically endangered.

The second resolution was adopted at the fourth meeting of Parties. *Resolution Conf. 4.15* (Gaborone, 1983) established measures to control trade in material derived from captive breeding operations involving Appendix I species. It also required the Secretariat to establish and maintain a register of such operations. Relative to later developments, the measures adopted at the fourth meeting were superficial. No mechanism was in place to independently verify the bona fides of individual operations. The Management Authority of the Party concerned was responsible for advising the Secretariat and there was no requirement for the Management Authority to provide information on the management of the captive breeding operation.

In 1987 the sixth meeting of the Conference of Parties recognised the enforcement difficulties of permitting trade in captive bred specimens of an Appendix I species and adopted *Resolution Conf. 6.21* (Ottawa, 1987). This resolution introduced the requirement for approval of the Parties for captive breeding operations involving the first use of an Appendix I species. It also provided a default mechanism whereby any Party, becoming aware of non-compliance by any registered breeding operation, could propose, through the Conference of the Parties, deletion of the operation from the Register of Approved Captive Breeding Operations maintained by the Secretariat. Resolution Conf. 6.21 made the first serious attempt to identify products derived from captive breeding operations by requiring a marking system similar to that established for products derived from ranching (Resolution Conf. 5.16).

At the seventh meeting of the Parties, *Resolution Conf. 7.10* (Lausanne, 1989) established a format and criteria for proposals to register the first commercial captive breeding operation for an Appendix I species. It consolidated all previous resolutions on captive breeding. In adopting Resolution Conf. 7.10, the Parties acknowledged that it was an interim arrangement and should be reviewed and considered by the eighth meeting of the Conference of the Parties. In formulating this resolution, the Parties acknowledged in paragraph (a) that some Appendix I listings did not apply to critically endangered or even rare species:

"a)(i) that if an Appendix I species is so numerous in the wild that its survival does not depend on a captive-breeding programme, the specimens used to start and maintain the first registered commercial captive-breeding operation should have been obtained without detriment to the wild population;"

Resolution Conf. 7.10 was subject to extensive review and a revised version was considered by the eighth meeting of the Parties in 1992. *Resolution Conf. 8.15* (Kyoto, 1992) provides a comprehensive registration procedure that defines the respective roles and responsibilities of each participant (captive breeding operation, Management Authority, Secretariat and the Conference of the Parties) in the approval process. Res. Confs. 4.15, 6.22 and 7.10 were repealed following the adoption of Resolution Conf. 8.15.

Under the present procedure, it is no longer necessary to obtain the approval of the Conference of the Parties for every proposal to register the first use of an Appendix I species for commercial captive breeding. However, the Secretariat is required to notify Parties that it has received a proposal to register a captive breeding operation and make that proposal available for examination, for a specified period, by any Party. If no objection is received during the review period, the operation is approved and included on the Register maintained by the Secretariat. Should any Party raise an objection, a decision on registration is postponed and the proposal is referred to the next meeting of the Conference of the Parties. Resolution Conf. 8.15 also introduced considerations related to the establishment of commercial captive breeding operations in areas where the taxon is not indigenous, and where the complex issues of range state property rights are involved. Resolution Conf. 8.15 also requires the Management Authority, where necessary, to ensure that a captive breeding operation will continue to make a meaningful contribution to the conservation of the species concerned.

The eighth meeting of the Conference of Parties also adopted a resolution which provided additional criteria for the establishment of captive-breeding operations and for the assessment of ranching proposals for crocodilians. *Resolution Conf. 8.22* (Kyoto, 1992) recognises that there is an inherently greater conservation risk in providing incentives for the establishment of captive breeding operations involving crocodilians than for ranching operations based on harvesting from the wild. In the long term captive breeding may have a negative impact and damage efforts to conserve wild populations than for ranching operations which, in principle, are more beneficial to the conservation of wild crocodilians.

Discussion

The Parties to CITES have devoted considerable effort towards refining and "tightening" the standards and controls which apply to the registration and operation of commercial captive breeding operations permitted to trade in specimens of Appendix I species. Clearly, the goal has been to ensure that any international trade in captive bred Appendix I species which are highly endangered in the wild does not contribute to further threatening the survival of the species in the wild.

Although the emergence of commercial crocodile farming based on closed-cycle captive breeding predates CITES, the proliferation of this form of commercial use can be traced back to the time when all the commercially valuable species were listed in Appendix I of CITES and trade in the species was only permitted for material that had been derived from this form of close order management. In this regard there can be little doubt that commercial captive breeding of crocodilians has contributed to conserving some species of crocodilians and benefited the continued recovery of formerly depleted stocks of the wild resource. Further indirect benefits from the establishment of crocodile farming have been their contribution to increasing community understanding and appreciation of crocodile conservation. Farms also provide a pool of stock for use in restocking programs such as that which is about to be commenced in Thailand with *Crocodylus siamensis*. Many developing world countries do not possess the administrative capacity to regulate effectively broad scale wild-harvest programs, particularly where harvests occur in remote areas and involve a large number of individuals. Under such circumstances, closed-cycle captive breeding may benefit conservation of the wild resource by enabling Management Authorities to concentrate their regulatory effort on a smaller number of operations. Enhanced enforcement is also achieved by focusing attention on exit ports or border crossings.

An assessment of the present conservation status of many of the species formerly included in Appendix I suggests one or both of the following conclusions:

a) that CITES has been successful and commercial use of these species through captive breeding has served its purpose and benefited the conservation of the wild resource; or

b) some species were inappropriately included in Appendix I in 1973 when the Convention was formulated and the extent of information on many of the species that were placed in Appendix I was less than complete.

The adoption of Resolution Conf. 3.15 on Ranching by the third meeting of the Conference of the Parties in New Dehli in 1981 provides further recognition that the conservation of some Appendix I-listed species may be enhanced more by prescribing manipulative management of the wild resource rather than restricting management to closed-cycle captive breeding. Resolution Conf. 3.15 acknowledges that the conservation of certain species or populations of Appendix I-listed species can benefit from commercial ranching. Parties have applied this form of management to Appendix I species sufficiently abundant to withstand the regular removal of a component of the population to be managed under controlled conditions.

The adoption of closed-cycle captive breeding, ranching or wild harvesting in a particular country is dependent on a number of factors. The conservation status of the species in some cases will directly determine the choice of management. The commercial use of Appendix I-listed species is confined to material derived from closed-cycle captive breeding. The socio-economic conditions prevailing in a country will obviously influence the choice on management. In Australia and some other countries is simply not realistic to base commercial use of wild crocodilians on ranching alone. In order to be commercially viable, the operation of many crocodile farms cannot be solely dependent on stock obtained from the wild. Stock obtained from ranching the wild resource must be supplemented by material derived from on-farm captive production. In many cases, it may be preferable to implement ranching as a sustainable conservation strategy following the establishment of closed-cycle captive breeding operations to enable on-farm husbandry technology to be developed. This approach would provide the lead time to refine egg incubation and hatchling husbandry in order to maximise the value of the wild resource. it would also enable the relevant government regulatory agency to develop a suitable monitoring program and control systems.

An increasing number of resource managers are subscribing to the concept that effective long-term conservation of natural habitats and their associated wild species will ultimately depend on the sustainable use of the wild resource. This form of management has the ability to confer an economic value to natural habitats in a manner that provides for an equitable distribution of benefits to landowners. The present debate on the relative conservation merits of closed-cycle captive breeding of crocodiles has evolved into a complex and potentially divisive issue. Much of the problem has arisen as a direct result of species which are not critically endangered being included in Appendix I of CITES. The issue is not so much whether or not closed-cycle captive breeding is a valuable conservation tool. The issue relates to the selection of species on which to focus captive breeding. In this regard closed-cycle captive breeding should be seen as one element, applicable to critically endangered species, in an overall continuum of management options. Management of a species which was formerly considered endangered but which is in the process of recovery and becoming more abundant, must be flexible and have the capacity to adapt to the constantly improving conservation status of the wild resource.

Captive Breeding and Conservation. Allies or Enemies?

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Crocodile conservationists, farmers and ranchers have a commonality of purpose whether they realize it or not. The Crocodile Specialist Group has as its goal **conservation** of all crocodilian species, but there is a huge overlap between conservation, trade in skins and the entire crocodile industry.

With the principles of sustained utilization of wildlife in mind I suggest to you that not only any activity that supports crocodile conservation should be embraced, but all activities. If the end result is positive conservation then it must be considered.

As with most species when numbers become dangerously low it would be foolhardy to 'leave it to nature' to ensure their survival. Nature has already been prostituted with the introduction of exotic species and foreign predators. To sit back and watch a species demise because of a principle against captive breeding would be ridiculous to the extreme.

As little as three decades ago captive breeding was hailed as the ideal method to ensure a genetic reserve of crocodile species that were considered endangered.

To actively remove the opportunity for,or fail to support, captive breeding as one of the tools of conservation has to be challenged. The argument for this action seems to be based on the success of captive breeding farms as businesses and the perceived threat that they may impede development of more esoteric sustainable utilization of wildlife projects.

Captive breeding's contribution to conservation is under attack and by placing it so we risk the reputation of being politically flirtatious and embracing fashionable, trendy policies. Conservation issues are long term ones and the future holds many more traps than the past.

We do live in a complex world where most people are seeking an increased standard of living but are also concerned about the environment - we **can,and must**,have economic development side by side with concern and care for the environment. Unfortunately, we are being told that the natural environment is a fragile and complex equilibrium; that human caused disturbance will lead to irreversible destruction.

Realistically no natural system has **ever** been in equilibrium and **never** will be. Natural systems get burnt, blown over and inundated. Climate is not constant; it varies under forces which are not understood and which go beyond the concentration of greenhouse gases in the atmosphere. Volcanoes and earthquakes obliterate entire ecosystems and fill the air with dust particles and acid gases. Without adaption to these changes many species will die. Man's intervention may save many of them but at a cost.

Let me quote from the Report of the World Commission on Environment, better known as the Bruntland Report:

Quote:

"The downward spiral of poverty, inequality and environmental degradation is a waste of opportunities and resources. In particular it is a waste of human resources. These links between poverty, inequality and environmental degradation formed a major theme in our analysis and recommendations. What is needed is a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable"

Unquote.

This most substantive report on the environment draws attention to the effects of poverty on the environment and calls for a new era in economic growth. It is only countries that have achieved high standards of living and have technology available to them that can afford, have the interest in and the technology to meet the increasing demands for an improved environment - most countries with crocodiles are not in this category.

The world's population is growing - from 2 billion in 1930 to over 5 billion in 1990. Population growth is intimately connected with most aspects of current human predicament, including rapid depletion of non renewable resources, deterioration of the environment (including climate change) and increasing international tensions. Nearly one billion people are hungry every day.

Expanding populations are impacting on natural plant and animal communities. Plants, animals and microbes are now being threatened with a colossal extinction epidemic.

Global warming, acid rain, depletion of the ozone layer, vulnerability to epidemics, exhaustion of soils and ground water are all related to population size.

The relationship between population density and available resources is constantly changing.

Poorer nations will double their populations in 30 years.

Richer nations will take 120 years.

The distribution of the world's resources is not even and thus there are pressures in the poorer countries to exploit resources for survival of their people.

We can argue substantially to prevent commercialization or exploitation of resources in the richer nations as we only effect peoples wealth - but in the poorer nations the same argument may remove their ability to survive, let alone have much of any quality of life.

The population problem is not a private matter. The world's population is increased by 80 million more each year and pressure on our natural resources is becoming extreme.

Predicting the future effects of the exponential growth of human population will be difficult but it is unlikely that any government will choose the well being of crocodiles over the survival of its people. Population growth **will** result in depletion of sound crocodile habitat, reduction of numbers and maybe even extinction of several species.

The philosophy behind sustainable use of any wildlife is one based on the future security of its survival.

Sustainable use of crocodiles is not necessarily based on wild population size - even small populations can be utilized and the species can benefit as long as the rewards are used to support the ongoing conservation programme.

Sustainable use also has its critics. The fact that most sustainable use projects are singularly species specific, there is little knowledge of the impact of these projects on the bio diversity of the rest of that ecosystem. The arguments for and against captive breeding, sustainable use and the conservation value of each of them must take into account the social and cultural importance that crocodiles have in a community, their ecological importance and their economic importance. The interaction of these three elements will vary per crocodile species, and per country, and will change in the future.

History **should** have taught us by now to be flexible with our management practices. To remove any element of conservation practice or any management tool would only reduce our options for the future. Surely part of future conservation includes placing strategic incentives for the well being of crocodilian species. It seems incongruous that we accept commercial fishing and fish farming, forestry and timber plantations as industries exploitable for consumption. We also can accept domesticated animals and plants that have originated from wild species in the farming situation - so why not the wild species themselves?

To suggest that closed cycle crocodile farming may be detrimental to the viability of sustainable utilization projects is fallacious and should not be considered. Crocodile farming has a notoriously slow rate of return on capital investment and is generally taken up by those people who actually like the animal and commercial interests are secondary. Conversely where a substantial utilization programme is in place, it is more likely to attract people who have strong business interests but may have little empathy for the crocodiles themselves.

To suggest that one farm could be large enough to impact on sustainable utilization programmes would be like saying that the cattle industry in Australia could be owned by one company. Economics of scale, conflicting interests, available services etc. help position any farm at an appropriate level within its environment and its industry. Natural business laws determine the level of operation.

Farms provide a focal point for crocodile research, behavioural studies, community education and are generally self funding. They hold a genetic reserve of the species used and farmers are generally cognizant of the problems of conservation. To alienate these facilities as being separate and apart from the objectives of the Crocodile Specialists Group would be unwise, weak and inappropriate. Economic management is playing a vital role in the costly job of conservation and will be even more vital in the future.

Also in the future crocodile farming will come into competition for protein required for the health of the growing human population and so limit development.

History has also demonstrated that quite often it is the purists of the conservation world i.e. those that want areas locked up under government supervision and the banning of wildlife trade that quite often win support. Their arguments are often full of emotive substance which can damage the future prospects for conservation and limit our management prerogatives.

Unfortunately we have heard too much in the past of management prerogatives. There really aren't many but there are very definite management responsibilities. The most important of which is to ensure the survival of all of the world's crocodilian species.

I suggest that it is far better to have 4,000 Chinese alligators in captivity than to have none at all - or

20,000 *Crocodylus Siamensis* captive with very few in the wild. At least there is still a genetic reserve on which to base a revival programme.

Management has a responsibility to create within an organization a climate which is conducive to improved survival opportunities. People must feel they can be creative and try new approaches to problems, not be restricted in their choices. Certainly under these circumstances some mistakes will be made but it is not a case of organizations such as the Crocodile Specialist

Group not being able to make mistakes - rather organizations cannot afford the cost of limiting alternatives.

Crocodile farming is an ally, not an enemy, in the conservation process.

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CROCODILE MANAGEMENT AND RESEARCH IN THE NORTHERN TERRITORY: 1992-94.

by

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The central aim of this paper is to summarise progress with crocodile research and management in the Northern Territory over the last two years (August 1992 to April 1994). It is intended to complement the four previous updates presented at successive Crocodile Specialist Group (CSG) meetings [1986, 1988, 1990, 1992 (Manolis and Webb 1990; Webb 1989a; Webb *et al.* 1990a, 1992)].

MANAGEMENT PROGRAMS AND CITES

Both species of crocodilian (*Crocodylus porosus* and *C. johnstoni*) in the Northern Territory are on Appendix II of CITES. *Crocodylus johnstoni* has always been on Appendix II, whereas *C. porosus* was transferred from Appendix I to Appendix II for the purposes of ranching (Resolution Conf. 3.15) in 1985 (Webb *et al.* 1984).

Within Australia, wildlife conservation and management is a State/Territory responsibility, but the export and import of wildlife and products derived from them, into or out of Australia, is a Commonwealth responsibility. It is controlled by the Australian Customs Service and the Australian Nature Conservation Agency (ANCA - formerly Australian National Parks and Wildlife Service) according to the provisions of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. This Act makes export and import of species listed in CITES Appendices subject to the Federal Minister approving management programs for those species.

The current Northern Territory Crocodile Management Program, approved in January 1990 (CCNT 1989), terminates in January 1995, and a new 5-year program is in preparation. However, where management in the Northern Territory has progressed beyond ranching of eggs, Resolution Conference 8.22, passed at the Kyoto CITES Conference of Parties, now requires management to be restricted to ranching indefinitely if the original transfer to Appendix II occurred under Resolution Conf. 3.15. Thus, Australia has prepared a proposal for the 9th CITES Conference of Parties to have their *C. porosus* population retained on Appendix II pursuant to Resolution Conf. 1.2 (the Berne Criteria), rather than Resolution Conf. 3.15 (Ranching) so that more flexible management programs can be implemented.

Ranching has proved a very successful interim management strategy in the Northern Territory. As described later, the wild population has increased by 50% since it was introduced in 1984. However, it also has some serious limitations. For example, the only landowners that can benefit financially from the increasing populations of *C. porosus* are those with nesting habitats on their lands. Those without nesting habitats have had to put up with significant costs, in terms of stock losses, without any tangible benefits. The egg collection program has also proved to be only marginally profitable in remote areas, where the costs of helicopter access are significant.

HARVESTS

Under the current Northern Territory management program, wild harvests for all purposes come under a single, annual harvest quota (Table 1). These quotas were developed to allow increased utilisation by landowners, but Resolution Conf. 8.22 now restricts the ability to do so.

Table 1. Annual harvest quotas under the current Northern Territory management program.

	C. porosus	*C. johnstoni*
Viable Eggs	15,000	4000
Hatchlings	400	6000
Juveniles	500	1000
Adults	250	200

The estimated total wild take of *C. porosus* in the Northern Territory, since 1980, is summarised in Table 2. Estimates of Aboriginal harvests and mortality as a by-product of fishing indicate a reduction in the subsistence use of eggs (partly as a consequence of the ranching program) and a planned reduction in commercial fishing effort.

Table 2. Estimated numbers of *C. porosus* removed from the wild in the Northern Territory, 1980-1993, including estimates for Aboriginal harvesting and fishing mortality based on a reassessment (reduction) of estimates derived in 1984 (Webb *et al.* 1984).

Year	Crocodiles				Eggs	
	Problem	Stock	Aborig.	Fishing	Harvests	Aborig.
1980	39	6	150	250	-	2,500
1981	142	50	150	250	917	2,500
1982	55	-	150	200	-	2,500
1983	34	-	150	170	-	2,500
1984	38	-	150	170	2,320	2,500
1985	39	-	150	150	3,518	2,000
1986	51	-	150	150	3,737	2,000
1987	130	-	150	120	4,401	2,000
1988	112	-	150	120	5,300	2,000
1989	116	-	150	120	6,497	2,000
1990	205	-	150	120	12,010	2,000
1991	235	-	150	120	9,212	2,000
1992	139	-	150	120	15,298	2,000
1993	220	-	150	120	12,379	2,000
ALL	1,555	56	2,100	2,180	75,589	30,500

CROCODILE INDUSTRY STRATEGY

Up until 1992, most issues associated with crocodile conservation, use, research and monitoring in the Northern Territory were the responsibility of the Conservation Commission of the Northern Territory (CCNT), with ad hoc assistance from other Government Departments as required. In 1992, the Government introduced a "Northern Territory Crocodile Industry Strategy" at the request of some crocodile farmers, and this Strategy came into effect in October 1992.

All monitoring within farms and research into farm production aspects of crocodilian biology are now undertaken by the Northern Territory Department of Primary Industry and Fisheries (DPIF). Issues associated with industry development and marketing are the responsibility of the Northern Territory Department of Industries and Development (DID). The CCNT retains responsibility for the conservation, use, monitoring and management of the wild populations.

MONITORING - PROBLEM CROCODILES

Since August 1992, there have been no fatal attacks on people in the Northern Territory, although interactions between crocodiles and people swimming and fishing are regularly reported in the press. Added to this are steadily increasing stock losses on cattle properties. Calls for culling are on the increase and the economic value of crocodiles remains the single most important incentive for the public to accept the negative side of having large wild populations of *C. porosus* throughout the coastal wetlands.

As part of the public safety campaign within the Northern Territory, "problem" crocodiles are removed from the wild and assigned to crocodile farms. Such animals are broadly defined as "those within settled areas or areas of intense recreational use where public safety is a prime consideration and those individuals which affect a land-use activity (e.g. taking stock on pastoral land). In intensive contact areas such as Darwin Harbour and Gove recreational beaches, any crocodile, regardless of species or size, constitutes a 'problem'" (CCNT 1989). Annual numbers of "problem" crocodiles removed are summarised on Table 3.

Table 3. Numbers of problem crocodiles removed from the wild: 1986-1993.

Year	*C. porosus*	*C. johnstoni*	Total
1986	55	-	55
1987	157	1	158
1988	146	8	154
1989	132	7	139
1990	220	4	224
1991	237	11	248
1992	141	1	142
1993	220	15	235
Total	1308	47	1355

During 1992 and 1993, 361 problem *C. porosus* were dealt with by the CCNT (Table 3). Of these, 346 (95.8%) were distributed to crocodile farms, 4 (1.1%) were relocated in the wild, 11 (3.0%) died at capture. Most of the animals came from Darwin Harbour (82.5%) and Gove (6.6%).

Sixteen *C. johnstoni* were also regarded as "problem" animals during 1992 and 1993 (Table 3); three were taken to crocodile farms.

MONITORING - HARVESTS

Crocodylus johnstoni Harvests

No harvests of *C. johnstoni* hatchlings took place in 1992 or 1993. Egg harvests were limited to 49 eggs collected in 1992 (Table 4), all of which were considered viable at the time of collection.

In 1993, 27 *C. johnstoni* ranging between 1.0 and 1.72 m total length (mean= 1.37 m) were harvested from the Daly River, and were provided to crocodile farms.

Table 4. Numbers of *C. johnstoni* hatchlings and viable eggs (eggs containing a live embryo at the time of collection) harvested from the wild between 1986 and 1991.

Year	Hatchlings	Viable Eggs
1986	928	-
1987	2916	-
1988	1804	1505
1989	3400	2501
1990	1621	2071
1991	4579	953
1992	-	49
1993	-	-
Total	15,248	7079

Crocodylus porosus Egg Harvest

The results of *C. porosus* egg harvests are in Table 5. *Crocodylus porosus* have a prolonged nesting period (November to May) that coincides with the wet season. Large numbers of eggs are flooded before collection, and in some locations, where nests are constructed in the open, the eggs overheat (Webb and Cooper-Preston 1989). There is also a significant relationship between the extent of mortality in the field and the extent of mortality after collection [during artificial incubation;Webb (1989b)]. Thus although our assessments of "viable" eggs are based on live embryos at the time of collection, many of those embryos are already compromised. Variation in the numbers of eggs harvested each year (Table 5) reflects annual variation in nesting effort (Webb *et al.* 1990a), and also variation in harvest areas. Annual variation in nesting effort for some areas is summarised on Table 5.

Table 5. Numbers of *C. porosus* eggs harvested from the wild with an assessment of viability (containing live embryos at the time of collection), and the percentage of viable eggs that produced viable hatchlings.

Season	Total Eggs Collected	% Viable Eggs	% Viable Hatchlings
1986/87	4401	62.7	80.1
1987/88	5300	64.3	82.7
1988/89	6497	67.2	84.5
1989/90	12,010	74.5	85.5
1990/91	9212	59.6	77.4
1991/92	15,298	64.3	80.5
1992/93	12,379	68.7	79.0

Table 6. Numbers of *C. porosus* nests located (excluding false nests) and total eggs collected, in three areas where collection effort has been more or less constant in most years. * indicate where effort was reduced.

Season	Adelaide River (mainstream)		Adelaide River (Melacca Swamp)		Finniss River	
	Nests	Eggs	Nests	Eggs	Nests	Eggs
1983/84	*	*	28	678	*	*
1984/85	23	1025	22	959	20	960
1985/86	21	695	22	934	23	1057
1986/87	26	859	26	1002	36	1172
1987/88	37	1272	12	581	41	1443
1988/89	39	1756	27	1189	*	*
1989/90	56	2250	37	1560	41	1936
1990/91	27	1171	11	622	51	1848
1991/92	45	1547	32	1327	64	3179
1992/93	56	1974	21	939	46	1395
1993/94	56	2041	31	1252	50	1603

Total Harvest Limits

Total harvests of both *C. johnstoni* and *C. porosus*, for all purposes, during the tenure of the current Management Program (CCNT 1989) are summarised in Table 7.

Table 7. Numbers of *C. johnstoni* and *C. porosus* eggs, hatchlings, juveniles and adults taken from the wild during the last two years, with harvest limits applicable in those years.

Species	Year		Limit	Harvested
C. johnstoni	1990	Viable Eggs	4000	2071
	1991	Viable Eggs	4000	953
	1992	Viable Eggs	4000	49
	1993	Viable Eggs	4000	0
C. johnstoni	1990	Hatchlings	6000	1621
	1991	Hatchlings	6000	4579
	1992	Hatchlings	6000	0
	1993	Hatchlings	6000	0
C. johnstoni	1990	Juveniles	1000	20
	1991	Juveniles	1000	187
	1992	Juveniles	1000	1
	1993	Juveniles	1000	19
C. johnstoni	1990	Adults	200	0
	1991	Adults	200	2
	1992	Adults	200	0
	1993	Adults	200	23
C. porosus	1990	Viable Eggs	10,000	8953
	1991	Viable Eggs	10,000	5491
	1992	Viable Eggs	15,000	9838
	1993	Viable Eggs	15,000	8498
C. porosus	1990	Hatchlings	400	13
	1991	Hatchlings	400	10
	1992	Hatchlings	400	7
	1993	Hatchlings	400	15
C. porosus	1990	Juveniles	400	120
	1991	Juveniles	400	162
	1992	Juveniles	400	102
	1992	Juveniles	400	168
C. porosus	1990	Adults	200	70
	1991	Adults	200	63
	1992	Adults	200	32
	1993	Adults	200	35

MONITORING - WILD POPULATIONS

Crocodylus johnstoni

Annual spotlight and helicopter surveys are conducted in representative samples of *C. johnstoni* habitat as part of a long-term monitoring program.

The Daly River (Fig. 1) is surveyed annually, and is one of the main rivers from which *C. johnstoni* hatchlings are harvested. It provides a good system for evaluating the general impact of harvesting. For surveying, the river is subdivided into 9 segments separated by rockbars and waterfalls (total distance = 196.3 km). Hatchling and egg harvests are restricted to the upstream 91.9 km and the downstream 68.5 km; the central area of 35.9 km has been surveyed but not harvested.

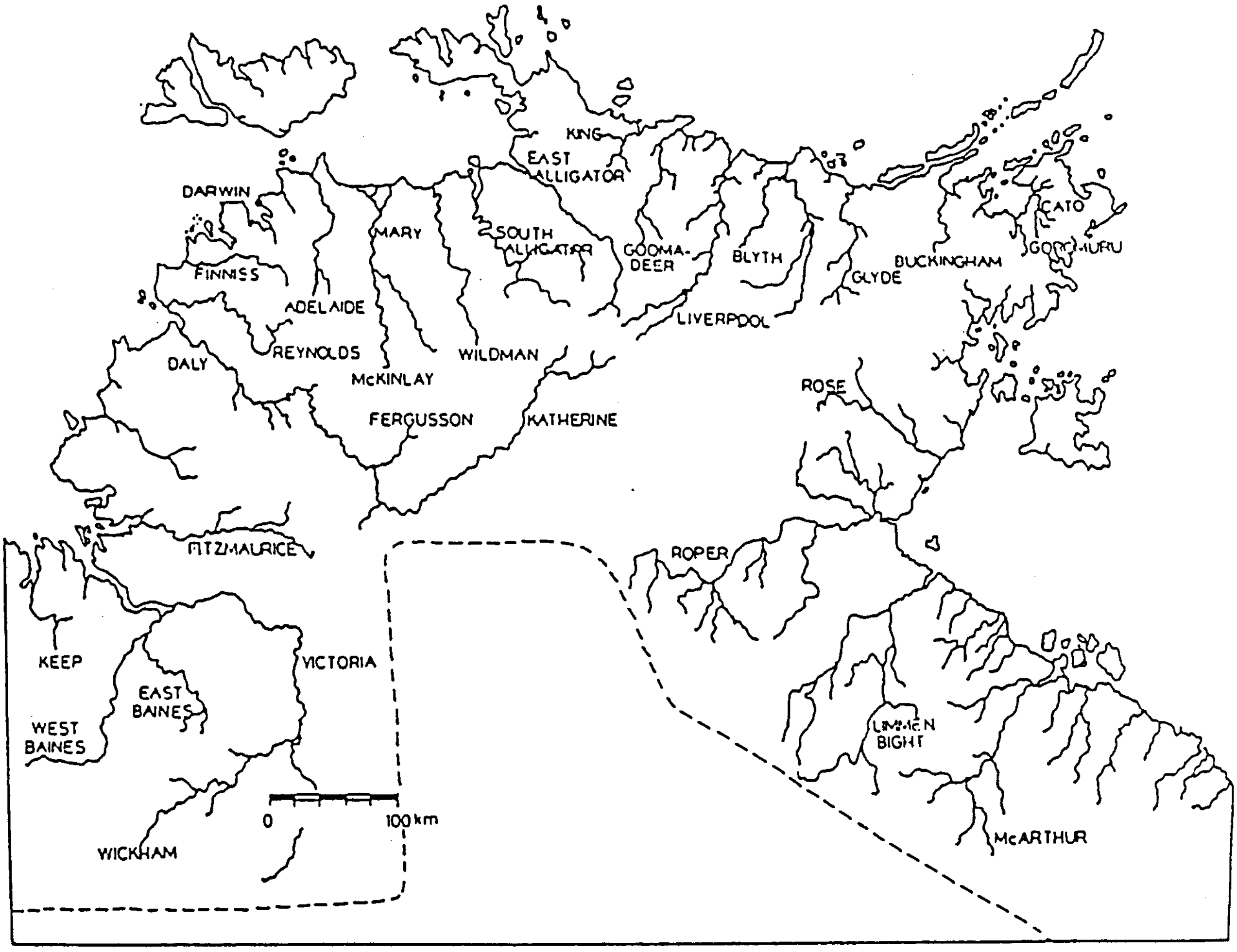

Figure 1. Locations of major rivers in the Northern Territory.

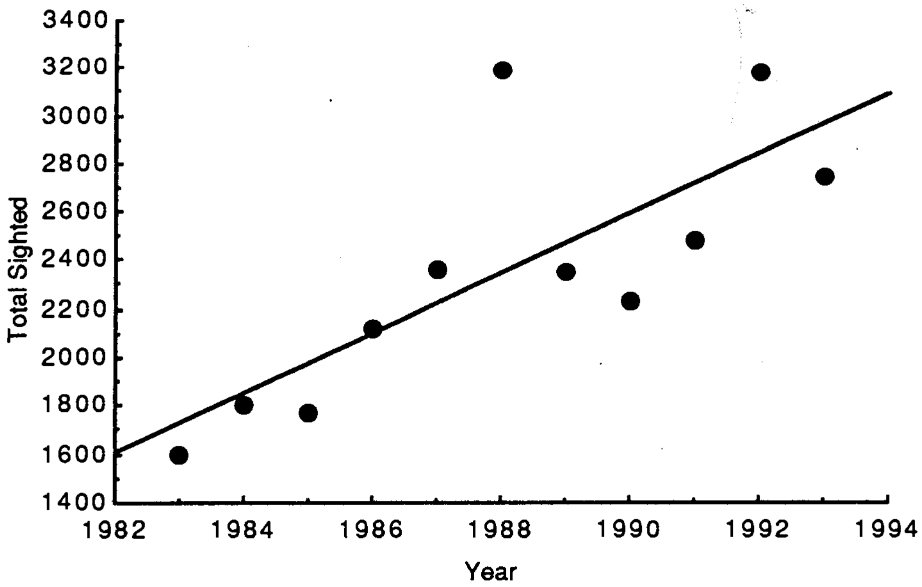

Figure 2. Total numbers of *C. johnstoni* counted by spotlight in the annual surveys of the Daly River between 1983 and 1993.

The population of *C. johnstoni* in the Daly River has continued to increase (Fig. 2) regardless of the harvest of 866 eggs and 15,655 hatchlings between 1982 and 1993 (Table 8). The natural logarithm of the density of crocodiles sighted in the spotlight surveys was regressed against year to estimate **r**, the exponential rate of population increase (the regression line slope)(Caughley 1980). To express **r** as a mean percentage change, the exponent of **r** is used [percentage change = $(e^r - 1)*100$].

Table 8. Numbers of *C. johnstoni* hatchlings and eggs harvested from the Daly River between 1982 and 1993.

Year	Hatchlings	Eggs
1982	1299	0
1983	825	548
1984	1317	318
1985	0	0
1986	928	0
1987	2297	0
1988	1560	0
1989	2700	0
1990	1223	0
1991	3506	0
1992	0	0
1993	0	0
Total	15,655	866

The exponential rate of population increase for all sightings in all areas of the Daly River (Table 8) was 0.055 ± 0.014 (P= 0.003), indicating an average increase of 5.7% per year over the period 1983 to 1993.

Table 9. Annual spotlight counts in 7 harvested and 2 non-harvested sections of the Daly River. **r** = the exponential rate of increase; SE = standard error; P = the probability that **r** is due to chance. Totals for 1983 and 1984 are based on estimates for the 3 segments not surveyed.

	Non-harvested		Harvested							All
Section	1	2	3	4	5	6	7	8	9	1-9
km	14.3	21.6	31.0	15.5	22.0	18.9	39.4	17.1	16.5	196.3
1983	171	-	-	216	448	139	172	205	95	1600
1984	240	197	70	233	400	95	283	164	-	1800
1985	292	247	109	197	297	114	177	210	132	1775
1986	203	346	112	199	263	173	413	210	206	2125
1987	220	331	229	303	520	91	303	201	166	2364
1988	303	470	383	422	567	165	423	235	223	3191
1989	195	380	266	275	390	150	329	200	165	2350
1990	196	313	398	262	434	85	252	161	127	2228
1991	201	442	312	276	352	110	361	192	239	2485
1992	308	462	277	453	627	153	434	221	244	3179
1993	245	426	360	316	441	127	353	200	276	2744
r	0.01	0.07	0.17	0.05	0.03	0.00	0.06	0.0	0.08	0.055
SE	0.02	0.02	0.04	0.02	0.02	0.02	0.03	0.01	0.03	0.014
P	0.51	<0.01	<0.01	0.03	0.31	0.88	<0.05	0.84	0.02	0.003

Table 10. The size structure of *C. johnstoni* sighted in spotlight surveys in the Daly River between 1983 and 1993. Percentages refer only to non-hatchlings whose size could be estimated. Harvests in any one year (Table 8) are conducted after the surveys.

Year	Total Count	Eyes Only	<2'	2-4' (%)	4-6' (%)	6-8' (%)	>8' (%)
1983	1433	706	105	81.0	16.4	1.8	0.8
1984	1682	889	91	82.5	15.5	2.0	0.0
1985	1843	1495	64	45.4	43.0	11.3	0.4
1986	2125	1402	183	69.3	26.9	3.7	0.2
1987	2364	1510	50	83.5	14.3	2.2	0.0
1988	3188	1858	71	75.0	21.8	3.1	0.2
1989	2350	1512	87	92.4	7.1	0.5	0.0
1990	2228	1438	83	77.8	19.1	3.0	0.1
1991	2485	1448	99	79.7	17.6	2.6	0.1
1992	3179	1866	106	75.6	21.0	3.3	0.1
1993	2744	1644	102	75.4	22.2	2.4	0.0

Within the 9 individual survey sections (2 non-harvested and 7 harvested) **r** reached significance in 5 sections (1 non-harvested and 4 harvested)(Table 9). In all cases the change was positive, indicating annual average increases of 7.6% (Section 2; non-harvested) and 9.6% (Sections 3, 4, 7 and 9; harvested). There is almost certainly interchange of animals between the harvested and non-harvested populations, which confounds any detailed analysis.

In both harvested and non-harvested areas of the Daly River, the percentage of juveniles in the population (2-4' long) has remained high (Table 10), indicating that recruitment continues despite the harvests.

The helicopter monitoring program for *C. johnstoni* started in 1985, and involves counts over 31 survey areas within the Baines, Daly, Victoria and Wickham Rivers (Fig. 1). The results to 1993 are summarised in Table 11. All but three survey sections have shown a positive exponential rate of increase, and the mean rate, over all areas, is 0.171 ± 0.022, indicating an 18.6% increase per year.

Table 11. Exponential rates of increase (**r**) for *C. johnstoni* in areas surveyed by helicopter annually. In surveys where no crocodiles were spotted in a particular area, in any one year, 1 sighting has been added so that a log (ln) value could be computed. * indicates a significant regression relationship.

River	Survey Area	N	Years	r	P
Daly	Downstream tidal	9	1985-93	0.208	0.00 *
Daly	Crossing-Island	9	1985-93	0.163	0.03 *
Daly	Island-Fish	9	1985-93	0.168	0.02 *
Daly	Fish-Witch Wai	9	1985-93	0.130	0.19
Daly	Witch Wai-Beeboom	9	1985-93	0.162	0.04 *
Daly	Beeboom-Rockbar	9	1985-93	0.185	0.17
Daly	Rockbar-Oolloo	9	1985-93	0.213	0.07
Daly	Oolloo-us rapids	9	1985-93	0.283	0.05
Baines	Bullita	7	1987-93	0.223	0.25
Baines	ds East Baines Pool	9	1985-93	0.208	0.13
Baines	East Baines Pool	9	1985-93	-0.012	0.92
Baines	Homestead Pool	8	1985-93	0.177	0.09
Baines	TH Hole	9	1985-93	0.027	0.75
Baines	us East Baines Pool A	7	1985-93	0.232	0.15
Baines	us East Baines Pool B	9	1985-93	0.071	0.55
Baines	us East Baines Pool C	9	1985-93	-0.042	0.79
Wickham	Homestead Hole	9	1985-93	0.367	0.02 *
Wickham	Humbert River Pool	9	1985-93	0.223	0.10
Wickham	Humbert Station	9	1985-93	0.166	0.04 *
Wickham	Irrigation Hole	9	1985-93	0.283	0.01 *
Wickham	Stoney's Crossing	9	1985-93	0.282	0.07
Wickham	Victoria/Wickham Jn.	9	1985-93	0.304	0.04 *
Wickham	Yarralin	9	1985-93	0.367	0.01 *
Victoria	Downstream Bridge	9	1985-93	0.294	0.07
Victoria	Jasper A	9	1985-93	0.058	0.55
Victoria	Jasper B	9	1985-93	-0.173	0.17
Victoria	Old Vic. R. Crossing	9	1985-93	0.341	0.05
Victoria	Pigeon Hole	9	1985-93	0.077	0.39
Victoria	Policeman's Point	9	1985-93	0.028	0.61
Victoria	Rockhole	9	1985-93	0.086	0.17
Victoria	Upstream Bridge	9	1985-93	0.204	0.03 *
Mean all areas (± SE)				0.171 ± 0.022	

Most river systems were monitored originally by spotlight, and some continue to be monitored by this method. The results (Table 12) indicate a mean exponential rate of increase of 0.029 ± 0.017; the population has been expanding at about 2.9% per year over the period of study. The mean rate of increase in the harvested rivers (0.043 ± 0.014; 4.4% per year) was positive and higher than the rate from the non-harvested rivers (-0.002 ± 0.043; -0.2% per year) which was itself highly variable.

Table 12. Exponential rates of increase (**r**) for *C. johnstoni* in river systems spotlight surveyed regularly in the Northern Territory. * indicates a significant regression relationship at the 5% level; N= number of years surveyed; P= the probability that **r** is due to chance.

River	Survey Area	N	Years	r	P
Baines	East Baines River	3	1982-86	-0.002	0.97
Katherine	Katherine Gorge	9	1980-88	-0.084	0.06
Mary	Downstream bridge	9	1984-93	0.059	0.08
Moyle	Moyle River	4	1984-88	-0.025	0.91
Finniss	Buffalo Hole	7	1984-90	0.176	0.02 *
Reynolds	Waterhole	7	1984-90	-0.115	0.35
Mean Non-harvested		6		-0.002 ± 0.043	
West Baines	TH Hole	7	1883-91	-0.017	0.72
Daly	Daly River	11	1983-93	0.055	0.01 *
Finniss	Finniss mainstream	11	1983-91	0.009	0.75
Mary	Upstream bridge	10	1984-93	0.029	0.44
Reynolds	Reynolds mainstream	11	1983-93	0.012	0.81
Reynolds	Fish Camp	10	1984-93	0.006	0.88
Victoria	Rockhole	7	1982-91	-0.019	0.56
Victoria	Upstream bridge	5	1984-88	0.112	0.47
Victoria	Pigeon Hole	5	1982-91	0.041	0.12
Victoria	Downstream bridge	7	1982-88	0.101	0.28
Wickham	Yarralin	5	1982-87	0.066	0.38
Wickham	Homestead	5	1982-87	0.124	0.16
Mean harvested		12		0.043 ± 0.014	
Mean All rivers		18		0.029 ± 0.017	

The disparity between the rates of increase indicated by helicopter and spotlight counts reflects in part the limitations of helicopter counting with *C. johnstoni*. A small proportion of the total population is sighted, and in this case, it could be reflecting changes in the larger animals. Although the disparity is under investigation, it is significant that both survey methods indicate a positive rate of increase despite harvesting.

Crocodylus porosus

As with *C. johnstoni*, monitoring of the *C. porosus* population involves surveys at two levels of resolution. Firstly, spotlight counts in selected rivers are carried out annually to monitor the biological aspects of continuing recovery (see "Recovery Trends in the Blyth-Cadell River System" below). Helicopter counts are the method used to monitor the population as a whole.

Within individual rivers subjected to intense harvesting of eggs, the population has continued to increase despite harvesting (Fig. 3). Significant numbers of nests are not detected and local recruitment still occurs (Fig. 4). The population size structure does not reflect a "missing" cohort that could be expected to influence adult numbers in the future (Table 13).

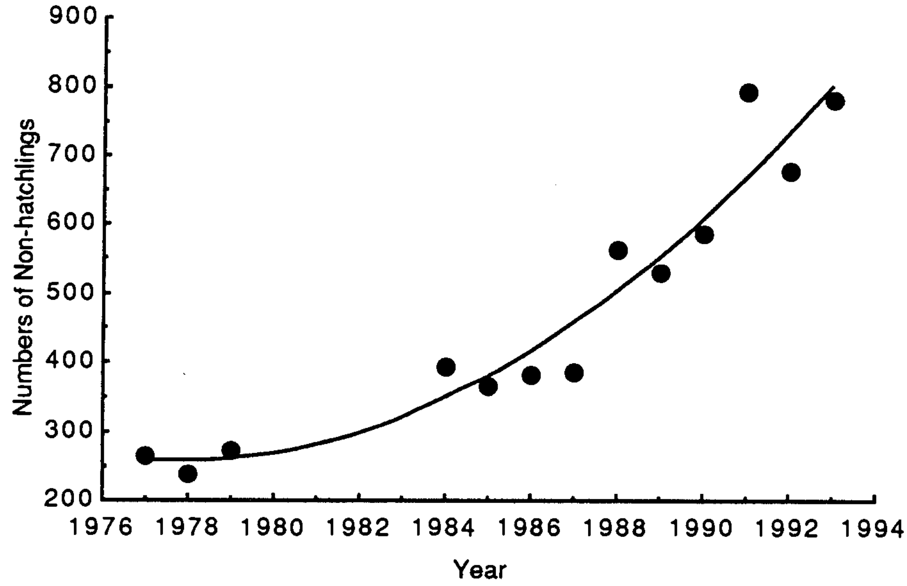

Figure 3. Annual spotlight counts of non-hatchling *C. porosus* in the mainstream of the Adelaide River, Northern Territory (60 km east of Darwin). Numbers of eggs harvested from 1984/85 to 1992/93 are in Table 5; in 1983/84 525 eggs were collected from the mainstream. Since 1983, 24,989 eggs have been harvested from the system.

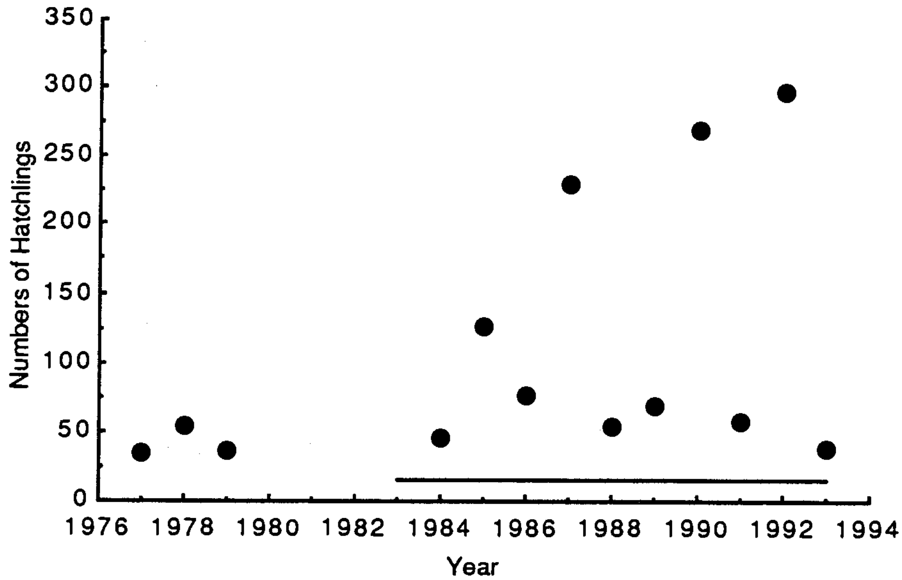

Figure 4. Numbers of hatchlings sighted during spotlight surveys of the Adelaide River mainstream (117.0 km). The line indicates the period in which eggs have been harvested (1983/84 to 1992/93 wet seasons).

Table 13. Size structure of *C. porosus* sighted in spotlight surveys in the Adelaide River between 1977 and 1993. Percentages refer only to non-hatchlings whose size could be estimated. Survey results are those nearest June in each year. * indicates years in which eggs were collected in the wet season before a survey; between 1977 and 1979 animals greater than 7' in length were recorded as ">7".

Year	Total Count	Eyes Only	<2'	2-4' (%)	4-6' (%)	6-8' (%)	8-10' (%)	>10' (%)
1977	427	36	48	36.1	52.6	--------	11.3	------
1978	388	33	62	36.4	51.0	--------	12.6	------
1979	387	36	53	23.1	56.8	--------	20.1	------
*1984	618	144	80	36.5	28.9	21.8	10.4	2.3
*1985	582	137	137	31.5	32.1	20.8	9.7	5.8
*1986	572	112	99	40.7	30.5	17.5	8.9	2.5
*1987	785	130	259	46.7	26.8	19.7	5.8	1.0
*1988	751	154	56	47.3	22.0	15.0	11.5	4.3
*1989	709	161	76	45.2	22.6	17.8	11.0	3.5
*1990	936	168	350	41.8	16.7	22.6	16.0	3.0
*1991	876	161	85	55.3	18.0	14.0	7.2	5.4
*1992	1082	233	403	43.9	21.1	23.8	9.2	2.0
*1993	869	290	89	54.7	14.5	15.5	12.2	3.1

Annual spotlight count surveys were carried out in 8 river systems in both 1992 and 1993 (Table 14), the majority of which had eggs harvested from them. The exponential rate of increase was calculated for each major river section. Those with a significant change in population size over the study period had all increased. The mean **r** value for all survey sections was 0.056 $\pm$ 0.012, indicating a mean annual rate of increase of 5.8% per year over the period of study. The rate of increase in the harvested sections (0.048 $\pm$ 0.012; 4.9% per year) was less than the mean rate in the five non-harvested sections (0.085 $\pm$ 0.037; 8.9% per year), although they were highly variable.

Table 14. Exponential rates of increase (**r**) for *C. porosus* in river systems surveyed by spotlight. In the 5 instances where no crocodiles were spotted in a particular creek, in any one year, 1 sighting has been added so that a log (ln) value could be computed. * indicates a significant regression relationship; 'H' indicates areas from which eggs are harvested each year. "NH-D" = the non-hatchling density recorded during the last survey.

Survey Area	N	Years	NH-D	r	P		
Adelaide - downstream	12	1977-93	4.91	0.038	0.002	*	H
Adelaide - upstream	17	1977-93	6.80	0.068	0.0001	*	H
Adelaide - sidecreeks	13	1977-93	0.94	0.025	0.108		H
Blyth - mainstream	19	1975-93	4.31	0.023	0.011	*	H
Blyth - sidecreeks	17	1975-93	0.70	-0.029	0.090		H
Cadell - mainstream	19	1975-93	2.56	0.005	0.590		H
Daly - mainstream	11	1979-93	4.30	0.085	0.001	*	
Finniss - Bullcoin	8	1984-91	20.00	0.092	0.137		H
Finniss - Patj Patj	8	1984-91	22.58	0.086	0.435		H
Liverpool - Gudjerama Ck	16	1976-93	0.83	0.023	0.237		H
Liverpool - mainstream	17	1976-93	2.48	0.042	0.0001	*	H

Table 14 continued

Survey Area	N	Years	NH-D	r	P		
Liverpool - Atlas Ck	15	1976-93	0.48	-0.034	0.212		H
Liverpool - Maragulidban Ck	17	1976-93	2.28	0.047	0.006	*	H
Liverpool - Morngarrie Ck	17	1976-93	2.07	-0.014	0.528		H
Liverpool - Mungardobolo Ck	17	1976-93	1.15	0.042	0.023	*	H
Liverpool - Tom's Ck	12	1976-93	1.92	0.115	0.003	*	H
Reynolds - Deep Hole	10	1984-93	0.00	-0.051	0.513		
Reynolds - Horseshoe	10	1984-93	6.25	0.144	0.069		
Reynolds - McEddy's	10	1984-93	15.75	0.171	0.003	*	H
Reynolds - Noaklies	10	1984-93	33.08	0.110	0.018	*	H
Reynolds - Welltree	10	1984-93	16.40	0.082	0.047	*	H
Tomkinson - mainstream	17	1976-93	2.24	0.021	0.036	*	H
Mary - Sampan-Alligator Ch.	7	1984-93	2.30	0.085	0.039	*	
Mary - Sampan-Shady Camp	7	1984-93	17.00	0.161	0.0001	*	
Mean: Harvested	19			0.048 ± 0.012			
Mean: Non-harvested	5			0.085 ± 0.037			
Mean: All	24			0.056 ± 0.012			

Monitoring of the total population involves helicopter counts within seventy segments (<10 km long) in 68 tidal rivers and creeks around the complete coastline. As explained previously (Webb *et al.* 1990a,b), in order that the extensive historical database of spotlight counts (4 to 17 years after protection; 1975-88) not be lost with the changeover to helicopter surveys, a procedure was adopted for correcting the spotlight counts to helicopter count equivalents (Webb *et al.* 1990b). The results of this monitoring program up to 1993 are on Figure 5.

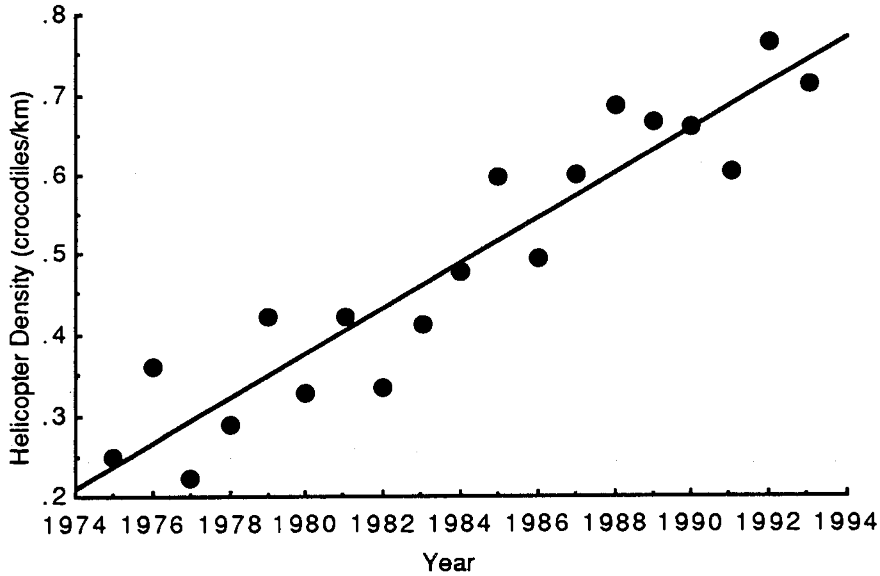

Figure 5. The relationship between the mean density of non-hatchling *C. porosus* (helicopter count/count equivalents) and years since protection (1971). Values for years 4-17 (1975-1988) are corrected spotlight counts. The last 5 values are mean helicopter counts.

Over the last five years, the helicopter counts have demonstrated mean values and levels of variation consistent with those predicted from spotlight counts. This tends to support our contention that the corrections used to derive helicopter count equivalents from spotlight counts were realistic. It also supports the hypothesis that a large proportion of the variation in numbers of *C. porosus* seen in tidal rivers from year to year reflects variation in the extent of the population found in such rivers; real rises and falls in the total population are much more subtle.

The regression line relating helicopter count density (HD) to years since protection (Y)(Fig. 5) describes the mean increase in the density of animals sighted with time since protection (Y; 1992 = 21, 1993 = 22, etc.):

$$HD = 0.126 + 0.0280Y \pm 0.003 \quad (R^2 = 0.94;\ P = 0.0001)$$

The exponential rate of increase, using helicopter counts, is 0.061 $\pm$ 0.006 (P = 0.0001), indicating a mean rate of increase of 6.3% per year over the period 1975 to 1993. This estimate is consistent with the mean value derived from spotlight counts within 8 river systems (0.056 $\pm$ 0.012; 5.8% per year) discussed above. The two methods are thus giving comparable results for *C. porosus*, whereas they are widely divergent with *C. johnstoni* (see above).

The size distribution of crocodiles sighted in 1993 was significantly different from those in 1989-1992 (χ^2= 11.62-28.46; P= 0.0001-0.0088; Table 15). This was due to a lower proportion of smaller crocodiles and a higher proportion of large ones.

Table 15. Size distribution of *C. porosus* sighted in helicopter surveys. Numbers in brackets are percentages.

Year	Total	Small	Medium	Large	Extra-large
1989	461	41 (8.9)	115 (24.9)	224 (48.6)	81 (17.6)
1990	454	48 (10.6)	116 (25.5)	236 (52.0)	54 (11.9)
1991	407	38 (9.3)	122 (30.0)	184 (45.2)	63 (15.5)
1992	535	49 (9.2)	196 (36.6)	227 (42.4)	63 (11.8)
1993	491	20 (4.1)	129 (26.3)	269 (54.8)	73 (14.9)

In 1984, the total wild *C. porosus* population (hatchlings and non-hatchlings) was estimated to be at least 40,000 individuals (Webb *et al.* 1984). As mean density derived from the regression line on Figure 5 has increased from 0.50 km^{-1} to 0.74 km^{-1} between 1984 and 1993 (a 48% increase), the total population in 1993 is now estimated to be at least 59,200 *C. porosus*.

MONITORING - CROCODILE FARMS

There are currently six crocodile farms in the Northern Territory. Total captive stocks have been increasing steadily (Table 16), as has the production of *C. porosus* through captive breeding (Table 16). Culling for skins and meat was initiated in 1987, and since that time there has been a steady increase in production (Table 17). On-farm monitoring is now the responsibility of the Department of Primary Industry and Fisheries (since 1992).

Table 16. Captive population of crocodiles held on Northern Territory crocodile farms. Stocks are at 31 December each year, as reported in the monthly stock returns. Culling and export of skins started in 1987.

Year	No. of Farms	*C. porosus*	*C. johnstoni*	Total
1987	4	5711	10,543	16,254
1988	4	7172	12,267	19,439
1989	4	9183	15,601	24,774
1990	4	12,986	15,450	28,436
1991	6	14,407	17,837	32,244
1992	6	16,750	14,712	31,462
1993	6	18,870	9,904	28,774

Table 17. Numbers of hatchlings produced through captive breeding on Northern Territory crocodile farms.

Year	No. of Farms	*C. porosus*	*C. johnstoni*	Total
1983	3	99	26	125
1984	3	362	105	467
1985	3	463	95	558
1986	3	675	167	842
1987	3	614	116	730
1988	3	444	90	534
1989	3	922	164	1086
1990	4	1120	91	1211
1991	6	1576	58	1634
1992	6	2436	43	2479
1993	6	3226	0	3226

Table 18. Numbers of skins produced in the Northern Territory since 1987. *the number refers to the number exported; **approximation based on real production from 3 farms and estimate from one farm based on end-of-year stock returns.

Year	No. of Farms	*C. porosus*	*C. johnstoni*	Total
1987	4	251	323	574
1988	4	962	1020	1982
1989	4	1402	923	2325
1990	4	1954	1373	3327
1991	6	2381	908	3289
1992	6	3277	2314	5591
1993	6	* 4625	** 4460	9.085

Given that mortalities on farms are usually highest during the first year of life, the monitoring program is based largely on inventories of 1-year-olds. There is significant variation between farms, and within the one farm from year to year, in both growth and mortality rates. Mean mortalities and sizes at one year of age, are summarised on Tables 19 and 20 respectively.

Table 19. Mean percentage mortality between hatching and one year of age on Northern Territory crocodile farms. N = number of farms. * = two farms had *C. johnstoni*, but inventories at one were at 18 months (data not included). Year refers to the year in which they were one year of age. **mortalities calculated at approximately 8 months of age.

Year	*C. porosus*				*C. johnstoni*			
	Mean ± SE	Min.	Max.	N	Mean ± SE	Min.	Max.	N
1986	62.5 ± 18.0	28.1	89.0	3				
1987	24.6 ± 6.5	18.0	31.1	2	17.0 ± -	17.0	17.0	1
1988	29.9 ± 2.5	25.7	34.3	3	15.2 ± 10.6	4.5	25.8	2
1989	31.2 ± 3.9	24.6	38.1	3	9.8 ± 5.2	4.6	15.0	2
1990	26.3 ± 10.1	10.9	45.3	3	16.4 ± 6.1	4.5	24.5	3
1991	36.3 ± 11.7	7.2	63.9	4	13.4 -	-	-	1*
1992	23.5 -	-	-	6	23.0 -	-	-	2
1993	** 17.5 -	-	-	6	No hatchlings collected in 1992			

Table 20. Mean total length of one-year-old crocodiles on Northern Territory crocodile farms, for years in which there are comparable data. N = number of farms. * = two farms had *C. johnstoni*, but inventories at one were at 18 months (data not included). For *C. porosus*, detailed inventories were not carried out in 1992 or 1993.

Year	*C. porosus*				*C. johnstoni*			
	Mean ± SE	Min.	Max.	N	Mean ± SE	Min.	Max.	N
1987					558.3 ± -	408	811	1
1988	696.4 ± 3.3	313	1075	3	569.2 ± 1.2	407	791	2
1989	689.7 ± 3.2	340	1262	3	561.7 ± 1.2	347	820	2
1990	675.8 ± 2.3	307	1279	3	573.1 ± 1.1	354	1198	3
1991	687.5 ± 2.7	304	1374	4	541.1 ± 1.9	359	635	1*
1992	- -	-	-	6	609.4 ± 2.1	410	894	1
1993	- -	-	-	6	No hatchlings collected in 1992			

RESEARCH

1. Alligator mississippiensis

In January 1993, 49 *Alligator mississippensis* eggs, from three clutches, were obtained from the Australian Reptile Park (Gosford, New South Wales). Twenty-eight eggs (57%) were infertile, two (4%) died at the time of collection, and the remaining 19 eggs were incubated on open racks in water-jacketed incubators. Nine hatchlings were produced; 3 died soon after hatching and 6 hatchlings were raised in controlled-environment tanks maintained at 32C. The incubation and raising regimes (temperature, diet, etc.) were the same as those used for *C. porosus* previously.

Hatching success was low (47% of 'viable' eggs produced hatchlings; 32% produced viable hatchlings; see above). Incubation of 20 eggs (from two clutches) received in 1994 also resulted in low hatching rates (40% hatched; 30% produced viable hatchlings) under the same incubation conditions. Similar results were obtained by Craig Smith (Macquarie University) in the same year. It is possible that transport may have affected the eggs, as they were very cool by the time they reached Darwin. However, the hatch rate of captive-laid eggs may be lower than for wild alligators, as encountered by Ted Joanen and his colleagues in Louisiana.

The growth rates of the 6 alligators hatched in 1993 are shown on Figs. 6 and 7. Size of the alligators at 12 months of age was compared to a group of 60 fast-growing *C. porosus*; the fastest growing animals raised under these same raising conditions. The mean size of the alligators was greater than the mean for the 60 *C. porosus*, and also greater than the mean of the top 6 animals within that group (Table 21).

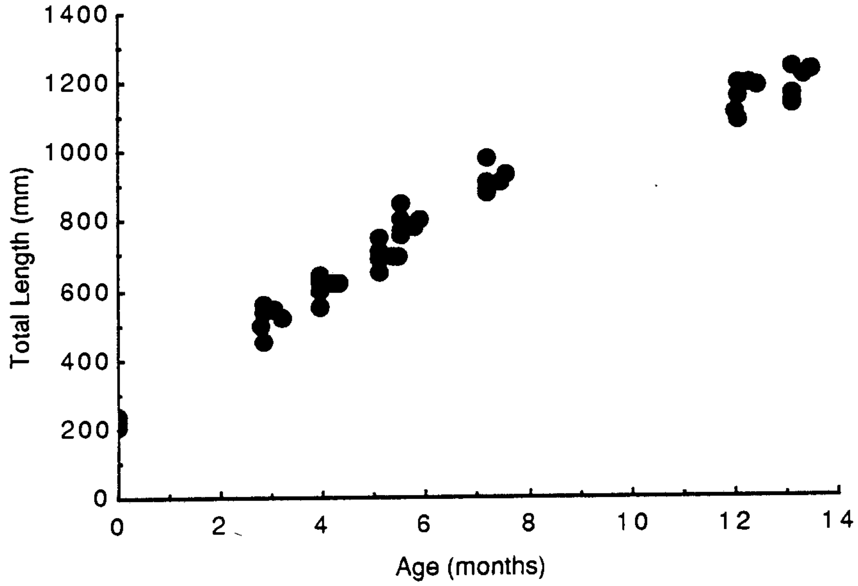

Figure 6. Total length of *Alligator mississippiensis* hatched in March 1993.

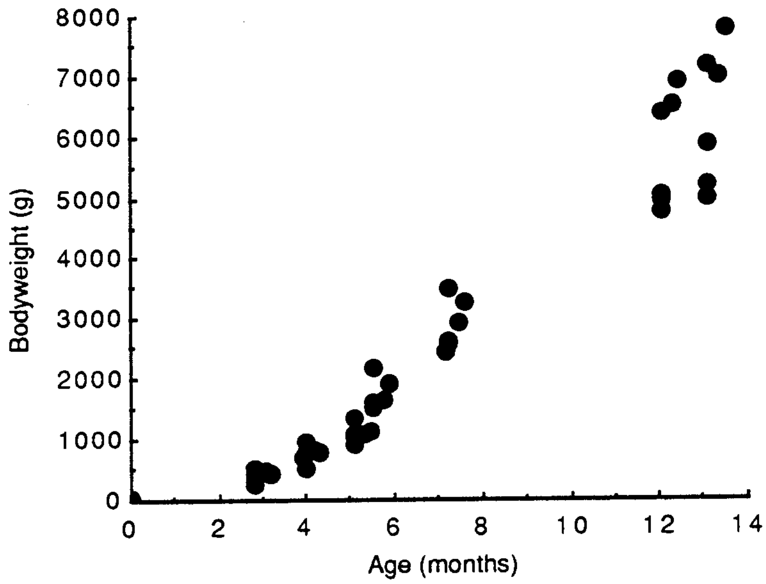

Figure 6. Bodyweights of *Alligator mississippiensis* hatched in March 1993.

Table 21. Mean sizes [total length (TL) and bodyweight (BWt)] of *Alligator mississippiensis* and *Crocodylus porosus* incubated and raised under similar conditions. The data for *C. porosus* refer either to a group of 60 fast-growing animals, or to the top 6 animals within that group.

	Age (mth)	TL (mm)	SE	N	BWt (g)	SE	N
C. porosus	0	297.1	1.11	60	64.9	0.47	60
C. porosus	0	290.5	2.62	6	64.0	1.48	6
A. mississippiensis	0	222.2	6.28	6	47.2	2.41	6
C. porosus	12	869.3	13.57	60	2149.2	129.73	60
C. porosus	12	1074.2	23.92	6	4323.2	367.77	6
A. mississippiensis	12	1152.8	19.09	6	5742.2	385.00	6

Although the sample size of alligators was small, and they originated from three clutches, there was clearly a species difference with regard to growth. The alligators accepted food more readily than *C. porosus* raised alongside them. The differences in growth between farmed alligators and crocodiles is probably due largely to genetic differences, rather than differences in farming practices.

2. Scaling of Anaerobic Muscle Work in *C. porosus*

As reported in a previous report (Webb *et al.* 1992), John Baldwin (Monash University), Bill Runciman (Royal Adelaide Hospital) and Roger Seymour (University of Adelaide) carried out another set of experiments on the physiological effects of capture (exercise) on *C. porosus* (see Baldwin *et al.* 1994).

Exercise time to exhaustion increased with body size; small animals (240 g) were fatigued in 3.5 minutes, and the largest animals (180 kg) in 57 minutes. Lactate concentrations in the blood and tail muscle also increased with increasing body size, with muscle lactate concentrations always being higher than those in the blood. Small animals produced lactic acid faster, but for shorter periods.

Muscle glycogen also showed positive allometric scaling, and the effects of pH on muscle phosphorylase and phosphofructokinase were independent of body size. It is proposed that anaerobic activity may be determined by the size of the muscle glycogen reserves and by glycolytic inhibition at the lower pH levels in larger crocodiles. Mean anaerobic scope and phosphorylase activity (tail muscle) decreased with increasing body size, but dehydrogenase activity was not dependent on body size.

The negative allometric scaling of anaerobic scope is possibly related to changes in predator-prey and social interactions, with reduced dependence on anaerobic muscle work with increasing body size.

3. Stress in Hatchling *C. porosus* 180 h

Jenny Turton and Phil Ladds (James Cook University of North Queensland) carried out trials to investigate the relationship between husbandry practices, stress, immunity and disease susceptibility in *C. porosus* hatchlings

(Turton 1994). Animals were held at high (36C), low (28C) and optimum (32C) water temperatures. Plasma corticosterone levels were used as indicators of stress, and plasma immunoglobulin levels and total and differential white blood counts as indicators of immune fuction.

A total of 140 hatchlings from five clutches were divided between five treatments after 10 weeks at 32C, to initiate feeding. The treatments were:

1. 32C
2. 36C
3. 36C for 10 d, then back to 32C
4. 28C
5. 28C for 10 d, then back to 32C

Blood samples were taken on four occassions, before and after temperature changes were applied.

Mean corticosterone level was 7.09 ng ml^{-1} (range 0.25-16 ng ml^{-1}). Crocodile immunoglogulin was determined to be IgG, with a molecular weight of 218 kDa, and light and heavy chains of 27 and 57 kDa respectively.

The high temperature treatments resulted in elevated corticosterone levels and total white blood cell counts. Immunoglobulin levels were not significantly affected by water temperature. Growth was affected by clutch of origin, and there were clutch-specific differences with regard to corticosterone and immunoglogulin levels. Change in bodyweight (as a proportion of initial bodyweight) was negatively correlated to both corticosterone and immunoglobulin levels, although there was no interaction between the two.

The findings of the study indicated that the high temperature treatments were stressful, whereas the low temperature treatments were significantly so.

ACKNOWLEDGEMENTS

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A COMPARISON BETWEEN THE BREEDING RESULTS OF CAPTIVE AND WILD NILE CROCODILES AND THE CONSERVATION MERITS OF CLOSED CYCLE BREEDING IN SOUTH AFRICA

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ABSTRACT
This paper serves to document, compare and evaluate the breeding results of captive and wild Nile Crocodiles in South Africa, in an attempt to illustrate the conservation merits of closed cycle breeding in South Africa.

INTRODUCTION
It is assumed that while crocodiles have value, man will strive to conserve them. In order to conserve them as best possible, these crocodile populations must be managed according to specific economic and ecological criteria. Also to propose a generalised conservation strategy for crocodiles without due consideration being given to the economic well being of the humans in that region is short sighted and will be detrimental to the crocodiles in the long term.

Habitat loss remains the single biggest threat to the survival of crocodiles. No trade ban or legislation will save a species on the edge of its range nor increase the numbers of a species affected by habitat loss (Hutton & Behra 1992) It is obvious in many areas that crocodiles are valuable to the human population and are surviving outside protected areas. In many instances the protection afforded the crocodiles by these populations is directly proportional to the value placed on the crocodiles. In South Africa this protection is afforded both by wild protected areas and by closed cycle breeding. The merits of closed breeding given certain predetermined economic and ecological parameters is therefore demonstrated.

DISTRIBUTION OF THE NILE CROCODILE IN SOUTH AFRICA (CURRENT AND HISTORICAL)
The Nile Crocodile in South Africa was formerly extensively distributed in all eastward flowing rivers from the Limpopo in the north (Transvaal) to the mouth of the Keiskamma river (some 76km west of East London, Cape Province) in the south. Westwards distribution in these rivers being restricted by climatic conditions.

Current distribution is still in the eastward flowing rivers from the Limpopo in the north to the Tugela river in the south (Natal).Westward distribution is restricted by climatic conditions as well as human pressure. Major and fully protected populations occur in the Kruger National Park, (Transvaal), Ndumu Game Reserve and Lake St Lucia (Natal). (Blake 1993)

High skin prices and relatively low capital costs saw a rapid growth in the crocodile farming industry in the early 1980's. Since then approximately twenty five million dollars have been spent establishing the thirty four farms which are presently registered with conservation authorities in South Africa. While a few of the farms are only considered tourist farms the majority of the farms in the North East of the country conduct close cycle breeding. At present approximately 2400 adult breeding animals which have been obtained either from neighbouring countries or from other farms, are accomodated on these farms. Approximately 37 000 skins have been produced in South Africato date. The annual estimate for the 1994 season,(as conducted by the Nile Crocodile Farmer's Association of South Africa) indicates that approximately 15 500 skins will be offered in 1994 and close to 25 000 in 1995.

TABLE 1 : Survey of wild crocodile populations in South Africa, 1979 - 1992.

	79/81	84/85	88/89	91/92	%Increase
Transvaal					
Outside protected Area	602	-	868	-	44%
Kruger National Park	1750*	-	2453	-	40%
Natal					
Lake St Lucia	-	545	-	806	48%
Ndumu Game Reserve	-	99	-	339*	341%
Hluhlwe	-	37	-	238*	643%
Lake Sibaya	-	67	-	240*	358%

* Indicate estimations

The last 12 years have seen a steady but gradual increase in the number of crocodiles in the wild. It must however be emphasised that the wild cannot sustain a population much greater than that which exists at the moment. In unprotected areas habitat loss as a result of a rapidly expanding human population and polluted rivers is of major concern.

THE ECONOMIC VIABILITY OF EXISTING CLOSE CYCLE BREEDING FARMS

Low skin prices and a depressed local and foreign market have resulted in many of the crocodile farms running at a loss and indeed some closing down. It would appear that farms have finally reached the bottom of the economic trough considering the current skins prices, exchange rates and increased production on the farms. The farms which have mature adult breeders are only now starting to attain the breeding results which can be compared with the reproductive results of wild crocodiles.

CLOSE CYCLE BREEDING VS WILD BREEDING

It would be impossible to forecast whether or not close cycle reproduction will ever attain the reproductive success of wild populations per se. However we are certain that these farms exhibit a far higher post hatching survival rate than do wild crocodiles. Based on this facts there is no doubt that overall productivity per breeding animal is higher in close cycle breeding systems than in the wild.

The breeding capabilities of both wild and captive Nile Crocodiles have been well documented, analysed and evaluated (Hutton 1989). However, in an attempt to compare the breeding ability of Nile crocodiles in the wild and in closed cycle breeding farms in South Africa this paper serves to document such data obtained over the last five breeding seasons on two of the farms and from wild nests collected in South Africa.

FARM AND WILD DATA

Data has been collected from the two oldest closed cycle breeding farms in Natal namely Riverbend Crocodile Farm (est 1981) and the St Lucia Crocodile Centre (est 1974). Both farms are succesfull tourist operations and breeding units are exposed to the stress of seasonal tourism. Both farms are situated on the East coast of South Africa less than 1km from the Indian ocean and experience mild winters and hot humid summers. Riverbend is situated approximately 250km south of St Lucia and egg laying normally commences in the last week of September, while St Lucia laying begins at the end of November.

Data collected from wild nests has been obtained from the Natal Parks Board who have undertaken a wild utilization program over the last 5 years. Data from the collection of "doomed" nests has been correlated and can now be compared with closed cycle data. A "doomed" nest is identified as a nest which, due to a number of factors, is unlikely to be successful (see Appendix 1).

The data obtained from the two farms represent the averages for clutch size and percentage hatch for all nests in a given season. The wild data represents information obtained for all doomed nests collected for a particular season. Incubation of eggs in all three sets of data have been exactly the same with both the closed cycle and wild eggs at St Lucia being incubated in the same incubator. The obvious fact that had the "doomed" eggs not have been collected none would have hatched cannot be overlooked.

TABLE 2 : Clutch size

	89/90	90/91	91/92	92/93	93/94
St Lucia Crocodile Centre	41	45	52	36	44
Riverbend Crocodile Farm	35	33	30	33	34
St Lucia Estuary	47	52	49	43	47

TABLE 3 : Percentage Hatch

	89/90	90/91	91/92	92/93	93/94
St Lucia Crocodile Centre	65.1	68.4	56.5	49.3	45.5
Riverbend Crocodile Farm	55.6	48.5	57.0	70.4	67.0
St Lucia Estuary	75.3	79.4	82.9	83.5	66.0

Small clutch sizes and low percentage hatch in the seasons 92/93 and 93/94 can be attributed to two successive droughts which had a devistating effect on these areas. The small clutch sizes for the Riverbend crocodiles can be attributed to the fact that these are small F1 generation crocodiles. On the positive side, a gradual increase in percentage hatchability is evident suggesting maturity. Analysis of this data indicates no gross irregularities between close cycle and wild crocodiles in terms of nest size and percentage hatchability.

THE CONSERVATION MERITS OF CLOSED CYCLE FARMING IN SOUTH AFRICA.

Given the status quo of crocodile farming in South Africa the following question needs to be asked. "Is the crocodile population in South Africa better off now than what it was in the early 1980's ?". The answer is obviously "yes" and while we cannot ignore shrinking habitat and pollution problems it is obvious that the crocodiles in South Africa especially the wild population in protected areas is in a better position now than what it was in the early 1980's. Based on sound economic trade foundations the closed cycle farms will continue to operate affording both captive and wild animals protection.

The conservation merits of closed cycle farming in South Africa can be listed as follows.

1. There has been an increase in the wild population as a result of a decrease in poaching even in unprotected areas. (See Table 1). Poachers cannot compete with farmers when it comes to quality and quantity of skins. Farming has also resulted in a ready supply of crocodile fat which is used medicinally and hence a reduction in poaching.(Marais and Smith 1994)
2. The tourism industry has been boosted by the crocodile farms resulting in employment for many people and the establishment of associated industries. Approximately 500 000 people visit tourist farms annually.
3. Important research is taking place on an on going basis at many of the farms and in this way more and more is being learnt about crocodiles and other animals.
4. Closed cycle farming has resulted in the easy regulation of the skin trade and the establishment of standards for the trade.
5. From an educational point of view, thousands of students and scholars are able to learn about crocodiles by visiting the farms. Closed cycle farms have resulted in the image of crocodile being improved as the public is now able to learn and understand the crocodiles role in nature.
6. The expenses of establishing and running closed cycle farms ensure that crocodiles will always have a monetary value which has significant positive implcations for the wild crocodiles.

CONCLUSION

In pure economic terms closed cycle farming is the only option for crocodile producers in South Africa. With the exception of St Lucia, the wild population in South Africa would not be able to sustain a Sustainable Use program. The conservation of genetic integrity and the importance of maintaining a biological balance in the wild can never be over emphasised. The maintenance of habitat and value of the crocodiles remain the primary conservation incentives for all those concerned with their survival.

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APPENDIX 1

Criteria for the identification of "high risk" crocodile nest sites from which doomed eggs may be removed

1 High salinity of above 35ppt is measured in the lake adjacent to the nest. At this salinity, most prey items (fish etc) move out of the system, also the young crocodiles are likely to suffer from desiccation. This condition does not apply if there is fresh water within 20 m that they can move into.

2 There is no available protection from wave action within 50 m (vegetation, inlets etc). The female crocodile can possibly transport her young this distance to a suitable nursery site when they hatch.

3 The nest is so low that it will be flooded by a 10 cm rise in groundwater level. The average nest depth is 40 cm, therefore if the water level is within 50 cm of the surface, the nest can be regarded as "high risk". The depth of the water table is to be measured in a hole dug close to the nest (within 0,5 m).

4 The nest is situated along a bank in a site where there is more than an 80% probability of being flooded. The probability is to be calculated from measured water levels.

5 The nest is situated where there is a constant daily threat by people in a manner that cannot be controlled by the NPB.

6 The nest is in soil so impervious, that the eggs will be saturated by heavy rain falls.

7 As well as the above, no crocodile egg collection will be permitted in the area demarcated as wilderness area. The wilderness ethic is such that any interference by man is to be minimised. This therefore precludes egg collecting.

NOTES:

These criteria can be assessed in November or December each year, but if conditions have ameliorated at the time of egg collection, the "high risk" status is no longer valid and egg collection should not take place. Similarly, if conditions have deteriorated, more nests may be placed in the "high risk" category.

There is a need for all these criteria to be considered for each nest, yet only one need to apply for the nest to be placed in the "high risk" category. These criteria are at present rough and research should be conducted to be able to refine them.

With the present lack of understanding of the population dynamics of the crocodiles, it is considered that additional ecological disruption could be caused by releasing 1 m long crocodiles into the system to try and compensate the effects of egg removals. We therefore advise against this action at this stage.

RH Taylor (R/SL), GW Forrest (CLS), WD Densham (CCN), H Bentley (WLS), DK Blake (WCC) & C Pullen (SR)

December 1988

Caiman latirostris RANCHING PROGRAM IN SANTA FE, ARGENTINA, WITH THE AIM OF MANAGEMENT

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INTRODUCTION

Caiman latirostris is one of the two species of crocodilians occuring in Argentina, it is widely distributed in northern Santa Fe and certainly it is the most abundant specie in the Province.

The goal of the " *Caiman latirostris* ranching program in Santa Fe" is to determine if there are a mensurable caimans population recovering in the studied area. The program starts in 1990 and throughout the first three years of the work differents activities were carried out:

Nests detection and harvest of eggs: Nests were marked by us or by local inhabitants. The eggs were always harvested by us.

Artificial incubation: It was carried out at the rearing station in Santa Fe city, in a humed chamber (about 95% of hummidity), with automatic control of the temperture (31 degree C.). The incubation room has a capacity of 3000 eggs.

Controlled rearing: It was carried out in concrete heated pools with a rearing density of about 12 to 15 animals per square meter, fed ***ad libitum*** three times a week.

Caimans releasing: After 8 to 10 months of controlled rearing, the animals were returned to the wild (at the same place in wich the eggs were harvested before). The young animals were released tagged by·year and by nest number.

Night counts: In all the sampling points, spot light counts were carried out from boats, horses and airboats, recording the animals' quantity, air and water temperture and moonlight. A correction factor was used in order to determine the real populational situation.

RESULTS

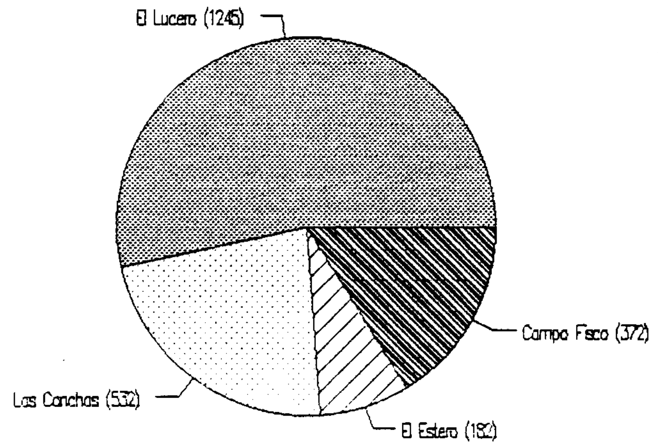
Nest detection and harvest of eggs

During the first three years of the program 59 ***Caiman latirostris*** nests were harvested in the differents sampling places. Those places were:

1) **"Estancia El Lucero". San Cristóbal State. (29o 55' S; 60o 50' W)**
2) **"Las Conchas". San Cristóbal State. (30o 5' S; 60o 55' W)**
3) **"El Estero". San Javier State. (30o 15' S; 59o 75' W)**
4) **"Campo Fisco". San Cristóbal State. (30o 15' S; 60o 50' W)**

The harvested eggs come from four differents sampling places (Figure 1).

Figure 1
Harvested eggs



The average clutch size registered was 37.3 and it was recorded year by year (Figures 2, 3 and 4).

Figure 2

Clutch Size (1991)

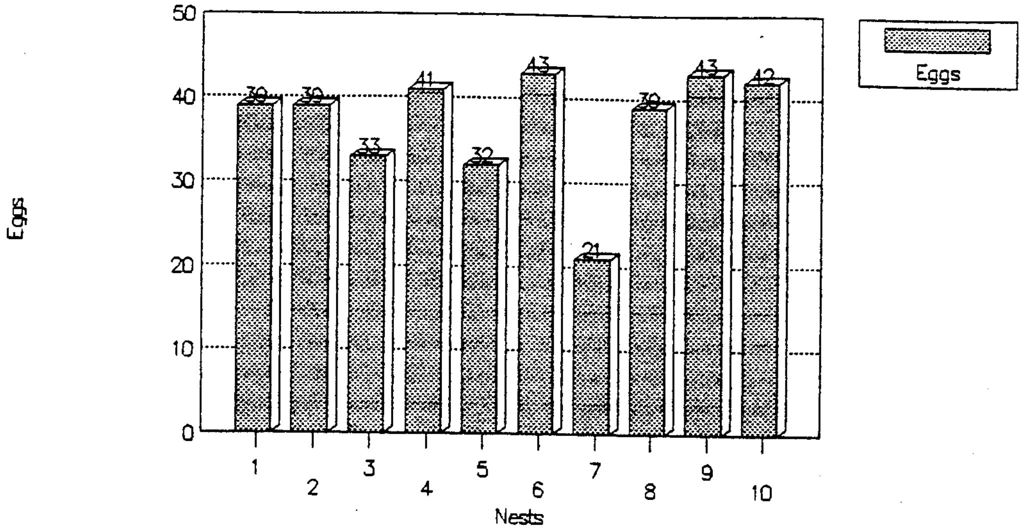


Figure 3

Clutch Size (1992)

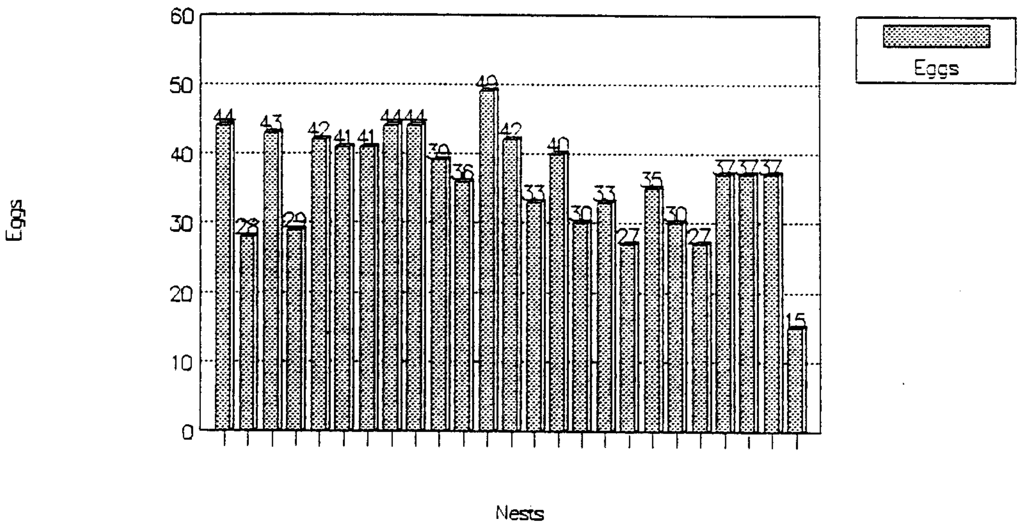
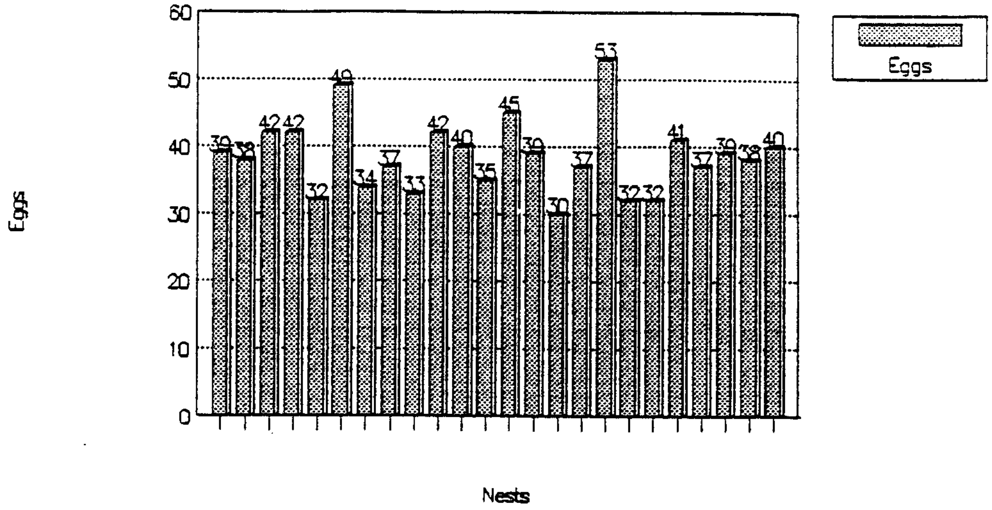


Figure 4

Clutch Size (1993)



The amount of eggs harvested year by year was registered by place (Table 1).

TABLE 1
Eggs by Place

Year	Place	Nests	Eggs
1991	El Lucero	10	372
1992	El Lucero	15	561
	Las Conchas	4	160
	El Estero	6	182
1993	El Lucero	8	312
	Las Conchas	6	242
	Campo Fisco	10	372
TOTALS		59	2201

Artificial Incubation

Throughout the three years work were artificially incubated 2201 eggs, obtaining 1527 hachlings (average hatching success of 69.3 %).

The amount of eggs and hatchlings produced nest by nest in each year were recorded (Figures 5, 6 and 7).

Figure 5

Hatching Success (1991)

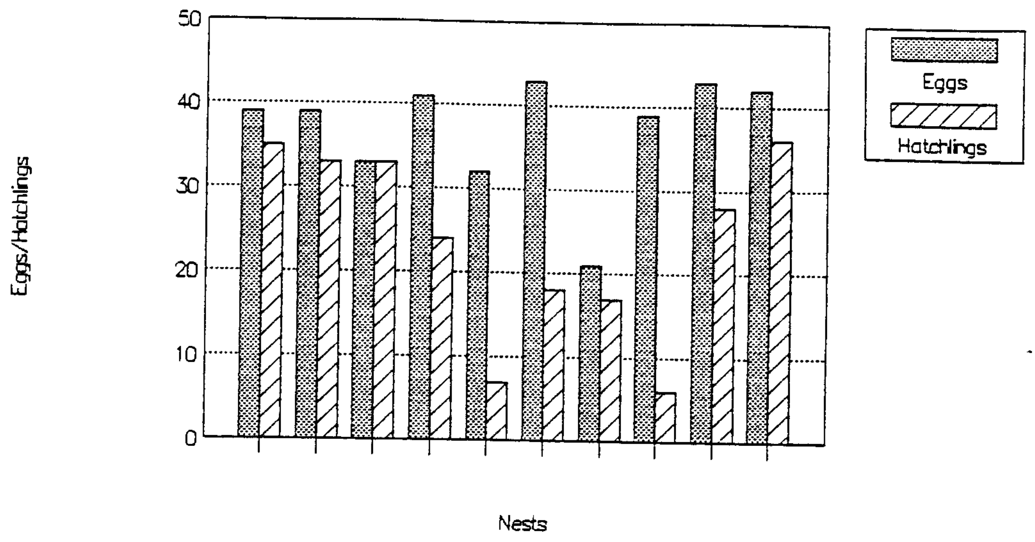


Figure 6

Hatching Success (1992)

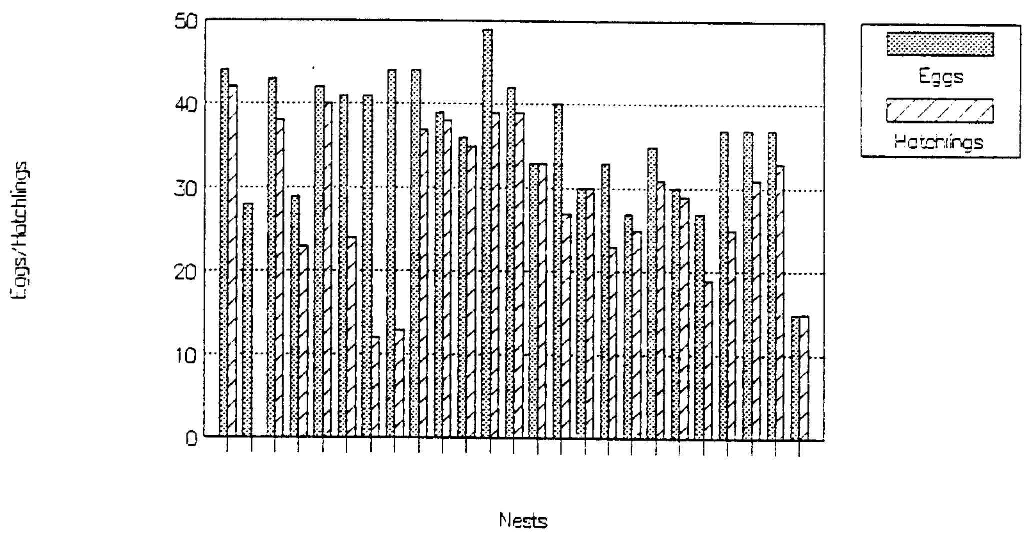
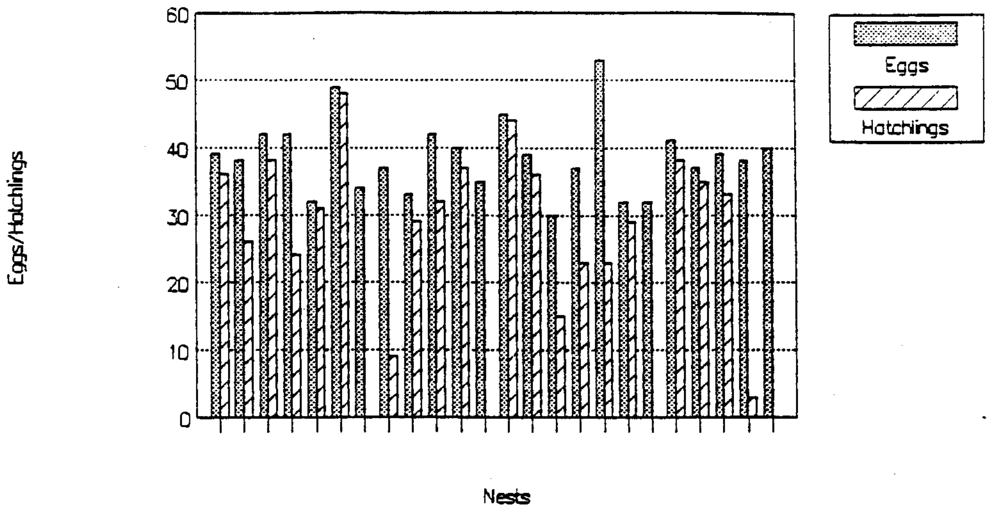


Figure 7

Hatching Success (1993)



Controlled Rearing

After 8 to 10 months of controlled rearing in concrete heated pools, feeding ***ad libitum*** the animals three times a week with a food composed by minced chicken, bran cereal and vitaminic mineral mixture, the average weight increased troughout the three years work was 655 %.

The final average weights of the hatchlings by year in the differents sampling areas were recorded (Table 2).

TABLE 2
Released animal weight

Year	Place	Final weigth (gms.)
1991	El Lucero	350.5
1992	El Lucero	224.3
	Las Conchas	191.3
	El Estero	185.6
1993	El Lucero	337.8
	Las Conchas	315.7
	Campo Fisco	326.6
AVERAGE		275.1

Animals releasing

The survivorship of the animals untill the releasing moment, as an average of the three years work was 93 %.

The amount of hatchlings and the animals finally released nest by nest and year by year were recorded (Figures 8,9 and 10).

Figure 8

Survivorship (1991)

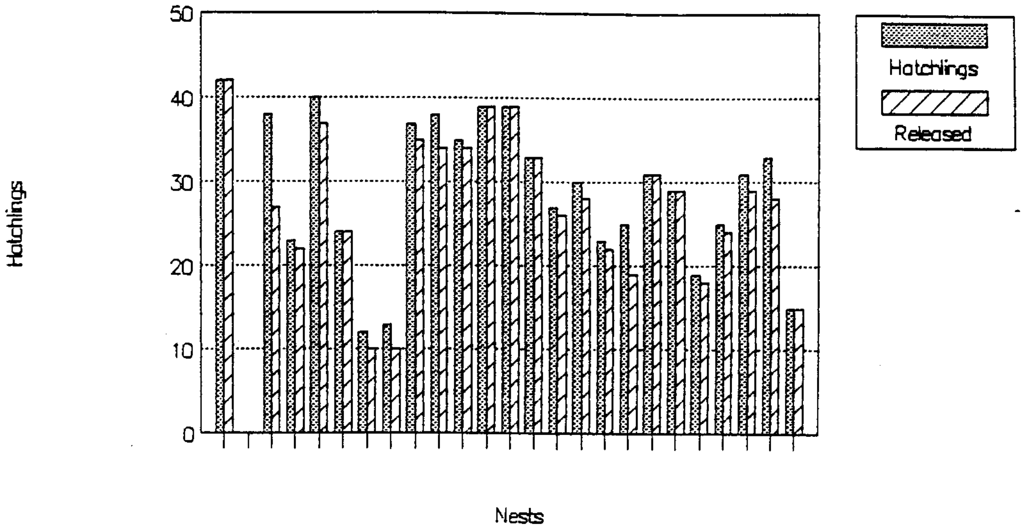


Figure 9

Survivorship (1992)

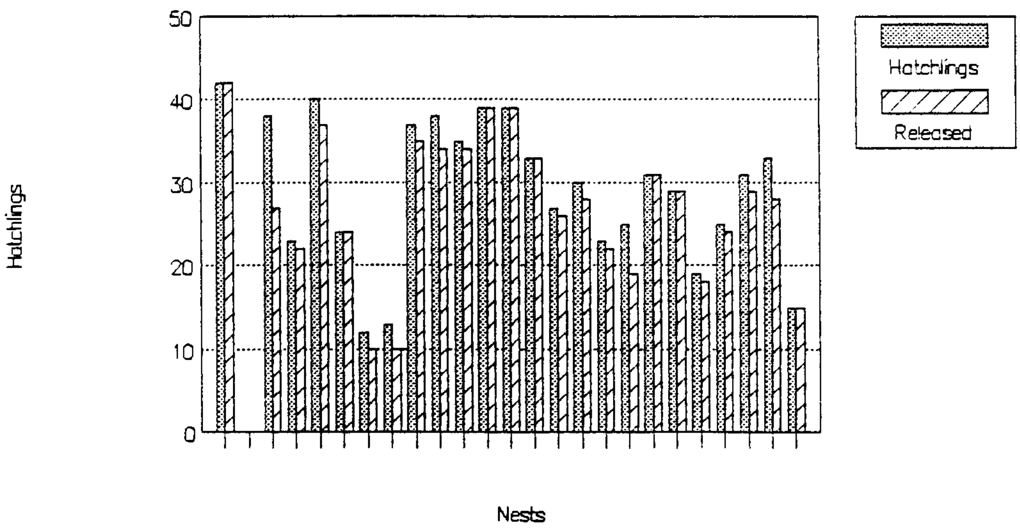
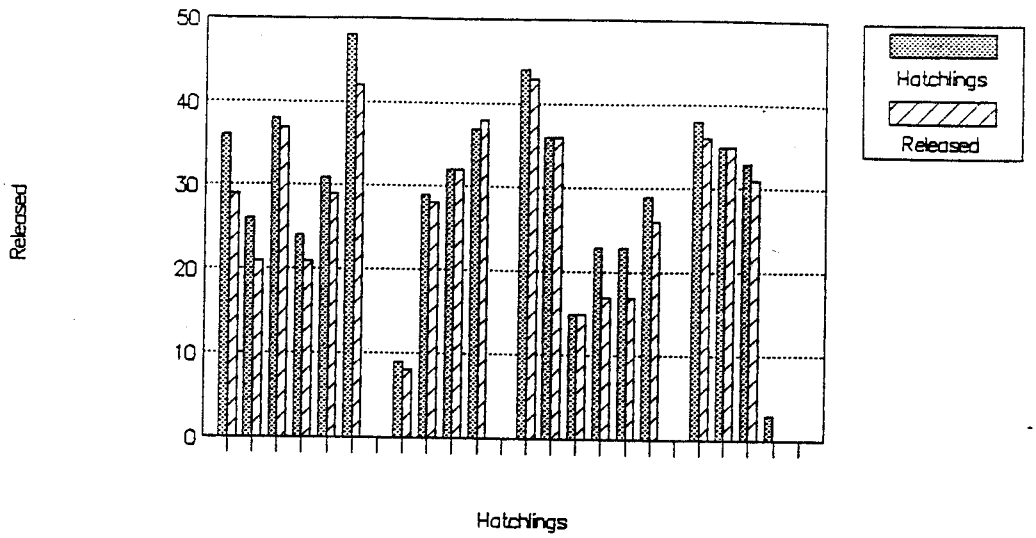


Figure 10

Survivorship (1993)



Monitoring

In the different sampling areas an improvement of the populational situation was detected and in some cases grew significantly. A correction factor was used, taking into account the environmental variables recorded in each night count (Larriera et. al. 1993) and it was found that the water temperture was the best indicator of the real situation. In Table 3 it is summarized the recorded results from three differents places and the populational increase considering the water temperture.

TABLE 3
Monitoring

Place	Date	W Temp.	Found	Estimate	Increase
El Estero	08/92	14o C.	4	12	
	12/92	24o C.	7	12	
	11/93	29o C.	40	66	550%
El Lucero A	03/92	29o C.	15	22	
	11/93	22o C.	16	28	127%
El Lucero B	12/91	23o C.	7	12	
	11/93	29o C.	129	211	1758%

Despite the fact that this is not a capture-recapture work, we did 15 captures in the field, founding that 8 (53%) of the animals were released caimans, indicating that the captive reared animals are an important portion of the actual population.

1994 EGGS HARVEST

This year 57 *C. latirostris* nests (2197 eggs) were detected and 44 (1715 eggs) were incubated because 13 nests (482 eggs) were lost due to the flooding. Finally 1196 hatchlings were obtained and discarding the flooded eggs, the **Hatching Success was 74.5%.**

We did the harvest in three embryo developing moments and found that early harvest (more than 60 days of artificial incubation) and medium harvest (between 30 to 59 days of artificial incubation), produced better hatching success than late harvest (less than 30 days of artificial incubation) (Figure 11), (Table 4).

Figure 11

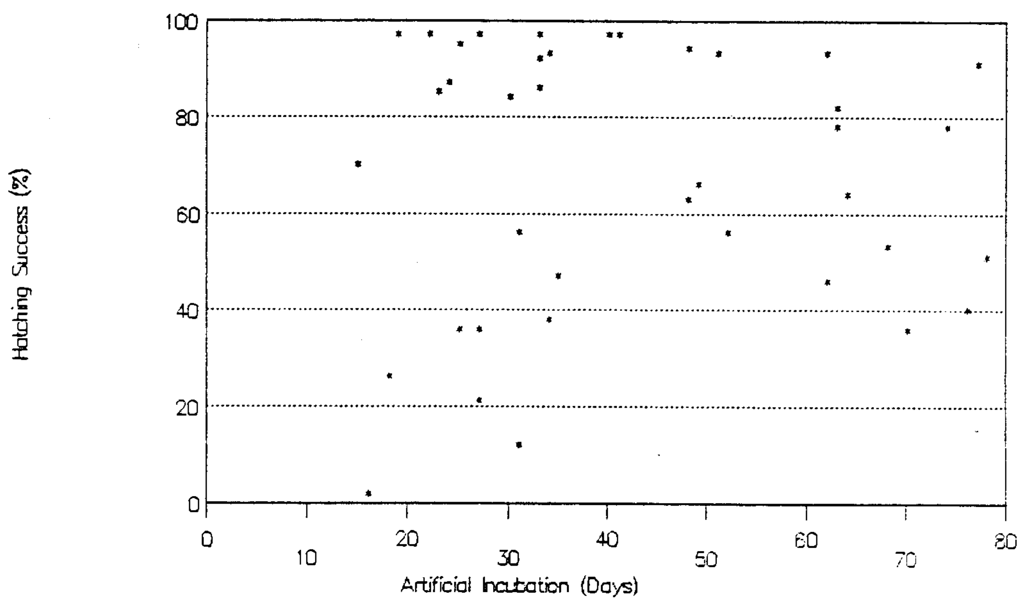


TABLE 4

Harvest Moment	Medium Hatching Success	Variance
Late	39.536%	1768.85
Medium	73.813%	687.89
Early	63.615%	368.92

An analysis of variance of single design was carried out for the differents treatment (early, medium and late harvests) and a "Test A Priori" in order to detect differences between mediums was done (Table 5).

TABLE 5

Analysis of Variance

Source of variation	d.f.	SS	MS	Fs
Between groups	2	13313.50	6658.25	5.725**
Tret. 2 Vs. others	1	8168.74	8168.74	7.057**
Within groups	54	62504.47	1157.49	
Total	56	75820.98		

The very significant Fs value (p 0.025) shows that early and medium harvest produce a real improvement of the hatching success.

PROSPECTS

It is clear now that the *C. latirostris* population is growing up in Santa Fe province, because we are finding more animals, more eggs and more sampling places (places in wich we did not found caimans before). May be this gowth can recognize two sources, on one hand the released animals are apearing now in the wild and probably they are a significative portion of the young population in the sampling places, and certainly on the other hand, stop poaching from the tanneries requirements (may be waiting for a management program, may be because the low prices), could explain the improved situation of the adult population.

The obvious improving of the populational situation of *C. latirostris* in the Province, and the success in the use of the **Ranching technic** here, make us think that it will be useful for the conservation of the specie, to change the Santa Fe *C. latirostris* population from Apendix I to Apendix II of CITES in a near future.

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LOUISIANA'S ALLIGATOR RESEARCH AND MANAGEMENT PROGRAM: AN UPDATE

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12th Working Meeting of the Crocodile
Specialist Group
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Pattaya, Thailand

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. This 84,000 acre refuge is located in coastal southwestern Louisiana. The primary objective of this refuge is to serve as a wintering area for waterfowl in the Mississippi and Central Flyways. Many years of research at the refuge has led to development of marsh management techniques practiced today for multi-species use. Emphasis is on production of desirable vegetative species, maintenance of hydrology/salinity stabilization, and marsh enhancement.

An extensive research program on the biology of the American Alligator (Alligator mississippiensis) was undertaken some 35 years ago by the staff at Rockefeller Refuge. Management practices developed and regulations enacted have led to the recovery of the alligator from low populations of the early 1960's, and this is generally recognized as one of the success stories in wildlife management.

Further research and legislation led to the development of alligator programs based on the concept of sustained utilization, managing the alligator as a renewable resource. This has been well-documented in the scientific literature (Palmisano et al 1973, Joanen and McNease 1987).

The objectives of this paper are to review the recent status of Louisiana's alligator management program; and present updated information on our research findings since the last meeting of the Crocodile Specialist Group in Zimbabwe, Africa in 1992.

MANAGEMENT

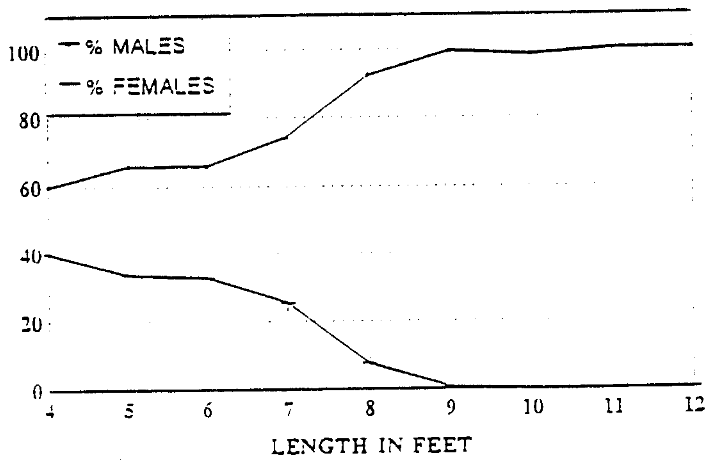
Wild Alligator Harvest

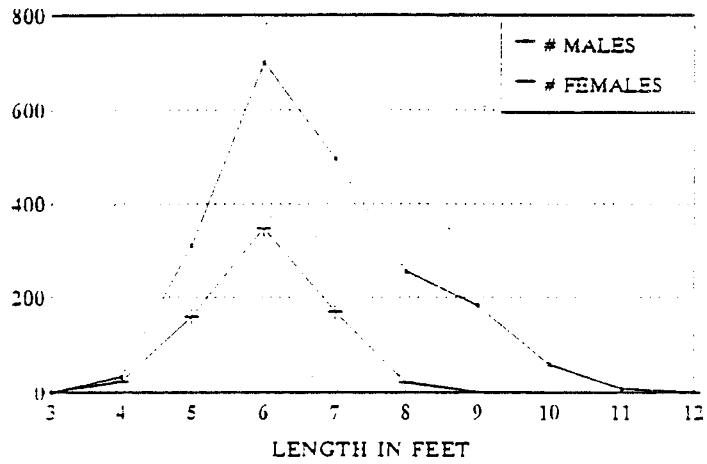
A commercial harvest of alligators has taken place each September since 1972 (excluding 1974 and 1978). This program expanded to a statewide harvest in 1981. In 1993, some 24,000 alligators were harvested by approximately 1600 hunters. Sales of meat and skin generates 6 - 7 million dollars annually. (Table 1)

Alligator tag quotas are carefully calculated each season based on aerial nesting surveys. Landowners/hunters are allocated a closely regulated number of tags based on the amount of land they own or manage, and the quality of the alligator habitat based on vegetative types (brackish, intermediate, or fresh marsh; cypress-tupelo swamp, public lake, etc.). Methods used for the nest surveys (coastal helicopter transect counts, night counts in northern Louisiana) are described in detail in another paper at this conference (McNease et al 1994).

Harvest techniques for the annual September hunt have been described previously (Joanen and McNease, 1987). Telemetry studies have shown that at this time of year nesting females are deep in the marsh interior at isolated ponds; while males move freely through large open canals, bayous, and lakes (Joanen and McNease, 1970, 1972). Thus, a September season would select for harvest of adult males, and protect the nesting females in the population.

In September 1993, we checked 2,774 harvested alligators brought to skinning sheds for processing. Five hundred twenty-eight (19.0%) were immature (<6' total carcass length) of which 65.3% were males and 34.7% were females. Of the 2,246 mature adults harvested, 76.0% were males and 24.0% were females (See Figures 1 and 2 below). Overall, 73.6% males were taken. The average total length of all 2774 checked was 6'10½" carcass length; the hide length would be several inches longer.





Nuisance Alligators

Nuisance alligator complaints are, in general, handled by the LDWF's Enforcement Division and by Fur and Refuge Division personnel. Licensed nuisance alligator trappers may legally harvest alligators that are considered a threat to humans, their livestock, etc. Small alligators considered a problem are generally live captured and relocated. Eight hundred twenty nuisance tags were issued in 1992 to 55 nuisance hunters.

Alligator-induced human casualities are very rare. A 32-year old man living in French Settlement, La. was bitten by an alligator on July 25, 1992. He was doing repair work under his house on the bank of the Amite River when he was attacked. Just one month earlier he had been bitten by a water moccasin, also at his house on the muddy riverbank.

To our knowledge there have been no alligator-related fatalities in Louisiana, although it was believed that a blacksmith was attacked and killed by an alligator while bathing in the Red River at Fort St. Jean Baptiste in Natchitoches, LA in 1734.

Alligator Farming/Ranching Program

Louisiana has an extensive alligator farming/ranching program which has been described previously (Joanen and McNease 1987,1991, Elsey et al 1991). Most stock is derived by ranching of wild eggs collected from privately-owned wetlands. A percentage of the eggs hatched is returned to the wild when alligators are approximately 4 feet in length to ensure wild populations are not depleted. A conservative program such as this was established due to the aggressive egg collections (nearly 300,000 harvested in 1990) and superimposed annual September harvest of 25,000 (predominantly adults) alligators.

Declining prices of crocodilian skins caused some of the smaller, less well-established farms to discontinue production in recent years. The maximum number of farms licensed was 136 in 1991, however only 119 had stock. Some "licensed farms" actually are land managers selling eggs, or egg hatcheries that collect, incubate, hatch eggs and sell hatchlings, etc. but do not have facilities to raise alligators nor sell skins. At present there are 101 licensed farms in Louisiana, of which 86 have stock.

The sizes (by inventory) of the farms in La. is shown in Table 2 below. Twenty farms are very small, having only 1-100 alligators left in stock. Ten have between 101 and 500 alligators, and the rest are larger farms. Six farms have over 10,000 alligators; the largest has some 59,000 alligators. Total year-end stock (December 1993) was approximately 258,314 (Table 3 below).

LOUISIANA ALLIGATOR FARMS YEAR END INVENTORIES					
INVENTORY	1989	1990	1991	1992	1993
1 - 100	8	10	10	17	20
101 - 500	16	24	25	21	10
501 - 1,000	18	21	22	17	15
1,001 - 2,500	21	30	33	29	20
2,501 - 5,000	8	17	15	11	10
5,001 - 10,000	8	8	6	8	5
> 10,000	3	9	8	5	6

Fifty farms were "active" in egg ranching in 1993, some 122,409 hatchlings were added to Louisiana farms from ranched eggs. The downward trend in egg collection since the peak in 1990 appears to be stabilizing; only four fewer farms ranched eggs in 1993 compared to 1992 (Table 4 below).

LOUISIANA ALLIGATOR FARMS			
YEAR	HATCHLINGS ADDED	# FARMS W/HATCHLINGS	TOTAL YEAR END STOCK
1989	150,095	57	194,807
1990	249,616	78	325,451
1991	180,313	72	318,177
1992	146,077	54	291,983
1993	122,409	50	258,314

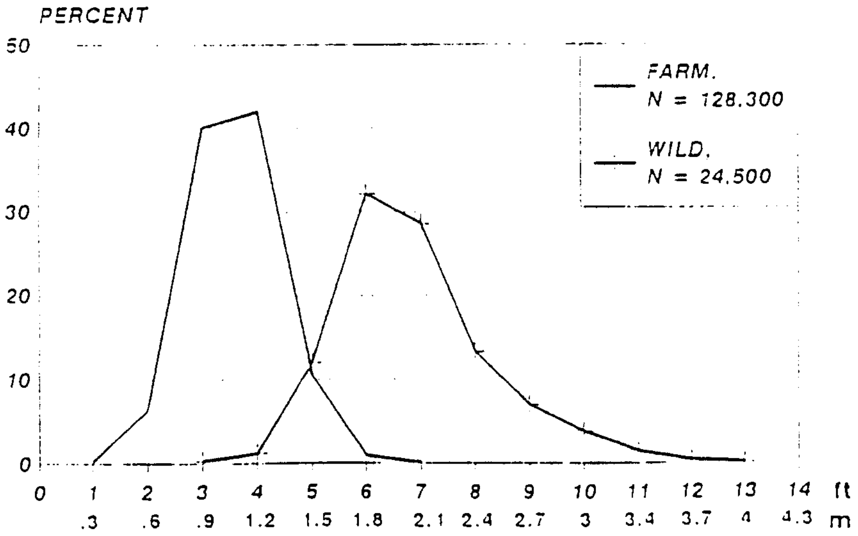
All sheds on alligator farms/ranches were inspected by Fur and

Refuge Division personnel in 1992/1993 to ensure compliance with farming regulations and standards of care. Extensive annual reports documenting inventory, hatch rates, etc. are required and reviewed in detail prior to issuance of the new year's farming license.

Recent changes (Sept 1992) in alligator regulations stipulate that every skin (farm or wild) be inspected by LDWF before shipping in state to a tannery or overseas. A manifest containing CITES tag numbers, lengths, buyer dealer records and severance tax must be provided; and each CITES tag is individually verified before a shipping tag is issued. Also (since Sept. 1993), the $4.00 CITES tag fee is now paid by the dealer at the time of shipment, rather than by the farmer/hunter before the alligators are harvested. It would be naive to presume the dealers do not adjust their skin price so the farmer pays all or a portion of the tag fee, but this does prevent the farmer from having to pay the tag fee "up front" before a definite sale for his skins is set.

More interest has been seen recently in the demand for smaller (3') farm skins (Figure 3 below), whereas the wild skins taken still average 7' length.

FREQUENCY BY SIZE OF ALLIGATORS, 1992 - 93



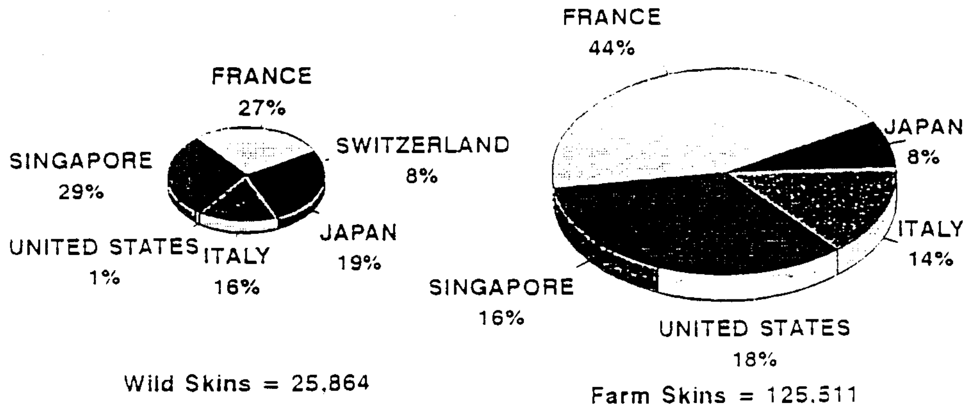
The number of Louisiana farms selling skins and the number of skins sold is shown in Table 5 below. Again, the rising number of skins sold in 1991/1992 reflects the very high egg collection rates from 1989/1990, taking 1-2 years for an alligator to reach market size. The number of skins sold in the 1993 tag year should decrease in proportion to the decrease in egg collection in 1991/1992, and then stabilize as has the number of hatchlings added annually recently.

LOUISIANA ALLIGATOR FARMS
SKINS SOLD BY TAG YEAR

TAG YEAR	TOTAL SKINS SOLD	# FARMS SELLING
1988	27,749	37
1989	66,737	67
1990	88,220	79
1991	118,796	90
1992	126,335	80

Major receivers of Louisiana skins is shown in Figure 4. This represents skins sold in the 1992 tag year (September 1992-August 1993). There has been a substantial increase in the percent of skins sent to Singapore (7% in 1990, 17% in 1992) and tanneries in the United States (4% in 1990, 16% in 1992); while Italy received 39% in 1990 but just 15% in 1992. This may be due to the trade ban at that time in Italy and expansion of US tanneries, including two in Louisiana. France continues to receive the majority of Louisiana produced skins.

MAJOR RECEIVERS OF LOUISIANA SKINS



Farm "returns to the wild" Program

Due to the very large number of alligator eggs harvested in Louisiana and the superimposed adult harvest, alligator ranchers must return a percentage of eggs hatched to the wild as juvenile alligators. The amount to return is based on estimated natural survivorship/mortality curves in alligators (Taylor and Neal 1984) and varies with the size of the alligators. A sliding scale of return percentages is based on the average length of the alligators to be returned. For example at 36" average length, 29.6% of eggs hatched are returned; at 48" a 17% return rate is needed, and at 60" only 9.8% are returned, as larger animals presumably survive better and would be less prone to cannibalism, probably the highest mortality factor in subadult alligators (Rootes, 1989). Alligators are measured, sexed, and tagged by LDWF personnel and releases carefully monitored. The number of eggs ranched and alligators returned is shown in Table 6 below. The rancher has two years from the year the eggs were collected until a 3′-5′ alligator must be returned to the wild. Preliminary results documented that released alligators grow as well as wild alligators and feed normally (Elsey et al 1991, 1992).

FARM STOCKING AND WILD RETURNS		
YEAR	RANCHED EGGS	ALLIGATORS RETURNED
1986	1,523	
1987	18,041	
1988	64,887	1,680
1989	181,819	7,078
1990	293,412	6,088
1991	198,089	44,405
1992	164,892	35,531
1993	144,841	28,512

An extensive wild "mark and recapture" program of night work was started in 1990 for comparison of growth and survivorship to the farm-released alligators, and also to attempt to recapture farm-released alligators. In 1990, 183 alligators were caught in 2 nights; 1004 alligators were caught in 1991 in 8 nights; 300 alligators were caught in 1992 in 3 nights; and in 1993 over 1400 alligators were caught in 9 nights. Also during September wild harvests, alligators trapped and brought to skinning sheds are searched by LDWF personnel at processing sheds to check for retrapped wild or farm alligators. Over 1100 retraps have been recorded. Numerous farm-released juveniles have reached adult size class, and several 6′-7′ farm-released alligators were harvested in 1993. The largest farm retrap was a 7′3" male caught 9-16-93 which was released nearly 4 years earlier at 3′3".

A series of reproductive tracts has been collected from farm-released alligators which were harvested in the wild season. It has been shown that alligators can attain sexual maturity earlier when raised initially in heated tanks than wild alligator (Joanen and McNease 1987). We are comparing the reproductive tracts of farm-released alligators (gonad dimension and status) to similar sized wild alligators.

As the ranched egg collection peaked in 1990, the alligators released peaked in 1991 (Table 6 prior page). Generally released farmed alligators average 42"; thus these alligator's growth rates in the wild should have them approaching 6 feet in length in 1994/1995 and appear in the September harvests those years, generating more recapture data. Combined with additional years of night work data we anticipate having an adequate database upon which to evaluate survival of the farm-released alligators. A recent telemetry study also showed good survival of farm-released alligator's (67% after two years), not significantly different than radio collared wild alligators (Addison, 1993). Survival should probably have been higher than this, as the author noted the radio collars hindered movement and feeding.

Our current preliminary data (excellent growth, normal feeding, many retraps) suggests our required experimental return rates (17% at 48" average length) need not be raised. Further data collection and analysis is underway to see if return rates could be lowered, thus decreasing this overhead cost to alligator farmers and ranchers. A limiting factor is that our population numbers are based on nest surveys, so an overharvest of eggs without supplemental juveniles returned to the wild would not be seen for many years. Wild alligators reach sexual maturity at 10 years of age, thus a declining population trend in nest counts wouldn't be seen until 10 years after a possible egg overharvest without compensatory returns.

To assist in evaluating the necessity of returning juvenile alligators to compensate for egg harvesting and adults trapped, experimental harvests on several different sites were established with varying harvest rates and return rates. Nesting surveys and resulting population figures on these areas will be analyzed in conjunction with recapture data for wild and farm-released alligators to determine the need for and/or degree of returns needed at different harvest levels to conserve the wild resource while promoting maximum sustained utilization.

RESEARCH

The technical staff at Rockefeller Refuge has numerous ongoing research projects related to the biology and culture of the alligator. These projects are outlined briefly below as are some studies completed since the last working meeting of the Crocodile Specialist Group.

Nesting Vegetation and Hatch Rates

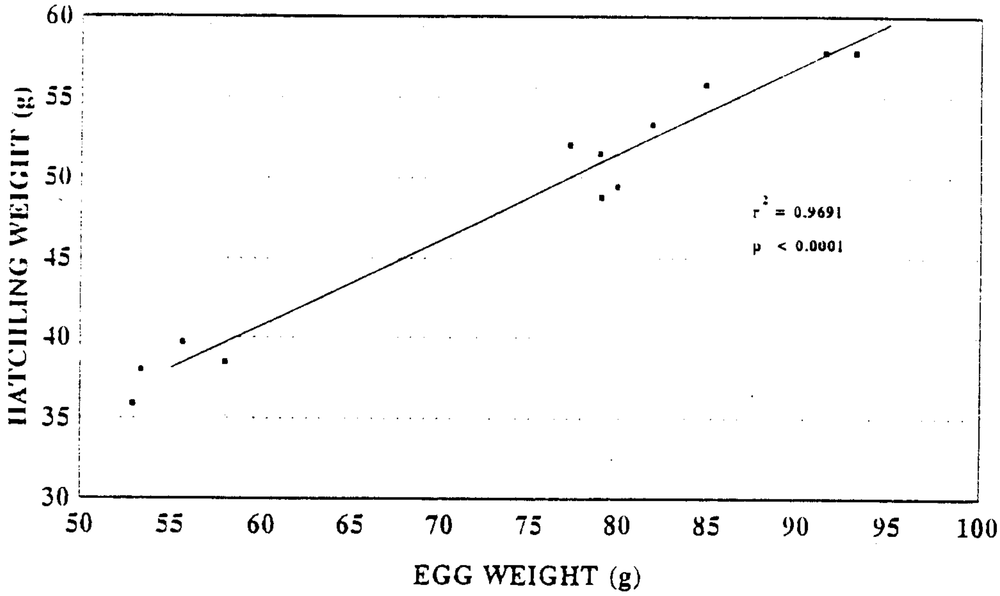
During routine egg collections made in 1989-1991 we noticed high egg mortality early in incubation from nests constructed of certain fresh marsh vegetative species, particularly bulltongue (Saggittaria sp.), on Salvador Wildlife Management area in southeast Louisiana. Several nests of each vegetative type were located and continuous 24° Taylor recorders placed to monitor temperature through the nest cavity. Vegetative types studied include bulltongue (Saggittaria sp.), cutgrass (Zizaniopsis), and maidencaine (paille fine, Panicum hemitomon). Temperatures in the Saggittaria nests were well above 100°F within the first few days of incubation, associated with nearly total mortality early in embryonic development. Moderate mortality was seen in the cutgrass/organic materials nests and less in the paille fine. A follow-up study in 1993 again documented marked embryonic mortality associated with alligator nests of certain vegetative types. Data from this study is presently being analyzed in detail for publication.

Hurricane Andrew Study

On August 25-26, 1992 coastal Louisiana was hit by Hurricane Andrew with winds of 120 mph near Atchafalaya Delta Wildlife Management Area and 110 - 115 mph surrounding New Iberia, Louisiana. A study was initiated to evaluate the effects of the storm on alligator populations; of note the hurricane hit just at the time hatching was beginning in the 1992 nesting season. Three sites were chosen (two designated "impacted" by the storm's location and one control area "not impacted", not in the path of the storm surge). Trips were made to conduct night counts in each area (three trips to each site) over the weeks following the storm. Data will be analyzed to see if there are changes in the size class frequency distribution (SCFD) seen in affected vs. non-impacted areas. Also, harvest data from wild alligator seasons will be reviewed from three years preceding the hurricane and two years following the storm, again to look for changes in SCFD possibly to do mortality or dispersal caused by the hurricane. This study is being directed by Noel Kinler of the New Iberia office.

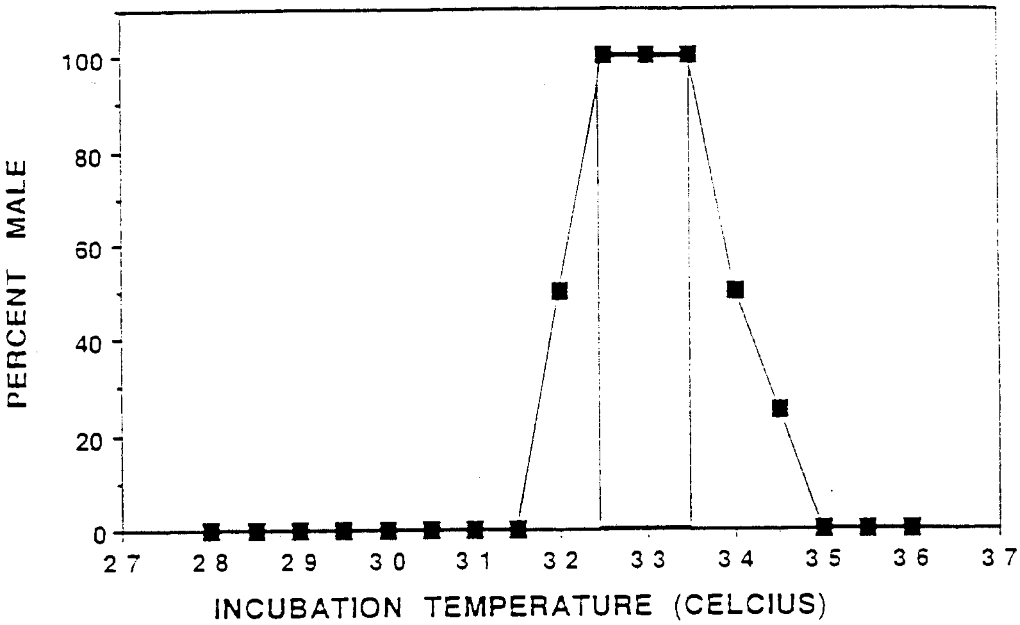
Egg/Hatchling Size

We have long noted a wide variation in the size of alligator eggs between clutches, although eggs within a single clutch are fully uniform. We assumed that larger eggs would produce larger hatchlings, and small eggs would produce small hatchlings, but had not previously documented this. Two clutches of "very large" eggs, four clutches "very small" eggs, and five "normal" egg-size clutches were selected for this study. Just after eggs were collected from the wild, each egg was weighed, measured, and incubated at 89°. One day after hatching, the alligators were weighed to the nearest gram, and total body length recorded to the nearest 0.1 cm. Hatchling weights were strongly positively correlated to egg weights ($r^2 = 0.9691$, $p < 0.001$) (Figure 5). A study this summer will compare growth rates of the extremely large and extremely small hatchlings.



Sex ratio wild alligators/TSD

Many prior studies have examined sex ratios of crocodilians. Some studies have been difficult to analyze as adult alligators have sex-specific habitat preferences (Joanen and McNease 1970, 1972) and collection or harvest techniques may favor the selection of one sex over the other. Such a problem does not occur in juvenile alligators before they choose their adult habitat. As part of our ongoing night work collecting alligators to evaluate our farm-release program, we were able to collect a large sample (n=2500) of juvenile alligators to check sex ratios. A higher percentage of males (57.4%) was found. This is particularly interesting as temperature dependent sex determination in alligators has a narrow window at which males can be produced (Figure 6 below). A manuscript discussing possible mechanisms to explain why naturally occurring sex ratios differ from what TSD (temperature dependent sex determination) might predict would occur is being authored by Dr. Val Lance and Rockefeller personnel.



Culture of Capture Breeder Alligators

As discussed in detail recently (Elsey et al 1993 Darwin), captive breeding of crocodilians has met with limited success, but can play a role in crocodile conservation and pose some interesting physiology questions. Recently we have noted a decline in reproductive performance in a group of known age captive breeding alligators at Rockefeller Refuge (Elsey et al 1993 Darwin). We are examining the role of diet in the low fertility/hatchability of captive-produced eggs in association with Dr. Mark Staton & Professor Mark Ferguson.

The breeding pens at Rockefeller Wildlife Refuge are generally colony-type pens, with multiple males and females in one pen; all of which were raised entirely in captivity and in recent years have been fed nutria meat. In 1993, we added vitamin E and selenium to the diet of the females in two pens, added vitamin E, selenium and fatty acids to the diet of females in two other pens, and had one control pen. Two of each of the six unitized pen (1 ♂ with 1 ♀) were placed as controls. The additives were provided in the form of "sausages" and fed individually to the pen females; to avoid possible oxidation by allowing additives to be exposed to the sun for extended time periods before consumption.

Hatchability in one of the colony pens (Pen 6) increased dramatically to 56.5% with the addition of vitamin E and selenium. However, no such increase was seen in the other colony pen under this treatment. No improvement was seen in the colony pens receiving vitamin E, selenium, and fatty acids; however very few females would approach to take the "sausage" as offered; and thus a fair trial was not really given. No improvement was noted in the unitized pens on either treatment and overall nesting remains poor. However the marked improvement in Pen 6 is encouraging and further work on this project is ongoing.

The importance of fresh food for breeders cannot be emphasized enough. Previously we found that frozen marine fish was an inferior diet as compared to red meat (nutria, Myocastor coypus) (Joanen & McNease 1987) and caused lower hatch rates. Recently we discovered that "old" frozen nutria (6 - 12 months) can undergo oxidation and have higher TBA (thiobarbituric acid) rancidity and peroxide values than fresh frozen nutria.

Wild-caught captive breeders-"unitized" pens

American alligators are solitary nesters in the wild, so colony type pens may create adverse social interactions and stressors which limit reproduction (Elsey et al 1993). Some improved captive breeding was noted in C. porosus in "unitized pens" of one male stocked with one female (Webb 1990, Hutton & Webb 1992). Early attempts at unitized pens at Rockefeller in the 1960's stocked with wild-caught alligators resulted in excessive fighting and mortality, with a nesting rate of 48% (Joanen and McNease, 1971). We constructed six unitized pens in 1990 and stocked these with alligators bred entirely in captivity and previously housed in the colony pens at Rockefeller. Nesting rates have been good, but fertility and hatchability remain quite low. Some problems may be due to obesity of the animals or nutritional deficiencies.

In June 1993, we built ten new unitized pens (approximately 55' X 35') and stocked these with wild caught adult females. The females were captured defending successful nests, so they are proven nesters. We caught small alligators (ranging from 5'6½" to 7'5") and will limit feeding to try to avoid overfeeding and resulting obesity. After the females were "settled", we caught the male alligators in October 1993 (size range 6'3½" to 7'4") and stocked them with the appropriately size matched female. The diet will be dead, day-old chicks rather than nutria as our other pens are fed due to possible oxidation problems with frozen nutria, which is only available fresh in winter months. Five of the ten pens will be supplemented with fish oils/fatty acids.

It should be stressed that we feel that collecting wild eggs is the preferred and more economical method of acquiring stock for alligator farming/ranching. However there is a role for captive breeding in crocodilian conservation and a challenging husbandry problem that must be solved in order to further understand captive breeding physiology of crocodilians.

Long term growth in captive alligators

The captive breeders at Rockefeller are a unique and valuable herd, as they are known-age animals (hatched in 1972 or 1973). A database is being maintained on lengths and weights when alligators are captured periodically for any reason (relocation to a new pen, obtaining blood samples, or simply to check interval growth). Six males were caught on July 26, 1993 to be weighed and measured. Unfortunately, two (11'10", 590 lbs; and 11'6", 585 lbs.) had no remaining web tags as growth of the massive foot displaced the tags. Changes in growth are as below in Table 7.

Location	Length	Weight (lbs.)	Last Caught	Prior Length	Prior Wt. (lbs)
Lake 14	14'0"	910	Aug. 5, 1985	13'4"	793
Pen 1	12'10"	826	Aug. 5, 1985	12'5"	745
Pen 6	11'9"	645	April 25, 1991	11'10"	
Pen 7/8	12'0"	550	April 19, 1991	11'9"	520

Thus, these alligators are continuing to grow slowly in length but substantially in weight. The alligator at Lake 14 is an older alligator and was initially caught in the wild as a hatchling in 1953. It was donated to Rockefeller Refuge in 1959.

Four adult pen females were caught in June/July 1993 and ranged in size from 8'10" to 9'4". In 1991 they ranged from 8'5" to 9'0½". Weights were not obtained as we tried to minimize the time restrained for the nesting females.

Chinese alligator (*A. sinensis*) culture

Rockefeller Refuge has on loan one pair of Chinese alligators (*A. sinensis*) obtained from the New York Zoo. They have successfully nested several times, and in each of the last three years. We obtained 4 hatchlings in 1991, 14 in 1992, and 20 in

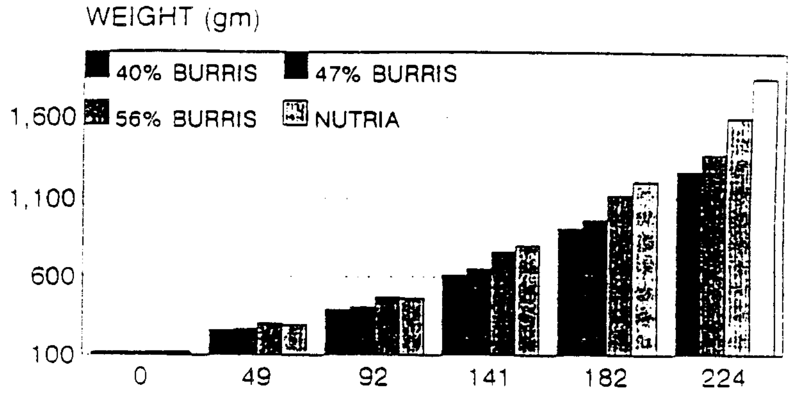
1993. The nest in 1993 was located on 6-16-93 at which time the eggs appeared to be 7 days of age. We were asked by the NYZS to incubate the eggs at 91° to attempt to further study temperature dependent sex determination in this species, and try to produce males. On 8-6-93 the eggs began to hatch and 20 hatchlings were obtained from a clutch of 31 eggs; of the remainder one egg was infertile; 3 died at 2 weeks incubation, one at four weeks, three died at 8 weeks of incubation and 3 at an undetermined stage. All hatchlings were shipped to the Bronx Zoo.

Another study on the morphology and ultrastructure of the Chinese alligator eggshell has been completed in collaboration with Dr. C. S. Wink and is "in review" for publication in the Journal of Morphology.

Juvenile Alligators Feeding Trials

Annual feeding trials are conducted at Rockefeller Refuge to assist the farming industry by testing commercially available diets (alone or supplemented with meat) to make recommendations to alligator farmers on the best diets available.

One of our recent tests in 1991-92 showed that growth achieved with commercially available extruded dry pelletized rations increased linearly with increasing available protein by percentage. Diets tested included Burris Alligator Feed with 40%, 47%, and 56% protein; and ground nutria (Myocastor coypus) meat. Nutria gave the best growth (Figure 7), though the economics and convenience of providing dry foods which need not be stored frozen must be considered.

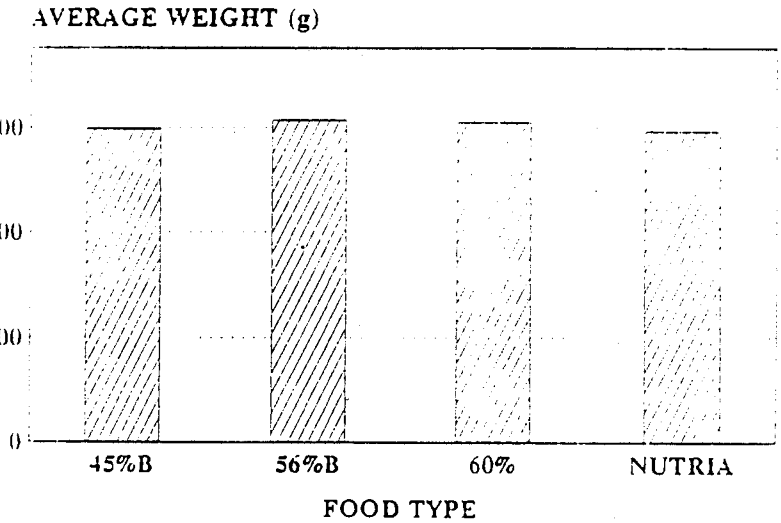


40% BURRIS	121	265.8	394.7	615.3	910.1	1,274.4
47% BURRIS	120.7	272.9	413.5	656.6	964.5	1,378.5
56% BURRIS	121.5	307.7	473.2	763.5	1,122.2	1,604
NUTRIA	120.9	294.8	464	800	1,205.8	1,847.7

DAYS IN STUDY

In 1992-93 we tested feeds with reportedly 45%, 56%, and 60% protein versus nutria; surprisingly this year no differences were noted with protein levels throughout the study (Figure 8). The manufacturer felt that there may have been a quality control/manufacturing problem and the actual protein levels were in question.

Both years three replications of each of the four diets were used, and twelve alligators were used in each group to study each diet (total 144 alligators used each year).

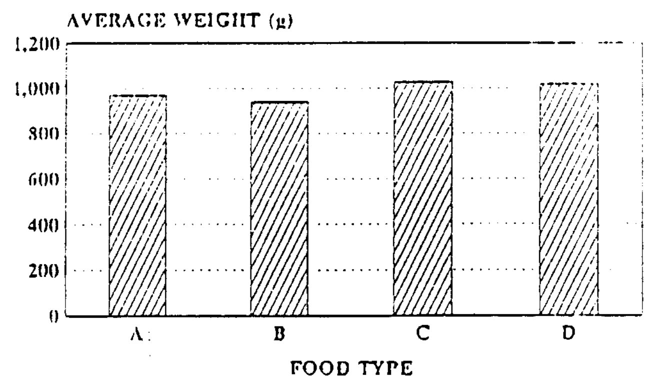


September 23, 1992 through February 5, 1993

This year (1993-94) we are studying the effects of various feed components (certain vitamins, minerals, arginine, etc.) on skin quality. These have been shown to improve skin integrity and promote wound healing in other species. This should be useful to the farming industry as recent competition due to the falling skin prices has made the grade of the skin of unprecedented importance. Preliminary results have shown significant differences in growth in the three diets tested (Three replicates of each diet, 23 animals per treatment group for a total of 207 animals in the study). We will assess skin quality and wound healing from the various diets. This study is being managed under the direction of Dr. Mark Staton.

A second feeding trial was conducted in 1991-92 to determine if the addition of steroids as an appetite stimulant would enhance growth in juvenile alligators. Three groups of alligators were supplemented with increasing doses of prednisone, and a control group was fed only dry pelletized rations. A modest increase in growth rate was achieved with the addition of steroids (compared to controls) but it was not sufficient to warrant the required testing as to clearance of the drug from alligator tissues/meat to be used for human consumption. (Figure 9).

Effect of Prednisone (Steroids)



September 26, 1991 through March 27, 1992
n = 11 per group, from single clutch
A = Control B = 1mg / kg / d C = 2mg / kg qod D = 2mg / kg / d

Juvenile alligator nutrition is being studied intensively by Drs. R. Coulson and Dr. J. Herbert at the LSU School of Medicine, Department of Biochemistry. The addition of gelatin and glycine are being studied this year. Much of their work suggests that alligators fed pelletized diets supplemented with meat grow better than those on dry pelletized feeds alone. Work continues studying the stomach emptying times of dry diets, the efficacy of proline and other supplements, and attempts to find the least amount of meat needed to add to a dry pelletized diet to get maximum growth.

Rockefeller Refuge Egg Harvest

Alligator nesting study sites are mapped carefully each year, and data recorded on nesting efforts relative to water levels, salinity, temperature, etc. Intensive egg harvests continue at Rockefeller Wildlife Refuge to supply eggs for research, "Rockefeller Supplement" farm program, and "Private Assisted" programs. The Rockefeller Supplement is a continuation of an early program wherein the first few alligator farmers in Louisiana were provided hatchlings from eggs from state-owned properties as a source of stock to encourage the fledgling industry; as egg ranching was not allowed at that point. Later, when the demand for eggs exceeded what could be provided from Rockefeller Wildlife Refuge the ranching program was developed. Many early ranchers collected eggs with the assistance of Louisiana Department of Wildlife & Fisheries personnel while the ranching program techniques were being developed. These programs are phasing out, only four farmers have not yet completed their ten years on the supplement program. Eggs are still collected extensively for researchers as outlined elsewhere in this paper. In 1993 approximately 4,000 eggs were collected for research; and 11,695 hatchlings were provided for the private assisted and supplement programs.

Alligator Embryology/Temperature Dependent Sex Determination

Numerous distinguished international scientists have worked out highly specialized aspects of the development of the alligator embryo using samples collected at Rockefeller Refuge. A wealth of data has been generated by these individuals and their expertise in molecular biology techniques, radioimmunoassay, tissue grafting, etc., has answered many questions on the reproductive biology and physiology of the alligator. We have had the pleasure through the last several years of providing alligator eggs and tissues to Drs. Paul Cardeilhac, Harriet Austin, Mark Ferguson, Anne Marie Coriat, Jean Joss, Val Lance, Jeff Lang and Craig Smith and others in order to support their research.

Molecular Genetics of the American Alligator

Work continues with Dr. Herb Dessauer to study questions of multiple parentage, pair bond existence, etc. in alligators using blood samples from captive breeders at Rockefeller and resulting hatchlings. Preliminary data suggests all genotype distributions can be explained by single male-to-female crosses (only one male alligator fathered the entire clutch in the 5 clutches studied in 1993, i.e. other males did not contribute to the female's clutch). There is no evidence of multiple male parentage of a single brood thus far. A single dominant male appeared to have mated with three females in Pen 6; this large male was the presumptive father of 3 of the 5 clutches in that pen.

Biliary system of the alligator

Several projects were initiated in early 1992 in association with Dr. Steve Tint and Dr. Guorong Xu to study the rate of production of bile in the American alligator and its' exact composition using labelled cholesterol. Bile fistulas were surgically constructed to allow complete collection of bile, and to monitor the amount produced over certain time periods. Final lab analysis of the samples collected is nearly complete. Another radiologic study on the ultrastructure of the biliary system was done in 1992-93 as several variations were noted in the anatomy of the biliary tree on initial dissections.

Alligator nematodes

During a study of food habits of farm-released and native wild alligators, we noticed that wild alligators more frequently (83.3%) had nematodes present than farm-released alligators (47.4%; $p < 0.05$) (Elsey et al 1992). Also, nematodes were more numerous in native wild alligators (13.1 $\pm$ 3.8 nematodes/stomach) when present in wild alligators versus 2.1 $\pm$ 0.5 nematodes/stomach in farm-released alligators with nematodes ($p < 0.05$) (Elsey et al 1992). These nematode samples are being identified by Dr. Robin Overstreet and his staff at the Gulf Coast Research Laboratory.

WWF (World Wildlife Fund) Project/Sustained Utilization

A special project is underway to document the conservation benefits of sustained utilization of crocodilian species. Although the philosophy of "sustained use" is widely accepted by most crocodilian biologists and managers, the conservation benefits derived from the economic gain of utilization of these species is not well documented, though generally accepted by those in the field. We are preparing an extensive manuscript for the World Wildlife Fund to document the conservation benefits of the well managed and strictly regulated sustained use programs involving the American alligator (wild harvest and egg ranching). Interviews with land managers and the role the alligator plays in their wetlands management practices will be included to demonstrate how crocodilian utilization can conserve and enhance marshlands and the many species utilizing those wetlands.

Extension Services

Due to the resources available at Rockefeller Wildlife Refuge and the interest in supporting alligator research, we often provide samples to various investigators to help support their research on alligators or reptiles in general. A partial list of those individuals, their institutions, and general areas of research follows.

Acknowledgments

We thank Guthrie Perry, Leisa Theriot, and Karen McCall for assistance with data analysis and preparation of the manuscript. We acknowledge Barry Wilson for helpful review of the manuscript.

Recent Extension Researchers

Austin, H. University of Colorado. Department of EPO Biology. Boulder, Colorado. Regulatory mechanisms of Mullerian duct regression.

Cardeilhac, P. University of Florida. College of Veterinary Medicine. Gainesville, Florida. Factors affecting captive breeding/reproductive success; disease, etc.

Canfield, W. University of Oklahoma Health Sciences Center. Oklahoma City, Oklahoma. Evolution of the mannose 6-phosphate/insulin like growth factor II receptor system (reptile model).

Conlon, J. M. Creighton University School of Medicine. Omaha, Nebraska. Neuroendocrine peptides, tachykinins.

Coulson, R. A./Herbert, J. (see text). Louisiana State University. Department of Biochemistry. New Orleans, Louisiana. Alligator biochemistry, physiology, nutrition.

Dessauer, H. (see text). Louisiana State University. Department of Biochemistry. New Orleans, Louisiana. Molecular genetics, breeding physiology.

Ferguson, M./Coriat, A. M. (see text). University of Manchester. Cell and structural biology. Manchester, England. Genetic factors/regulation of TSD, egg hatchability/embryology.

Janke, A. University of Germany, Zoology Institute. Munich, Germany. Molecular phylogeny of tetrapods (liver tissue for DNA source).

Jones, D./Phelps, R. University of British Columbia. Vancouver, BC, Canada. Cardiovascular physiology/cardiac anatomy and blood shunting.

Joss, J./Smith, C. Macquarie University. Sydney, Australia. TSD/gonadal sex differentiation/reproductive endocrinology.

Kasinsky, H. University of British Columbia. Vancouver, BC, Canada. HPLC/protein sequencing of sperm protamines.

Lance, V. (see text). San Diego Zoological society. San Diego, California. Comparative and developmental endocrinology, reproductive physiology, stress physiology/hematology.

Lang, J. University of North Dakota. Grand Forks, North Dakota. Control of and temperature sensitive periods in TSD, reproductive biology, incubation physiology.

Owen, W. Mayo Clinic. Rochester, Minnesota. Nonmammalian clotting systems/thrombin biochemistry.

Powell, J. George Washington University. Washington, D.C. Postembryonic development of sexually dimorphic osteological characteristics in living/extinct archosaurs.

Rieppel, O. Field Museum of Natural History. Chicago, Illinois. Patterns of ossification in the endo- and exoskeleton.

Staton, M. (see text). P. O. Box 30985, Lafayette, Louisiana. Alligator nutrition, skin quality, breeder diets.

Tint, S./Xu, G. (see text). Veteran's Administration Hospital. East Orange, New Jersey. Bile composition, synthesis, biliary tree anatomy.

Urtl, R. Louisiana State University. Baton Rouge, Louisiana. Function of the cytochrome P450-dependent microsomal mixed function oxidase system.

Vigna, S. Duke University, Durham, North Carolina. Evolution/physiology of the regulatory peptides of the cholecystokinin/gastrin family.

Weldon, P. Texas A & M University. College Station, Texas. Composition and function of glandular secretions, feeding behavior, chemical attractants.

Wharburton, S. University of Nevada. Las Vegas, Nevada. Effects of hypoxia on cardiovascular/respiratory development in embryogenesis.

Witmer, L. New York College of Osteopathic Medicine. Long Island, New York. Growth/morphemetrics of the skull and sinus system.

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CAPTIVE BREEDING IN COLOMBIA:

Some Aspects of Policy and achievements

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The Conference of the CITES Parties Resolution 8.22 (environmental value of captive breeding and ranching) and the Editorial Note in CSG NEWSLETTER 12 (2) make us think we, as a whole community, could go to one extreme. Past experiences have shown that extremes are not good or safe and provide very limited management conditions.

Within the debate on captive breeding versus ranching, Colombia would like to stay somewhere in the middle and keep options open in both directions. Of course, we will strive to keep our attention on ecosystem dynamics and productivity while achieving conservation and sustainable use of species.

Conditions particular to Colombia have led us to work very hard on the captive breeding side of the sustainable use options, and we are interested in telling the public about our work with some species, their wild population, restocking, and sustainable utilization.

With many species (crocodiles for example), we think it will be easier to refocus our conservation efforts on the wild population once regulated legal trade and the economic benefits from closed-cycle farming are established, rather than it would be to conserve the species in the wild while at the same time trying to regulate a wild harvest. After a case by case analysis, we should know which option to follow. Building management expertise and appropriate trade conditions cannot be accomplished in one day, and in the past we were very close to losing some crocodilians.

This presentation will be brief. Colombia has presented to previous Steering Committee meetings of the CSG and to the 29th and 30th Standing Committee Meetings of CITES (Washington and Brussels, 1993) reports on the captive breeding scheme we have been managing. More recently, the Chairman of the Animals Committee of CITES and the Vice-Chairman of the CSG have presented a comprehensive report on Colombia to the 31th meeting of the Standing Committee of CITES (Geneva, March 1994) and to this 12th meeting of the CSG Steering Committee.

At this time we would like to stress some main relevant considerations about the Colombian program.

1. The total internal and external trade in animals in Colombia has decreased significantly since regulations banned commercial hunting of wild animals and opened the captive breeding option.

2. Crocodilians became truly protected and the legal sustainable use is helping to stop illegal non-sustainable trade. Wild crocodilian populations in Colombia are recovering or stable in most forested areas.

3. The most endangered species in Colombia, *Crocodylus intermedius*, urgently needs captive breeding before wild populations can be restocked.

4. The costs of protecting the threatened crocodiles and rearing them in captivity have been paid by the closed-cycle farms and legal trade in 'babilla', *Caiman crocodilus*.

5. 'Babilla' (caiman) legal trade also has helped pay the cost of developing farms for sustainabale utilization of other species, giving continuous employment to people in rural depressed zones, and contributing to increased awareness of nature conservation and sustainable use.

6. Closed-cycle farms in Colombia are located mostly in areas where nature is highly disturbed, where main human settlements are located, and where cattle ranching and extensive agriculture has developed. Thus, the close-cycle farms help bring wild animals back to these regions as land use alternatives.

7. In Colombia, closed-cycle farms, and also crocodilian tanneries, are examples of advanced enterprises taking care of the environment. They control water disposal, recycle nutrients, avoid soil erosion, and promote economic investment in conservation in rural areas where cattle and agriculture traditionally are not involved in conservation.

8. Closed cycle operations in Colombia have provided a valuable opportunity for team work between government and the private sector, thus helping policy development and implementation.

9. Closed cycle farms in Colombia are contributing to the knowledge of wild species and to the training of people for management. They are also providing much more information than in the past, when the capture and export of wildlife was widespread and uncontrolled.

10. The program we have developed now is giving us the opportunity to approach new forested regions where local people could be implementing options for ranching or harvesting from the wild under technically based quotas.

Colombia is re-evaluating its wildlife programs. That review will lead to improved regulation and policy for wildlife utilization. It might lead to a general policy of captive breeding of CITES Appendix I species, and ranching and wild harvest of Appendix II and III species.

The management of the market for sustainable utilization of species is not a single country task. In striving to reach that goal, we want to share experiences and efforts with other countries and organizations. Cooperation will be needed to ensure that trade will be carried out with products of legal origin. If this is not possible, Colombia will have to stick to captive breeding as the only option to maintain control.

An Assessment of Crocodile Resource Potential in Bangladesh

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Thanks are also due to Jamil Ahmed, P.K. Barman, Jillur Chowdhury, and A.K. Shamsuddin Kahn of the private sector for their important contributions related to evaluation of feed prospects. Songklod Chantarasri, Peter Myers, Kirti Tamang, and Gusti Tantra of the Food and Agriculture Organization (FAO) graciously provided information, facilities and hospitality. In addition, support by Serge Darroze of FAO Headquarters for suggested follow-up measures is most appreciated.

Bangladesh Biman staff facilitated travel on several occasions by coming up with airline seats when none were to be had. Similar fine assistance was provided by many other people in various walks of life, enabling a great deal of ground to be covered and relevant persons contacted during a brief and gratifying stay.

Appreciation is also extended to Harry Andrews, John Hutton, Phil Hall, and Rom Whitaker for their comments and constructive criticisms of this report and its preceding version.

2. Introduction:

Bangladesh is a largely alluvial country in southcentral Asia (Figure 2) of approximately 120 million people and supports one of the world's highest densities of rural human population. Most lowland habitat has been converted for agricultural purposes to meet the basic needs of a burgeoning class of hard-core poor. Almost all remaining crocodile habitat is under intense pressure from fishing, transportation, and forest product extraction.

At least three crocodilians have historically occurred and persist in Bangladesh: the gharial *Gavialis gangeticus*, mugger (or marsh crocodile) *Crocodylus palustris* and estuarine crocodile *C. porosus*. The gharial is restricted in present distribution to the Indian sub-continent (and possibly Myanmar), while the mugger extends to the Near East and Sri Lanka, and the estuarine or saltwater crocodile is a wide-ranging Indo-Pacific species.

A two week review was carried out from 10-25 January 1993 to assess the current status of crocodile populations in Bangladesh and potential for conservation-based rehabilitation of the resource. Pertinent literature and data were collated and studied. Interviews were conducted with a variety of government officials, aid agency personnel, researchers, captive stock managers, and other interested entrepreneurs. Most captive stock locations and potential farming/ranching areas were visited, but time constraints did not allow direct inspection of representative examples of remaining crocodile habitat. Emphasis was given to evaluating the economic viability of ranching and farming, and how such potential operations could enhance the *in situ* prospects of crocodilians in Bangladesh.

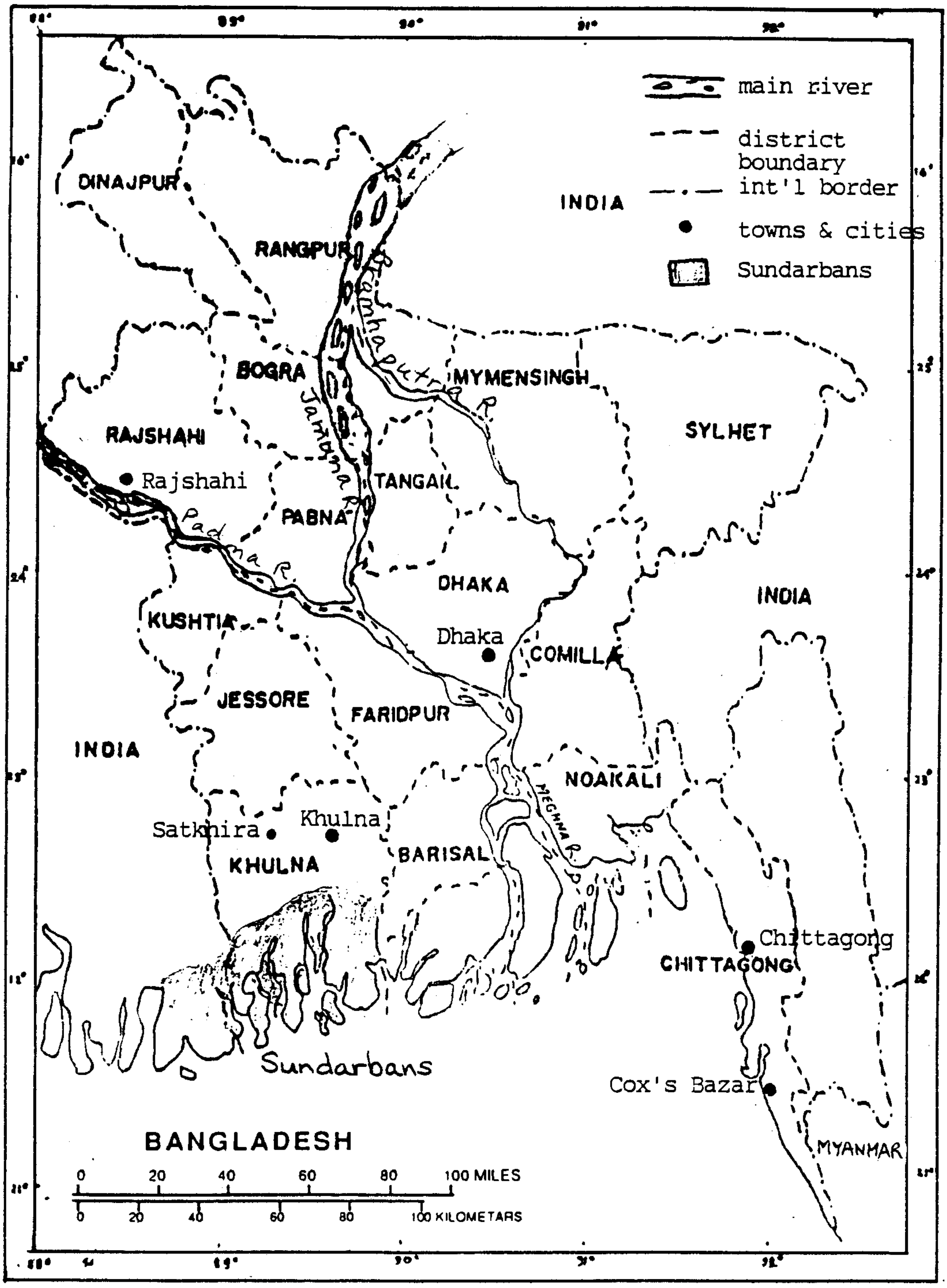
This report is an updated version of a report prepared in May 1993 for CTAA that describes in detail the findings of the visit and recommendations for follow-up action.

3. Crocodilian Status and Distribution:

3.1 *Gavialis gangeticus*:

Gharial were reportedly common about 100 years ago in large freshwater rivers such as the Jamuna, Padma, Meghna and Brahmaputra (Sarkar 1986). Until 1950 the species was also distributed in many tributaries (Faizuddin 1985). Since then sub-populations throughout Bangladesh have undergone a steep decline. In 1982 the total population was estimated at 20 (Khan 1982), and a 1985 survey recorded 28 gharials in the Padma, Jamuna and Brahmaputra rivers (Faizuddin 1985). A year later, only 8-10 was estimated (Husain et al. 1986a). Caution with these figures is advised because systematic survey methodology has not been used. Most surveys have relied on counts of basking crocodiles and anecdotal information from local communities. The figures should be regarded as minimum approximations of population size,

Figure 2. Map of Bangladesh with annotated features (source: Rahman 1992)



although owing to the relatively conspicuous behavior of gharials, their novelty as a rare species, and the highly dispersed local presence of human informants, it is unlikely that gharial abundance has been seriously underestimated.

Since 1986 there have been very few sightings of the species in degraded primary habitat comprised by the main channels of the Padma, Jamuna and Brahmaputra rivers. No nests have been reported for the past three years along the best known nesting banks near Rajshahi on the Padma (M. Rahman, pers. comm.), whereas during the period 1982-1985 two nesting colonies produced 12 nests (Rahman 1990). The last incidental capture of a gharial appears to have been a yearling in 1990 from Aricha near the confluence of the Padma and Jamuna (Md. Samsul Alam, caretaker, Dhaka Zoo, pers. comm.). The animal is being reared under good conditions at Dhaka Zoo, where an additional 1.7 m juvenile (♀?) is kept (pers. obs.). The only other captive stock are two juveniles at the Rajshahi Zoo (Rahman 1991a), which was not visited.

Although the gharial is protected by legislation in Bangladesh (Wildlife Preservation Act of 1973), the law is yet to be effectively implemented for crocodilians. Local people unintentionally drown gharials in fishing nets and attendant females tip off villagers to the location of nests, which are excavated and destroyed with the unfounded belief that gharials reduce the fish catch.

Gharial habitat is intensively utilized throughout Bangladesh for fishing and as major transportation arteries. The nesting banks SE of Rajshahi are said to be still relatively undisturbed (village informants, pers. comm.); however, no comprehensive survey has been conducted in Bangladesh to assess the extent of suitable remaining or recoverable habitat.

To further complicate the situation, much of the suitable habitat in the Padma River system was lost in 1986 due to a course shift in the river to the Indian side of the border. After subsequent recovery, the monsoon of 1991 again transferred the gharial populated section of the Padma to Indian jurisdiction (Andrews 1992).

Considering the extremely low, decreasing population estimates and continuing degradation of remaining habitat, the gharial in Bangladesh now faces the imminent threat of being extirpated from the wild.

3.2 *C. palustris*:

The mugger is evidently extinct in the wild in Bangladesh. In captivity, only six individuals - all wild-derived adult pairs - remain. Two of these are housed at Dhaka Zoo, where the females are said by the grounds keeper to nest annually, laying as many as 25 eggs each. However, successful hatching has yet to occur. The other pair is well-maintained in a shrine pond at Bagarhat, south of Khulna. The female, ostensibly aged and very tame, was reported by the caretaker to still nest annually beginning in March. Since 1984, 25-30 hatchlings have been produced in most years, but (all?) were allegedly cannibalized by one or both parents. Clutch data for the period 1981-1987 has been compiled by Rahman (1991b). A hatchery is being constructed by the Bangladesh Forest Research Institute (BFRI) at Chittagong. It is envisaged that this facility will be used to incubate fertile eggs produced by the last remaining breeders.

Mugger were probably once widespread in rivers and associated *haors* (marshes) of Bangladesh but extensive habitat loss and modification, in addition to hunting for hides, has virtually extirpated the species. Although mugger are highly adaptable to a variety of aquatic habitats, no significant expanses of intact habitat - and in particular any suitable nesting habitat - could be identified.

3.3 *C. porosus*:

The estuarine crocodile formerly inhabited the coastal mangrove associations of Chittagong district in SE Bangladesh (and probably inhabited the main inland rivers of the country as well) but is now restricted to the 3,800 km^2 Sundarbans Reserve Forest (Whitaker 1982). This vast maze of mangrove forest and tidal mudflats features some 1,200 km^2 of waterways, much of which remains good general habitat for *C. porosus* (Figure 3.3).

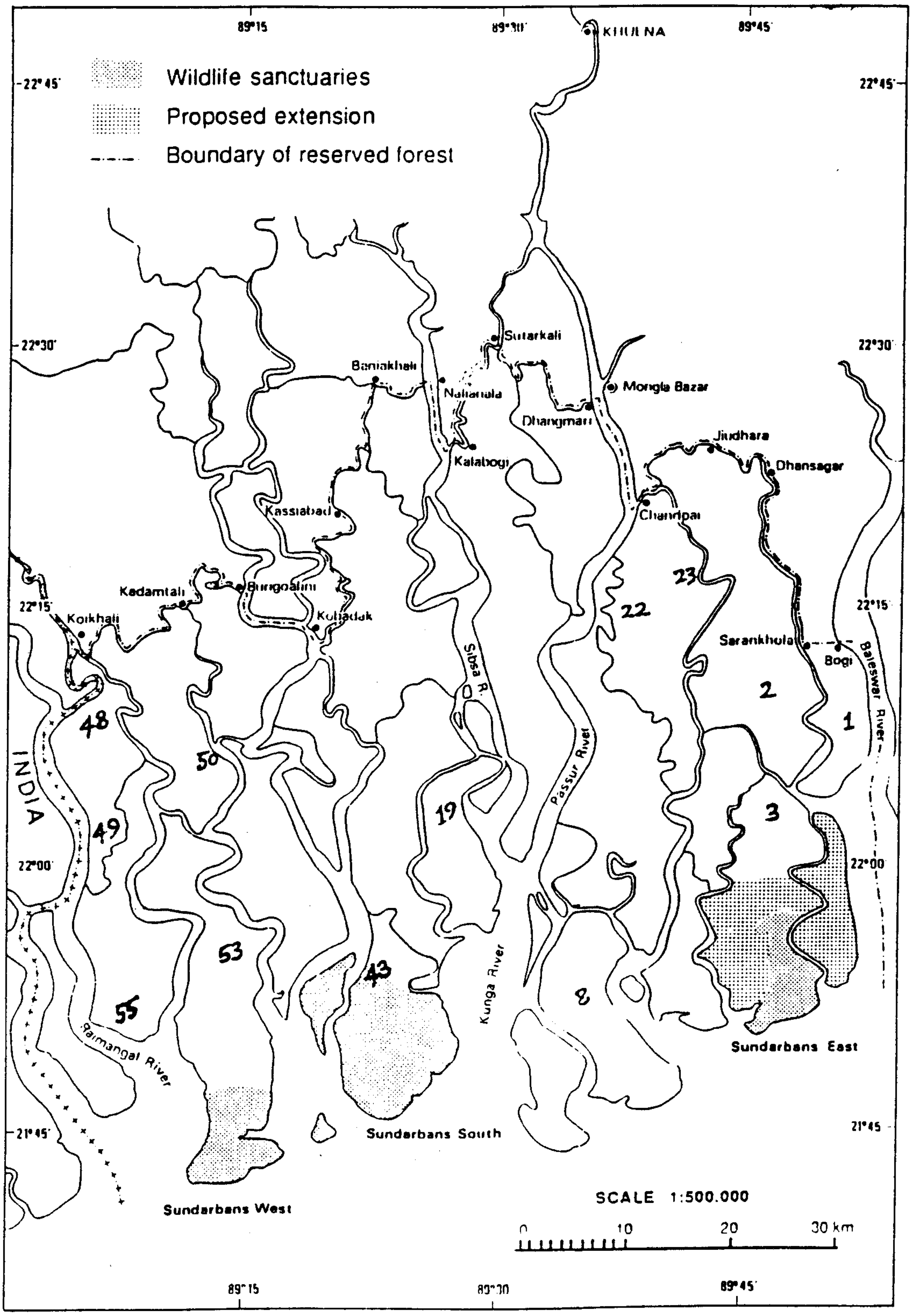
Estuarine crocodiles were common in the Sundarbans until unregulated hunting for skins between the 1940s and 1970s reduced the population from a minimum of several thousand to probably no more than a few hundred (Whitaker 1982). Despite the implementation of a hunting ban since 1972, the population showed little if any sign of a recovery over the next decade, possibly as a result of a severe reduction in female breeding cohorts (Whitaker 1982).

No comprehensive survey of the estuarine crocodile population in the Sundarbans has been conducted, but an indication of population status can be gained from one major and several preliminary surveys. Akonda (1981) conducted day and night counts of crocodiles in the Swarankhola - Katka area. Supplemented with local information, he estimated a minimum (non-hatchling?) density of 0.16 crocodiles/km over a course of 56 km. During a nine day, wide-ranging stay in the Sundarbans, Forestry Department officers confirmed the persistence of a breeding population (Husain, et al. 1986b). Other non-systematic estimates of minimum population size range from 40 (Rahman 1992) to 200 (Khan, cited in Rahman 1991b).

A major population survey was carried out by Whitaker in 1982 but because of weather and logistical constraints night counts covered just 95 km. However, forest product extractors recounted the presence of some 85 nests and numerous sightings of estuarine crocodiles. On the basis of this information, it may be inferred that a minimum population on the order of a few hundred existed.

The most recent indication of status comes from initial fieldwork conducted in early 1993 during the current FAO/Government of Bangladesh project to assist

Figure 3.3 Sundarbans Reserve Forest



N.B. Annotated figures refer to divisions where *C. porosus* reported.

sustained-yield management of the Sundarbans. Although there are no data to suggest that crocodile numbers are increasing, evidence of a further decline is lacking. Estuarine crocodiles are occasionally seen basking on mudflats and there are several reports of nests destroyed by local gatherers. Poaching of wildlife is considered uncommon if not virtually non-existent (K. Tamang [Append. 4], pers. comm.). As surmised by Whitaker (1982), the human disturbance generated by the collection activities of some 100,000 daily users (latest estimates) may be causing females to abandon their nest guarding behavior, leading in turn to increased clutch predation and lack of recruitment into the population. It is also interesting (and somewhat puzzling) that tiger mauls remain frequent but no crocodile attacks have been reported in recent years (K. Tamang, pers. comm.).

4. Ranching and Farming Prospects:

4.1 Concepts and strategies

Where crocodile populations have been depleted to the level that direct cropping of animals is no longer feasible, there are two other management strategies: farming and ranching, that can be utilized to develop commercial potential and simultaneously promote recovery of the resource. Both strategies possess conservation value in that a proportion of reared animals can be returned to the wild in order to replenish populations. The adoption of such strategies is especially appropriate in countries such as Bangladesh where multiple species of crocodilians feature dissimilar population status and utilization potential. Where suitable tracts of crocodile habitat still exist, a conservation-based farming scheme may later be phased into a ranching program.

Farming of crocodiles is based on the breeding of adults in a controlled environment. Eggs laid by females are collected from nests and artificially incubated; hatchlings are then reared to desired size for slaughter. An important advantage of this strategy is that optimum conditions for breeding stock enable eggs of maximum fitness to be produced.

The ability to obtain young eggs is very important because they can be manipulated by temperature to choose the sex of offspring. Incubation under ideal conditions also allows maximum growth rates to be 'programmed' for the entire life of the animal, thus enhancing performance and profit.

The major drawbacks of farming lie in its closed-cycle character. The costs of constructing breeding facilities and maintenance of breeding stock are substantial and can hurt the profitability of the operation, particularly in today's increasingly competitive marketplace. Moreover, because there is no economic dependence on the maintenance of healthy wild populations, benefits to conservation are minimal (Thorbjarnarson 1992).

Ranching of crocodiles is based on the collection of eggs or young from the wild. Because these population components exhibit high natural mortality, the risk of adversely impacting the population is considerably less than a harvest of larger animals subject to much lower mortalities in the wild. By salvaging a largely doomed component, ranching stretches the productivity of the resource to the mutual benefit of conservation and commercial production.

The recent worldwide surge of interest in this strategy is attributable in part to its ability to confer a high degree of conservation value. Ranching forges a direct link between the health of wild populations and the ability to obtain rearing stock (Thorbjarnarson 1992). Dependance on a harvest of eggs or young animals also underscores the value and importance of protecting breeding stock in the wild.

Eggs are particularly well-suited to this strategy due to even greater mortality in the wild ($\approx$50-90%) than hatchlings or yearlings. Another advantage of choosing eggs over young animals is that higher quality "starter material" can be obtained if eggs are harvested soon after deposition and transported properly to a rearing facility. Early collection also allows a higher percentage of vulnerable eggs to be salvaged before the effects of flooding and predation take their toll.

Ranching is also more favorable to the economical conduct of a rearing operation than farming. Less investment is required because the costs associated with pen construction and maintenance of breeding stock can be by-passed.

4.2 Species suitability

Ranching prospects for the Bangladesh populations of mugger and gharial are bleak because the species have been nearly extirpated and suitable habitat for eventual recovery is evidently very limited. Even so, commercial farming of mugger for skins and by-products should be a viable long-term strategy. The skin quality of this species falls within the valuable "classic" category and by-products such as meat, oil and glands could add another 30-50% to export value.

A possible near-term contingency exists for the ranching of mugger utilizing stock obtained from India. Since 1975 a recovery program initiated with the technical assistance of FAO has succeeded in resuscitating the mugger resource in India by rearing juveniles from wild-collected eggs (and more recently) captive breeding for reintroduction.

However, mugger habitat in India is limited to a small network of refugia within suitable protected areas and all locations now approach (or have reached) population carrying capacity (H. Andrews [Append. 4], pers. comm.). More than 12,000 mugger remain in captivity (Anon. 1993) due to the lack of additional release sites and the government's continued unwillingness to permit commercial utilization. The cost of feed and shortage of pen space for stock is creating hardship for rearing facilities, and contrary to the aim of their establishment, leaving no alternative for many but to destroy clutches or allow them to rot (Andrews 1992). Bangladesh would appear to be the ideal country within the home range of *C. palustris* to help alleviate this unfortunate situation by import of eggs or excess juveniles and, in turn, demonstrate the many merits of a ranching strategy to Indian authorities. Such a scheme would mutually benefit Bangladesh by expediting development of mugger ranching in addition to providing founder stock for a possible re-introduction program.

Although the ossified character of gharial skin renders it of low value for the production of leather, cost-effective breeding of the species could be facilitated by integrating such a venture with tourism and the rearing of other resident crocodilians. Excellent potential to integrate domestic tourism was found in the Chittagong and Cox's Bazaar areas (see sections 4.4.1 and 4.4.2). The uniqueness, rarity and unusual appearance of the gharial make it an exemplary tourist attraction.

C. porosus continues to command the highest price of all crocodilian skins on the international market (USD 7-10 per cm bellywidth), and because captive breeding of the species has thus far met with only limited success, and *in situ* utilization is limited by the seriously depleted nature of most remaining populations, marketing prospects for the near future (and perhaps well beyond) are likely to remain favorable.

A systematic survey is first required to confirm a viable breeding population of estuarine crocodiles in the Sundarbans and the practicality of locating active nests, but a ranching scheme based on wild egg harvests should present an attractive management option for this species. Ranching could be tailored to not only sustainably utilize the existing estuarine crocodile population but promote its replenishment and provide a stronger economic incentive to conserve habitat.

If the apparent high rate of failed nesting in the Sundarbans can also be corroborated, then the wild population should incur virtually no risk from egg harvesting. Indeed, to rapidly restore the estuarine crocodile resource and expand the source of commercial "starter material", a proportion of harvested eggs could be restocked within two years as young juveniles with greatly increased chances of survival.

4.3 Critical factors

Other than accessibility of stock, the single most important factor in establishing a ranching or farming venture in Bangladesh is a secure, regular supply of cheap, fresh protein as crocodile feed. Rural sources in the form of cow and goat offal are reportedly available (Whitaker 1982), but these appear difficult to mobilize for the almost daily delivery and quantity required. Moreover, such sources are dangerously unreliable because the investor would have to bank on uninterrupted cooperation from several small scale ventures or a host of independent farmers. Lacking control over feed cost could prove risky, especially when suppliers see a profitable venture coming on line. The importance of feed security is further emphasized by the lengthy period (≥ 5 years) needed to bring a ranching or breeding enterprise into full operation and recoup the substantial initial investment.

Waste animal protein is scarce in Bangladesh and there is virtually no trash fish. The "hanging meat" (brain and connective tissue) discarded by the shrimp industry was found in interviews with factory managers to be minuscule (<1 kg per ton of catch). Crocodile feed would be largely restricted to locally marketable fish, of which several species are suitable and relatively cheap (USD 0.20 - 0.50/kg), and incidental catches of even less expensive skate and shark.

A long-term joint venture with a large parastatal such as Bangladesh Fisheries Development Corporation (BFDC) could alleviate feed cost uncertainty, but there are not yet any competing large suppliers to assist the prospects of smooth sourcing. Ample supplies were found in most centers but availability drops seriously during the monsoon months of June through August when trawlers are reluctant to venture into the stormy Bay of Bengal. Because even a few weeks without feeding can induce stress in rearing stocks that carries over well beyond the time feed is again provided, installation of freezers may be necessary to extend supplies of fish.

Relying on fish is also potentially risky as this can lead to imbalances in metabolism and result in disease if the feed is not fed fresh or is composed of a high fat content. The problem can be overcome with vitamin and mineral supplements, and the use of freezers, but these add considerably to the overall cost of operation.

To further ensure a regular supply of feed and less expensive procurement, the potential for development of a fish meal based pellet feed merits scrutiny.

Alternative sources of feed are questionable because commercial production of meat and hides in Bangladesh is highly decentralized and largely rural-based. Offal from local production of frog legs and chicken is available in small quantities, but greater potential exists with integrated poultry production and to a lesser degree with commercial rearing of frogs for legs and skins. The potential for frog farming is still largely unknown (Fugler 1983) and particularly deserving of further investigation as Bangladesh has in recent years become the world's largest exporter of frozen frog legs (Anon. 1992). Conservation-based frog farming could also prove valuable as there are increasing concerns that a decline in frog populations due to overharvesting has led to the proliferation of insect pests, which are in turn adversely affecting agricultural production and community health through the increased use of pesticides (Fugler 1983).

Notwithstanding the current weak international market in crocodile leather, economic prospects for ranching and farming in Bangladesh are promising. These are typified by:

- availability of suitably priced feed in the form of sea fish and possibly other sources;

- inexpensive land, costs of construction and general labor;
- a favorable export market and near-future prospects for *C. porosus* skins;
- excellent potential for integration with tourism to enhance viability;
- a tropical climate conducive to low cost grow-out of rearing stock; and,
- creation of a new export market to generate much needed foreign exchange;

Because of less than ideal feed costs, the design and establishment of rearing enterprises must, however, pay particular attention to the scale and efficiency of operation. This includes incorporation of advanced technologies, where feasible, to compete effectively with established producer countries. Present indications are that for a venture to be economically viable, skin production costs must not exceed USD 2.00/cm bellywidth.

Integration with domestic tourism was appraised as an excellent way to significantly cut overhead at two locations and perhaps singularly finance a ranching or farming venture at one of them (c.f. sections 4.4.1 and 4.4.2).

Similarly, joint ventures with overseas tanners to produce processed skins for export could increase operational viability and in-country profits (and thus add value to the resource), as well as enable tanners to cut their manufacturing costs.

4.4 Evaluations of potential rearing locations

Several towns and cities were investigated for the feasibility of ranching and farming of resident crocodilians. The availability of freshwater, feed, eggs and tourism potential were the primary factors considered in evaluating the following locations.

4.4.1 Cox's Bazaar

This small town at the southeastern tip of the country is the center for domestic tourism in Bangladesh. The principal attraction is a wide, largely undeveloped beach, which from September through April draws as many as 100,000 visitors on weekends and 20,000 to 30,000 on weekdays. As there is a near total lack of recreational and entertainment facilities, an attractively designed, well-managed and publicized crocodile enterprise should be able to offset most if not all operational costs. In addition, an excellent venue could be developed to raise public awareness concerning crocodile and other wildlife conservation.

The all-important factor of a cheap dependable source of protein as crocodile feed is to some degree limiting. Only fresh ocean fish is available, but can be organized by BFDC in sufficient quantity (>500 kg/day) during most of the year. While there is a local market for nearly all the catch, less palatable small species are sufficiently inexpensive (USD 0.35 - 0.50/kg). Tuna, which is a particularly good feed species, and small prawns are usually available in the same price range. From September through November, the prime commercial species, hilsa *Hilsa ilisa* floods the market at reduced price (USD 0.25 - 0.40/kg). Skates and sharks are available most months and cheapest of all (USD 0.20 - 40/kg).

All types of feed are subject to reduced supply during the monsoon months and there is a lean period in supply from early December through mid-February. Nonetheless, the annual catch appears adequate to feed a minimum of 2,500 mixed age class crocodiles, and may be expandable with supplements such as unpopular chicken cuts, and offal from local slaughterhouses and frog leg producers. There are at least eight fish and prawn processing factories operating in the vicinity of Cox's Bazar, but virtually no waste feed other than fish guts, which due to its high oil and fat content is usually unacceptable for crocodiles.

An adequate source of clean freshwater is somewhat problematic. Only the river at the outskirts of town appears to contains ample volume. Groundwater supplies are said to be barely sufficient for the town in the hot months before the arrival of the monsoon. The feasibility of an artesian system is worth exploring. Acceptable quality of the river water could be attained with installation of a filtration system made primarily of local materials and a back-up pump and header tank system.

4.4.2 Chittagong

Similar potential exists for integrated development with tourism as most visitors bound for Cox's Bazar and vacation areas in the Hill Tracts must pass through this busy city of one million. Chittagong is the country's largest port and a center of fish and prawn (shrimp) exports.

The feed situation is more encouraging with large quantities of inexpensive and suitable fish species available through BFDC. One interested, well-diversified entrepreneur plans to establish a commercial poultry operation in the near future which could supply quality cheap feed in the form of guts, heads and feet for a ranching or farming venture. The combined feed sources appear sufficient to support a commercial operation of 5,000 - 10,000 crocodiles.

4.4.3 Khulna

This small city in southwestern Bangladesh is an important transit point for the several hundred foreign tourists who annually visit the Sundarbans. Domestic tourism remains insignificant but the planned development of additional facilities could boost this sector of the industry as well. One existing tourism enterprise plans to add crocodile farming to its attractions. A small hatchery for estuarine crocodile eggs collected from the Sundarbans appears eminently suitable.

Khulna is best known as the principal fish and prawn producing region in Bangladesh. More than 60% of the country's prawn exports transit the city. Although these industries produce a negligible amount of waste feed, small prawns and fish are regularly available for USD 0.40 - 1.00 per kg and constitute a feed source for the rearing of $\geq$2,500 mixed size class crocodiles. The relatively high cost of fish feed can be partially offset by integration with tourism and perhaps further reduced by procurement of frog and other offal.

4.4.4 Satkhira

About 30 km north of the Sundarbans and the same distance west of Khulna lies the marshy area of Satkhira where freshwater is reportedly available in sufficient quantity and feed prospects are bolstered by an abundance of crabs in nearby brackish channels (E. Hoque, Crocodilian Tanning Assistance Associates, pers. comm). The crabs, which for religious reasons are not locally consumed, can be harvested by area residents at low cost during much of the year, except the cold season months of December and January when they are harder to find. Fish from the docks at Khulna can probably be arranged in times of decreased supply and to complement the diet.

Although Satkhira was not visited by the authors, the area appears too distant from the Sundarbans to attract a substantial number of foreign tourists. A more in-depth study of the crab resource and its potential for sustained harvesting, as well as for other possible feed sources (fish and frogs), is needed to confirm the economic feasibility of a ranching or farming operation in the Satkhira area. The location should, however, attract government support because of the income a crocodile enterprise can generate for impoverished local communities which supply feed.

4.4.5 Dhaka

The economics of ranching and farming in the vicinity of the capital are favorable because of the availability of chicken offal from several poultry operations; however, most of these are small-scale. Prospects for fish feed are less promising because of erratic supplies and significantly higher (30-65%) costs than other centers.

One advantage the capital offers is the proximity of major institutions of higher education, particularly Dhaka University, and the main offices of the government.

4.5 International considerations

Owing to concern for the possible effects of commerce on the conservation of wildlife resources, the Bangladesh government signed and ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1981. This agreement regulates the export and import of species considered to be threatened or potentially threatened by international trade. Species are listed by appendix depending on the severity of the threat and updated at Conferences of the Parties (COP) to CITES which are convened every two to three years.

Appendix I is the most restrictive and includes species threatened with extinction which are or may be adversely affected by trade. Although the intent of this category is to prohibit trade for primarily commercial purposes, an important exemption is afforded animals bred in captivity, where it can be demonstrated that the operation is not only innocuous to the survival of the species in the wild but accords conservation value.

Appendix II is more flexible and applies to less endangered species. This listing is compatible with trade primarily for commercial purposes; however, a system of strict regulation is necessary in order that trade is brought under effective control. Specimens of captive-bred Appendix I species meeting the non-detrimental and conservation value criteria are treated for purposes of trade as Appendix II listed.

Appendix III is seldom employed and primarily for individual Parties that wish to enhance in-country trade control and for which the cooperation of other Parties is sought for monitoring and reporting of trade.

Because of their apparent highly endangered status, populations of all three crocodilians in Bangladesh are currently listed by CITES as Appendix I species. While the listings are certainly appropriate for the mugger and gharial, indications are that population surveys of the estuarine crocodile would confirm the feasibility of a conservation-enhancing commercial utilization scheme.

Several resolutions have been adopted at COPs which define the criteria for amendments to the Appendices. The most important of these for threatened crocodilians prior to the 1992 COP specify procedures to downlist populations of Appendix I species to Appendix II under ranching criteria. These are Ranching (Resolution Conf. 3.15), Trade in Ranched Specimens (Resolution Conf. 5.16) and Monitoring and Reporting Procedures (Resolution Conf. 6.22).

The basic criteria set forth in the resolutions are that:

- the harvest of eggs or young to supply the ranching operation shall not have a detrimental effect on wild populations;
- the operation shall be primarily beneficial to the conservation of the local population (i.e., where applicable, contribute to its increase in the wild) through reintroduction or in other ways;
- the operation shall be carried out in a humane (non-cruel) manner;
- a uniform marking system is adopted for products entered into trade, including an inventory of current stocks of specimens and products on hand.
- a monitoring program is established to track changes in the status of wild populations, including information on the number of eggs or young taken from the wild; an estimate of the percentage of the total population taken; the number of animals released and their survival rates as ascertained by surveys and tagging programs, if any; and, the mortality rate in captivity and

causes of mortality. Results are to be reported to the CITES Secretariat along with data related to production, sales and exports of products.

(source: Bräutigam 1989)

Recognizing the significant conservation spin-offs of ranching, a resolution setting forth additional criteria (Conf 8.22) was adopted at the March 1992 COP. Ranching proposals based on collection of eggs and young are to "***be accepted as a matter of routine*** provided that appropriate inventories, harvest level controls and monitoring programmes are proposed and that sufficient safeguards are established in the proposal to ensure that adequate numbers of animals are returned to the wild if necessary;" (CITES 1992a; emphasis added). Because of the critical reproductive functions of adult crocodiles in the wild, schemes based on a wild harvest of these cohorts are discouraged by other parts of Conf. 8.22 and call for much more stringent appraisal by the Parties.

Another section of Conf 8.22 and a separate resolution Conf. 8.15 have revised criteria for the approval of captive breeding operations and replace several earlier resolutions. More stringent procedures are set forth to register and monitor operations which breed Appendix I species primarily for commercial purposes. Such enterprises must now be registered with the CITES Secretariat and satisfy the national Management Authority that "the captive breeding operation will make a continuing meaningful contribution to the conservation of the species" (CITES 1992b). Such concern for populations of crocodiles in Bangladesh should be easily allayed by the important role a captive breeding facility can perform in the preservation of remaining gene pools. This is particularly so for *C. palustris*, due to the current reproductive failure caused by apparent lack of proper incubation facilities, technical know-how and hatchling care. If a remnant breeding population of gharial is found to persist, this species may be similarly rescued by captive breeding.

Marketing prospects for crocodile products is another international aspect of farm and ranch development that should be carefully considered. There appears to be negligible potential for domestic demand in Bangladesh because of very limited purchasing power. For virtually all producer nations, the markets for crocodile skins exist overseas in developed countries that manufacture luxury items such as handbags, wallets, and belts. Most of these products are sold in-country but some are exported, primarily to other developed countries. Japan, France, Italy, and Singapore import the great majority (>90%) of raw or semi-processed crocodile skins for tanning and manufacture of finished products.

The history of the skin trade has been a volatile one, with the industry at present in a depressed cycle. Prices for classic skins have fallen to less than half that received three years ago. The current downturn is a result of two main factors: 1) the continuing international recession and 2) oversupply of crocodile products coupled with large rearing stocks, brought on by the boom in ranching and farming during the past decade. The industry finds itself in a shakeout period in which many enterprises that cannot substantially reduce their production costs are failing.

However, in a longer term view, there is a silver lining to this dark cloud. If failures occur on a wide scale, the decrease in overall world production of crocodile skins and ensuing depletion of stockpiles should serve to stimulate price recovery. Moreover, even if prices remain at current levels, this will enable manufacturers to reduce the costs of products and make them affordable to many more potential consumers, thus serving to increase demand. There remains vast, untapped potential for an international campaign to promote the value-added returns to conservation of purchasing crocodile products from approved programs worldwide, both to educate the general public and effectively counter the arguments of animal welfare rights groups.

5. <u>Development of a Management Program</u>:

Available data on the status and reproductive biology of mugger and gharial in Bangladesh was recently reported in detail by Rahman (1991a; 1991b). Sponsored by the UNCTAD/GATT International Trade Centre, Whitaker (1982) conducted an earlier in-depth and favorable evaluation of export prospects for commercial farming of crocodiles, particularly *C. porosus*. Although the findings by Whitaker and Rahman clearly present a critical yet opportune situation, Bangladesh has yet to formulate a program to conserve and sustainably utilize its crocodile resource. With at least two of Bangladesh's three crocodilians in apparent dire straits, there is urgent need to move quickly before the situation deteriorates further and renders rehabilitation of the resource a much costlier and time consuming endeavor.

5.1 Conservation requirements

Because of the current severe threats to the viability of crocodilian populations in Bangladesh, a management program should initially emphasize a strong conservation component. Immediate efforts are needed to secure the gharial and mugger breeding stock in captivity as at least partial founder populations. Indications are that the current reproductive failures of the mugger females can be easily resolved by applying proven, cost-effective techniques in the design and management of hatcheries and hatchling care facilities. Madras Crocodile Bank in Tamil Nadu, South India is an ideal regional center, well-experienced in the transfer of necessary technical knowledge and skills involving a variety of crocodilians, particularly the mugger and gharial.

Existing founder stock for recovery of the mugger and gharial could be supplemented by acquisition of eggs and juveniles from countries within the home range of the species. The Department of National Parks and Wildlife Conservation (DNPWC) in Nepal has indicated its willingness to provide captive-reared juvenile gharial from Chitwan National Park (T. Maskey, pers. comm.). As described in section

4.2, a large excess of captive-bred mugger and eggs, in addition to substantial numbers of juvenile gharial, are maintained in India (Anon. 1993).

Boosted reintroduction of mugger and gharial by import of excess juveniles from regional rearing centers should not present a species introduction (or related) problem. Due to proximity of range and absence of topographical barriers, Indian and Nepalese stocks of these species are unlikely to exhibit significant differences in genetic composition at the population level. However, this assumption should be substantiated by comparative DNA and other biochemical analyses.

In laying the foundation for a comprehensive program, the conservation component of a Management Plan for crocodiles in Bangladesh should stress a recovery strategy for each species. Because of the dissimilar status and commercial potential of each resident crocodilian, a combination of strategies is appropriate.

C. porosus. An initial, comprehensive survey is urgently required in the Sundarbans to assess population status and recovery potential. Particular focus should be afforded to nesting cohorts and the formulation of a nest protection → egg harvest → restocking plan. The interaction of crocodiles with local communities should be studied, and where potential exists, the support and active participation of local people with sustainable utilization of the resource encouraged.

C. palustris. Efforts should be directed at achieving successful reproduction of relict breeding stock and acquisition of appropriate extralimital specimens. An attempt should be made to identify and protect any remaining and potentially restorable habitat considered suitable for reintroduction of the species to the wild.

Gavialis gangeticus. The immature stock at present should be reared at locations and in conditions conducive to captive breeding for eventual reintroduction. Acquisition of additional stock to supplement this effort and improve its chances of success should be investigated. A systematic survey of the relict wild population and assessment of remaining habitat, particularly in the Padma and Jamuna rivers, should be conducted with the major aim of effectively protecting crocodiles and at least some primary habitat (especially nesting banks).

The BFRI hatchery can perform a important role in the recovery of crocodile populations by hatching eggs and rearing hatchlings for eventual release. Priority should be given to obtaining eggs from mugger breeding stock at Bagarhat and Dhaka, and possibly later from estuarine crocodile nests in the Sundarbans. Refinements of present construction in order to fully meet the requirements of incubation and hatchling care will enable the hatchery to function as a conservation center as well as benefit private enterprise by demonstrating the proper techniques of egg and hatchling management. With additional upgrading, there is also scope for husbandry research and expanded conservation education.

5.2 Establishment of a monitoring unit

A unit within the Management Authority will be needed to oversee ranch and farm operations and monitor the trends of crocodile populations in the wild. Field surveys should be established as a regime that affords repeatability in order to maximize their interpretive value. Standard night counts of crocodiles over a representative sample of habitat types appears to be the most appropriate method, but an investigation of nesting for egg harvest potential could include assessment of nest counts during the peak nesting period as an indicator of population status. Nest counts may be efficiently conducted in tandem with egg collection activities. For whichever technique used, its conduct should be cost-effective in relation to the returns from resource utilization. Baseline surveys of the relict gharial population should also be an initial priority of the monitoring program.

As the designated CITES Scientific Authority in Bangladesh, the Bangladesh Wildlife Advisory Board should be involved in the decision-making process concerning harvest quotas for eggs of *C. porosus*, and after assessing population survey results, assist in the determination of restocking requirements.

With some 100,000 people directly dependent for their livelihood on collection activities in the Sundarbans, local people's support and participation will be essential. To achieve this they must receive significant benefits (extending to the long term) so that the renewability of the estuarine crocodile resource is recognized as fundamental to its economic value, and therefore acts as a stimulus to further its conservation. Part of the unit's responsibilities could be to identify interactions of forest extractors with crocodiles and their habitat, and to pose incentives (particularly economic ones) that would elicit local support for crocodile conservation.

5.3 Revised legislation

To put the Management Plan into effective action, revision of current legislation will be required to permit ranch and farm establishment and to incorporate key protection needs for each crocodilian species.

Private enterprise should be encouraged to play a leading role in firmly establishing the industry. An attractive mix of investment incentives and regulations setting minimum standards of operation and providing for a reasonable percentage of fit stock to be made available for reintroduction will likely prove pivotal to success of the program. Its effectiveness will also be advanced by incorporation of recording and reporting procedures for ranching and farming operations. This will greatly enhance the ability of the Management Authority to adequately monitor resource utilization and the preparation of required annual reports to CITES.

Legislation is also needed to set aside habitat for reintroduction and regulating the *C. porosus* egg harvest. Existing legislation (i.e., The Wildlife Protection Ordinance of 1972) needs to be strengthened to include enforceable penalties for serious violations (e.g., poaching, nest disturbance). The representativeness of the country's protected areas system should be reviewed to ensure that each type of crocodile habitat is included. For any gaps found to exist, initiatives should be undertaken to formally protect examples of sufficient size to promote perpetuation of the country's crocodile populations.

5.4 CITES endorsement

The CITES Management Authority designated by the Government of Bangladesh is the Office of the Chief Conservator of Forests located in the Ministry of Forestry. In order for a *C. porosus* ranching scheme to be considered for approval by CITES, the Management Authority must submit a *C. porosus* downlisting proposal pursuant to Res. Conf. 3.15 and 8.22 at least 330 days prior to a Conference of the Parties (COP). Because the deadline for the 1994 COP in Ft. Lauderdale has passed, CITES approval cannot be sought until the following COP, approximately mid-1997.

In order to encourage investment by private enterprise in the development of a crocodile industry, efforts are needed to convince the Management Authority of the critical, yet opportune, situation facing crocodiles in Bangladesh, and for the agency to endorse the conservation-enhancing strategy of ranching based on wild-harvested eggs.

The objectives of the current FAO/Government of Bangladesh project to strengthen integrated resource development of the Sundarbans Reserve Forest would be well-served by inclusion of a crocodile component. A modest amount of funding would allow a extensive survey of the wild population, as well as preparation of a comprehensive Management Plan and draft CITES proposal.

6. Recommendations for Follow-up Action:

I. Given the existing policy priorities for a country such as Bangladesh it is unrealistic to expect the government to devote scarce resources to crocodile management. External assistance with funding and expertise is needed for program start-up but this should be viewed as a short-term measure phased into local execution as soon as possible. Owing to a perceived strong, mutually beneficial linkage between the needs of conservation and commercial interests, private enterprise should be encouraged to play a leading role in the rehabilitation of the resource. This sector arguably has the most to lose or gain, and the fates of crocodilians in Bangladesh appear inextricably tied to the conservation spin-offs of successful ranching and farming operations.

II. As a matter of urgency, the services of a crocodile specialist should be engaged to assist formulation of a management strategy, including preparation of a Management Plan and draft ranching proposal to CITES, for the Government's consideration of approval.

III. External governmental and non-governmental organizations should be approached to provide assistance with the training of national researchers in the techniques of crocodile husbandry and population monitoring. Due to limited sources of in-country funding, external assistance should be considered to support the purchase of basic equipment and other capital inputs of the BFRI hatchery at Chittagong, and possible establishment of a similar one at Khulna.

IV. Contacts should be initiated with appropriate crocodile enterprises and the CITES Management Authority in an effort to obtain mugger eggs and/or juvenile stock for experimental rearing and release in Bangladesh. Indian authorities should also be solicited as to their willingness to export *C. palustris* stock (eggs included) for eventual commercial rearing as ranching products.

V. Because the Sundarbans ecosystem extends considerably into the Indian state of West Bengal, initiatives should be undertaken to coordinate management of crocodiles and other wildlife with the Government of India.

V. Cooperation should be established with officials of the Management Authority in Nepal (DNPWC) with the view of obtaining gharial eggs and/or juveniles for the purposes stated in point IV, and initiating other forms of collaboration relating to crocodiles.

VI. Contacts with overseas tanners should be established to attract added-value to the resource through joint ventures in the manufacturing and export of high quality products from raw classic crocodile skins, particularly top-of-the-line luxury items made from the estuarine crocodile.

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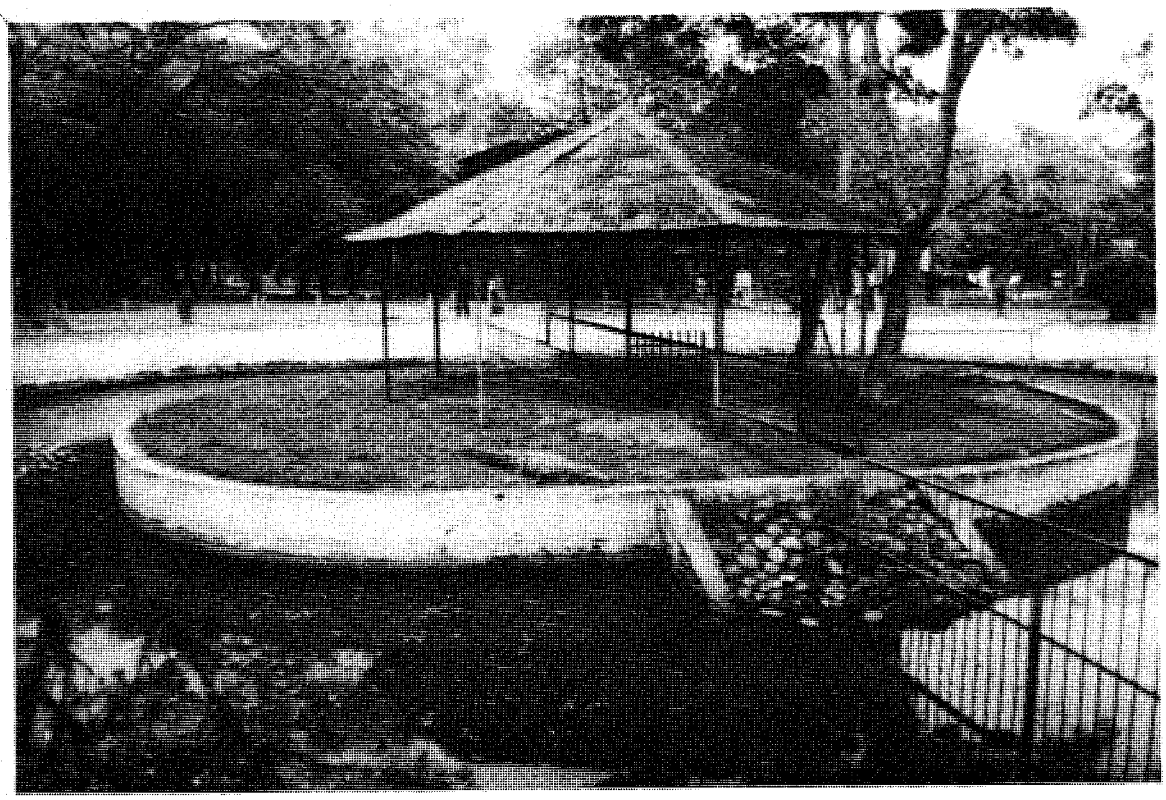
Appendix 3. Itinerary

Date	Location	Remarks
10 January 1993	Kathmandu - Dhaka	flew via SQ 413 direct to Dhaka.
11 January 1993	Dhaka and vicinity	booked flights; visited FAO/UNDP.
12 January 1993	Dhaka and vicinity	visited Mirpur Zoo & Dhaka Univ.
13 January 1993	Dhaka - Chittagong	departed on BG 611 to Chittagong.
14 January 1993	Chittagong city	no activities due to general strike.
15 January 1993	Chittagong-Cox's Bazar	visit to BFRI, hatchery; afternoon departure by bus to Cox's Bazar.
16 January 1993	Cox's Bazar	toured 2 fish processing plants; offices of tourism, district forestry.
17 January 1993	Cox's Bazar-Chittagong	early morning visit to fish market; met O.I.C. at BFDC; returned to Chittagong by bus in afternoon.
18 January 1993	Chittagong	no morning activities due to strike; afternoon visits to landing docks, BFDC and A.K. Khan Co.
19 January 1993	Chittagong - Dhaka	travelled by all day (12 hr) train.
20 January 1993	Dhaka-Jessore-Khulna	departed on BG 461 0945 hrs; continued to Khulna by car; visited Sundarban Tourist Complex Ltd.
21 January 1993	Khulna area	visited GOB/FAO Sundarbans project office at Boyra; afternoon at Conservator of Forest office.
22 January 1993	Khulna-Bagarhat-Khulna	afternoon excursion to shrine of Mahzar Khan Jahan Ali.

23 January 1993	Khulna	fish market and bazar in AM; afternoon at Sundarbans project office, Boyra.
24 January 1993	Khulna-Jessore-Dhaka	departed via bus at noon to Jessore; evening flight BG 468 to Dhaka.
25 January 1993	Dhaka - Kathmandu	late afternoon return flight to Nepal



Mugger breeding facilities at Mirpur Zoo, Dhaka.

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Breeding male mugger at shrine pond, Bagarhat

ECOLOGICAL STUDIES OF INDIAN CROCODILES

AN OVERVIEW

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Since the initiation of the Indian Crocodile Project in 1975 studies of crocodilian biology, ecology and conservation management have been carried out through collaboration among FAO, Government of India, State Forest Departments and different Universities in the Country. This paper deals with the progress that has been made with research and management of three species of crocodiles, *Gavialis gangeticus, Crocodylus porosus* and *Crocodylus palustris*. Recent developments in the field of crocodilian management are described.

1. INTRODUCTION

In India many rivers, lakes and marshes offer a variety of habitats for three species of crocodiles. They are gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*) and saltwater crocodile (*C. porosus*). The early records reveal that these aquatic reptiles at one time, were very abundant throughout their distributional range (Smith, 1933). However, due to commercial exploitation and habitat destruction populations of crocodile species were reduced to near extinction (FAO,1974). A timely action was taken during 1975 when Govt. of India initiated a crocodile project to save all three species of crocodiles, by adopting a number of rehabilitation programs (Bustard, 1980). Since then attempts have been made to evaluate population trends and other ecological aspects of crocodiles in India.

This paper highlights the research activities carried out on the ecology and conservation management of crocodiles in India.

1.1. CROCODILE PROJECT

With a view to conserve Indian crocodile species whose populations were depleted throughout their distributional range, the Govt. of India started a crocodile breeding and management project during 1975 in collaboration with FAO/UNDP (Bustard, 1980 b). The success of the project was mainly due to the significant research activities carried out on biology and ecology of crocodiles by various scientists in the country.

2. RESEARCH

Since 1975 a significant research effort into crocodilian studies has been made in India. In the early stages of crocodile research Govt. of India, in collaboration with FAO/UNDP, had promoted management oriented studies. A major research program on all three species of crocodiles was started in

Orissa in collaboration between FAO/UNDP, Orissa State Forest Department and the Utkal University, Bhubanswar, Orissa (Bustard,1980). Other establishments involved in crocodile research in the country are Wildlife Institute of India (Crocodile Research Centre, upto 1986), Dehradun, Madras Crocodile Bank (Tamil Nadu), Lucknow University (U.P.), Aligarh Muslim University (U.P.), Bharatidasan University (Tamil Nadu), Kurukshetra University (Haryana), Jiwaji University (M.P.) and Saurashtra University (Gujarat). Various doctoral and other studies carried out in different Universities and other establishments are aimed broadly on the ecology, habitat selection and behaviors of all three species of crocodiles (Singh, 1978; Choudhury, 1981; Shrivastava, 1981; Kar, 1981; Singh, 1985; Rao, 1988; Sharma, 1991; Hussain, 1991; Sharma. R, 1991). The crocodile rearing stations where active research was carried out are Gharial Research and Conservation Unit, Nandan Kanan Biological park, Orissa; Madras Crocodile Bank, Tamil Nadu; Kukrail Crocodile rehabilitation Centre, Uttar Pradesh; Nehru Zoological Park, Andhra Pradesh; Crocodile and Fresh water Turtle Rehabilitation Centre, Madhya Pradesh.

2.1 *HABITATS*

Research studies have been undertaken to identify the habitats occupied by saltwater crocodiles in West Bengal (Bustard, 1982), Orissa (Kar, 1981), and Andaman and Nicobar Islands (Choudhury and Bustard, 1980). Fairly good population of saltwater crocodile occur in the mangrove habitats of Sunderbans and Bhitarkanika tidal rivers and Andaman islands. Reports are also there for stray animals of saltwater crocodile in Tamil Nadu (Whitaker, 1982) and Andhra Pradesh (Bustard and Choudhury, 1980; Rao, 1991).

The major habitats of *Gavialis gangeticus* were also identified in most of the North Indian rivers (Singh U., 1978; Whitaker, 1979; Choudhury, 1981; Shrivastava, 1981; Whitaker and Basu, 1983; Singh, 1985; Rao, 1988; Basu, 1991) and East India in Mahanadi river system (Singh U., 1978) as also in neighbouring countries like Nepal, Bhutan and Bangladesh (Bustard, 1982 a,b).

The mugger (*C. palustris*) inhabits in large and small rivers, lakes, marshes and village ponds in different States except Himachal Pradesh and Jammu and Kashmir (Whitaker and Whitaker, 1989). It is sympatric to gharial in latter's distributional range (Rao and Choudhury 1990).

2.2 STATUS SURVEYS

Large number of Crocodile habitats in different States have been surveyed to determine the status of different species (FAO, 1974; Behura and Singh, 1979; Whitaker and Daniel, 1980; Singh and Choudhury, 1982; Singh, *et al.*, 1984)..

2.3 ECOLOGY AND NATURAL HISTORY

2.3.1 GAVIALIS GANGETICUS

The ecology of gharial has been studied in India in the Mahanadi river (Singh, 1978,1993), Chambal river (Choudhury, 1981; Singh,1985; Rao, 1988; Hussain, 1991) and Narayani river in Nepal (Bustard, 1982).

2.3.2 CROCODYLUS POROSUS

An extensive study on the ecology of saltwater crocodile has been undertaken in the Bhitarkanika Sanctuary in Orissa (Kar, 1981). Choudhury and Bustard (1980) studied the ecology of *C. porosus* in Andaman and Nicobar islands.

2.3.3 CROCODYLUS PALUSTRIS

Research studies on ecology of *C. palustris* have been undertaken in different States particularly in Tamil Nadu (Choudhury and Bustard, 1982; Whitaker and Whitaker, 1989), Andhra Pradesh (Choudhury and Bustard, 1982), Orissa (Singh, 1984) and Rajasthan (Choudhury and Rao, 1988).

2.4 LIMNOLOGICAL STUDIES

Detailed studies on limnological characteristics of different aquatic ecosystems where crocodiles inhabitat have been undertaken in the Jiwaji University, Gwalior (Sharma H. 1991, Rao, 1993).

2.5 SEX DIFFERENTIATION

Sex ratio in nature particularly at the time of hatch is a major study developed in India (Singh,.1984 a). A study carried out at Madras Crocodile Bank revealed that incubation temperature determines sex in the mugger crocodile *C. palustris* (Lang, *et al* , 1989).

2.6 EGG CHEMISTRY

Studies based on the relationships of micro-habitat in a nest to the development of embryo were initiated in the National Chambal Sanctuary. In collaboration with Jiwaji University detailed analysis of the Chemistry of gharial eggs were undertaken (Sharma, 1991).

2.7 BEHAVIOR

Studies on various behavioral aspects such as parental care of gharial (Singh and Bustard, 1977, Bustard, 1980c) salt - water crocodile (Bustard and Choudhury, 1980)., Mugger (Lang *et al.* 1986) courtship behavior of mugger (Singh, 1984b), nesting behavior of gharial (Bustard, 1980 d; Rao and Singh, 1993), territorial behavior of saltwater crocodile (Bustard and Maharana, 1982), mugger (Singh 1991) and gharial (Bustard and Maharana, 1981; Singh and Rao, 1990) and other general behaviors of crocodiles (Lang, 1987; Rao and Singh, 1987) were carried out.

2.8 CROCODILE REHABILITATION

Significant research efforts have been undertaken by various establishments for successful implementation of crocodile rehabilitation program in the Country. The crocodile rehabilitation program aims in establishment of captive populations of crocodiles, which can be released in the wild in specially protected areas or sanctuaries (Rao, 1985). The number of areas in which active protection is given to crocodilians is 34 and the number of specially created crocodilian sanctuaries is 13 (Singh *et al*, 1984). Since the initiation of the project in 1975 sixteen crocodile rearing centres have been established as part of State rehabilitation schemes in different States throughout the Country (De Vos, 1982). Under the rehabilitation program more than 5000 crocodiles of all three species were released in the wild (Singh *et al*, 1984; Choudhury and Choudhury,. 1986; Rao, 1988, 1992).

2.9 POPULATION MONITORING

Periodic or annual surveys have been carried out in different States by the respective State Forest Departments to monitor the populations (Choudhury and Choudhury 1986; Rao and Sharma, 1987; Kar and Bustard, 1991, Prusty and Singh, 1994; Sagar and Singh, 1990). The Wildlife Institute of India has carried out crocodile surveys in the National Chambal Sanctuary in collaboration with M.P. Forest Department while using radio tracking method (Singh, 1985). The State Forest Department of Madhya Pradesh is regularly conducting monitoring studies in the protected areas (Sharma, 1993).

2.10 CAPTIVE BREEDING

Research studies have been carried out to develop and improve techniques for breeding of crocodiles in captivity (Bustard, 1980a; Whitaker, 1984, Dani *et al*, 1991). Successful breeding of mugger has been taken place in more than 15 centres, of the gharial in three centres-Nandankanan Biological Park, Bhubaneswar (Orissa), Kukrail Crocodile Rehabilitation

Centre, Lucknow (U.P.) and Madras Crocodile Bank, Madras (Tamil Nadu) and of saltwater crocodile in two centres - Bhagabatpur Crocodile rehabilitation centre, (West Bengal) and the Madras Crocodile Bank, Madras (Tamil Nadu) (Singh *et al*, 1984, Anon, 1993).

2.11 CONTRIBUTION TO CROCODILE RESEARCH

Since the initiation of the crocodile project in 1975 large number of papers, thesis and reports on crocodile biology, ecology and conservation management have appeared. The proceedings of the First Indian Crocodile Researchers' symposium prepared by Singh and Choudhury (1982) is a significant contribution towards the Status and conservation of crocodiles in India. Other significant reports on different aspects of crocodiles are management (FAO, 1974 and 1975; De Vos., 1982 a,b; Singh. 1984 a) and ecology and population monitoring (Singh, 1985; Rao, 1988). A comprehensive list of Indian crocodile literature till 1982 was prepared by Bustard and Singh (1982) and this bibliography was very much used by scientists working with Indian crocodiles. The major National Journals which publish research work on ecological studies are Journal of Bombay Natural History Society, Bombay; Hamadryad, Madras Crocodile Bank, Madras; Journal of Ecological Society, Pune; Cheetal and Indian Forester, Dehradun etc. Research findings were also presented by Scientists who participated in the IUCN/SSC/Crocodile Specialist Group working meetings at Victoria Falls, Zimbabwe; Caracas. Venezuela; and Florida,.U.S.A (Singh, 1984; Singh et al. 1984; Choudhury, 1990; Rao, 1990; Rao and Choudhury 1990). The results of crocodile research carried out at National Chambal Sanctuary were incorporated as significant contributions in Life Sciences of the Encyclopedia of Britannica, Book of the year 1990. A report on evaluation of crocodile project was prepared as a follow up of a workshop by the Indian CSG members at Madras during March 1993 (Anon; 1993).

3. MANAGEMENT

As a result of the Wildlife (Protection) Act, 1972, and the subsequent crocodile project in 1975, crocodile populations in different States have recovered. Monitoring of crocodiles in different habitats is under progress by various State Forest Departments. New areas were identified for rehabilitation of gharial. So far a total of 3342 captive reared gharial have been released in 12 rivers. Eco-development programs are initiated to help rural people dependent on natural water supplies especially in areas like National Chambal Sanctuary. Effective measures have been taken to control conflict between crocodiles and rural people. The Eco-tourism in crocodile areas has been identified as one approach for crocodile conservation. A workshop was organized during March 1993 at Madras Crocodile Bank, Tamil Nadu to evaluate crocodile management programs to prepare an Action plan for sustainable use of the crocodile resources in India.

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Harvesting Wild Crocodilians:

Guidelines for Developing a Sustainable Use Program

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Table of Contents

PREFACE

There has been considerable interest in the farming, ranching and harvesting of crocodilians following both the economic and conservation success of sustainable use programs in many parts of the world. The Crocodile Specialist Group (CSG) of the IUCN's Species Survival Commission is commonly asked for guidance in the development of new crocodilian programs. With the benefit of a great deal of experience and expertise the CSG, at the suggestion of the author, decided to develop clear guidelines for a "model" management program appropriate in the majority of situations that are likely to be faced. Subsequently, a workshop was held on the subject at the 1990 CSG meeting in Gainesville, Florida U.S.A. However, it was not until February 1992 that sufficient funding was available (from TRAFFIC (USA) and industry) to allow the author to travel to countries with successful crocodilian programs to document approaches that could be replicated elsewhere.

Using attributes and elements from most crocodilian management programs around the world, the first draft of this document was detailed and established review criteria that generated a "score" to define acceptable programs. In review, however, the consensus was that this was too "idealistic" and there was a danger of the guidelines being misinterpreted as minimum requirements.

This document primarily seeks to develop practical guidelines which are close to the minimum necessary for success. A secondary objective (in part a hold-over from the "idealistic" first draft) is to identify practical measures that can be taken to enhance a program to improve its likelihood of success and enhance its conservation merits.

The two most important elements of any sustainable wild crocodilian use program are effective trade control and technically sound monitoring. However, there is no single prescription for a program to utilize wild crocodilian resource; each and every region of the world has unique needs requiring a different emphasis. Considerable effort has gone into attempting to define minimum requirements that are flexible and relatively simple, while ensuring high technical standards are maintained to safeguard against depletion of wild stocks. It is impossible to prescribe specific criteria for the establishment of every possible crocodilian use program. In the most unique and difficult cases, common sense, coupled with a conservation community commitment to promoting wise resource stewardship, will hopefully prevail. This document should prove useful in guiding and provoking innovative thinking for those considering developing a program aimed at the sustained commercial use of a wild crocodilian resource, and it will provide a standard for judging the adequacy of new and existing commercial crocodilian use programs.

BASIC CONSIDERATIONS FOR PROGRAM DEVELOPMENT

1.1 Sustainable Use

Man has relied on the natural resources sharing his environment for millennia. Only in the last few hundred years, with expanding human populations and increasing consumption rates, has a need to conserve renewable natural resources been recognized. Cases of over-exploitation of natural resources have left many people with the opinion that **utilization** and **conservation** are incompatible. On the contrary, sustainable use can encourage conservation. Sustainable use of natural resources is use at a level that can be indefinitely replenished. Establishing systems that allow sustainable use of commercially valuable natural resources can provide economic incentives for their conservation.

Crocodilians have been commercially utilized for their valuable hides for nearly two centuries. In recent years, commercial use of the meat has further enhanced the value of crocodilians. The high economic value of crocodilians, coupled with effective harvest and trade controls have resulted in successful and sustainable programs. Widespread success of well planned and implemented crocodilian use programs served, in part, as a stimulus for broad acceptance of the opportunities and conservation merits of sustainable utilization.

Development of a sustainable crocodilian utilization program can result in the formation of a constituency of beneficiaries that may be comprised of hunters, farmers, landowners, processors, hide tanners, exporters, and product manufacturers. Such a diverse group of constituents that all rely on the sustained production of raw materials (i.e. wild crocodilians) from natural areas can become a formidable proponent for long term conservation of crocodilian habitats. The protection of wetland habitats benefits not only crocodilians, but all forms of wetland wildlife.

1.2 CITES Criteria and Controls

Historically, uncontrolled commercial hunting led to declines of many crocodilian populations and endangerment of others. To slow the decline, international trade controls in crocodilians and their products were imposed through an international treaty convened in 1975, The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES took the first steps to establish international standards to ensure trade in crocodilian products does not adversely affect crocodilian populations. To encourage sustainable harvests, CITES sanctions trade only from harvest programs that are biologically sound and have adequate controls to prevent illegal trade. The majority of countries that import raw materials and consume crocodilian products are parties to the CITES, and all trade with such countries must be in compliance with the provisions of CITES. Nations that are not parties to CITES may trade with CITES parties, provided that they substantially comply with the provisions of the convention.

CITES controls are complex, having evolved through a number of "Resolutions" that outline criteria under which crocodilian populations may be classified for international trade. A history and explanation of CITES Resolutions and Appendices can be found in Attachments 1 and 2 at the end of this document. Under CITES controls, all species of *wild* crocodilians are listed as either Appendix I, for which no commercial trade is permitted, or on Appendix II where they may be traded, with certain restrictions. It is possible for a species to be listed as Appendix I in one country, and Appendix II in another.

The establishment or expansion of a crocodilian management program involving international trade often requires a change in the CITES appendix classification of the crocodilian population in question. CITES meets every two years to consider such changes. The timetable for seeking action by CITES is lengthy and strictly adhered to, often requiring submission of documents in excess of a year in advance. Because timetables are critical and subject to revision, it is advisable to check directly with CITES regarding current deadlines and procedures for submitting proposals (The CITES Secretariat may be contacted at: 15 chemin des Anemones, Case postal 456, CH-1219, Chatelaine-Geneva, Switzerland; Tel: 4122 - 9799139/40; tex: 415391 ctes ch; fax: 4122 - 7973417).

For a CITES appendix classification change to be considered the Management Authority of the country concerned must submit a proposal to CITES, and this will usually include a **management plan** describing and justifying the proposed program. The plan is critically reviewed by various CITES technical committees and the international conservation community. CITES relies heavily on the CSG for recommendations. Reviewers evaluate the information provided in the management plan to judge the likelihood of whether the harvest is sustainable, and if adequate controls will be provided to guard against illegal harvest. Unfortunately, CITES controls do not identify clear standards that plans must meet, which can result in inconsistencies in the evaluations. This is particularly true of comments sought by CITES from technical review committees and the international conservation community.

Although CITES resolutions are complex their implementation has been important to the successful conservation of crocodilians throughout the world. The lack of clarity in CITES regulations is, in part, necessitated by the variety of circumstances that must be accommodated. The "risk" posed by different types of harvest under differing circumstances requires varying levels of regulatory control and supporting biological information. Individual countries often have differing goals and motivation for instituting a program. Hence, it is impossible to write a single prescription for a crocodilian management program. Fundamentally, however, crocodilian management plans need only address the principles of CITES; to ensure that harvest programs are not detrimental to the survival of crocodilians, and that effective controls are in place that assure that crocodilian products are legally obtained and traded.

One of the principal purposes of this document is to outline the CSG position on the regulatory and biological information standards that should be provided in a Crocodilian **management plan** to accommodate the fundamental principals of CITES. The guidelines attempt to explain the varying biological and regulatory "risks" associated with different types of harvest of different species and different cultural and political constraints; provide insight on the biological information needed to support different types of harvest programs; identify regulatory approaches, resource needs, and funding mechanisms that should be considered; suggest scientific methodologies that are generally accepted as effective and technically sound; and provide examples of successfully established commercial utilization programs in differing regions. Countries proposing programs that satisfy these guidelines can be assured of receiving the support of the CSG.

Judgement of a management plan will be based on how well the plan can: (1) identify the type and extent of harvest; (2) demonstrate the planned harvest is biologically sound, feasible and sustainable; (3) identify the biological monitoring and regulatory controls intended to limit over harvest and illegal trade; and (4) show that adequate infrastructure will be provided to oversee the program.

1.3 Harvest Strategy

The harvest strategy selected (type and extent of wild crocodilian harvest) depends on the life history of the species, its population status, traditional economic value and the ability of the management authority to control wildlife use. The harvest strategy and intensity of harvest will dictate the amount of resources required to implement a program.

The **Ranching** and **hunting** of wild crocodilians are the two most widely practiced forms of commercial crocodilian utilization. **Ranching** relies on the collection of eggs and/or juveniles from the wild for rearing in captivity until the animals are large enough to produce commercially valuable hides and meat. **Hunting** involves the killing of free ranging crocodilians from the wild for the immediate sale of the hides and meat. There are varying levels of biological and regulatory "risk" involved with allowing either type of harvest. When identifying the type and extent of the harvest in a management plan there must be a clear declaration of the type of harvest and the anticipated number of animals to be taken (usually on an annual basis).

Adult crocodilians produce many eggs and young to compensate for high juvenile mortality. Under some circumstances, the offspring from only one in a hundred eggs are needed to sustain a second generation. Consequently, it is possible to remove substantial numbers of eggs and juveniles in a ranching program without adversely affecting the number of animals reaching breeding size. In these programs regulatory controls are generally focused on the rearing facilities (farms) that can be inspected and monitored relatively easily. The "regulatory risk" of a ranching program can be minimized through implementation of stringent harvest quotas, stock inventory, and skin tagging requirements.

The "biological risk" increases with the proportion and the age of animals removed from the wild. Thus, the hunting of sub-adult and adult crocodilians is much harder to manage for a sustainable yield. The risk of hunting can be greatly reduced if ways can be found to avoid taking breeding females. Breeding-size females can be protected by (1) allowing hunting of only those animals that are smaller or larger than breeding size females or by (2) restricting hunting to specific seasons when males and females occupy different habitat and permit hunting only in those areas preferred by males. Predominantly male harvests pose little or no biological risk to a crocodilian population provided harvest restrictions are effectively enforced. Hunting programs generally require a great degree of control and enforcement, particularly in the field. This may entail enforcing quotas on the number, size and areas where animals are taken, and requiring a system of hide tagging and inspection to monitor compliance.

The amount of "evidence" required for a proposal to obtain the approval of the CITES Parties follows a gradient that is directly tied to the "risk" of a proposed harvest. Gaining the support of the conservation community requires reasonable assurance that the proposed utilization scheme is sustainable. Adult harvests require extensive monitoring and control while harvests that target low risk ages and/or harvest at very conservative levels require less controls. For example, ranching programs that rely on the collection of eggs from only a small proportion of the nests of a widely distributed species such as the common caiman (Caiman crocodylus sp.) would be considered low risk, and would require less biological information and require less regulatory controls than a program that sought to harvest eggs, juveniles and breeding adults of a more narrowly distributed species such as the black caiman (Melanosuchus niger). Because the "risk" posed by harvest programs varies for different crocodilian species and for different populations, it is not possible to establish a single set of criteria. Each proposed program will ultimately be judged on the circumstances affecting the crocodilian resource and the information provided in a country's management plan.

Risk factors are graphically depicted in Figure 1. The relative biological risk increases as the size or age of the crocodilian harvested increases. These are compared with additional relative economic risk discussed in section 1.4, and the trade control risk and the number of participants (i.e. potential benefactors) discussed in 3.21.

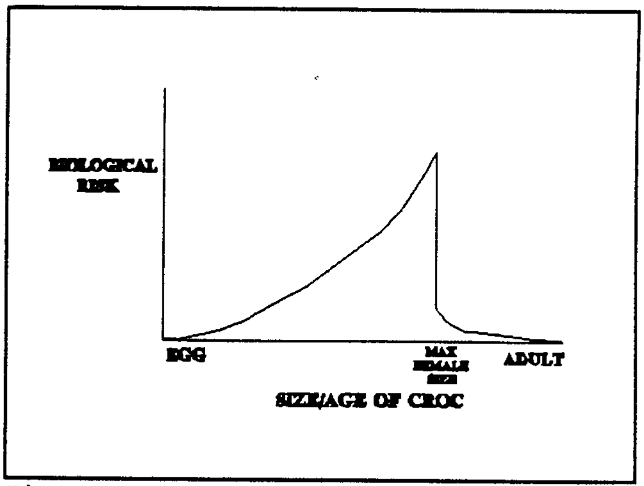

Figure 1

1.4 Economic Feasibility

Although it may be possible to provide ample evidence that a harvest strategy is biologically sound and can be carefully regulated, it is usually pointless to implement a program that is not economically feasible. After all, the objective of commercial utilization is aimed at providing economic benefits. Therefore, economic feasibility should be considered in selecting a harvest strategy.

It is commonly assumed that there are enormous profits for those involved in the production, processing or sale of crocodilian products. Although crocodilian products, particularly finished luxury goods, have a high value, commercial utilization is not always profitable. Indeed, recent history demonstrates that the market for crocodilian products is volatile in response to typical supply and demand factors, changes in global economy and luxury fashion trends. Additionally, regional or species-specific factors can influence the commercial value of a crocodilian resource, which, in turn, may influence the type of program implemented. Some of these are: (1) the traditional value of a species; (2) the suitability of a particular species for captive rearing; (3) capital and operating costs of rearing facilities; (4) operating costs (collecting eggs or hunting, processing, and transporting products) in difficult-to-access regions; and (5) agency costs incurred from inventory, monitoring, and administering a program (generally offset by industry user fees).

Several factors should be examined when evaluating the economic feasibility of a program, potential operating procedures, and regulations. Traditionally, "classic" skins (e.g. crocodiles and alligators which have very few bony plates or osteoderms in the skin) are more valuable than "non-classic" (e.g. caiman) skins. Programs dealing with classic skins, therefore, can absorb higher harvest and/or rearing costs. Behavioral differences among species make some species more suitable for breeding and/or growing under intensive culture that requires more crowded conditions than animals experience in the wild. Constant warm temperatures are necessary to achieve optimal growth in captive crocodilians, and fluctuating or suboptimal temperatures can often lead to decreased growth rates and high mortality. Establishing and operating captive ranching facilities with high capital investment and energy demands is costly. The cost and feasibility of collecting and transporting eggs or juveniles from remote areas differs considerably among regions. Moreover, many species of crocodilians nest during the wet season making access to the eggs difficult and expensive. The development of sanitary processing facilities to suitably process meat for human consumption, particularly for export, coupled with the logistics of obtaining freshly killed carcasses can be extremely costly. Markets for crocodilian meat are small and difficult to develop or expand. The manpower and operating funds necessary to provide a sound technical basis for supporting harvests and to effectively administer a program may require substantial user fees.

Generally, ranching involves greater economic risk than hunting programs, Figure 2. However, the economic and conservation benefits of a successful ranching program can be great. A high capital investment is needed to build and operate ranching facilities. In poor market conditions, ranchers are usually forced to harvest the annual crop to pay the bills. Attempts to "hold" animals until markets improve results in losses form overcrowding. Alternatively, hunting program participants are not forced to take animals from the wild if it is not profitable. When prices are depressed, participants can forgo the opportunity (and income) that year. Historically, crocodilian hunters have turned to some other form of natural resource use to supplement their income until market conditions become more favorable.

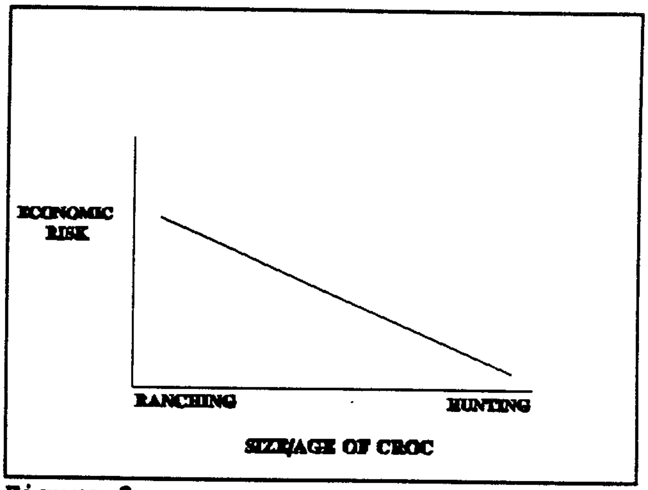

Figure 2

Economic feasibility assessments are rarely given adequate attention. However, it is necessary to carefully consider the economic feasibility of a program **prior to** actual implementation. An objective assessment of the economics of a management program, preferably by a qualified economist, can help preclude investment losses by ranchers, hunters, and processors. When confronted with economic losses the industry will typically seek relaxed regulations, operational procedures, and fees, which may ultimately jeopardize conservation of the resource.

BIOLOGICAL INFORMATION

2.1 Population Assessment

Some sectors of the wildlife management and conservation community strongly believe that, in an ideal world, crocodilian utilization programs would be started or expanded only when there is a strong biological "evidence" that the effects of such use will not be detrimental to the population being exploited. In fact, with the exception of programs in developed countries (such as Australia and the United States) no programs started with this concept. Management has generally involved an adaptive approach in which crocodilians were harvested, the effects were monitored, and subsequent harvests were modified accordingly. However, success is highly unlikely when the management authority has little idea of the basic status of the target population and where there is no monitoring of population trends through direct or indirect means. In addition, although many well established programs were developed through "trail and error", under the requirements of CITES, this approach is more difficult today. As a result, new programs generally start with surveys of the wild resource and often rely on harvest program results in other regions as models, though this approach requires some mechanism for local "validation".

2.11 Population Status Surveys

Survey data give the wildlife manager the information needed to plan, implement and monitor harvests. Population status surveys are designed for many reasons, from determining minimum number of animals present to the establishment of population indices for monitoring purposes. Crocodilians are difficult to count because of their cryptic habits and because they often inhabit inaccessible areas. The most common techniques to estimate population densities and/or establish population indices include direct methods such as night spotlight counts and daytime basking counts, and indirect methods such as the counting nests. Each technique is suited for different habitat characteristics. To detail survey techniques is well beyond the scope of this paper, but it is important that surveys are conducted by trained personnel to ensure their accuracy, repeatability, and credibility.

2.12 Effects of Harvest

During the past two decades a number of excellent studies have evaluated the effects of harvest on crocodilian populations. The findings from these studies can provide a basis for justifying the sustainability of harvests in other regions. This is particularly true when studies were conducted on the same or closely related species. Information from Nile crocodile ranching in Zimbabwe has been used to design similar ranching programs in neighboring African countries, while experience of hunting and ranching in Louisiana and Florida, U.S.A. has been used in programs in several other states. However, such an approach should be taken with care - there is considerable evidence demonstrating that different crocodilian species, and even individual populations within the same species, respond very differently to harvest.

Experimental harvests can evaluate different procedures and regulations on a small scale, prior to implementing an operational program. They also allow limited utilization of the resource while a balanced harvest scheme is being developed. Because crocodilians have long generation times, long-term monitoring is usually necessary. The simplest approach is to monitor population trends through systematic surveys, measuring changes in population abundance, population size structure, and reproductive effort. The experimental harvest approach has been used to develop hunting programs in Venezuela and Florida, and ranching programs in Florida and the Northern Territory, Australia, though in the latter, there has been a strong element of adaptive management.

In some cases, the effect of proposed harvests can also be evaluated from the outcome of computer simulations. There are a few population models available that can, through computer simulations, estimate the effect various egg, juvenile, or large crocodilian harvest strategies have on populations. Accuracy of a population model, however, is dependent on the availability of regional information on survival, growth rates, and fecundity. Where such regional information is lacking, models should be used to provide general approximations of sustainable harvest rates and to determine population sensitivity to changes in selected parameters. A balance of existing and regional biological information should be used in simulating harvests through population models. Too much reliance on studies from other regions can provide misleading results when modelling populations.

2.13 Habitat Availability

The quantity and the quality of habitat available to crocodilians is obviously an important factor in conservation and the evaluation of sustainable use strategies. However, it should not be assumed that because habitats (and by implication, crocodilian populations) are small or declining that there should be no harvesting program. An economic incentive for conservation is often essential where habitat is being converted and lost because of land use pressures. Crocodilian harvests can often provide such economic incentives for conservation.

It is often assumed that the measurement of different habitat types, when coupled with population inventories, will provide a means of estimating the total crocodilian resource. However, care should be used in extrapolation. Population estimates should be obtained systematically (i.e., randomly) to ensure all habitat types are represented. Where extrapolation is unavoidable, it is usual for the lowest density estimates for each habitat type to be used.

2.2 Monitoring the Effects of Harvest

Crocodilian populations most commonly decline as a result of over-harvesting and/or habitat loss. Any crocodilian harvest program must employ a monitoring scheme capable of detecting adverse declines in populations before the population is badly harmed. The ability to sustain a harvest and the credibility of a management program depend on the ability to detect changes in population levels, identify the cause of change, and adjust harvest levels accordingly.

Monitoring techniques fall into three categories. These include: (1) monitoring population trends through on-site surveys; (2) monitoring the harvest trends (e.g., number and size of crocodilians taken annually); and (3) monitoring habitat change. A management plan should identify the operational procedures and the manpower needed for monitoring. It is tempting to avoid the added cost of monitoring when there are many other pressing economic or social needs. However, a well designed population monitoring system is an obligation that comes with the harvest of any species, regardless of its status or the level of harvest. It is certain, however, that population levels will change whether harvested or not, and monitoring is the only vehicle that will provide a quantitative measure of changes that can be used to ensure credible and sustainable harvests.

2.21 Monitoring Population Trends

Sustainable utilization requires limiting the harvest of crocodilians to a level that can be replaced through natural reproduction. In an adaptive management approach, monitoring of population trends provides the basis for the setting of annual harvest quotas and for the restriction or liberalization of harvests, provided the monitoring technique is capable of measuring changes in the population.

If monitoring is to provide credible population trend information, particular attention should be given to technical design for appropriate statistical analysis. The type of monitoring system selected and the associated costs in manpower and equipment depend on habitat accessibility, species status and distribution, and the risk of the harvest imposed (i.e. ranching or hunting). Physical characteristics of the habitat impose obvious limitations on the types of surveys that can be considered. For example, aerial surveys are of no value in an area where the closed forest canopy obstructs potential observation of animals or their nests. Similarly, nighttime spotlight surveys from a boat are not practical on impassable water bodies. Survey techniques and associated statistical analyses should be designed to account for variation due to habitat and environmental variables.

Basking surveys have been used to monitor crocodile populations through aerial surveys of representative rivers in Australia and Tanzania, and from ground observations on private lands in the llanos of Venezuela. Aerial nesting surveys are used as an index of alligator population trends in the relatively open and homogenous coastal brackish and freshwater marsh in Louisiana and the portions of the Brazilian Pantanal and remote swamps of PNG. However, in many areas such surveys are ineffective because nests are obscured by vegetation. Annual night-spotlight surveys have been useful as a population monitoring tool in Zimbabwe, Tanzania, Venezuela, Guyana, Florida, Georgia and Louisiana U.S.A., and the Northern Territory in Australia, and to a lesser extent in Papua New Guinea, Irian Jaya, and Indonesia. Night-light surveys allow technical personnel to observe changes that otherwise would be unobservable from the air (such as habitat degradation, changes in reproductive success, behavior, and physical condition of juvenile and adult animals).

2.22 Monitoring Harvest Levels

Where species are entering international trade, CITES requires that a record of the number and size of animals harvested is compiled annually. This same harvest record can provide, to a limited degree, biological information about the size of animals taken under hunting programs. In hunting programs, harvest levels can be monitored through inspection of hides (which should be tagged at time of offtake). Under a ranching program harvest levels are most often monitored through stock counts on farms, but it is also common to inspect at the time of collection and slaughter.

Trends in the number or size of animals taken (or hide size) have limited utility in evaluating the impacts of hunting. This is because a decline in the size of hides can be a sign of a real decline in populations or only reflect changes in "availability" of animals to hunters. Changes in availability of crocodilians to hunters can occur because of numerous causes; examples include 1) increased wariness of animals as a result of harassment associated with hunting activities or other waterbody uses, 2) changes in environmental conditions, such as increases in water levels that allow animals to access extensive areas of inaccessible flooded marsh, 3) changes in demand for different size hides, which gives hunters economic incentives to "target" specific size animals. Information on the number and size of hides from hunting programs is relatively inexpensive to collect, but because of its potential bias is best utilized in conjunction with some form of on-site survey technique.

Programs in Indonesia and Papua New Guinea rely heavily on information derived from the number and size of hides produced. Much of the crocodilian resource in these countries occurs in remote areas, where traditional on-site surveys are simply not feasible. There are dangers, however, in such an approach. False impressions of the status of the population can result from fraudulent or delayed reports.

2.23 Monitoring Habitat Change

Degradation or loss of habitat can have much greater long term adverse impacts on crocodilian populations than harvest programs. If a harvest program is to be sustained and remain credible, managers must be capable of adjusting harvest quotas in response to changes in habitat. Habitat alteration (such as impoundments for hydroelectric projects, drainage projects that change natural water level fluctuations, eutrophication from agricultural and urbanization) can have adverse affects on crocodilian populations. Increased human activity, such as residential development, fishing practices and industrial activities, often accompanies habitat changes that can displace crocodilians or cause inadvertent mortality.

Monitoring habitat change is usually more costly and less precise than population surveys for tracking population status. However, it is presented here as an alternative approach where no other system of monitoring population changes is adequate. Additionally, there is considerable merit in the inclusion of habitat monitoring as part of an overall monitoring scheme.

The monitoring of habitat changes can be accomplished at individual sites or over broad areas, or both. A habitat inventory compiled in the initial program development phase can provide a vital baseline for assessing future changes in habitat quality and quantity. Where on-site population monitoring surveys are conducted annually, changes in habitat can be measured at little additional cost. Quantitative measures should provide a record of habitat changes that are most likely to affect crocodilian populations. These should include changes in available water surface area; proportion of the shoreline or area affected by human encroachment such as villages, agriculture, mining or other industry; and natural changes in river courses or water levels as a result of droughts and floods. Where potential adverse affects are documented, quick remedial actions can be taken. If a proposed habitat change will generate fewer economic benefits than the sustained harvest of crocodilian populations, then the sensible course of action may be to leave the habitat in a natural state.

INFRASTRUCTURE AND REGULATION NEEDS

Illegal harvests usually have a deleterious affect on crocodilian populations and damage markets for legal products by undercutting prices and damaging the image of crocodilian products in the eyes of retail consumers. Therefore, both the conservation community and the legal crocodilian production industry demand assurances that the infrastructure is in place to adequately control and administer a program.

Implementation of an operational program requires (1) an agency which has the responsibility for establishing program policy and enacting legislation; (2) regulations to define operational procedures, and (3) a method of indefinitely funding the program.

3.1 Responsible Government Agency

One government agency should have authority and responsibility for the crocodilian utilization program. Where the program results in international trade, this requirement is enshrined through the articles and resolutions of CITES.

Under the provisions of CITES, the national government must appoint a "Management Authority" and a "Scientific Authority" to administer the CITES system. The Scientific Authority is responsible for monitoring the effects of harvest and for ensuring that harvest programs are not "detrimental to the survival of the species". This is generally accomplished through monitoring. In many cases it is beneficial to write into legislation that monitoring information be provided or funded by those undertaking the exploitation. The Management Authority is responsible for administration of the program (from the CITES perspective). This includes the development and enforcement of regulations, issuance of permits and harvest tags, compilation of harvest reports, authorization of exports and reporting of trade figures.

Where the crocodilians have limited national distribution, central government is generally an effective management authority, but where habitat and crocodilian populations are dispersed over wide geographical regions with social and cultural differences, management authority may be most effective when delegated to a regional level. When regional authority is granted, the central government usually continues to provide a supervisory and coordinating role. Regional management programs typically meet some reasonable minimum criteria established by the central government. Where diverse cultural and social practices exist, regionally managed programs may enhance local involvement, tailor programs to the specific needs of communities and encourage the development of technical expertise within the immediate region. The distribution of responsibilities over several different governmental agencies is usually problematic. The benefits of a single wildlife management agency include improved accountability, efficiency, specialization and, most importantly, resource stewardship. The proper authority and support for a wildlife management agency comes from a commitment at the highest level of government. The consolidation of wildlife and natural resource conservation responsibilities under a single cabinet or ministry level office has been advocated by the IUCN, in "Caring for the Earth".

All programs should aim for a minimum of bureaucracy. In relatively small programs little additional government bureaucracy is necessary; it is possible to assign duties to only one individual that may be responsible for authorizing annual harvest quotas, and monitoring and compiling annual reports. However, in cases where a program is large and/or expected to generate a significant industry, considerable burdens may be placed on the responsible agency. Under some circumstances, it is possible to minimize "government" costs of a program by reliance on industry or outside technical consultants to undertake critical tasks. Many programs utilize this approach to one extent or another, though considerable care must be taken to ensure that sound biological information is obtained. In both Venezuela and Florida, USA, government relies on qualified consulting biologists to provide survey information used to establish annual harvest quotas on private property. In Zimbabwe and Australia's Northern Territory, programs rely on consultants to provide biological research and monitoring to support their programs. Papua New Guinea relies on the industry to contribute aircraft for annual surveys used for monitoring and to establish annual egg collection quotas.

3.2 Harvest Regulations

Regulations are needed to provide controls that will restrict a harvest to sustainable levels and ensure that products for export are legally acquired. A management plan should identify regulatory controls that will be imposed, and also show how proposed regulations will work. Early enactment of regulations ensures that regulatory issues do not delay the start of a program and is often considered an administrative demonstration that regulations can and will be enforced.

There are a number of functioning regulations in ranching and hunting programs throughout the world (Attachment 3). Most of these programs have developed effective controls that have been practically tested. Prior to developing new regulations, functioning regulations used in other programs should be reviewed as possible models.

3.21 Harvest Program - Controls and Tagging Requirements

Biological information coupled with an assessment of economic feasibility provide the basis for electing to establish a harvest program that focuses on ranching or hunting, or some combination of the two.

In a crocodilian program relying on export, the Management Authority is responsible for issuing CITES export tags and permits for each export shipment as a measure to guard against illegal trade. To be an effective control, all tags must be self-locking and bear information on the country of origin, year of production, and a unique serial number. Different tagging systems may be necessary for controlling hunting programs and ranching programs.

Hunting - Regulatory controls for hunting programs should be aimed at ensuring animals are taken in the correct number and sizes from designated localities. Control and monitoring of harvest levels under hunting programs is best accomplished through hide tagging requirements and requirements for hide validation (i.e., the inspection, measuring, and marking of hides prior to sale or export).

Under some programs, hunters or landowners are typically issued harvest permits and serially numbered harvest tags that authorize the taking of a specific number of crocodilians from designated areas during a specified time period. To prevent stockpiling of hides prior to the designated harvest period, a common practice is to require adherence to "skinning instructions" that are revealed immediately prior to the beginning of the harvest period. Skinning instructions denote a unique skinning pattern that is not typically followed in the normal course of skinning an animal (i.e. flaps of dorsal scutes or specified foot pads attached to the hide). Tagging animals immediately upon taking reduces the opportunity to take animals from improper localities. Inspection and measuring of hides at central "validation" sites provides the opportunity to check for compliance with skinning instructions, collect biological information on the size of harvested animals, collect any tag fees that may be charged, and attach CITES export tags and return unused harvest tags. Hide validation requirements often provide a reasonable time-frame following the close of the designated harvest period to allow for logistical transport of hides from remote harvest areas to central validation sites.

A hunting program is usually adequately controlled through a system of permits and accompanying harvest tags, tagging of carcasses, written harvest records documenting the size and transport of animals taken, followed by a physical inspection and validation of individual hides prior to export authorization. Regulations should be adopted that identify procedures for: permit requirements; issuing and possession of tags; carcass and/or hide tagging requirements; the specific information about the carcass and hide to be reported; restrictions on the possession and processing of the carcass, meat, or hide; and requirements and time frame for meeting physical inspection and validation of hides.

Manpower requirements for hide validation can be considerable - particularly for programs that produce thousands of hides annually. However, a physical inspection is the most effective means to limit illegal activities. Validation is best accomplished through the attachment of a separate numerically numbered CITES export tag. When the attachment of the CITES export tag is tied to the collection of a hide tag fee then revenues can be generated (see section 4.5) and the incentive to provide adequate staff and accurately account for each hide is enhanced. Additionally, regulations can be formulated that require the industry supply manpower and facilities to assist with validation of hides and off-set manpower demands of the agency. This arrangement can often be mutually advantageous to the exporter because they are able to solicit a validation at their hide storage facility and avoid the added cost of transporting hides to an agency facility.

Ranching - Regulatory controls for a ranching program are primarily needed to ensure that all stock is legally acquired and that no illegally taken wild hides, allegedly reared in captivity, are "laundered" through ranches. Harvest permits, on-site inventories of rearing facilities, and maintenance of inventory records by ranchers are an effective means of monitoring ranched production. Regulations should exist that ensure the collection of eggs or juveniles does not deplete wild stocks. Under low intensity harvests (where there is little impact on the resource) regulations on the number of animals taken by ranchers are unnecessary or minimal.

Where harvest rates approach the maximum sustainable level, more stringent controls are necessary. Regulations may require crocodilian ranchers to obtain harvest authorization for a specified number of eggs or juveniles from designated areas during a specified time period. Some mechanism that verifies the number of captive crocodilians legitimately reared in captivity are needed to ensure illegally hunted wild hides are not laundered through ranches. This may include regulations requiring physical counts of the young immediately following completion of hatching (in the case of egg collection) and immediately following the specified collection period (for juvenile harvests). A suitable inventory approach will establish the minimum number of eggs/juveniles removed from the wild and the maximum number of hides eligible for tagging at slaughter. Additional controls may include requirements for ranchers to maintain inventory records and periodically report any changes in stock resulting from natural mortality or transfers to other rearing facilities. Often, it is not feasible to conduct a complete inventory of large animals in captivity because the handling of such animals is often dangerous and stressful. Under such circumstances, the issuance of harvest tags up to the limit of the ranch inventory is often the most effective control.

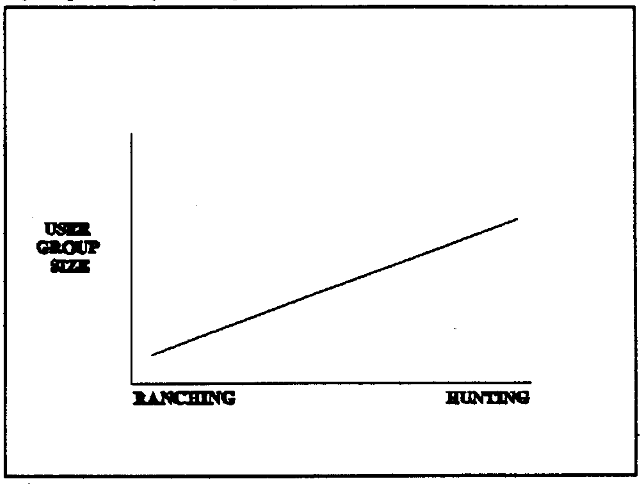

Figure 3

Regulations requiring periodic spot-checks of stock and a review of farm records are generally adequate to avoid abuse by ranchers. A trained inspection team may be necessary to ensure the proper treatment of eggs and stock. It may be necessary to regulate for the design of facilities and for minimum rearing performance standards to promote good husbandry practices and minimize the waste of the resource through mismanagement and poor husbandry care.

Generally, there are a greater number of participants involved in hunting programs than in ranching programs, Figure 3. Hunting programs can benefit a greater number of individuals; a larger constituency can increase the incentives to conserve crocodilians and their habitat. However, hunting can be more difficult to control because it typically involves large numbers of hunters taking animals in remote areas. This is in contrast to ranching operations that are usually much more limited in number and are easily subject to inspection, Figure 4.

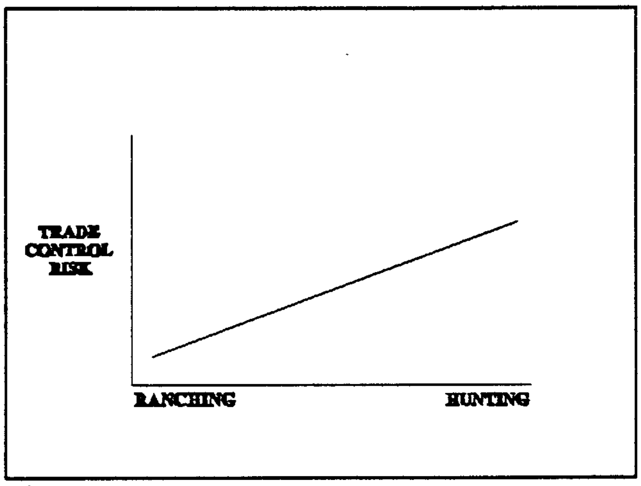

Figure 4

3.22 Harvest and Protected Zones

Regulations should identify protected areas. The establishment of protected areas, such as selected national parks or preserves, that represent a cross section of suitable crocodilian habitat in the region is often important to serve aesthetic, ecological and scientific needs. This is particularly important in areas where tourism may be an important component of the economy, and in unique circumstances may provide the greatest economic return from crocodilians. Although the ecological role of crocodilians is not fully understood, the establishment of preserves where crocodilian populations are totally protected from any harvest or molestation ensures that "natural" populations exist for future study. Therefore, provisions should call for the periodic "re-establishment" of harvest areas based on a technical review of the effects of harvest on the wild population.

3.23 Seasons and Methods of Take

All crocodilians follow an annual behavioral cycle in which some members, such as breeding females, are more vulnerable to harvest. It is particularly important to consider the breeding season when developing regulations governing harvests. Seasons and methods of take should be established after considering their biological, logistical and economic costs. Regulations should clearly define the calendar dates that harvest may occur, any specific records or permits required, and clearly identify the methods that are permitted. Regulations should prohibit harvest during any period or by any means other than those defined in the rules.

FUNDING SOURCES

In spite of what seems to be a constant lack of funding for new programs, the relatively high economic value of crocodilians provide an ideal means of financing sustainable-use management programs. In the developmental stages of a program it is not unusual for the private sector, interested in establishing a crocodilian industry, to provide significant contributions to fund studies that will provide the biological basis that support a harvest program that will provide a sustainable source of product. The potential rural employment and foreign currency earnings also commonly motivate government and international aid organizations to fund programs. Support for sustainable programs makes wise economic sense when industry has made high capital investments in the establishment and building of captive rearing and processing facilities.

Some funding sources are more appropriate for supporting the initial stages of a program, others the operational phase. The most important consideration should be to settle on a funding source that will provide a **stable** funding base. Agencies that are responsible for the stewardship of the resource cannot remain credible if they fail to carry-out monitoring and regulatory functions as a result of wide fluctuations in a funding base. We recommend using several different funding sources to spread out program cost among all participants in the utilization program and provide a cushion against loss of revenue from any one funding source.

4.1 Diverting From Other Programs

Diverting or reassigning technical personnel from other programs within an agency is often a means of initiating a crocodilian utilization program where a very cursory review of the population status and the feasibility of initiating a program must be assessed. Such personnel can often serve as the "seed" necessary to germinate other funding sources (such as those discussed below) and formulate a comprehensive package that will allow development of a program. Agencies may find that adequate manpower or funds can be provided by the elimination of existing outdated or less important programs. However, the diversion can affect other conservation programs or may be inadequate to meet the needs of a credible and biologically sound program.

4.2 International Aid Organizations

Funding from international aid organizations is often designed to promote the development of sustainable-use programs. The greatest obstacles to such funding is often the bureaucracy involved and the long lead time between application and granting of support. International aid is most useful as one component of a comprehensive package that also includes the diversion of resources from other programs and industry funding for pilot projects (see section 4.3).

4.3 Industry Funding

The crocodilian industry has demonstrated the ability and desire to work with governments to develop new programs. Often entrepreneurs from the private sector are willing to provide financial support for experimental harvests or ranching programs in the hope of encouraging an industry. Landowners who are custodians of crocodilian habitat are often potential supporters, as are agricultural associations (such as cattle ranchers). Governments seeking to develop funding should initiate an early dialogue with the private sector. However, governments and the private sector generally have different objectives. Governments are primarily interested in wildlife conservation and the well-being of citizens; businesses, on the other hand, are generally interested in realizing a profit from utilization of crocodilians. Private industry is often willing to take some risks that governments cannot afford. However, in exchange for their risk, the private sector often seeks exclusive access to the crocodilian resource. This may or may not be advantageous to the government, local inhabitants, and, most importantly, conservation of the crocodilians. Although the vast majority of those in the crocodilian industry deal honorably, an uninformed government can be at a disadvantage at the bargaining table.

4.4 Sale of Harvested or Confiscated Products

The sale of hides produced under an experimental harvest, or those taken illegally and confiscated can be used to generate substantial revenues during the early stages of program development. Experimental hunting programs generally involve the removal of a proportion of the animals. The cost of hunting and properly processing the hides and meat can be relatively high. However if adequate labor is available, or can be temporarily contracted, the sale of the products can be used to fund research. Any studies that are funded in such a manner should be of the highest technical caliber to avoid any perception that science is being used to cloak an ill-conceived harvest program.

In some parts of the world, thousands of crocodilian skins are seized by government enforcement agencies and customs officials each year. Generally these hides are destroyed under the provisions of national law. However, under some circumstances, the hides may be legally sold or auctioned on the international market with the approval of CITES. Generally this will require that the species is already listed on Appendix II.

4.5 License and Tag Framework Based on Raw Product Value

A license and tag framework for funding is generally enacted through legislation in the operational stage of a program. By this stage, the harvest strategy (hunting and/or ranching schemes) as well as the anticipated annual harvest level, manpower and funding needs are well defined. Provided monies are not available elsewhere (as invariably is the case) license fees and tag fees must be adequate to operate the program on a self-sustaining basis.

Tag fees are a charge or tax imposed on each individual product (e.g., hides), a *license fee* is a charge or tax imposed on a participant involved in the taking or possession of crocodilians (e.g., rancher or hunter). Often, the costs of a program increase with the number of animals harvested. Therefore, it is preferable to tie the bulk of program revenues to tag fees rather than license fees, which are less likely to track program expansion and costs.

Although there are commonly inequities in the costs of products from ranching and hunting, a tag fee system based on the average value of hides is often adopted. Each individual program is unique and many factors must be considered when establishing equitable "tax" rates.

Ranchers generally are permitted to take far greater number of animals than hunters and, although their net profit per animal may be lower than wild hunted animals, their overall net can be considerably greater. The time the tag fee is imposed can also have a bearing on the real cost to a rancher. A fee that is paid at the time of egg collection and must be carried as debt for the 1 to 3 years during rearing is a much greater burden on the rancher than a tag fee that is paid at the time of slaughter. However, under this system, ranchers that exercise poor husbandry and loose considerable number of animals pay no fee for the resource removed from the wild (and no penalty for a wasted resource).

On the other hand, hides produced from hunting programs are, almost invariably, cheaper to produce than those from ranched animals. However, hunting costs also can vary, and in remote regions can be substantial.

The most equitable method of determining tag fees is to consider the costs of production and calculate the average hide value (the net value where possible) for each type of animal taken and determine the percentage tax necessary to fund the program. In a program that permits hunting and ranching, a fee of approximately 1% to 15 % of the **average** raw product value can generate adequate revenue to make the program self-sustaining. Generally, when legislation is needed to enact tag and license fees it is advisable to establish a tag fee of "up to" a given fee amount. This will provide the flexibility to increase or decrease fees in increments without need to revise state or national legislation.

Those seeking to develop a license and tag framework should investigate the systems employed in other programs to draw on the experience and mistakes of other programs (see Attachment 3).

4.6 Severance or Export Tax Based on Export Value

In many cases value is added to crocodilian hides prior to export (e.g., through partial or complete tanning). In these cases an alternative to forcing the entire tax burden on the primary producer is to place a tax on products at export. This can be an additional tax that pays a portion of the program's operating costs, or which functions as the sole support mechanism. As a sole support mechanism, however, a loss in revenue could result if the internal market for products strengthens or market forces cause extended slumps in exports. In creating a tax structure for exports a minimum fee per piece, regardless of size, should be considered to circumvent possible low export value declarations by unscrupulous exporters.

The revenue from export taxes can be erratic because the sale of crocodilian hides and products follows the demand of fashion. Producers often reduce production or exports when prices and profits are low, awaiting improved market conditions. This can cause agency revenue shortfalls in some years, followed by surplus in good market years. Therefore it is wise to consider reliance on this revenue source in combination with some other form.

ATTACHMENT 1

CITES Controls

Excerpt from: Luxmoore, R.A. 1992. *A Directory of Crocodilian Farming Operations*. Second Edition. IUCN, Gland Switzerland and Cambridge, UK. 350pp., PART 1: AN INTRODUCTION TO THE FARMING OF CROCODILIANS, Edited by J.M. Hutton and G.J.W. Webb (pp.5-7).

1. Regulations

The term *crocodilians* is used to refer to the 23 different species of crocodile-like animals around the world: alligators and caimans (8 species), true crocodiles (13 species), and gharials and false gharials (2 species). Within most countries, crocodilians cannot just be kept and traded like domestic animals and pets. They are "wildlife", and there will usually be laws restricting what private individuals can do with them. For example, wild crocodiles may be totally protected, or they may be managed through a system requiring licenses and permits for catching, keeping, selling, trading, killing, etc. As these laws vary from country to country, and enforcement of them ranges from strict to lax, we make no attempt to summarize them here. However, they are of critical importance to anyone considering crocodilian farming.

At the international level, trade in crocodilians and products derived from them is controlled through CITES - the Convention on International Trade in Endangered Species of Wild Fauna and Flora. The mechanisms by which CITES exerts control are more complex with crocodilians than with any other group of living organisms. There are two basic levels of control. Most crocodilian species are listed in *Appendix I* of CITES, for which no commercial trade between nations is allowed, unless the animals being traded have been bred in captivity. The remainder are in *Appendix II*, for which trade is permitted if export permits are issued by the relevant authority. Since the inception of CITES in 1975, all species of crocodilians have been listed on Appendices I or II.

Since 1975, a number of local populations have been transferred from Appendix I to Appendix II, for a variety of reasons, and using a variety of mechanisms. Consequently, there are now at least five different levels of control accorded to crocodilans under CITES:

1.1. Appendix I

Appendix I contains "all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species ... must only be authorized in exceptional circumstances" (CITES, Article II, para. 1). The export of wild animals to be used as breeding stock for establishing farms or zoos is not permitted, unless the aim is to instigate a breeding programme intended to ensure the survival of the species. Hunting trophies intended for personal use (not resale) may be exported, although some nations (e.g. the USA) prohibit their importation unless a specific exemption is provided in their domestic import regulations.

1.2. Appendix I (Bred in captivity for commercial purposes)

Appendix I animals are controlled as though they were Appendix II animals if they are "bred in captivity for commercial purposes". This has been defined as: "born or otherwise produced in a controlled environment, ... of parents that mated ... in a controlled environment". For crocodilians, this means that the offspring must hatch from eggs laid in a farm, and that the breeding stock must be "established in a manner not detrimental to the survival of the species in the wild" and must be "maintained without augmentation from the wild, except for the occasional addition of animals ... from wild populations to prevent deleterious inbreeding". Resolution Conf. 8.22 forbids the removal of breeding stock from a depleted wild population unless it "is justified in a national management plan demonstrating conservation value". The breeding stock must also be managed in a manner designed to maintain it indefinitely, and that "has been demonstrated to be capable of reliably producing second-generation offspring" (Resolution Conf. 2.12). This does not mean that the farm cannot trade until it has achieved second-generation breeding, but rather that it must be using suitable and reliable husbandry techniques. Farms must also be registered with the CITES Secretariat (via the local Management Authority) and approval may be withdrawn if they fail to comply with the required conditions.

1.3. Appendix II (transferred from Appendix I for ranching)

Under CITES Resolution Conf. 3.15, Appendix I animals "which are deemed by the Parties to be no longer endangered and to benefit by ranching" may be transferred to Appendix II, if strict management criteria are adhered to. Ranching is defined as "the rearing in a controlled environment of specimens taken from the wild". The operation must be "primarily beneficial to the conservation of the local population (i.e. where applicable contribute to its increase in the wild)". In order for a country to transfer a population from Appendix I to Appendix II for ranching, it should have carried out research on the wild population and be able to ensure "that the taking from the wild shall have no significant detrimental impact on wild populations". With crocodilians, the harvesting of eggs and hatchlings (for ranching) appears to have a minimal impact on the wild populations relative to the harvesting of adults. Resolution Conf. 8.22 recognized that the removal of eggs and hatchlings carries less threat to the wild population than the harvesting of adults, and it recommended that proposed ranching operations based on such offtake should be "accepted as a matter of routine", provided that sufficient safeguards are established in the proposal.

1.4. Appendix II (an interim transfer from Appendix I on the basis of a quota)

CITES Resolution Conf. 5.21, now replaced by 7.14, was adopted as an interim measure in 1985 to allow limited quotas of skins of Appendix I animals to be exported, pending transfer of the population to Appendix II by other means (e.g. for ranching). Quotas are set by international agreement and must be based on surveys predicting the likely impact of the harvest. Quotas may be set separately for the export of wild-caught and ranch-reared animals or their skins. The system is intended to operate for a maximum of four years, after which a country is expected to have accumulated sufficient information to show either that the population has recovered and merits retention on Appendix II, or that a ranching scheme can operate.

1.5. Appendix II

Populations on Appendix II, or which have ben transferred back to Appendix II after having recovered, may be traded internationally provided that the Management Authority issues an export permit. This, in turn, may only be done when scientific advice indicates that the trade "will not be detrimental to the survival" of the species.

In order to export skins under any of the systems described under Sections 1.2-1.4 above, the skins must be marked with a tag bearing a unique number. In practice, several countries also tag skins from Appendix II animals (1.5 above), and there are now few crocodile skins in legal international trade that are not tagged. Resolution Conf. 8.14 was adopted in 1992 recommending that all crocodilian skins in international trade be tagged.

<u>ATTACHMENT 2</u>

History of CITES Controls

Excerpt from: Luxmoore, R.A. 1992. *A Directory of Crocodilian Farming Operations.* Second Edition. IUCN, Gland Switzerland and Cambridge, UK. 350pp., PART 2: DIRECTORY OF CROCODILAN-FARMING OPERATIONS, Edited by R.A. Luxmoore (pp 55-57).

History of CITES Control of Trade in Crocodile Products

The mechanisms by which CITES exerts control over the trade in crocodilian products are more complex than for any other group of organisms. They are summarized in Table 4. All Crocodylia were included in either Appendix I or II in 1975, with the majority in Appendix I. The only taxa left in Appendix II were the two freshwater crocodiles from Oceania, *Crocodylus johnsoni* and *C. novaeguineae novaeguineae,* two saltwater species, *C. porosus* and *C. acutus*, two dwarf caimans from South America, *Paleosuchus* spp., and three subspecies of *Caiman crocodilus* (all except *C. crocodilus apaporiensis*). In 1979, a reassessment of the status of the American Alligator led to its transfer to Appendix II, while certain geographically defined populations of the two widespread saltwater species were transferred to Appendix I: all populations of *C. porosus* outside Papua New Guinea and the population of *C. acutus* in the USA. Later, in 1981, the remaining populations of *C. acutus* were transferred to Appendix I.

Many countries, having experienced heavy exploitation of crocodiles in the past, had introduced protective legislation which had resulted in scattered population increases. These, together with the growing realisation that some other populations were not sufficiently rare to justify inclusion in Appendix I, were to bring calls for mechanisms to allow a resumption of trade in crocodilian products from some sources.

Article VII, para. 4 of CITES allows specimens of Appendix I species which were "bred in captivity" for commercial purposes to be treated as if they were Appendix II specimens. A Resolution adopted in 1979 in Costa Rica (Conf. 2.12) narrowed the definition of "bred in captivity".

At that time there were very few crocodilian farms which fulfilled this definition. One of the oldest, and largest, was in Thailand, which was not then a Party to CITES. The growing crocodile farming industry in Zimbabwe relied on the collection of eggs from the wild and therefore did not fulfil the new definition of "bred in captivity". Recognising that it nevertheless did not threaten the wild population and, indeed, benefitted it, the third meeting of the Conference of the Parties sought to arrive at a formula which would allow trade. As the only exemption allowed by the Convention to permit trade in Appendix I species (specimens bred in captivity) had been denied by the adoption of Resolution Conf. 2.12, the remaining option was to transfer the population to Appendix II. The normal mechanism for transferring species from Appendix I to Appendix II, as defined tin Resolution Conf. 1.2, requires that the population should be shown to have recovered sufficiently to justify its transfer. As this was not always possible, a new procedure was adopted (Resolution Conf. 3.15) under which "ranched" populations could be transferred to Appendix II. This was first used in 1983, when the Zimbabwean population of *C. niloticus* was transferred to Appendix II and, later, in 1985, for the Australian population of *C. porosus*.

The criteria for ranching, defined in Resolution Conf. 3.15, although not requiring the demonstration that the population has recovered, demand such strict controls on the management of the wild population and the conduct of the ranching operation that many countries without a long history of crocodile management would have great difficulty in fulfilling them. Furthermore, it was realised that as most crocodilians had been included in Appendix I in 1975, before the Berne Criteria for the addition of species to the appendices (Resolution Conf. 1.1) were adopted, their was, for the most part, no information on the size of the wild population at the time of inclusion in Appendix I, and therefore no easy way of demonstrating a population recovery since then. These considerations led to the adoption, in 1985, of some "special criteria for the transfer of taxa from Appendix I to Appendix II"(Resolution Conf. 5.21, later replaced by Resolution Conf. 7.14). These were intended as a temporary measure, until some other mechanism for allowing trade could be complied with, which would allow countries to transfer their populations of the species to Appendix II and export only limited quotas of certain products. Under this system, the populations of *C. niloticus* in Cameroon, Congo, Kenya, Madagascar, Malawi, Mozambique, Sudan, Tanzania and Zambia, and *C. porosus* in Indonesia, were transferred to Appendix II in 1985, followed in 1987 by those of *C. niloticus* in Botswana, and of *C. cataphractus* and *Osteolaemus tetraspis* in Congo. To these were added, in 1989, the populations of *C. niloticus* in Ethiopia and Somalia, and in 1992, those of South Africa and Uganda. Populations of *C. niloticus* in Botswana, Malawi, Mozambique and Zambia were retained in Appendix II under the terms of Resolution Conf. 3.15, and therefore no longer restricted by export quotas, followed by the populations of Ethiopia, Kenya and Tanzania in 1992. A further complication to the quota system is added by the practice adopted of specifying the source of the specimens which go to make up the quota. Thus the Ethiopian quota for 1991 comprised 2300 ranch-reared, live hatchlings, 6500 ranch-reared skins, 20 skins obtained from the wild and 50 wild hunting trophies. The Quotas adopted are shown in Table 5.

Further refinements were added in 1987 and 1992 to the mechanisms for allowing trade in captive-bred Appendix I species, to allay concerns that there was insufficient control over the establishment of breeding operations. Resolution Conf. 6.21 recommended "that, excepting species for which one commercial captive-breeding operation is included in the Secretariat's Register on 24 July 1987 [i.e. *C. niloticus, C. porosus, C. siamensis*], the first commercial captive-breeding operation for an Appendix I species be included in the Secretariat's Register only by approval of two-thirds majority vote of the Parties". *Alligator sinensis* was added to the register by this process in 1992. Resolution 8.15 set controls over the acquisition of breeding stock to ensure that farms were not established to the detriment of depleted wild populations.

The year 1987 also saw the introduction of mechanisms omitted from the early resolutions to terminate the trade from captive breeding (Resolution Conf. 6.21) or ranching (Resolution Conf. 6.22) operations which fell short of the requirements.

The procedure for transferring ranched populations to Appendix II as it was originally envisaged allowed the export both of the products of animals reared on ranches and those of wild-caught animals. The rationale for this is that there is a continuous interchange between the wild population and the stock held on the ranches and so they are both part of the same population. However, it was later realized that this might result in the extraction of large numbers of skins from wild populations. Resolution Conf. 8.22 therefore imposed clear restrictions by requiring Parties "to limit the manner of exploitation of wild populations to those techniques described in the proposal and not, for example, later to initiate new short-term programmes for taking wild animals without notifying the Secretariat". It further recommends that "any wild harvest component of a ranching proposal normally be limited to a reasonable number commensurate with the control of nuisance animals and sport hunting".

The result of this convoluted history is that there have been at least seven different mechanisms for exerting control over trade on crocodilians under CITES, ranging from Appendix I listing and a complete trade ban, through various limited trade regimes, involving captive breeding, quota systems and ranching, to simple inclusion in Appendix II. Different populations of any species may be included in different categories, the current record being held by *C. niloticus*, which is subject to five different control categories throughout its range (Table 4). The controls in force are summarized in Part I of this book.

Impact on Conservation

Crocodilian populations have declined in many parts of the world, and this has been linked to the uncontrolled trade in their skins which took place before the implementation of CITES. Crocodilian skins are a luxury product and, with the exception of *alligator mississippiensis* and *Crocodylus acutus* in the southern USA, most major wild populations are remote from the main markets. As they are seldom hunted for meat, the majority of trade is international and therefore susceptible to control by CITES.

The ban on commercial trade imposed by inclusion in Appendix I varied in effectiveness: in some countries, such as the USA and Australia, the trade was brought under control with the aid of strict domestic protection measures. In others, commercial extinction contributed to a decline in trade, as with *Melanosuchus niger* in South America and *C. porosus* in the Indian sub-continent. Elsewhere, where large populations of Appendix I species remained, such as *C. porosus* in Southeast Asia and *C. niloticus*, trade continued, mostly to non-Parties and Parties holding reservations, especially Italy, France and Japan. From 1984 onwards, these routes became progressively restricted, and there is evidence that the volume of trade in Appendix I skins began to fall as a result of CITES controls (Dixon and Barzdo, 1988). It is perhaps no coincidence that this was accompanied by widespread moves from around the world to find legitimate alternative methods to continue trade in the more abundant populations and this provides evidence that CITES may have begun to work as it was intended. In the following sections, the implications for the conservation for crocodilians of the various different trade control regimes will be discussed.

Appendix I listing

Although theoretically providing the greatest level of protection, a complete trade ban has several drawbacks. It requires substantial investment in local protection measures by the range states if it is to be effective in the absence of unanimous efforts by all potential markets to control imports. More importantly, it provides no immediate commercial incentive to counter the conflicting demands for the eradication of crocodilians. If sometimes ill-informed, these are numerous because, even if crocodilians are not perceived to pose a threat to humans or livestock, they are often considered to damage fishing gear or compete for fish stocks. There is therefore the double cost of policing protection measures amongst a potentially alien public who would wish crocodilians removed even in the absence of commercial skin hunting.

In compensation, a complete trade ban is more simple to police and legislate for than a partial ban and, if it is successful in reducing the demand for the final product, may result in a drop in price which could reduce the incentives for illegal trade. Both of these advantages are offset by the existence of several populations of crocodilians in Appendix II, the skins of which are scarcely distinguished by the final consumer and only with difficulty by the enforcement agencies.

Captive breeding

The breeding of crocodilians in captivity in accordance with Resolution Conf. 2.12 need have minimal direct impact on wild populations. Theoretically, once the founder breeding stock has been obtained, the breeding operation can be entirely self-contained and place no further drains on the wild. In practice, captive-breeding operations are often only set up after the local wild populations have become seriously depleted, and obtaining breeding stock depletes them further. Crocodile farming is an expensive business, and the need to hasten a positive cash flow may encourage even successful farmers to obtain further stock from the wild. It was in response to concerns such as these that a resolution was adopted at the CITES conference in 1992 controlling the permissible means for establishing the breeding stock.

Furthermore, although captive breeding need have no direct negative impact on wild populations, it also has no direct positive impact. A captive-breeding operation, once independent of the wild, provides no incentive for conserving wild populations.

One final problem associated with the commercial captive breeding of crocodilians concerns the deliberate release or accidental escape of exotic (non-native) species. Although the breeding and release into their former habitat of severely endangered crocodilians, such as the Gharial, can and does benefit their conservation enormously, the release of crocodilians into areas outside their natural range has caused problems. If the habitat is suitable they may breed and establish feral populations which may have serious effects on the local ecosystems. Feral populations of *Caiman crocodilus* have built up in Florida, Cuba and Puerto Rico where they have proved impossible to eradicate. The *Caiman* introduced to Isla de Juventud, Cuba, have been blamed for the disappearance of the native *Crocodylus rhombifer* from the island as a result of ecological competition. These releases are thought to have resulted from animals originally imported as pets and none has yet occurred as a result of farming activities. However the industry is still young and, if not checked, releases are bound to occur eventually. The experience of the fur farming industry has many examples of such escapes and it is responsible for the introduction of Mink, Coypu, Raccoon Dog and Musk Rat well outside their natural range. In the early stages of an industry, the livestock command high prices and great care is usually taken with their security, but as time goes by and profitability declines, maintenance of the facilities tends to be neglected. These concerns led the IUCN/SSC Crocodile Specialist Group to recommend against the use of crocodilians for farming operations outside their natural range especially within the range of other species of crocodilian.

ATTACHMENT 3
Established Crocodilian Utilization Programs

An alphabetical list of CITES Management and Scientific Authorities for countries having established crocodilian utilization programs recognized by CITES, *and* examples of selected provincial institutions that have developed harvest programs with innovative approaches and regulations that are suitable for replication in other regions.

* Australia
Management Authority and Scientific Authority:
Australian Nature Conservation
Agency (ANCA)
G.P.O. Box 636
Canberra, ACT 2601, Australia
tel: (6162) 500270; 500200
tex: anpws aa 62971
fax: (6162) 500303; 500399; 500274
Provencial institutions: Conservation Commission of the Northern Territory, P.O. Box 496, Palmerson, N.T. 0831, AUSTRALIA, tel. 6189 894533; contractual crocodilian research provided by G.Webb Pty. Ltd., P.O. Box 3851, Winnellie, N.T. 0821 AUSTRALIA, tel 6189 221355, fax 6189 470678.

* Botswana
Management Authority and Scientific Authority:
Fauna:
Department of Wildlife and National Parks
P.O. Box 131
Gaborone, Botswana
tel: (267) 371405
tex: 2674 trade bd
cbl: GAME GABORONE
fax: (267) 312354

* Colombia
Management Authority:
Instituto Nacional de los Recursos
Naturales y Renovables y del
Ambiente (INDERENA)
Gerente General
Carrera 10o
Numero 20-30
Apartado Aereo 13458
Bogota, Colombia

Scientific Authority:
Unidad de Investigaciones Federico Medem
Instituto Nacional de los Recursos
Naturales y Renovables y del
Ambiente (INDERENA)
Carrera 10o
Numero 20-30
Apartado aereo 13458
Bogota, Colombia

tel: (571) 2434071; 2431850
tex: 44428 inde co
fax: (571) 2833458

tel: (571) 2434071; 2431850
tex: 44428 inde co
fax: (571) 2859987

* Ethiopia

Management Authority and Scientific Authority:
Ministry of Agriculture and Environmental
Protection and Development
Environmental Protection Main Department
Wildlife Conservation Organization
P.O. Box 386
Addis Ababa, Ethiopia
tel: (2511) 514417; 514418
tex: 21460 gtzfp et (At. Wildlife
Conservation Organization)
cbl: WILDGAME ADDIS ABABA
fax: (2511) 518977

* Guyana

Management Authority:
The Permanent Secretary
Ministry of Agriculture
Attn: Head, Wildlife Services Division
P.O. Box 1001
Georgetown, Guyana
tel: (5922) 75527
fax: (5922) 73638

Scientific Authority:
The National Science Research Council
Institute of Applied Science and Technology
University of Guyana Campus
Turkeyen, Guyana

* Indonesia

Management Authority:
Directorate General of Forest Protection
and Nature Conservation
Departemen Kehutanan
Direktorat Jenderal Perlindungan Hutan
dan Pelestarian Alam
Manggala Wanabakti VIIIth floor
Jalan Gatot Subroto
Jakarta, Indonesia
tel: (6221) 584818; 5803312; 5803313
tex: 45996 dephut ia (for "PHPA-BOGOR")
cbl: DITPALAM BOGOR
fax: (6221) 584818; (62251) 323067

Scientific Authority:
Indonesian Institute of Science
Jalan Gatot Subroto 10
Tromol Pos 1250
Jakarta 10012, Indonesia
tel: (6221) 511542
tex: 67554 ia
cbl: LIPI JKT
fax: (6221) 5207226

* Kenya

Management Authority and Scientific Authority:
Kenya Wildlife Service
P.O. Box 40241
Nairobi, Kenya

tel: (2542) 501081-7
tex: 25016 utalii ke
cbl: WILDLIFE NAIROBI
fax: (2542) 505866; 505752

* Madagascar
Management Authority:
Direction des eaux et forets
Foiben'ny Rano sy Ala MPAEF
B.P. 243
Antananarivo 101, Madagascar
tel: (2612) 40811; 40610
tex: 22520 mpaef mg
cbl: DIRFORET ANTANANARIVO
fax: (2612) 40230

Scientific Authority:
Ministere de l'enseignement superieur
Antananarivo, Madagascar

Ministere de la recherche scientifique
et technologique pour le developpement
Antananarivo, Madagascar

* Malawi
Management Authority:
The Chief Parks and Wildlife Officer
Department of National Parks and Wildlife
P.O. Box 30131
Lilongwe 3, Malawi
tel: (265) 723566; 723676
tex: 44465 forenar mi (to/at. Dept. of
National Parks and Wildlife)
fax: (265) 723089

Scientific Authority:
The Senior Parks and Wildlife
Research Officer
Department of National Parks and Wildlife
P.O. Box 30131
Lilongwe 3, Malawi
tel: (265) 723566; 723676
tex: 44465 forenar mi (to/at. Dept. of
National Parks and Wildlife)
fax: (265) 723089

* Mozambique
Management Authority and Scientific Authority:
Direccao Nacional de Florestas e
Fauna Bravia
Ministerio da Agricultura
Cx. P. 1406
Maputo, Mozambique
tel: (2581) 460036; 460129; 460096
tex: 6209 sogma mo; 6195 monap mo;
6596 mademo mo
fax: (2581) 460060

* Papua New Guinea
Management Authority:
Secretary
The Conservator of Fauna
Department of Environment
and Conservation
P.O. Box 6601
Boroko, Papua New Guinea

Scientific Authority:
First Assistant Secretary
Division of Wildlife
Department of Environment
and Conservation
P.O. Box 5266
Boroko, Papua New Guinea

tel: (675) 271793
fax: (675) 271900; 271044

tel: (675) 271793
fax: (675) 271900; 271044

* Somalia
Management Authority and Scientific Authority:
Wakaaladda Daaqa Qaranka
(National Range Agency)
P.O. Box 1759
Muqdisho, Somalia
tel: 80710
tex: 715 SPC
cbl: SOMALRANGE MUQDISHO

* South Africa, Republic of
Management Authority:
Department of Environment Affairs
Environmental Conservation Branch
Private Bag X 447
Pretoria 0001
Republic of South Africa
tel: (2712) 3103702; 3103911
tex: 320142 enom sa
cbl: OMGEWING PRETORIA
fax: (2712) 3222682

Scientific Authority:
The Director of Nature and
Environmental Conservation
Orange Free State
P.O. Box 517
Bloemfontein 9300
Republic of South Africa
tel: (2751) 4055245; 4054262
fax: (2751) 4054873

* Sudan
Management Authority and Scientific Authority:
Wildlife Conservation and
National Parks Forces
Central Administration
P.O. Box 336
Khartoum, Sudan
tel: 70458; 74573; 72593
tex: 22203 siaha sd
cbl: SAYADIN KHARTOUM

* Tanzania, United Republic of
Management Authority:
The Director of Wildlife
Wildlife Division
Ministry of Tourism, Natural Resources
and Environment
Ardhi House
Kivukoni Front
P.O. Box 1994
Dar es Salaam
United Republic of Tanzania
tel: (25551) 21241-9

Scientific Authority:
The Co-ordinator
Tanzania Wildlife Conservation
Monitoring Program
P.O. Box 1994
Dar es Salaam
United Republic of Tanzania
tel: (25551) 21241; 21246

tex: 41725 nareto tz
cbl: MALIASILI DAR ES SALAAM
fax: (25551) 23230

tex: 41725 nareto tz
cbl: MALIASILI DAR ES SALAAM
fax: (25551) 23230

* Thailand

Management Authority and Scientific Authority:
Wildlife Conservation Division
Royal Forest Department
Paholyothin Road, Jatujak
Bangkok 10900, Thailand
tel: (662) 5791565; 5792776; 5794847
fax: (662) 5798611

* United States of America

Management Authority:
Chief, Office of Management Authority
U.S. Fish and Wildlife Service
4401 N. Fairfax Drive, Room 420 C
Arlington, Virginia 22203
United States of America
tel: (1703) 3582093; 3582095
cbl: 4900005150 WASHINGTON
fax: (1703) 3582280 (Chief and Operations Branch); 3582281 (Branch of Permits)

Scientific Authority:
Chief, Office of Scientific Authority
U.S. Fish and Wildlife Service
725 Arlington Square Building
Washington, D.C. 20240
United States of America
tel: (1703) 3581708
cbl: 4900005150 WASHINGTON
fax: (1703) 3582276

Provencial institutions: Florida Game and Fresh Water Fish Commission, Alligator Management Section, 4005 South Main Street, Gainesville, FL. 32601, U.S.A., tel. 904 3362230, fax. 904 3765359; Louisiana Wildlife and Fisheries Commission, Route 1, Box 20-B, Grand Chenier, LA. 70643 U.S.A., tel.318 5382165, fax 318 491 2595.

* Venezuela

Management Authority:
Ministro del Ambiente y de los Recursos Naturales Renovables
Director General del Ministerio del Ambiente y de los Recursos Naturales Renovables
Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR)
Torre Sur, 19o piso
Centro Simon Bolivar
Caracas 1010, Venezuela
tel: (582) 4833917; 411030
tex: 24434 marnr vc
fax: (582) 4831148

Scientific Authority:
Consejo Nacional de la Fauna Silvestre (CONAFASI)
Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR)
Centro Simon Bolivar
Edificio Camejo Norte
(frente al Pasaje Zingg)
Entrada Oeste; Nivel Mezzanina
Caracas 1010, Venezuela
tel: (582) 4081643

fax: (582) 5453912

* Zambia

Management Authority:
The Director
National Parks and Wildlife Service -
CITES Management Authority
Attn: Chief Wildlife Research Officer
Private Bag 1
Chilanga, Zambia
tel: (2601) 278366; 278524; 278244
tex: game za 70520
cbl: DIROGAM CHILANGA
fax: (2601) 278365

Scientific Authority:
The Wildlife Research Division of the
Department of National Parks
and Wildlife Service
Private Bag 1
Chilanga, Zambia

tel: (2601) 278366; 278524; 278244
tex: game za 70520
cbl: DIROGAM CHILANGA
fax: (2601) 278365

* Zimbabwe

Management Authority and Scientific Authority:
Department of National Parks
and Wild Life Management
P.O. Box 8365
Causeway
Harare, Zimbabwe (WL)
tel: (2634) 792786-9
tex: 4254/2141 zimgov zw (To/At. Dept. of
National Parks and Wild Life Management)
cbl: PARKLIFE HARARE
fax: (2634) 791114

Provencial institution: Contractual research and monitoring provided by J.M. Hutton (Pvt) Ltd, 16 Cambridge Ave, Highlands Harare, Zimbabwe.

CITES Secretariat:
CITES Secretariat
15, chemin des Anemones
Case postale 456
CH-1219 Chatelaine-Geneva
Switzerland
tel: (4122) 9799139/40
tex: 415391 ctes ch
fax: (4122) 7973417

ATTACHMENT 4

Developmental Aid Expertise

Fund raising suggestions for crocodile projects contributed by:

James Perran Ross, Executive Officer, CSG
Florida Museum of Natural History
Gainesville FL 32611, USA

Funding support for crocodile projects is potentially available from hundreds of sources. It is not practical to try and list them all here, and directories detailing many of these can be found in most libraries. Instead we can offer an overview of the wide scope of possibilities and some tips on how to approach them. Funding sources can be roughly classified as follows:

International Aid agencies
National Aid agencies
International Conservation Organizations
National Conservation Organizations
Business groups and Commercial Associations
Private Companies
Private and non profit Foundations
Private individuals

These are listed in inverse order of the ease and speed in which they usually provide assistance. In general it is far easier and quicker to make a direct approach to an individual or a company. A company president or a wealthy individual can often just write a check. In contrast the higher up the list you ask, the more complex the process and the more committees, reviewers and special conditions are required. A few of the more prominent sources are listed in Table 1.

In most instances a proposal must be submitted to the source and the normal period between submission and receiving funds is 1-3 years. Minimal information you need to know is the following:

1) The address and name to which to submit an application.
2) The format and content required in the proposal.
3) The deadlines for submission and the time when a decision will be made.

Most proposals require the following content although the order and specific details requested are very variable:

1) The name, address and description of the submitting individuals and organization.
2) A statement of the period of time and the amount of support requested.
3) Background information on the problem.
4) A description of the scope of the proposed project.
5) A detailed account of the activities proposed and the schedule of work.
6) A description of the specific results and outcomes that are expected.
7) The names and qualifications of personnel.

8) A detailed budget indicating major types and amounts of expenditures.

In many cases the success of an application is only partially related to the merit of the project you have in mind. The key to success in soliciting financial support for a project is to correctly match the proposed activities with the interests of the funding source. You may think you have a terrific proposal but if the agency you approach doesn't support that sort of project, you are unlikely to succeed. In most cases each source has specific guidelines for submitting proposals and specific interests that it will support. It is absolutely mandatory to submit a proposal in the format that the source requires, if they want it in Swahili, on pink paper with scalloped edges, that's the way to do it. Remember that most sources receive many more requests for assistance than they can support. Therefore they are always looking for a way to eliminate your proposal quickly and minimize the number of proposals they have to spend a lot of effort to review. A great deal of your time and energy can be wasted preparing and submitting proposals to inappropriate sources.

The most important activity you can undertake is researching potential sources. It is also instructive to review the past giving history of a source. Public libraries maintain reference material on many sources and most agencies, organizations and foundations will provide written guidelines on their interests and requirements upon request. Universities often collate aid information for their faculty and embassies and consulates can usually provide information on aid available from official sources from their country.

Another critical factor, independent of the merit of your project, is the re-assurance you provide that you and your organization are fully capable of completing the work successfully. Agencies dislike wasting their money and usually have requirements to qualify. They are often as interested in your qualifications, your bookkeeping ability, the members of your board of directors and your track record of organizational accomplishments as they are interested in the project itself.

Another important consideration is to match the request to the amount the source wants to give. It is obviously unproductive to request $100,000 from a small foundation that usually gives $500 travel grants. It is equally unrewarding to request a small personal grant from FAO who usually provide very large grants to national governments, they just can't be bothered with small grants.

You can't beat the personal touch. Like everything else, who you know is just as important as what you know. It is usually beneficial to make personal contact with a representative of the source you are considering. Most agencies and organizations and many companies and foundations have paid staff dedicated to managing the gift program. These people get their professional credit and often their personal gratification, from their success at picking good projects for their agency to support. They will often provide detailed information and valuable advice. Use them. Begin with a phone call, arrange a visit, follow up, keep them informed of your activities while your proposal is pending and while your project proceeds. These people are the ones who usually present your proposal, with their recommendation, to the review board. A relationship of confidence and trust based on good communication can really help your project.

Reports are very, very important. Most funding sources require you to report during and at the termination of a project. A disturbingly high proportion of fund recipients fail to fulfill their reporting requirements. As a result they do not get renewed support. Most successful fund raising builds on success. A small proposal for a pilot project can be the introduction for a larger proposal later and ongoing support. Developing a relationship of success with a funding agency is a very valuable activity.

Finally, it should be clear from the preceding material that fund-raising is a serious, time consuming activity. It takes effort to succeed and success is usually proportional to your effort.

Having made these dismal points, don't be discouraged. There is lots of assistance money out there and most of these sources are required by their charters to give it away. It's just a case of making the best match between what you want to do and what they want to fund, and presenting a convincing proposal that you can accomplish what they want to achieve.

Table 1:
Potential Sources of funding for projects on sustainable use of crocodilians.

A. Information about funding sources.

The Conservation Directory. National Wildlife Federation, 1400 Sixteenth St. NW Washington DC 20036-2266 USA.

The Foundation Directory. The Foundation Center, 79 Fifth Ave., New York, NY 10003-3076 USA.

The National Directory of Corporate Giving. The Foundation Center, 79 Fifth Ave., New York, NY 10003-3076 USA. ISBN 0-87954-485-6.

World Directory of Environmental Organizations. California Inst. of Public Affairs, P.O. Box 10, Claremont CA 91711 USA.

World Environmental Directory. Business Publishers Inc., 951 Pershing Drive, Silver Spring, MD 20910 USA.

B. International Aid agencies.

These maintain impossibly ponderous bureaucracies and fund multimillion dollar projects. They usually work directly with national governments.

UN FAO - Food and Agricultural Organization, Rome , Italy.
UN UNDP- United Nations Development Program
UN UNEP- United Nations Environment Program. P.O. Box 30552, Nairobi, Kenya.
The World Bank, 1818 H St. NW, Washington DC 20433 USA.

C. National Aid Agencies

Most of these function as arms of the foreign policy of their country and their aid allocation can be very focussed and political. Most maintain offices in the countries of their interest and can be contacted through the embassy and scientific attache.

US AID -Agency for International Development, Washington DC 20523, USA.
NORAD- Norwegian Agency for Development
AUSTRAD- Australian Agency for Development

EC- European Commission
JICA - Japan International C... Aid

D. International Conservation Agencies

IUCN-World Conservation Union. Ave du Mont Blanc, Gland CH-1196, Switzerland.
WWF- International. World Wide Fund for Nature, Ave du Mont Blanc, Gland CH-1196, Switzerland.
WCI (NYZS)- Wildlife Conservation International, 185th and So. Blvd., Bronx, NY 10460.
CI- Conservation International, 1015 18th St. NW Suite 1000, Washington DC 20036 USA.
National Geographic Society.

E. National Conservation Organizations

WWF- World Wide Fund for Nature- National organizations, function and provide grants independently of WWF-International. Major WWF affiliates in US, UK, France, Netherlands, Germany, Malaysia.

F. The commercial sector.

Corporations - Nearly every international corporation gives away some funding in every country it operates in. They do this for reasons of prestige, public relations and sometimes tax benefits. Oil companies, car companies, electronic companies, food companies are all potential sources. Contact the national office and the director of public relations and enquire about the corporate giving program. Of course if your boss fishes with the company President, that should help. The obvious targets are companies with a commercial interest related to your project. For crocodilians, manufacturers, fashion houses, retail stores, tanners, traders and commercial farms and ranches are all possibilities. This publication was prepared with financial assistance from conservation organizations, tanners and traders.

Crocodilian related Trade groups

ACSUG- Asian Conservation and Sustainable Use Group. Y. Takehara, Pres. Horiuchi Trading Co. No 2-17-6 Tsukasacho, Kanda, Chiyoda-ku, Tokyo, Japan.

JLIA- Japan Leather Industries Association, CITES Promotion Committee, 2F, Meiyu Bldg., 2-4-9 Kaminarimon, Taito-ku, Tokyo 111 Japan.

NCFA- Nile Crocodile Farmers Association of South Africa, C/) Riverbend Crocodile farm. P.O. Box 245, Ramsgate, 4285, South Africa.

CFAZ- Crocodile Farmers Association of Zimbabwe, P.O. Box 2569, Harare, Zimbabwe.

FAFA- Florida Alligator Farmers Association, C/O Ashley Associates, P.O. Box 13679, Tallahassee, Fl 32317 USA.

ICFA- Indonesian Crocodile Farmers Association. S. Tazir Pres. P.T. Sentani Valley, JL Ciputat Raya No 192, Pasar Juma'at, Jakarta, Indonesia.

CMAT- Crocodile Management Association of Thailand, Dr. P. Ratanakorn, Pres. Wildlife Lab. Dept. Zool. Kasetart University, Bangkhen, Thailand.

ACFA- Australian Crocodile Farmers Association, C/O J. Bache, P.O. Box 39745, Winnellie NT 0821, Australia.

AZOOCOL- Associacion Zoocriaderos de Colombia, c/o M. Stambulie, Zoocriadero Bucaintu Ltda. Cartagena de Indias, Colombia.