

# **CROCODILES**

## **7th Meeting**

### **1984**

**Special Reprint of the Proceedings of the  
7th Working Meeting  
of the Crocodile Specialist Group**

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

**convened at**

**Caracas, Venezuela 21 - 28 October, 1984**

**(Unedited and Unreviewed)**

**IUCN - The World Conservation Union  
Rue Mauverneyey 28, CH-1196, Gland, Switzerland**

**Reprinted 2002  
by Taxon Media, Inc.  
PO Box 192  
Lanesboro, MN 55949**

**IUCN**  
**The World Conservation Union**



# CROCODILES

## 7th Meeting 1984

The designation of geographical entities in this book, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of IUCN or Taxon Media concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The views expressed in this publication do not necessarily reflect those of IUCN or Taxon Media.

Originally published by IUCN, Gland, Switzerland and Cambridge, UK  
Reprinted with permission by Taxon Media, Lanesboro, MN, USA

Copyright © October, 1984, International Union for Conservation of Nature and Natural Resources

Reproduction of this publication for educational or other non-commercial purposes is authorized without prior written permission from the copyright holder provided the source is fully acknowledged.

Reproduction of this publication for resale or other commercial purposes is prohibited without prior written permission by the copyright holder.

Citation: Author (date). Title. IUCN, Gland, Switzerland and Cambridge, UK. xx + xx pp.

ISBN: 1-885209-30-4

Cover design by: Dan Beaver

Cover Photo: F Wayne King

Available from: Taxon Media  
PO Box 192  
403 Parkway Ave N  
Lanesboro, MN 55409  
Tel: (507) 467.8733; Fax: (507) 467.8735  
e-mail: orders@taxonmedia.com

**Cover Credit: Caiman crocodilus crocodilus, Spectacled Caiman  
Photo by F Wayne King. Copyright © 1996**

*J. Wayne King*  
1990

C R O C O D I L E S

Proceedings of the 7th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources

C O C O D R I L O S

Memorias de la Séptima Reunión de Trabajo del Grupo de Especialistas en Cocodrilos de la Comisión de Supervivencia de Especies de la Unión Internacional para la Conservación de la Naturaleza y de los Recursos Naturales.

Caracas-Venezuela  
21 al 28 de Octubre de 1984

International Union for Conservation of Nature and Natural Resources IUCN.

Fundación para la Defensa de la Naturaleza FUDENA.

Universidad Experimental de Los Llanos Occidentales UNELLEZ.

Ministerio del Ambiente y de los Recursos Naturales Renovables MARNR.

Florida State Museum (U.S.A.)

New York Zoological Society (U.S.A.)

The publication of these Proceedings has been made possible by funding from SSC/IUCN, TRAFFIC USA, and FUDENA

La publicación de estas memorias ha sido posible gracias al financiamiento de la Comisión de Sobrevivencia de Especies IUCN, TRAFFIC USA, y FUDENA.

Las opiniones de los autores expresadas en estos documentos no reflejan necesariamente aquellas de las organizaciones participantes.

### C R O C O D I L E S

Proceedings of the Seventh Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources.

Copyright © 1986 Fundación para la Defensa de la Naturaleza FUDENA  
International Union for Conservation of Nature  
and Natural Resources (IUCN).

ISBN 2-88032-306-1

Available from FUDENA  
Apartado 70376 Caracas 1071A-Venezuela  
IUCN Publication Services  
Avenue du Mont Blanc  
CH-1196 Gland  
Switzerland

Cover photo : WWF/Kans Dossenbach Caiman sclerops  
Foto Portada : Spectacled Caiman

Cover design : Emilio Fuentes  
Diseño Portada

Printed by : Editorial Texto S.R.L.  
Impreso por : Caracas - Venezuela

The International Union for Conservation of Nature and Natural Resources (IUCN) was founded in 1948, and has its headquarters in Gland, Switzerland; it is an independent international body whose membership comprises states, irrespective of their political and social systems, government departments, and private institutions as well international organizations. It represents those who are concerned at man's modification of the natural environment through the rapidity of urban and industrial development and the excessive exploitation of the earth's natural resources, upon which rest the foundations of his survival. IUCN's main purpose is to promote or support action which will ensure the perpetuation of wild nature and natural resources on a world-wide basis, not only for their intrinsic cultural or scientific values but also for the long-term economic and social welfare of mankind.

This objective can be achieved through active conservation programs for the wise use of natural resources in areas where the flora and fauna are of particular importance and where the landscape is especially beautiful or striking, or of historical, cultural, or scientific significance. IUCN believes that its aims can be achieved most effectively by international effort in cooperation with other international agencies, such as UNESCO and FAO.

The World Wildlife Fund (WWF) is an international charitable foundation for saving the world's wildlife and wild places. It was established in 1961 under Swiss law, and at present jointly shares headquarters with those of IUCN. Its aim is to support the conservation of nature in all its forms (landscape, soil, water, flora and fauna) by raising funds and allocating them to projects, by publicity, and by education of the general public and young people in particular. For all these activities it takes scientific and technical advice from the IUCN.

Although WWF may occasionally conduct its own field operations, it tries as much as possible to work through competent specialists or local organizations.

Among WWF projects financial support for IUCN and for the International Council for Bird Preservation (ICBP) has highest priority, in order to enable these bodies to build up the vital scientific and technical basis for world conservation and specific projects. Other projects cover a very wide range from education and ecological studies and surveys to the establishment and management of areas as national parks and reserves and emergency programs for the safeguarding of animal and plant species threatened with extinction.

WWF fund-raising and publicity activities are mainly carried out by National Appeals in a number of countries, and its international governing body is made up of prominent personalities in many fields.



TABLE OF CONTENTS

FOREWORD.....	VII
SUMMARY OF THE MEETING.....	IX
DECISIONS OF THE CROCODILE SPECIALIST GROUP.....	IX
LIST OF PARTICIPANTS.....	XXIII

VENEZUELAN REPORTS

Medina Padilla, G. La Administración de Fauna Silvestre en Venezuela.....	1
Mago de Pérez, Y. Convención sobre el Comercio Internacional de Especies Amenazadas de Flora y Fauna (CITES), su Aplicación en Relación a los Crocodílidos en Venezuela.....	5
Rivero Blanco, C. y B. D'Andria. El Estado Actual y las Tendencias de la Investigación sobre los Crocodílidos en Venezuela.....	8
Seijas, A.E. Situación Actual de las Poblaciones de Babas y Babillas ( <u>Caiman crocodilus</u> ) en la Región Norte-Coste- ra de Venezuela.....	28
Gorzula, S. y A. Paolillo, O. La Ecología y Estado Actual de los Aligatódidos de la Guayana Venezolana.....	37
Rivero Blanco, C. y B. D'Andria, "Babos en Bateas" Una mane- ra de Parecerse al Alligator de Florida.....	55
Rivero Blanco, C., y B. D'Andria. Censos de <u>Caiman crocоди- lus</u> una Variación Metodológica.....	59
Rodríguez Arvelo, G., y M.D. Robinson. Estudio del Crecimien- to en Cautiverio de la Baba, <u>Caiman crocodilus</u> , durante sus Primeros Meses de Vida.....	62
Boede, E.O., M.E. Párraga, N. Sánchez de Boede, N. Medina de López, y H. Castaño. Un caso de Caquexia en una Baba <u>Caiman crocodilus</u> ) del Zoológico Las Delicias de Maracay, Estado Aragua, Venezuela.....	80
Seijas, A.E. Situación Actual del Caimán de la Costa, <u>Crocody- lus acutus</u> , en Venezuela.....	96
Ramo, C., y B. Busto. Censo Aéreo de Caimanes ( <u>Crocodylus - intermedius</u> en el Río Tucupido (Portuguesa-Venezuela) con Observaciones sobre su Actividad de Soleamiento.....	109
Thorbjarnarson, J., and T. Blohm. Captive Rearing of Orinoco Crocodiles on Hato Masaguaral - Venezuela.....	120

CENTRAL AND NORTH AMERICAN REPORTS

Brisbin, I.L., C.A. Ross, M.C. Downes, and B. Gammon. The - Compilation of a Cross-indexed Topical Bibliography for the American Alligator. A Study of Trends in the Lite- rature Concerning and Endangered Species.....	124
Hines, T., C. Abercrombie, F. Percival, and C. Woodward. Florida Alligator: Economics, Harvest, and Conservation.	132
Hope, C.A., and C.L. Abercrombie. Hunters, Hides, Dollars - and Dependency: Economics of Wildlife Exploitation in Belize.....	143

Jacobsen, T., and J.A. Kushlan. Alligator Nest Flooding in the Southern Everglades: a Methodology for Management.....	153
Joanen, T., and L. McNease. Classification and Population Status of the American Alligator.....	167
Joanen, T., L. McNease, G. Perry, and D. Richard. Louisiana's Alligator Management Program.....	175
Kushlan, J.A., and F.J. Mazzotti. Population Biology and Status of the American Crocodile in South Florida....	188
Thorbjarnarson, J. The present Status and Distribution of <u>Crocodylus acutus</u> on the Caribbean Island of Hispaniola	195
Vliet, K.A. Social Behavior of the American Alligator...	203

#### AFRICAN AND AUSTRALASIAN REPORTS

Blake, D.K., Status, Conservation and Utilization of the Nile Crocodile in Zinbabwe.....	212
Hollands, M., A Preliminary Examination of Crocodile - Population Trends in Papua New Guinea from 1981-1984..	219
Messel, H., G.C. Vorlicsek, W.J. Green, and I.C. Onley. <u>Crocodylus porosus</u> - A Ten Year Overview: the Populaion Model and Importance of "Dry Wet" Season and Status, Management and Recovery.....	239
Messel, H., G.C. Vorlicsek, A.G. Well, W.J. Green, and I.C. Onley. Status of <u>Crocodylus porosus</u> , July 1984, in the Tidal Waterways of the Alligator Region and in the - Adelaide River System of Northern Australia Recovery - Under Way.....	307
Ross, C.A. Comments on Indopacific Crocodile Distributions	349
Singh, L.A.K., S. Kar, and B.C. Choudhury. India: Status of Wild Crocodiles.....	355
Singh, L.A.K., S. Kar, and B.C. Choudhury. Indian Crocodilians: a 10-Year Review of Management.....	362
Van Jaarsveldt, K. Status of African <u>Crocodylus niloticus</u> Populations (Botswana, Malawi and Mozambique).....	372
Whitaker, R. Status of Asian Crocodilians: an Update.....	376

#### TRADE, CONSERVATION AND MANAGEMENT

Brazaitis, P. An Assessment of the Current Crocodilian Hide and Product Market in the United States.....	379
Brazaitis, P. Biochemical Techniques: New Tools for the Forensic Identification of Crocodilian Hides and -- Products.....	384
Brazaitis, P. Management, Reproduction and Growth of <u>Caiman crocodilus yacare</u> at the New York Zoological Park	389
Hemley, G., and J. Caldwell. The Crocodile Skin Trade Since 1979.....	398
Luxmoore, R.A., J.G. Barzdo, S.R. Broad, and D.A. Jones A. World Survey of Crocodilian Farming.....	413
Magnusson, W.E. The Peculiarities of Crocodilian Population Dynamics and their Possible Importance for Management - Strategies.....	434
Whitaker, R. The International Crocodile Bank.....	443
Whitaker, R. Multiple Clutching: Conservation and Commercial Implications.....	445



## FOREWORD

As a private organization, member of IUCN and affiliate of **WWF** FUDENA was honoured to host the 7th working session of the IUCN/SSC crocodile SPECIALIST group in Venezuela in October 1984, - chaired by Dr. Wayne King.

As FUDENA's major objectives are conservation of species and - habitats and environmental education and Venezuela having five and possibly six species of crocodilians, it seemed especially appropriate that we host the group's first meeting in Latin Amé- rica.

On behalf of all the countries representatives, FUDENA would - like to thank the participants for their cooperation and valuable exchange of ideas and hope that we can all continue to work - towards the common goal.

We would also like to acknowledge the Venezuelan Audubon Society for their assistance and the enthusiastic participation and help of the National Crocodile Specialist group coordinated by FUDENA.

Mr. Ivan Darío Maldonado, Dr. José Ayarzagüena, Tomás Blohm, and Dr. Pedro Urriola, Dr. Pedro Jáuregui, and Cristina Ramo from the Western Llanos University (UNELLEZ) generously hosted the field trips to Hato El Frío, Hato Masagüaral and Módulo Experimental - UNELLEZ which added greatly to the enjoyment and experience of the participants. The support of foreign and local organizations - like the Florida State Museum, New York Zoological Society, UNELLEZ and the directions of Information and Research (DGIIA), Administra- tion (DGAA), International Affairs (ODEPRI), and the National - Wildlife Service from the Venezuelan, Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR) contributed to make the meeting a success.

On behalf of all the participants a major vote of gratitude must be extended to Cecilia Blohm, assisted by Lupe Chávez for their year of hard working efforts to organize and coordinate this meeting; finally special thanks are due to the Ministry of the Environment and Natural Resources for opening the meeting by the Director General Dr. Arnaldo Morales Jattar and the closing ceremony by Ing. Rafael- Viloría Díaz, Director of Administration of MAPNR.

This report on the work of the IUCN/SSC Crocodile Specialist Group is dedicated to Federico Medem who died on the 1st May 1984.

Dr. Medem was born in Latvia to Baltic/German parents. He obtained his doctorate from the Humboldt University of Berlin. In 1950 he travelled to Colombia at the invitation of Dr. Mario Laserna of the Universidad de los Andes in Bogotá. He adopted Colombian --- citizenship in 1985. Dr. Medem was the author of more than 90 -

publications, but he is best known to the IUCN/SSC Crocodile Specialist Group for his work with South American crocodilians. His concern for the overall decline of crocodilians in South America led to his deep involvement with the IUCN/SSC and the World Wildlife Fund, of which he became a regional vice-president.

Dr. Medem stimulated countless biologists by his robust and - affable demeanor, his useful counsel and his constant desire to learn more about the world which surrounded him. In the words of William Lamar, who wrote his obituary for Copeia: "It was a Privilege to have known Fred, who showed me that one can age and still retain a youthful sense of wonder; and that one can be learned and remain eminently aware of the vastness of that which one does not know".

FUDENA hopes this work contributes to the conservation efforts we have all undertaken

Rafael Tudela R.  
President FUDENA.

## SUMMARY OF THE MEETING

The 7th Working Meeting of the Crocodile Specialist Group (CSG) was convened from 21 to 28 October 1984 in Venezuela, under the sponsorship of the Fundación para la Defensa de la Naturaleza (FUDENA), and in collaboration with the Sociedad Conservacionista Audubon de Venezuela (SCAV), the Universidad Nacional Experimental de los Llanos Occidentales "Ezequiel Zamora" (UNELLEZ), and the Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR). The first four days of the Working Meeting were filled with the presentation and discussion of formal papers -- the first day's presentations focused entirely on the situation in Venezuela, and the remaining sessions covered crocodilians and programs in other regions -- and with the business meeting. A fieldtrip occupied the last three days. The meetings were open to anyone actively involved in crocodilian conservation, as reflected in the participation in the meetings of more than 60 research biologists, wildlife managers, crocodilian farmers, government officials, and hide industry experts from 16 nations.

As at previous meetings, the agenda of the meeting was organized around four topics: 1) reports on the conservation status of the species and populations of crocodiles in various parts of the world; 2) reviews of management practices and options; 3) developments in research; and 4) decisions and priorities arising out of the business meeting. A total of 48 papers were presented; those that were submitted for publication appear below.

At the business meeting, the Crocodile Specialist Group reviewed a number of conservation issues, including the crocodilian management program of the Venezuelan government, and proposals from several nations to change the listing of their crocodile populations on the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The decisions arising from the review, and the priorities set for conservation action and for research are summarized here.

This volume was edited by Stefan Gorzula and typed by Armanda Berlaty and Gladys Tochón under the coordination of Cecilia de Blohm.

## DECISIONS

### RECOMMENDATIONS TO THE VENEZUELAN GOVERNMENT

The CSG commended the Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR) for the time and effort they have put into developing the program for conservation management of Venezuela's crocodilians. Particularly noteworthy is the initiation of a large and varied research program that provides

the data on which the management strategy is based. Without question the MARNR program is developing into the finest - crocodilian conservation program in Latin America and could serve as a model for other nations in the hemisphere.

Several participants questioned the MARNR estimate of 3,000,000 common caiman, Caiman crocodilus, present in the Venezuelan llanos. Gorzula explained that MARNR staff counted a total of 42,715 adult and subadult caimans in a survey of 234,000 hectares of habitat in the llanos. Using a correction factor of 1.29 for the caimans not seen in the survey produce a total of 55,000 - caimans or between 18 and 24 caimans per square kilometer. Other independent studies yielded estimates of 20 caimans/Km<sup>2</sup>. Vegetation and topographic maps indicate suitable habitat covers 108,900 square kilometers in the llanos, so a density of 20 caimans/Km<sup>2</sup> yields an estimated total of 2,179,000 adult and subadult caimans.

Gorzula further explained that MARNR plans to restrict the hunt to male caiman over 1.8 meters total length; females do not grow that large. Caiman that large represented 20% of the adult and subadult population sampled by MARNR. Staton and Dixon reported that size class represented 18% of their study population. Based on these two samples, there should be 390,600 to 434,000 males over 1.8 meters total length in the llanos. The MARNR program will not allow more than 50%, a maximum of 195,300 to 217,000, of these large males to be killed. This will assure reproduction in the wild populations is not hindered. During this year's - experimental harvest the quota will be far fewer.

Carlos Rivero Blanco expressed concern that the MARNR staff was not adequately censusing the wild populations either prior to the experimental hunts or afterward, was not checking to see if the hunters were killing only the large males, and was not accurately monitoring the sale and export of hides. Tomás Plohm expressed the same worries.

Peter Brazaitis urged the government to establish throughout the country a system of national parks and sanctuaries in which all of Venezuela's crocodilians can be protected adequately.

Professor Messel and several others indicated that despite the MARNR restrictions on killing caimans less than 1.8 meters in length, a number of smaller females will be killed. The only way to determine how many are killed is to have MARNR staff present when the caimans are skinned so they can be sexed and measured.

After additional discussion, the chairman of the CSG summarized the Group's recommendations for improving the already exceptional program developed by MARNR:

- 1) A major effort should be made to census, both before each hunt and afterwards, all the areas that are opened to hunting. Without these counts, it will be impossible to determine the effect hunting is having on the wild populations in time to make adjustments prior to the next open season.
- 2) MARNR staff should be present on the ranches when many of the caimans are skinned so they can be measured, sexed, and other biological data gathered. Also on each of the ranches that participates in the hunt, MARNR should train one or more persons to collect the required data when the MARNR staff cannot be present.
- 3) Hunters and ranches should not profit from killing caimans smaller than 1.8 meters total length or from exceeding the quota set by MARNR. Undersized and over the quota hides should be confiscated.
- 4) Laws and regulations governing the hunting of caimans must be rigorously enforced in order to protect the critically endangered crocodiles, Crocodylus acutus and Crocodylus intermedius. A hunter might not make a living hunting only the increasingly rare crocodiles, but caiman hunting can subsidize the continued slaughter of the few remaining crocodiles. If he can sell its hide without penalty, a commercial hunter earning adequate pay by legally hunting caimans, will kill every crocodile he chances to find.
- 5) Periodic, unannounced inspections should be made of every tannery and every dealer's warehouse to monitor trade in illegal hides. In addition, since hides are shipped internationally by airfreight, MARNR should monitor exports by checking the cargo records, bills of lading, and air waybills of the various airlines. All airfreight packages are weighed prior to loading, so the average weight of a tanned hide or crust can be used to estimate the number of hides in a shipment.
- 6) MARNR should establish protected sanctuaries for crocodylians in regions and suitable habitats that presently lack national parks or equivalent protected areas. This system of enclaves would assure that geographically widespread and genetically diverse populations of crocodylians would be protected in Venezuela in the event that hunting is not adequately controlled elsewhere.

## RECOMMENDATIONS TO THE CITES SECRETARIAT

The Australian Proposal to Transfer Its Population of Crocodylus porosus from Appendix I to Appendix II. As at the meeting of the CSG in Africa two years ago, Goff Letts led the discussion of the Australian submission. His presentation addressed many of the criticisms the CSG had made of the earlier submission, which the Australian government withdrew at the CITES Conference of the Parties in Botswana. After a thorough discussion by the various participants, Professor Messel spoke for the entire audience in congratulating the Australian government for correcting the major shortcomings of the previous proposed management plan. He then called on the CSG to endorse the present proposal. Kevin van Jaarsveldt, David Blake, Lala Singh, Gordon Grigg, and others asked that the CSG seek assurances that the Australian authorities will not allow the collection of eggs from national parks in order to stock crocodile farms; will not allow the sale of hides or meat from crocodiles drowned in fishing nets; will close the rivers and estuaries of Kakadu National Park to net fishing; and will support monitoring of the Australian crocodile populations by independent researchers. Goff Letts, Harry Butler, and other Australian representatives present at the meeting accepted the suggestions and indicated they would urge the Australian government to give these assurances. They also clarified the government's intention to kill or capture up to 100 saltwater crocodiles around centers of human habitation where they pose a threat to people. Approximately 80% of these nuisance crocodiles will come from Darwin Harbor, 15% from the Daly River, and 5% from the rest of the Northern Territory. Any of these nuisance crocodiles that are placed in a crocodile farm will have to be kept alive on the farm for a minimum of one year before they can be killed.

It was agreed that draft resolutions submitted to the IUCN General Assembly by various groups opposing or supporting the present Australian submission to CITES would be withdrawn in favor of a joint resolution endorsing the submission but calling for the assurances indicated above. It was further agreed that the CSG chairman would communicate the endorsement of the proposal, conditional upon receiving the assurances sought, to the CITES Secretariat prior to the CITES Conference of the Parties in Buenos Aires in April 1985. Gordon Grigg and Kevin van Jaarsveldt were enlisted to draft the joint resolution, which was carried to the General Assembly by the chairman and later transmitted to the CITES Secretariat in an 8 January 1985 letter:

"CONSERVATION OF THE AUSTRALIAN POPULATION OF CROCODYLUS POROSUS"

"After carefully examining the 1984 Australian proposal to CITES to transfer the Australian populations of C. porosus to Appendix II of CITES and noting that the proposal addressed a number of criticisms raised in respect to an earlier application, concerning crocodile population status, protected areas, aboriginal consultation, details of ranching and other aspects of management, the IUCN/SSC Crocodile Specialist Group, meeting in Caracas in October 1984, expressed its support for the proposal, believing that it will have benefits for the conservation of the species without detriment to the Australian saltwater crocodile population."

"In arriving at this conclusion, the Crocodile Specialist Group, expressed concern at the continuing commercial netting for barramundi fish in the estuaries of Kakadu National Park, to the detriment of C. porosus which are an important part to the park ecosystem, and requests the Australian Management Authority, in conjunction with the Northern Territory Authorities, to correct this situation as soon as possible".

"The Crocodile Specialist Group, accepted assurances from the Australian government representatives that egg harvests will be restricted to flood-prone sites and harvest of live crocodiles will be carried out strictly in accordance with the proposal and management plan".

"The Crocodile Specialist Group also, accepted assurances that the Northern Territory Conservation Commission would cooperate with a suitable person or persons nominated by the Australian Management Authority to act as independent monitors of field survey operations and data as required".

"The Crocodile Specialist Group commends the Australian authorities for the improved policies, programmes and updated information which have enabled this positive step to be taken, and recognizes the valuable contributions made to the programme by the University of Sydney over the past 13 years, and urges the Australian governments to encourage independent research programmes such as that of the University of Sydney".

The Proposal from Malawi in Behalf of Various African States to Transfer Crocodylus niloticus from Appendix I to Appendix II.

The CSG chairman explained the background for this proposal and it was discussed at length by the CSG members and meeting participants. After the discussion, Professor Messel proposed that the CSG oppose the weakening of protection justified by hard data. The CSG concurred and indicated it would like to support the African Parties but cannot for lack of information on population trends in the wild populations. The CSG chairman was instructed to communicate the decision of the Group to the CITES Secretariat, which was done in an 8 January 1985 letter:

"The primary justification for the Malawi submission on behalf of the African nations that participated in the Brussels seminar seems to be set forth in A STATEMENT PRESENTED BY MALAWI ON BEHALF OF THE AFRICAN GROUP ON THE NILE CROCODILE that was drafted and presented at the Brussels seminar. It sets forth the false premise that crocodile producing nations of Africa were not present or consulted when C. niloticus was placed on Appendix I of CITES, that placement of the species on Appendix I was done on the basis of "armchair conservation strategies", and not by people cognizant of on-the ground situations. This same false premise is repeated almost verbatim in Section 7.3 of the Malawi submission to CITES. The use of catch-phrases such as "adaptive Wildlife Management that rely (sic) on a sensitive, positive feedback loop of the interactions between the humans and the animals" adds no data to the submission and does nothing to clarify the situation in specific African nations. The premise simply is wrong.

"The African crocodile-producing nations participated fully in placing C. niloticus on CITES Appendix I at the 1973 Plenipotentiary Conference that wrote the CITES. The following African delegates participated in that conference: Algeria - S.A. Hadj-Mokhatar, A. Mekideche; Botswana - H.E. Amos M. Dambe, Samuel A. Mpuchane; Burundi - Félix Magenge; Cameroon Michel Kos Epanque, Thaddeus Nkuo, H.E. Francois-Xavier Tchoungu; Central African Republic - H.E. Michel Adama-Tamboux; Dahomey - Candide Ahouansou, Saturnin Soglo; Egypt - Ahmed T. Khalil, Mohamed Salam; Ghana - Anthony Korsah-Dick; Kenya - A.O. Adede, A.M. Changawa, D. Gichero, H.E.L.O. Kibinge, P. Olindo; Madagascar - H.E. Henri Raharijaona, Bernardin Rajonhanes; Malawi - Callisto M. Khona; Morocco - Omar Belkora, Abdelhaq Lahlou; Niger - H.E. Abdoulaye Diallo, M. Hadiza, Oumarou G. Yousoufou; Nigeria - G.N. Onuekwusi, A.M. Oseni; Rwanda - Jean-Marie Gatabazi; Senegal - H.E. Andre Coulbary, Birma Fall, Momar Fall; Sierra Leone - H.E. Philip J. Palmer, Claudius J. Thomas; South Africa - H.E. Hohan S.R. Botha, Douglas Hey, S.S. du Plessis; Sudan - Ahmed Dawood, Mamoun Abdel Gadir Yousif, El Payah Omer, Hassabalia, Mohamed Osman Abu Seneina; Swaziland - Malachia B. Lukhele, Absalom V. Mamba, H.E.S.T. Msindazwe Sukati; Tanzania - Martin A. Kivumbi; Togo - William Adjoyi, Parfait Dagba, H.E. Epiphane Ayi Mawussi; Tunisia - Abdelaziz Ghodbane, Moncef Riahi; Upper Volta - Dominique B. Sisso, H.E. Teleshpore Yaguibou; Zambia - Ferdanand E. Mwanza".

"In addition, the following observers participated: Chad - H.F. Lazare Massibe; Ivory Coast - H.E. Timothee N'Guetta Ahoua, Jean Batigne, Emmanuel Nouama".

"At that meeting, Botswana proposed that C. niloticus be listed on Appendix II. On the basis of Cott and Pooley's 1971 African survey (Crocodiles, IUCN Publ. New Series, Suppl. Paper N° 33), the U.S.A. recommended placement on



Appendix I. That placement was supported by Kenya and nearly every other African nation that spoke on the issue. Mohamed Osman of Sudan eloquently pointed out that while the Nile crocodile had been decimated in surrounding nations, the species remained abundant in the Sud; nevertheless in a gesture of cooperation with its neighboring states the Sudan supported an Appendix I listing. The delegates voted to place the species on Appendix I".

"The first meeting of the conference of the Parties in Berne, Switzerland, in 1976, was attended by delegates from: Ghana, 2 delegates; Madagascar, 2; Morocco, 1; Nigeria, 1; South Africa, 1; Zaïre, 2".

"Observers were present from: Cameroon, 1; Libya, 2; and Sudan, 1".

"At this meeting the U.K. delegation proposed amendments which would have put all crocodilians on Appendix I. It was defeated".

"The Swiss delegation proposed several amendments which removed subspecies from the Appendices. This was approved as was the replacement of all crocodilians individually listed on Appendix II with the inclusive taxa, *Crocodylidae* and *Alligatoridae*".

"Madagascar proposed a number of animals and plants for listing and delisting, but made no mention of any crocodilian".

"Morocco proposed transferring all three African crocodiles, i.e., *C. niloticus*, *C. cataphractus*, and *Osteolaemus tetraspis*, to Appendix II but offered no supporting data. Morocco is not a nation that produces or trades in crocodiles for the international reptile leather trade, but it does have ties with France, one of the largest importers of crocodile hides. The Morocco proposal was not approved by the Parties".

"However, the Parties did recognize that some species needed to be transferred from one appendix to another, or to be delisted altogether. They also recognized that additions, deletions, and transfers without supporting data would lead rapidly to political decisions overriding the purpose and provisions of the Convention. For this reason, the Parties drafted and approved the Berne criteria for addition and deletion of taxa, criteria based on best available data. The Parties also were particularly sensitive to criticism that would result if species were listed without consulting with the states in which they occurred. It was decided that all future proposals for listing and delisting would be circulated to range states for their comments prior to consideration by the Parties".

"To address the problem of reviewing the appropriateness of listing on the Appendices, the Parties scheduled a special session of CITES to be convened one year later to review the species listings. During the year, all the Parties were expected to gather data on listed taxa that occurred within their national borders or under their jurisdiction".

"The 1977 Special Working Session of the Parties in Geneva drew participants from: Ghana, 1 delegate; Madagascar, 2; Nigeria 1; South Africa, 3".

"No proposal on crocodilians were offered or considered".

"At the conclusion of the Geneva meeting, the Parties realized that not all the listing problems had been dealt with, so they agreed to continue to gather data on the species for consideration at the next Conference".

"The 1979 CITES Conference of the Parties in Costa Rica had participants from: Botswana, 2 delegates; Egypt, 1; Gambia 1; Ghana 1; Kenya 4; Madagascar, 1; Morocco, 1; Niger, 1; Nigeria 1; Senegal, 1; South Africa, 5; Togo 1; Zaire, 4".

"Observers attended from: Liberia, 2; Tanzania, 2; Zambia, 1".

"Botswana proposed transferring C. niloticus from Appendix I to Appendix II, but offered no hard data, though it was noted that "recent serial counts produced a counted total of over 100 breeding females on the Okavango River alone...." In light of Goren Blomberg's fieldstudies in the Okavango delta (conducted as part of an FAO project) and Pooley's documentation of the history of crocodile exploitation in Botswana, the Parties did not approve the transfer".

"The U.S.A. proposed transferring Alligator mississippiensis from Appendix I to Appendix II, and the U.S. population of Crocodylus acutus from Appendix II to Appendix I. Both proposals were well documented with data. Both were approved by the Parties".

"India also proposed transferring C. porosus from Appendix II to Appendix I. That proposal also was accompanied by information on the species' status in individual range states. Based on those data, the Parties agreed to transfer all C. porosus from Appendix I, except that the Papua New Guinea populations were left on Appendix II".

"Again the Parties recognized that the task of reviewing the appropriateness of Appendices listings had not been completed, and again they requested that a special effort be made to complete the job at the next conference".

"The 1981 CITES Conference of the Parties in Delhi, India, drew delegations from: Botswana, 2 delegates, Central African Republic, 1; Kenya, 2; Niger, 1; Nigeria, 2; Senegal, 1; South Africa, 3; Tanzania, 1; Togo, 1; Tunisia, 1; Zaire, 3; Zambia, 1".

"Observers attended from: Algeria, 3; Somalia, 2; Sudan, 1; Uganda, 1; Zimbabwe, 3".

"Panamá and the U.S.A. proposed transferring all the remaining populations of C. acutus from Appendix II to Appendix I (remember the U.S.A. populations were transferred in Costa Rica). Again data were supplied on status in individual range states. The Parties approved the transfer. In addition, Zimbabwe made the Parties aware of its intention to request a transfer of its population of C. niloticus from Appendix I to Appendix II at the next meeting of the Parties".

"The Parties noted that the next CITES Conference would be the 10-year anniversary of the Convention and would be an appropriate occasion upon which, once and for all, to clean up the Appendices listings. It was agreed that regional (continental) meetings would be held to pool data and develop positions on species listed from those regions. The Europe, North America, Asia, and Australia/Oceania meetings were held early enough to report the results to the Parties. The Latin America meeting was held after urging by the CITES Secretariat. The African meeting was convened in Nairobi after United Nations funding was found to reimburse the travel costs of delegates".

"The 1983 CITES Conference of the Parties in Botswana delegations from: Botswana, 29 delegates; Cameroon, 1; Gambia, 2; Kenya, 2; Liberia, 1; Madagascar, 1; Malawi, 2; Mozambique, 1; Rwanda, 1; Senegal, 1; South Africa, 3; Sudan, 2; Togo, 1; Zambia, 1; Zimbabwe, 3".

"Observers were present from: Congo, 2".

"Madagascar, Mozambique, Togo, Zambia, and Zimbabwe all submitted proposals for the transfer of their populations of C. niloticus from Appendix I to Appendix II. Only the Zimbabwe proposal was accompanied by hard data and a complete description of its conservation program for the species. The proposal was overwhelmingly approved by the Parties. The Madagascar, Mozambique, and Zambia proposals were not approved, and Togo withdrew its proposal".

"Unfortunately, it was in Botswana that some of the African Parties first voiced the opinion that many of the African species had been placed on the CITES Appendices by northern nations and not by African nations. The criticism resulted, in part, from the unhappiness over the Nile crocodile proposals that were turned down by the Parties, but more directly from heated debate surrounding the proposed transfer of the leopard from Appendix I without hard data. The claims were made largely by delegates who were unfamiliar with the history of participation by the various African nations recorded in the minutes of past CITES meetings. They also ignored the past actions of the Parties to protect the interests of the range states and to encourage development of data on the appropriateness of the species listings".

"By any measure, the crocodile producing nations of Africa did participate in putting C. niloticus on Appendix I of CITES, and

in the decade that has passed since that time they have had ample opportunity to generate data on the status of their populations".

"The most unfortunate aspect of the whole incident is it has produced a lot of rhetoric and very little data on the status of the species under question. Even minimal effort would have produced adequate data in the 10-years since CITES was written. It is not difficult to gather data on the status of crocodiles in river, lake, and estuary habitat, which is the habitat of C. niloticus in most of Africa. It is harder to census crocodile populations in marsh habitat, but successful programmes in Australia, Papua New Guinea, U.S.A., and Venezuela show it can be done even there".

"Despite the 1977 Special Working Session that examined the Appendices, despite the continued urging of the Parties for individual range states to review the status of listed native species for the Costa Rica and Delhi meetings, despite the effort involved in the regional 10-year reviews that preceded Botswana, the Parties involved, apart from Zimbabwe, did little to gather data. Following the Brussels seminar, Malawi did circulate a questionnaire on the status of C. niloticus to the African nations that are Party to CITES. Apparently only 10 nations had responded to the questionnaire in time for Malawi to compile their answers for Appendix II of the submission to CITES".

The Proposal from Indonesia to Transfer its Populations of Crocodylus porosus from Appendix I to Appendix II. The

Indonesian submission was so incomplete that discussion was difficult. Nevertheless, the chairman reviewed the latest information on the status of C. porosus in that nation, including international trade in hides originating there. The Group could not support the proposal and instructed the chairman to so inform the CITES Secretariat, which was done in an 8 January 1985 letter:

"The six page Indonesian submission contains very little information on the status of C. porosus in that nation. Section C.2 Biological Data contains only the most general, sketchy, and incomplete data. It does not utilize the data from relatively recent studies, e.g., R.Tarumingkeng et.al. 1976. Studi Habitat dan Kemungkinan Pengembangan Populasi Buaya di Daerah Aliran Sungai Lalan dan Palembang Sumatera Selatan. Dept. Pertamina, Dir. Jen. Kehutanan, or even recent anecdotal observations from reliable observers. In addition, the reference to the "wide distribution of crocodiles throughout the country" in C.2.3. Population is misleading. C. porosus does have a wide geographic distribution in Indonesia, having once occurred virtually throughout the archipelago. However, most populations were decimated before 1970. Only the populations in the less accessible parts of Irian Jaya remain relatively abundant".

"Sections C.3. Economic Value, C.4. Production Activity, and C.5 Trade Data are misleading. It is wrong to suggest that illegal marketing of crocodile hides in Irian Jaya is a result of traditional hunting of the local people. Many of the peoples of Irian Jaya have traditionally hunted crocodiles for subsistence, but the hide buyers operating in Irian Jaya for the most part are relatively recent transmigrants from other parts of Indonesia. Even before the crocodile was protected in 1980, many of the buyers operated crude ranches where small wild-caught crocodiles were reared to commercial size before slaughter. Reference was made to these operations in the John Lever/FAO crocodile survey of Irian Jaya cited in the Indonesian submission. Prior to 1970, at least three similar ranches were operated in Samarinda, Kalimantan (personal observation, W. King). One even operated in Jakarta, Java (personal observation, W. King). Most of these ranches went out of operation when the wild populations of crocodiles could no longer support an uncontrolled harvest of adult hides and live juveniles to stock the ranches. The Samarinda ranches had closed by 1972. The Jakarta ranch was still operating at a low level in 1976. Only the ranches in Irian Jaya and few in Sumatra continued to operate into the 1980s. Some of these ranches are now registering with the Directorate General of Forest Protection and Nature Conservation (PHPA)".

"Section C.6. Protection Status is particularly misleading. It states that C. porosus "has been protected (under Decree of the Minister of Agriculture N°716/Kpts/Um/10/1980)" in 1980. Section 7. Additional Remarks suggests that enforcement of the protected status began in 1980 and has continued to the present time. Unfortunately, no information is given on what protection was called for in the 1980 decree; it could do anything from prohibiting hunting and providing total protection for wild crocodiles to simply requiring dealers to register as farmers. Regardless of what was specified, protection exists mostly on paper. Enforcement has consisted largely of registering crocodile farms. Very little protection has been afforded the wild populations. The hide buyers and farmers operate with little on site regulation and have better control over the exploitation of crocodiles than does the government. It is interesting to note that Section C.6.3 mentions "local stricter regulations on poaching", which implies that central government restrictions on poaching are not strong or are not enforced".

"The Indonesian proposal also lacks detailed information on protection of C. porosus and its habitat throughout the range of the species in Indonesia. Section C.6.3. refers

to habitat areas that are to be reserves, mostly in Irian Jaya and Sumatra, but makes no mention of Kalimantan, Sulawesi, Java, or any of the other islands lying between Java and Irian Jaya or between Irian Jaya and Sulawesi. Unless C. porosus is protected in geographically and ecologically widely dispersed national parks and reserves, it will be impossible to conserve the genetic diversity of the species, and it seems unlikely that the species will be maintained throughout its range at a level that allows it to perform its role in natural ecosystems as called for in CITES Article III 2 (a)".

"The Indonesian submission contains no detailed information on government research on crocodiles aimed at establishing the status of the wild populations throughout the country. These data are needed in order to develop and implement any management scheme for sustained utilization of the crocodile resource. The submission also lacks detailed information on any existing management programme for the crocodiles, apart from the Irian Jaya and Sumatra crocodile farms. Section C.4. contains a passing reference to "the capture of young crocodiles of a defined size" for stocking the farms, but that size is not stated. Neither in any information on how these size limits were established, how they will contribute to the management of the crocodile resource, or how they are enforced".

"Similarly, no data are provided on how the government intends to distinguish legal hides produced on farms and ranches from illegal hides from poached crocodiles. Other crocodile producing nations, e.g., Australia, the United States of America, and Zimbabwe, have described in great detail their requirements for tagging legal hides with non-reusable tags, and their system of validating licenses and export permits with security seals that cannot be modified or forged".

"In the absence of these many data on the status of the wild populations, on fieldstudies to provide a factual basis for management of the resource, on control of hunting, on regulating the collection of young crocodiles to stock farms, on licensing of hunters and farmers, on marking of hides, on exports permits, on protection within national parks and protected areas, and on effective implementation and enforcement of the management programme, the Indonesian Scientific Authority cannot satisfy its obligations under CITES Article III 2 (a) with C. porosus on Appendix I, and COULD NOT SATISFY ITS OBLIGATIONS UNDER Article IV 2 (a) and 3 if the species were transferred to Appendix II. In the absence of these data, the Parties to CITES will not be able to make an informed decision on the Indonesian proposal to transfer its population of C. porosus from Appendix I to Appendix II. Without these data, the Indonesian submission does not satisfy the Berne criteria, neither does it fill the requirements of Com. 3.12".

"Although it was not part of the original Indonesian submission to CITES, the Director General of Forest Protection and Nature Conservation has authored a paper entitled, INDONESIA'S APPEAL: PROBLEM AND STATUS OF TURTLES AND CROCODILES, which was distributed to delegates to the 16th General Assembly of IUCN in Madrid in November 1984 ---see attached copy. This paper, like the original submission, contains little hard data on the status of crocodiles (or sea turtles). On the other hand it does elucidate a bit more of the crocodile ranching/farming scheme, i.e., "Ranchers are required to release at least ten percent of the reared products (sic) into the wild habitat ... (and) are required to develop ... full crocodile breeding farms". Unfortunately, the paper gives no indication that any effort is being made to enforce any protecting laws or regulations. Instead, it gives the distinct impression that the total crocodile (and sea turtle) conservation effort in Indonesia consists of providing a legal means whereby hides may be exported, in the hopes that the hunters and dealers will be persuaded to support conservation".

"The available data (Groombridge, 1982. IUCN Amphibia-Reptilia Red Data Book, vol. 3, Gland, Switzerland. xliii + 426 p.; King, Campbell, Messel, and Whitaker. 1979. Review of the status of the estuarine or saltwater crocodile, Crocodylus porosus. Mimeo report, 33 p.; R. Tarumingkeng et. al. 1976. Studi Habitat dan Kemungkinan Pengembangan Populasi Buaya di Daerah Aliran Sungai Lalan dan Palembang Sumatera Selatan. Dept. Pertanian, Dir. Jen. Kehutanan) suggest the following status for C. porosus populations in Indonesia:

Sumatra-Although still found in most large rivers, crocodiles are rare everywhere. Even in established national parks, e.g., Gunung Leuser National Park, their survival is not guaranteed.

Siberut - Depleted and rare. May be present in reserve in northwest portion of island.

Java - No confirmed sightings anywhere in the last 5 years, except in Ujong Kulon National Park in extreme west Java.

Kalimantan - Depleted everywhere; some populations endangered or extinct. Crocodile ranches operating at Samarinda on the Mahakam river ceased operations before 1972 because of scarcity of young crocodiles.

Lesser Sunda islands - Rare and depleted.

Sulawesi - Rare or endangered. A few small populations survive in estuaries on the northern peninsula.

Maluku - Depleted in Aru; still present on Buru; reported from Wahai on the north coast of Ceram; rare elsewhere.

Timor - Status unknown.

Irian Jaya - Locally depleted where heavily exploited, even in the Gunung Lorentz Reserve. Otherwise still widespread. The populations can easily recover if conservation action is taken".

"The preliminary data available to the Crocodile Specialist Group suggests that the C. porosus populations in Irian Jaya might be able to sustain a regulated harvest even now. These preliminary data come from the brief John Lever/FAO survey of Irian Jaya cited in the Indonesian proposal and from anecdotal observations of reliable field biologists working in Irian Jaya. It should be noted further, that a second, more detailed survey is presently underway which should provide better information on the status of the Irian Jaya crocodile populations. This second survey could serve as the start of an annual census programme that monitors the status of the resource and provides the database for a management scheme. The CSG does not believe the Irian Jaya populations should be exploited until such a census programme is established; sustained utilization is not possible without data on population numbers, on natality, on mortality, and on ecological requirements".

"It could be argued that the Irian Jaya populations of C. porosus should be transferred from Appendix I to Appendix II of CITES to allow for ranching to occur there, and the other Indonesian population of the species should remain on Appendix I. However, it will be impossible to protect these other populations if the central government does not provide adequate protection through development of a comprehensive conservation programme that takes into account the needs of the regional crocodile populations and then enforces it. Without such a programme and without enforcement, poached hides simply will be marketed under the guise that they are legal hides from Irian Jaya"

"At the present time, Indonesia lacks a comprehensive programme for the conservation of Crocodylus porosus, and it fails to enforce the existing regulations on crocodile hunting, ranching/farming, and hide sales and exports. The majority of Indonesian crocodile populations are rare, endangered, or depleted. For these many reasons, the Crocodile Specialist Group cannot support the Indonesian proposal to transfer its populations of Crocodylus porosus from Appendix I to Appendix II".



PARTICIPANTS IN THE 7TH WORKING MEETING OF THE  
IUCN/SSC CROCODILE SPECIALIST GROUP

---

- Abercombie, Clarence L., 4005 S. Main Street, Gainesville,  
Florida, 32601 - USA.
- Asanza, Eduardo, Avenida 12 de Octubre, Universidad Católica,  
Departamento de Biología. Apartado 2184, Quito -  
Ecuador.
- Ashley, Don. P.O. Box 13679, Tallahassee, Florida, 32317  
USA.
- Ayarzaguena, José, Fundación de Ciencias Naturales La Salle,  
Apartado 1930, Caracas - Venezuela.
- Blake, D.K. Box 127, St. Lucia Estuary, St. Lucia South  
Africa 3936.
- Blohm, Tomás, Fundo Pecuario Masaguaral, Apartado 69, Carac-  
cas 1010-A - Venezuela.
- Boede, Ernesto O., Zoológico Las Delicias, Avenida Las Deli-  
cias, Maracay, Estado Aragua - Venezuela.
- Boede, Nancy Sánchez de, Universidad Central de Venezuela, Fa-  
cultad de Ciencias Veterinarias. Quinta Avenida San Ja-  
cinto, Edificio Aparate, Apto. 8-F, Maracay, Estado Ara-  
gua - Venezuela.
- Boher Benetti, Salvador, Instituto de Zoología Tropical, Uni-  
versidad Central de Venezuela, Caracas - Venezuela.
- Brazaitis, Peter, New York Zoological Park. Bronx, New York,  
10460 USA.
- Brisbin, I. Lehr, 233 Third Ave. Aiken, P.O. Drawe E. Savannah  
River Ecology Lab., Aiken, South Carolina - USA.
- Busto Barrenechea, Benjamín, Universidad Nacional Experimen-  
tal de Los Llanos Occidentales "Ezequiel Zamora". La Co-  
lonia, Guanare, Estado Portuguesa - Venezuela.
- Butler, William Henry, GPO Box C1580 Perth West, Australia  
6001.
- Calderón, Claude, Empresa Tenera Suramericana, C.A. Paracotos,  
Vía Táchata, Km. 2, Estado Miranda - Venezuela.
- Castro, Hernán, Empresas Tenera Suramericana, C.A. Paracotos,  
Vía Táchata, Km. 2, Estado Miranda - Venezuela.
- Choudhury, B.C. Crocodile Research Centre, Lake Dale R. Nagar  
Road, Hyderabad 500264 - India.

D'Andria, Bianca, CRB Ecólogos Consultores, C.A. Apartado 80531, Caracas 1080-A. Venezuela.

David, Dennis, 4005, S. Main St., Gainesville, Florida, 32601 USA.

Díaz Matalobos, María de Los Angeles, Avenida Soublette, Edificio Oasis, P.H.-3. San Bernardino. Caracas - Venezuela.

Dorta G., Enrique, Residencias Fund. Maracay II, Edi. - 57, Apartado 02, Maracay, Estado Aragua - Venezuela.

Figueroa, Douglas - DGIIA, Ministerio del Ambiente y de los Recursos Naturales Renovables, Edificio Camejo, Esquina de Camejo, Caracas - Venezuela.

Godshalk, Robert, P.O. Box 773846, Steamboat Springs, Colorado 80477 - USA.

Gorzula, Stefan División de Cuencas e Hidrología, CVG, Electricación del Caroní, C.A. Apartado 62413, Caracas - Venezuela.

Goudie, Graham Stewart, Bus 423510, Mailand Holding PTY LTD, P.O. Box 20, Lae Papua New Guinea.

Grigg, Gordon, 8 Cherama Cr, Forestville NSW, Australia.

Gutiérrez Eljury, Saúl, Quinta Haydee, Calle Amazonas, Prados del Este, Caracas - Venezuela.

Hemley, Ginette, TRAFFIC/US 1601, Connecticut, Ave. NW, Washington D.C. 2009 - USA.

Hernández S., Gustavo E., Urb. El Viñado, Avenida Dr. Carlos Sanda, Quinta Belinda N° 101-223, Valencia, Estado Carabobo - Venezuela.

Hollands, Martin, Box 2141, Boroko NCD, Papua, New Guinea.

Hunt, R. Howard, Atlanta Zoological Society, 800 Cherokee, Ave. SE, Atlanta, Ga 30315 - USA.

Iskenderian, Nora de, Curtiembres Delta, C.A. Calle Colombia, entre 7a. Avenida y La Silsa N° 148, Catia, Caracas - Venezuela.

Jacobsen, Terri, Institute of Ecology, University of Georgia, Athens, GA, 30602 - USA.

Jenkins, Robert, Williams G., Australian National Parks & Wildlife Service, P.O. Box 636, Canberra City, ACT 2601 Australia.

Joanen, Ted, Rt. 1, Box 20-B Grand Chenier, Louisiana 70643 - USA.

Jomaron Darmancier, Bernard J., Tenerco - 1a. Avenida Santa Eduvigis, Local 9, Caracas 1071 - Venezuela.

- Kar, Sudhakar, Wildlife Conservation Division Chandabaci,  
Bacasore Orissa, India.
- King, F. Wayne, Florida State Museum, Gainesville, Florida  
32611 - USA.
- Lazcano Barrero, Marco Antonio, Real de Guadalupe N° 55, San  
Cristóbal, Las Casas 281, Chiapas, México.
- Letts, G.A. Conservation Commission (N.T.) Gap RD. Alice  
Springs N.T. Australia.
- Luxmoore, Richard, IUCN, 219c Huntingdon RD. Cambridge U.K.
- Magnusson, William Ernest, R. Nelson Batista Sales 126, INPA,  
CP 478,69000 Manaus AM, Brasil.
- Manolis S. Charlie, Conservation Commission N.T., P.O. Box  
38496 Winnellie NT 5789, Australia.
- Marcano Spósito, José Miguel, Comandancia General FAC, Calle-  
jón Machado, El Paraíso, Dirección de Guardería Ambien-  
ta de los Recursos Naturales Renovables, Caracas - Venezuela.
- Mazzei Mannarino, Leonardo, Universidad Central de Venezuela,  
Facultad de Ciencias Veterinarias, Maracay, Estado Aragua -  
Venezuela.
- Medina, Gonzalo, DGAA, Ministerio del Ambiente y de los Recur-  
sos Naturales Renovables, Torre Sur, Piso 22, Centro Simón  
Bolívar, Caracas - Venezuela
- Medina, Glenda, FUDENA, Apartado 70376, Caracas - Venezuela.
- Messel, H. Prof. University of Sidney, Sydney, Australia 2006.
- Messel P.I. Mrs., c/o University of Sydney, Australia 2006.
- Miliani R., Adolfo, Calle 3 de Montalban, Residencias Aurora,  
Piso 2, Apartamento 2, Caracas - Venezuela.
- Moler, Paul E., Wildlife Research Laboratory, 4005 S. Main St.  
Gainesville, Florida - USA.
- Muller, Kurt, Gugolzstrasse 8, CH-8004 Zurich, Suiza.
- Muñoz García, Ismael, IUTY San Felipe, Estado Yaracuy Edifi-  
cio 3, Apartamento 4, San Felipe, Estado Yaracuy - Venezuela.
- Ochoa G., José R. Ministerio del Ambiente y de los Recursos Na-  
turales Renovables, Servicio Nacional de Fauna Silvestre,  
Apartado 184, Maracay, Estado Aragua - Venezuela.
- Pérez Pérez, Francisco, Ministerio del Ambiente y de los Recur-  
sos Naturales Renovables, Servicio Nacional de Fauna Silves-  
tre, Apartado 184, Maracay, Estado Aragua - Venezuela.

- Pérez, Yuraima Mago de, DGAA, Ministerio del Ambiente y de los Recursos Naturales Renovables, Torre Sur, Piso 22, Centro Simón Bolívar, Caracas - Venezuela.
- Peña, Mirna Quero de, DGAA, Ministerio del Ambiente y de los Recursos Naturales Renovables, División de Fauna Silvestre, Torre Sur, Piso 22, Centro Simón Bolívar, Caracas - Venezuela.
- Onions, Víctor J.T., Edwards River Crocodile Farm PTY LTD, Suite 7/75, Abbott Street Cairns, Queensland 4870, Australia.
- Ottenwalder, José A., Florida State Museum D. Forest Res. Conservation UF, University of Florida, Gainesville, Florida, USA.
- Pantín Alfonso, Leslie, Hacienda Paya, Turmero, Estado Aragua - Venezuela.
- Paolillo O. Alfredo, Instituto de Zoología Tropical, Universidad Central de Venezuela, Apartado 47599, Caracas, 1041-A, Venezuela.
- Párraga, María Eugenia, Universidad Central de Venezuela, Facultad de Ciencias Veterinarias, Edificio Ana Cristina, calle Coromoto, Maracay, Estado Aragua - Venezuela.
- Pernalet N., José Manuel, Parque Zoológico y Botánico Bararida, Avenida Los Abogados con cruce calle Morán, Barquisimeto, Estado Lara - Venezuela.
- Ramo Herrero, Cristina, Universidad Nacional Experimental de Los Llanos Occidentales "Ezequiel Zamora", Guanare, Estado Portuguesa - Venezuela.
- Rebelo, George, Rua 5, Casa 88, Manaus-AM, Brasil, IBDF, Departamento Parques Nacionais e Reservas C.P. 185, 69.000 Manaus Brasil.
- Rivero Blanco, Carlos, CRB Ecólogos Consultores C.A., Apartado 80531, Caracas 1080-A - Venezuela.
- Robinson, Michael, Universidad Simón Bolívar, Departamento de Estudios Ambientales, Sartenejas, Caracas - Venezuela.
- Rodríguez Arvelo, Gustavo, Calle Alameda, Quinta Mariela, Prados del Este, Caracas - Venezuela.
- Seijas, Andrés Eloy, Ministerio del Ambiente y de los Recursos Naturales Renovables, Servicio Nacional de Fauna Silvestre, Apartado 184, Maracay, Estado Aragua - Venezuela.
- Serna, Celso, Agropecuaria San Francisco, Edificio General de Seguros, Piso 6, Chuao, Caracas - Venezuela.
- Sinba, Kayama, Departament of Primary Industry, P.O, Box 2141 Boroko, Papua New Guinea.

Singh, L.A.K., Camp. National Chambal Sanctuary, Post Box-11  
Morena 476001, Madhya Pradesh, India.

Suárez Rivero, Félix José, M.T.S. - G.N. Ofician Central de  
Incendios Forestales, Zona 1, Ministerio del Ambiente y  
de los Recursos Naturales Renovables, Caracas - Venezuela.

Thorbjarnarson, John, Florida State Musseum, Gainesville,  
Florida 32611 USA.

Van Jaarsveldt, Kevin, P.O. Box 2569 Harare, Zimbabwe, Southern  
Africa.

Vernet P., Pedro D., Avenida Principal de Caurimare, Residen-  
cias Kamar, Piso 1, Apartamento 1-B, Caracas - Venezuela.

Vliet, Kent A., University of Florida, Department of Zoology,  
Gainesville, Florida 32611, USA.

Vorlicek, George Carl, Maney University, Maney Sydney,  
Australia.

Watanabe, Myrna, 141, Columbia Heights, Brooklin, New York  
11201 USA.

Webb, Grahame, Conservation Commission c/ N.T., P.O. Box 38151  
Winnellie, N.T. 5789 Australia.

Whitehead, Peter John, Conservation Commission, P.O. Box 38496,  
Darwin, Australia.

Wilson Jay, 115 NW 34th St. Gainesville, Florida 32606, USA.

Wilkinson, Philip M., 407 Meetin St. Georgetown S.C. 29440,  
USA, So. Car, Wildlife and Marine Res, Dept. Fort Johnson -  
Charleston, South Carolina - USA.

Woodward, Allan R., 4005 Main St. Gainesville, 32601, Florida  
USA.

Yamakoshi, Megumi, R., Nelson Batista Sales, 126 Manaus -AM  
Instituto Nacional de Pesquisas da Amazonia, INPA Caixa  
Postal 478 Manaus Am - Brasil.

#### OBSERVERS

Artis, Mónica, Calle Morichal, Quinta Dalmacia, Prados del Es-  
te, Caracas - Venezuela.

Arvelo de Rodríguez, Mariela, Calle Alameda, Quinta Mariela,  
Prados del Este, Caracas - Venezuela.

Belda Alifa, Juan A., Calle Madrid, Residencias Puerta del Es-  
te, Apartado 102, California Norte, Caracas - Venezuela

Capriles, Alfredo L., 6a. Avenida Quinta Llaves, Altamira,  
Caracas - Venezuela.

Chang, Arelis, Servicio Nacional de Fauna Silvestre Ministerio  
del Ambiente y de los Recursos Naturales Renovables, Aparta-  
do 184, Maracay, Estado Aragua - Venezuela.

D'Urso Chávez, Ana I., Avenida Sur 8, 2da. Etapa, Quinta  
Maryfeld, Los Naranjos, Caracas - Venezuela.

Márquez Díaz, Norma, Servicio Nacional de Fauna Silvestre, Mi-  
nisterio del Ambiente y de los Recursos Naturales Renovables,  
Apartado 184, Maracay, Estado Aragua - Venezuela.

Ojasti, Juhani, Apartado 47058, Caracas 1041-A - Venezuela.

Padrón Marimón, Ricardo, Calle C. N° 110, Urbanización Santa  
Marta, Caracas - Venezuela.

Rodríguez, Alejandro, Calle Alameda, Quinta Mariela, Prados  
del Este, Caracas - Venezuela.

Rodríguez, Mariela, Calle Alameda, Quinta Mariela, Prados del  
Este, Caracas - Venezuela.

Useche, Edgar, Servicio Nacional de Fauna Silvestre Ministerio  
del Ambiente y de los Recursos Naturales Renovables, Aparta-  
do 184, Maracay, Estado Aragua - Venezuela.

## LA ADMINISTRACION DE FAUNA SILVESTRE EN VENEZUELA

Gonzalo Medina Padilla

Ministerio del Ambiente y de los Recursos Naturales Renovables  
Caracas - Venezuela

A mediados de los años veinte Venezuela comienza su transformación de país rural y apacible en uno de los más dinámicos del mundo. Es el momento en que el petróleo desplaza al café de su primer lugar en los productos de exportación. La tasa de crecimiento poblacional sube hasta alcanzar el primer lugar de América Latina, esta a su vez lo ocupa en el mundo, y en un lapso de cincuenta años nuestra población se ha quintuplicado. El crecimiento vegetativo de los venezolanos alcanza el nivel espectacular de algo más del 36%, como consecuencia de la elevación del nivel de vida de la población, particularmente en lo que se refiere a la alimentación y a los servicios asistenciales. Por ejemplo, la campaña antimalárica ha pasado a ser ejemplo en el mundo.

Como consecuencia de las innumerables oportunidades de trabajo, el país recibe una corriente inmigratoria que alcanza cifras records hacia la mitad de la década de los cincuenta. Como era de esperarse esta inmigración ejerce profunda influencia en la economía del país.

Hace cincuenta años Venezuela disponía apenas de 200 km. de carreteras pavimentadas, ahora ocupa el primer lugar en Latinoamérica, con más de 11.000 km. Aparte de esto los fondos provenientes del petróleo han permitido al estado emprender grandes obras de transformación del medio físico, lo cual ha traído consigo profundos cambios en el hábitat de la fauna silvestre. En términos generales, pudiéramos decir que los animales selváticos han sufrido por las deforestaciones que preceden a la actividad agrícola mientras que las especies acuáticas se han beneficiado por obras de riego; existen ahora en el país grandes embalses que han cambiado nuestra geografía.

Hace menos de cincuenta años, todavía no se había establecido en Venezuela el requisito de licencia para ejercer la cacería; lo único que se conocía a este respecto era una ley para recolección de plumas de garza promulgadas en 1917.

En 1936 aparece una primera ley de caza, que establece requisitos de permiso para el aprovechamiento de animales silvestres o sus productos, permiso que es expedido, aquel entonces, por la autoridad civil del distrito junto con la cédula de registro del arma de caza. En 1944, fue promulgada una nueva ley de caza con una mayor inspiración técnica, aunque evidentemente, resulta deficiente para un país sujeto a continuos cambios.

En la historia mundial de la administración de la fauna, se reconocen tres etapas: la primera, es total apatía del estado por el acontecer de los animales silvestres; la segunda, es el establecimiento de medidas netamente restrictivas de la utilización del recurso; y la tercera, es la promulgación de instrumentos legales en que la fauna silvestre es concebida como un recurso susceptible de aprovechamiento mediante un manejo adecuado. Esta tercera etapa comenzó en Venezuela hace catorce años con la promulgación de la Ley de Protección de Fauna Silvestre que como veremos más adelante, a pesar de su nombre, dista mucho de ser un simple instrumento con el único propósito de proteger la fauna silvestre.

Hace muy pocas décadas la cacería tenía un carácter que pudiéramos calificar de señorial; la época de las grandes partidas de caza en los viejos predios rurales, próximo a lo que hoy son grandes ciudades. El cazador de entonces estaba bien situado, tanto en el plano cultural como el económico y social. Hoy la cacería se ha popularizado. Como el incremento de la población ha traído consigo grandes concentraciones en los centros urbanos, existe una gran masa de habitantes que durante sus tiempos libres huyen de la rutina ciudadana para buscar solaz y diversión en el campo. La expresión más dramática de esta situación acontece durante los días de Semana Santa cuando las autoridades se colocan virtualmente en pie de guerra para afrontar las consecuencias del desplazamiento de millones de personas hacia los más recónditos lugares de nuestra geografía. Muchas de las personas que gustan del aire libre son aficionados a la cacería y disponen de los medios para proveerse de la gran diversidad de equipos que le ofrece la industria y cuentan con óptimas vías de comunicación y medios de transporte. Desgraciadamente, las posibilidades económicas de muchas de estas personas, nada tienen que ver con su nivel cultural, y el resultado ha sido la introducción de métodos y sistemas de caza totalmente reñidos con la ética de un verdadero deporte.

La inmigración no ha sido el factor determinante del crecimiento poblacional de Venezuela, pero en cambio estos inmigrantes aficionados a la cacería han cambiado en muchos sentidos la visión tradicional del venezolano con respecto a ésta.

Hace menos de treinta años no teníamos en este país, ningún profesional en la investigación y la administración de la fauna silvestre, ahora existe la carrera de biología en varias universidades nacionales, mientras que en diversas instituciones oficiales y privadas se realizan investigaciones sobre los más variados tópicos de la fauna silvestre. Hace apenas veinte años el tema de la conservación de los recursos naturales renovables era totalmente desconocido para la opinión pública; ahora se trata desde los niveles primarios de la educación hasta eventos altamente especializados. De ello se ocupa con frecuencia la prensa, la radio y la televisión. Se han creado organizaciones conservacionistas así como premios y reconocimientos oficiales y privados para esta actividad.



Reconoce la conveniencia de que la Administración Pública Nacional cuente con apropiado asesoramiento, a cuyos fines ha previsto la constitución de un Consejo Nacional de la Fauna Silvestre integrado por expertos en la materia. Asigna al estado la obligación de realizar y fomentar la investigación científica conducente a la utilización racional de la fauna, así como apoyar y estimular las investigaciones que sobre el recurso hicieran personas o instituciones privadas. Establece que el Ejecutivo Nacional tomará las medidas necesarias para preservar, modificar o restaurar el hábitat de los animales silvestres, y ha de tomar las disposiciones necesarias para evitar contaminaciones que puedan afectarlas. Otorga al Ejecutivo Nacional la facultad de disponer normas obligatorias de conservación y manejo de la fauna en los planes de desarrollo agrícola y pecuario.

Este es un breve resumen del articulado de la Ley de Fauna. En cuanto a la ordenación del territorio es evidente que en Venezuela se le ha dado alta prioridad a la compensación y transformación del medio físico del que se hablaba anteriormente. Más de un tercio del territorio nacional, que es una proporción bastante significativa a nivel mundial, está sometido a un régimen especial de protección y uso; la cifra es el treinta y seis punto cuarenta y dos por ciento (36.42%) del territorio venezolano, una proporción no superada por muchos países. El veintitres por ciento (23%) aproximadamente incluye áreas de régimen especial que prevén una protección concreta y directa a la fauna, al dictaminar normas prohibitivas de la caza; estos son los parques nacionales, los monumentos naturales, las reservas forestales y las reservas y refugios de faunas silvestres. El catorce punto doce por ciento (14.12%) de estas áreas, ofrecen una protección indirecta por cuanto que allí está prohibido la alteración del hábitat; estas son las denominadas zonas protectoras y las reservas hidráulicas. En lo que se refiere a la política, concretamente dirigida al provechamiento de los animales silvestres, tiene su punto de partida en la promulgación de la lista oficial de animales de caza, un documento de carácter conceptual, mediante el cual, el Estado Venezolano ha establecido cuáles especies de animales silvestres reúnen atributos para la caza. Cumple igualmente con facilitar el lenguaje y la comunicación a través de publicaciones y documentos oficiales relativos al recurso, lo que es importante en un país que se distingue por la diversidad de su fauna.

La lista oficial de animales de caza es una nómina de los animales que en Venezuela han de considerarse como "game". Es el primer y definitivo obstáculo legal para quienes, por ejemplo, quieren atrapar animales para mantenerlos en jaulas, o cazar monos, perezas, garzas o loros en vez de venados, conejos, patos y perdices. Lo que en Venezuela prevalece actualmente en relación con la cacería, es la experiencia de que toda política, que se parcialice hacia intereses u opiniones de personas o grupos de presión, está irremediablemente condenado al fracaso. Además de esto, hay indicios de un repunte de las poblaciones de tigrillos

u ocelotes que en pasado estuvieron muy mal, los perros de agua o nutria gigante y el caimán de la costa. Son indicios que ni remotamente permiten pensar en un aprovechamiento de estas especies, pero nos producen la satisfacción de saber que las medidas tomadas para su preservación comienzan a dar sus frutos. En el ámbito de la Convención Sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres, Venezuela ocupa una posición suigeneris, porque dispone de muchas especies animales que tienen demanda en el comercio internacional pero no interno, y porque las divisas resultantes de la exportación serían irrisorias en comparación con otras fuentes. Este hecho junto con una conciencia pública, cada vez más preocupada por el destino de los recursos naturales renovables, ha determinado que nuestro país se encuentra alineado con el grupo de los "duros" de la Convención, de aquellos, que siendo poseedores de la materia prima se oponen a su agotamiento por los países consumidores. Sin embargo, hay otra explicación que puede resultar más convincente, somos un pueblo nacionalista que prefiere disfrutar de sus riquezas puertas adentro, mientras no tengamos una clara noción de su valor y de la forma de como administrarla.

CONVENCION SOBRE EL COMERCIO INTERNACIONAL DE ESPECIES  
AMENAZADAS DE FLORA Y FAUNA (CITES) SU APLICACION EN  
RELACION A LOS COCODRILOS EN VENEZUELA

Ing. For. Yuraima Mago de Pérez MSC.  
Dirección General Sectorial de Administración del Ambiente  
Ministerio del Ambiente y de los Recursos Naturales Renovables  
Caracas

La Convención sobre el Comercio Internacional de Especies de Fauna  
y de Flora Silvestres Amenazadas de Extinción

La Convención sobre el Comercio Internacional de Especies de Fauna y Flora Silvestre Amenazadas de Extinción (CITES) es un Acuerdo Internacional que tiene por objeto regular el comercio (exportación, importación y tránsito) de especies específicas de animales y plantas silvestres, así como de sus respectivas partes o derivados y productos manufacturados, que se encuentran en vías de extinción o que son raras en el mundo.

La explotación excesiva del mundo animal y vegetal por el comercio internacional, ha sido denunciada muchas veces. Sin embargo, este comercio representa solo uno de los factores responsables de la desaparición de ciertas especies, existen otros tales como:

- La destrucción irreflexiva del espacio vital de numerosos animales y vegetales por el hombre.
- La sobreexplotación de los bosques.
- Cacería ilegal.
- La alteración de zonas pantanosas para la creación de zonas cultivables,
- y otras modificaciones en los procesos naturales, contribuyen también al empobrecimiento de la naturaleza.

Sin embargo, proteger a las especies a largo plazo únicamente desde el punto de vista del comercio internacional no será suficiente como para impedir la exterminación de alguna de ellas, por lo tanto no hay que limitarse a dicha Convención, sino que es necesario actuar a través de otras Convenciones Internacionales, Educación Conservacionista, Guardería Ambiental, recuperación de habitats, etc.

La necesidad de alguna forma de acuerdo para regular el comercio y, por consiguiente, poner obstáculos al comercio ilegal, se discutió en la Conferencia sobre el Ambiente Humano de Estocolmo de 1972. Decidiéndose en dicha Conferencia sobre la Resolución Nº 99 (3) que dice: "Se recomienda convocar una conferencia plenipotenciaria lo más pronto posible, bajo los auspicios gubernamentales o intergubernamentales pertinentes, con el fin de redactar y aprobar un convenio sobre la exportación, importación y tránsito de algunas especies animales y plantas silvestres".

El Gobierno de los Estados Unidos convocó a la Conferencia de Washington de 1973, y de allí surgió la Convención sobre el Comercio Internacional de especies amenazadas de fauna y flora silvestre (CITES).

Actualmente existen 87 países que son parte o signatarios de la citada Convención.

A raíz de las conversaciones sostenidas entre el Gobierno de Venezuela y la Secretaría de la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres, Venezuela se hizo partícipe del citado Convenio el 3 de mayo de 1976 mediante la Ley Aprobatoria de la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres, la cual entró en vigor el 10 de junio de 1976 por Decreto del Congreso de la República, publicado en la Gaceta Oficial de la República de Venezuela bajo el N° Extraordinario 1881 del 10-06-76. El Ministerio del Ambiente y de los Recursos Naturales Renovables, a través de la Dirección General Sectorial de Administración del Ambiente es quien maneja y coordina la aplicación de la Convención de la citada Ley en nuestro país y como tal tiene una Autoridad Administrativa y dos (2) Autoridades Científicas ante esta Convención.

La Ley Aprobatoria CITES Venezolana regula el comercio nacional e internacional de más de 1.000 especies de animales y plantas silvestres incluidas en tres apéndices.

En el Apéndice I, están incluidas especies en peligro de extinción que son o pueden ser afectadas por el comercio. El comercio de especímenes de estas especies deberá estar sujeto a una reglamentación estricta a fin de no poner en peligro aún mayor su supervivencia y se autorizará solamente bajo circunstancias excepcionales, tales como: donación o intercambio entre científicos o instituciones científicas registradas.

En el Apéndice II, están incluidas todas las especies que, si bien en la actualidad no se encuentran necesariamente en peligro de extinción, podrán llegar a esa situación a menos que el comercio en especímenes de dichas especies esté sujeto a una reglamentación estricta a fin de evitar utilización incompatible con su supervivencia.

En el Apéndice III, se incluyen todas las especies que cualquiera de las Partes manifiestan que se hayan sometidas a reglamentación dentro de su país con el objeto de prevenir o restringir su explotación y, que requieren la cooperación de los otros países en el control de su comercio.

#### La CITES y su Aplicación en Relación a los Cocodrilos en Venezuela

En Venezuela existen cinco (5) clases de cocodrilos:

Caimán del Orinoco y Caimán de la Costa: Como ha sido reportado por otros conferencistas, en Venezuela el Caimán del Orinoco (Crocodylus intermedius) y el Caimán de la Costa (Crocodylus actus), acusan bajos niveles poblacionales, lo cual motivó que el Ministerio del Ambiente y de los Recursos Naturales Renovables publicara la Resolución N° 95 del 28 de noviembre de 1979, declarando la veda por tiempo indefinido para una serie de especies faunísticas incluyendo los crocódilidos, con lo cual se contribuye en parte a brindar protección legal a las citadas especies.

Es importante señalar, que los bajos índices poblacionales del caimán del Orinoco y de la Costa, fueron reportados por varios países Partes de la CITES incluyendo Venezuela, motivo éste por el cual se les incluyó en el Apéndice I de la citada Convención.

Caimanes Enanos: Con relación a los Caimanes Enanos (Paleosuchus trigonatus y P. palpebrosus) existentes en Venezuela, conocemos que son especies que acusan bajos índices poblacionales y consecuentemente también incluidos en la Resolución MARNR N° 95 antes señalada, brindándoseles de esta manera protección legal en el sentido de que, solo se permite su captura con fines de investigaciones científicas o bajo planes de manejo.

Es oportuno señalar que los Caimanes Enanos están incluidos en el Apéndice II de la CITES, lo cual conlleva a una mayor protección desde el punto de vista del comercio internacional.

Aún cuando se sabe que los niveles poblacionales de estas especies han tenido cierta recuperación en Venezuela. El Ministerio del Ambiente y de los Recursos Naturales Renovables mantiene su veda, primero con considerar que dichos niveles no son suficientes como para suspender la veda; segundo por existir factores (cacería ilegal, alteración del habitat, poca guardería ambiental) que no ayudan a la recuperación de dichas especies).

Babas: Las investigaciones preliminares y las inspecciones técnicas de campo realizadas por nuestros técnicos en cuanto a la especie faunística Baba (Caiman crocodilus), han permitido comprobar la abundancia relativa de la referida especie, motivando así que el Ministerio del Ambiente y de los Recursos Naturales Renovables desarrolle un programa de: "Aprovechamiento Comercial Experimental de la mencionada especie".

En virtud de que la Baba se encuentra en el Apéndice II de la CITES, nuestro país comunicó a la Secretaría de la mencionada Convención de que se está aprovechando en forma experimental la citada especie.

La política del Ministerio del Ambiente y de los Recursos Naturales Renovables, dependerá en el futuro de cómo se comporten las poblaciones de Baba, después del aprovechamiento experimental al cual se encuentran sometidos actualmente.

En base a esta evaluación se ubicará la citada especie dentro de los Apéndices I - II ó III.

EL ESTADO ACTUAL Y LAS TENDENCIAS DE LA INVESTIGACION  
BIOLOGICA SOBRE LOS CROCODILIDOS EN VENEZUELA

Carlos Rivero Blanco  
Y  
Bianca D'Andria  
CRB Ecológos Consultores, C.A.  
Apartado 80531, Caracas 1080-A  
Venezuela

SUMMARY

All available literature pertaining to Venezuelan crocodilian biology was revised and classified. The information in the 78 references revised allowed the authors to identify those areas better studied and those in need of further work, as a means to indicate future research areas.

## Introducción

La investigación sobre la biología de las diversas especies de cocodrilos que habitan en Venezuela ha sido un tema que ha interesado a muchos científicos. Algunos han orientado sus estudios hacia la recopilación de datos acerca de la historia natural de las especies, mientras que otros han enfocado su atención hacia el estudio del aprovechamiento racional y técnicas de manejo de animales con altos niveles poblacionales o control de especies en peligro de extinción.

Los cocodrilos venezolanos son: el Caimán de la Costa, Crocodylus acutus; el Caimán del Orinoco, Crocodylus intermedius; la Baba, Caiman crocodilus, el Babo Negro, Paleosuchus trigonatus y el Babo Morichalero, Paleosuchus palpebrosus. El Caimán del Orinoco era muy abundante en los ríos caudalosos de Venezuela hasta el punto que el mismo Humboldt (40) escribió en su libro viaje a las Regiones Equinocciales: "...En las playas, "vense los cocodrilos, a menudo en número de 8 a 10, tendidos sobre la arena... Se han multiplicado de tal manera estos reptiles monstruosos, que a todo lo largo del río hemos tenido a la vista casi a cada instante, cinco o seis de ellos". (Tomo III, Cap. XVIII, pp.36). Sin embargo, junto al Caimán de la Costa, el Caimán del Orinoco fue exterminado casi en su totalidad debido al precio que por su piel pagaban los comerciantes. Hoy en día estas dos especies se consideran en peligro de extinción y las pocas poblaciones que aún habitan el territorio están sujetas a veda de caza.

La Baba es de menor tamaño y su piel, por el contrario, no despertaba interés en los comerciantes. Sin embargo, al ir desapareciendo los caimanes, la atención hacia la misma aumentó. De esta forma, otra de las especies cuyas poblaciones, según Humboldt, eran extremadamente numerosas, empezó a disminuir hasta alcanzar niveles muy bajos. En los últimos años, la Baba ha alcanzado, aparentemente, sus antiguos niveles poblacionales en algunos sectores de los Llanos de Venezuela. Ultimamente, se han intensificado los estudios acerca de la biología de esta especie ya que se piensa en la posibilidad de aprovechamiento racional de la misma, lo que requiere entonces de un conocimiento amplio sobre la ecología de este animal. Los estudios acerca de las dos especies del género Crocodylus se han visto limitados por la dificultad de localización y disposición de los individuos. Sobre Paleosuchus se tiene realmente muy poca información.

En este reporte se pretende recopilar las referencias bibliográficas existentes, así como el material en preparación, acerca de la biología de estas especies con el fin de proporcionar una idea acerca del nivel de información disponible y del enfoque que deberían tomar las investigaciones futuras.

Es importante indicar que se incluirán en este estudio los trabajos de Roberto Donoso Barros y Federico Medem como las referencias más importantes acerca de Distribución y Taxonomía de estas especies y el trabajo de Carmen Julia Medina como aporte sobre Paleontología. No quisimos ahondar más en ese tópico (SISTEMATICA) ya que nuestro interés se centra en los trabajos de Ecología y Manejo. Las personas, que por el contrario, tengan interés acerca de la SISTEMATICA de estas especies, pueden remitirse a las referencias bibliográficas que incluyen esos trabajos.

## Metodología

La mayor parte de las referencias bibliográficas estuvieron disponibles para la consulta de los autores. En el caso de los artículos en preparación y en prensa, se dispuso de resúmenes que brindaron una idea global del trabajo.

El contenido de cada referencia fue caracterizado de acuerdo al siguiente esquema: 1.- ECOLOGIA, donde incluimos: a) Hábitat; b) Relaciones con otras especies; c) Comportamiento individual; d) Comportamiento social; e) Ambito doméstico (Home range); f) Reproducción; g) Dinámica de población; h) Crecimiento y clases de edad; i) Dieta; j) Energética individual; k) Enfermedades y parásitos; l) Depredadores y Mortalidad; m) Fisiología y Anatomía. 2.- SISTEMATICA, donde incluimos: Taxonomía, Distribución y Paleontología. 3.- TECNICAS DE INVESTIGACION, donde incluimos: a) Técnicas de trampeo; b) Técnicas de marcaje; c) Técnicas de radiotelemetría; d) Otras técnicas de estudio. 4.- ADMINISTRACION RACIONAL: a) Manejo; b) Aspectos económicos. 5.- ASPECTOS DIVULGATIVOS: a) Divulgación; b) Creencias y leyendas; y 6.- SUGERENCIAS DE ESTUDIO: donde se presentan proposiciones de investigación.

El contenido de cada uno de las 78 publicaciones fue resumido en una matriz que se adjunta al final de este trabajo. Para la estructuración de dicha matriz, se ordenaron las referencias en orden alfabético por autor y se numeraron secuencialmente. Los números indicados en el eje horizontal de la matriz corresponden a las referencias. En ciertas oportunidades se cita bibliografía en el texto con el fin de indicar algunas publicaciones que incluyen algún tópico en particular. La llamada se hace con el correspondiente numeral encerrado en un paréntesis. Si son varias las citas, los numerales van separados por una coma y encerrados también en un paréntesis.

Se adjunta también un listado completo de las referencias bibliográficas consultadas. Al final se presenta gráficamente el total de referencias que tratan cada tópico en particular, pudiendo así proporcionar una idea acerca del nivel de información del que se dispone. De igual manera se presenta un gráfico que muestra la distribución en el tiempo de los estudios que se han realizado en Venezuela.

## Resultados

### 1 - ECOLOGIA:

a.- Hábitat (36 referencias): Encontramos Babas en el río Unare, Tuy y en el Lago de Valencia; en ríos, caños y lagunas de los llanos de Venezuela (6,42), en los de Guayana (31, 34, 35) y en la cuenca del Lago de Maracaibo. El género Paleosuchus habita en los morichales orientales, en caños de bosques y en zonas con mucha vegetación del Sur de Venezuela (Bolívar y Amazonas) (26, 78). Al caimán del Orinoco, se le encuentra en zonas boscosas de ríos y caños de la Cuenca del Orinoco, mientras que el caimán de la costa habita en ríos y aguas salobres del norte del país excepto en el Orinoco. Existen varios artículos que describen, entre otras cosas, el hábitat de estas dos especies (9,25,43).



b - Relaciones con otras especies (19 referencias): Como todos los animales, los cocodrilos presentan un comportamiento interespecífico. Las relaciones depredador-presa, ataque y defensa contra enemigos reales y potenciales son algunos de los muchos contactos que tienen los cocodrilos con las demás especies animales. Varios trabajos sobre la historia natural de los cocodrilos tratan estos tópicos (29, 40, 47, 49, 64).

c - Comportamiento Individual (22 referencias): El comportamiento individual de la Baba ha sido un tópico bastante estudiado. Se han señalado, entre muchas otras, pautas de conducta referentes a asealamiento, señales sonoras, movimientos migratorios, actitudes de caza y construcción de nidos (6, 35, 45, 75, 76). Medem (47), reporta algunos datos de comportamiento para las demás especies de cocodrilos.

d - Comportamiento Social (22 referencias): Algunos estudios han proporcionado datos, específicamente, acerca del comportamiento social de la Baba. Se ha reportado conducta de cortejo y combates de machos por una hembra durante la época reproductiva (34, 35, 41, 76). También se ha determinado la existencia de una jerarquización de edades donde los animales adultos disgregan a los jóvenes obligándoles a abandonar su territorio (6, 76). Romero (71) señala comportamiento de cuidado parental muy marcado para esta especie.

Se han estudiado variantes en el comportamiento individual y social en condiciones de cautiverio tanto para la Baba (70), como para Caimán del Orinoco (52).

e - Ambito doméstico (Home Range) (11 referencias): En ninguno de las publicaciones revisadas se define un límite de tamaño para el home rango de estas especies. Siendo animales tan dependientes de las condiciones climáticas para su subsistencia, deben de tener un ámbito doméstico bastante amplio durante todo el año. Las migraciones que deben realizar en busca de cuerpos de agua en la estación de verano, es una prueba de ello. Sin embargo, sí se ha hablado de la existencia de una territorialidad definida en la época reproductiva ya que muchas hembras vuelven a construir sus nidos en los mismos lugares de los años anteriores (6-19).

f - Reproducción (30 referencias): Este es un tema muy estudiado en la Baba (6, 19, 24, 34, 35, 69, 72, 76). Tanto en Crocodylus como en Paleosuchus no se tiene muchos conocimientos al respecto. El trabajo de Morillo (52) informa acerca de la reproducción de Crocodylus intermedius en cautiverio y el trabajo de Torriani (78) brevemente esboza posibilidades de cría de Paleosuchus. Este tópico es de gran importancia, ya que el futuro de estas especies depende mucho del éxito de la reproducción y sobrevivencia ante la depredación. Consideramos que aunque se ha trabajado bastante en este campo aún falta información detallada de valor práctico para proyectos de cría.

g - Dinámica de población (17 referencias): Siendo la Baba una especie sujeta a veda desde hace aproximadamente 10 años puede pensarse que deben de existir poblaciones que han alcanzado un equilibrio y el número de individuos que habitan hoy en día el territorio lo confirma (6, 45, 75, 76). La explotación de caimanes fue de tal magnitud que sus poblaciones no han

podido recuperarse todavía por lo que se pretende la implementación de planes de manejo. Humboldt (40) da una idea del status de los cocodrilos venezolanos al principio del siglo pasado. Godshalk (25, 27), Maness (43, 44) y Rivero Blanco (66) proporcionan información acerca del estado de las poblaciones de los caimanes hace algunos años. Los niveles poblacionales de Paleosuchus, tomando en cuenta que no han sido especies explotadas comercialmente, deben de mantenerse estables, siendo sin embargo sus poblaciones muy reducidas en número (26).

h - Crecimiento y Clases de edad (29 referencias): No se conoce la longevidad exacta de estos animales. Los estudios de crecimiento en vida libre de la Baba han determinado que alcanza su tamaño reproductivo (1, 1-1, 3 mts.) entre los 6 y 8 años de vida, dependiendo ello de la disponibilidad de alimento, (6, 35, 69, 76). Como es frecuente en los reptiles, su crecimiento es más rápido si disponen de alimento abundante, como suele suceder en condiciones de cautiverio (69). Para el caimán del Orinoco se tienen datos de crecimiento en cautividad (10). Medem (47) proporciona información al respecto para Paleosuchus y Crocodylus en vida libre.

i - Dieta (29 referencias): Los cocodrilos son animales carnívoros y varían su dieta desde insectos y otros invertebrados (alimento de las crías), hasta maníferos pasando por peces, cangrejos y gasterópodos (alimento de adultos) Morillo (52) y Blohm (10) nos proporcionan información acerca de la dieta del Crocodylus intermedius en cautiverio. No se han hecho estudios detallados en Venezuela sobre este tópico para Crocodylus y Paleosuchus en vida libre. Para los primeros, Humboldt (40) reporta que en su dieta incluían chiguires y seres humanos. La información acerca de la alimentación de la Baba es relativamente abundante (6, 17, 18, 34, 35, 74, 75, 76).

j - Energética individual (6 referencias): Sobre la Baba se tienen datos del valor calórico de su biomasa, así como de la dinámica energética de poblaciones de los módulos de Mantecal, Estado Apure (61, 63, 64). Seijas (73), proporciona datos sobre el metabolismo de este animal. Sin embargo del resto de las especies no se tienen valores al respecto.

k - Enfermedades y parásitos (7 referencias): Ayarzagüena (6) describe en su trabajo una enfermedad para las Babas que se manifiesta por un adelgazamiento excesivo del animal. Se reduce la musculatura hasta quedar únicamente huesos y piel. Las causas de la misma no han sido determinadas. Generalmente se manifiesta en animales adultos y puede ser la causa principal de muerte "natural" de los mismos. Este es el único dato de enfermedad que conocemos. Para las demás especies no se conoce nada parecido. Medem (47) y Staton (75), entre otros, determinan la presencia de parásitos internos y externos en la Baba.

l - Depredadores y mortalidad (15 referencias): La tasa de depredación de los animales adultos es menor que la de los individuos jóvenes. Ayarzagüena (6) reporta datos de depredación hasta individuos de 1 mt. de longitud total. Los animales entre los 25 y 50 cms. de longitud total pueden ser depredados por aves de rapiña, garzas, zorros, (69, 76). La mayor causa de mortalidad natural en estas especies es la depredación de huevos la cual puede producir hasta el 80% de pérdidas (6, 69, 75) siendo el Mato (Tupinambis teguixin) el principal causante. La cacería también es una de las causas de mortalidad de individuos adultos. No se han obtenido muchos datos acerca de mortalidad natural de las otras especies de cocodrilos.

m - Fisiología, Anatomía (33 referencias): Se han realizado diferentes estudios acerca de la anatomía de la Baba, y en menor grado de las demás especies de cocodrilos debido a la dificultad de su captura. Se tiene información acerca de la forma, tamaño, estructura y funcionamiento del cuerpo (6, 41, 60, 75, 76). Ultimamente se han venido realizando estudios hematológicos de la Baba (3, 4, 5, 28, 32, 33, 36, 55, 56, 57, 58).

## 2.- SISTEMÁTICA Y DISTRIBUCIÓN (15 referencias)

El trabajo de Staton (77) proporciona datos de biometría de las diferentes especies de cocodrilos entre los que se encuentran los venezolanos. El trabajo de Medem (47) proporciona información taxonómica así como datos acerca de la distribución de las diversas especies ya sea a nivel nacional como continental. Los trabajos de Donoso Barros ofrecen información completa acerca de este último tópico (20, 21, 22). En el área de Paleontología, Carmen Julia Medina (48) reporta sobre Melanosuchus fisheri.

## 3.- TÉCNICAS DE INVESTIGACIÓN

a - Técnicas de trampeo (4 referencias): Las técnicas de trampeo utilizadas comúnmente para capturar cocodrilos son los arpones, los lazos, las redes y las armas de fuego (6, 75, 76).

b - Técnicas de marcaje (8 referencias): Los individuos jóvenes suelen marcarse con anillos numerados que se les fijan en la membrana interdigital con etiquetas plastificadas (6) y numeradas que se les fijan en las crestas caudales y en algunos casos se realizan combinaciones de cortes de las crestas de la cola (70). Todas estas técnicas son de gran utilidad para estudios que requieran de captura y recaptura.

c - Técnicas de radiotelemetría (1 referencia): Staton y Dixon (compers.) realizaron un estudio de radiotelemetría con Babas del Hato Masaguaral en 1975. Los resultados no han sido publicados.

d - Otras técnicas de estudio (7 referencias): En este tópico se incluyen métodos de estudio (observaciones directas, seguimiento de rastro, censos nocturnos, etc.) que no se contemplan en los tópicos mencionados anteriormente pero que sin embargo son útiles para la recopilación de información. Gorzula (37) propone una técnica fotográfica que permite estimar el tamaño de los cocodrilos. Fotografiando únicamente la cabeza del cocodrilo (que es la parte del cuerpo que emerge del agua) y conociendo la relación longitud de la cabeza entre longitud del cuerpo (SVL) se puede calcular aproximadamente el tamaño total del cuerpo del animal.

## 4.- ADMINISTRACIÓN RACIONAL

a - Manejo y Conservación (29 referencias): Se han realizado diversos experimentos sobre la incubación y cría de caimanes y Babas, obteniéndose diversos resultados tanto en porcentaje de nacimientos como en crecimiento en cautiverio (10, 52, 67, 70, 72). En los últimos años se han venido haciendo muchos estudios acerca del manejo y conservación de las diferentes especies de cocodrilos (12, 13, 19, 27, 29, 46, 59, 66).

b - Aspectos económicos (14 referencias): Hasta el momento, sólo la piel de la Baba es un producto comerciable. Hoy en día se está pensando en el aprovechamiento integral de esta especie (carne, piel, huesos) ya sea para uso industrial o consumo humano (7, 19, 38, 54).

#### 5.- ASPECTOS DIVULGATIVOS

a - Divulgación (10 referencias): se han publicado algunos artículos en los periódicos y revistas, cuyo objetivo es el de dar a conocer al público en general lo que se está intentando hacer con la cría en cautiverio de las diversas especies de cocodrilos y la situación de las especies en extinción (1, 2, 15, 16, 49, 65, 68).

b - Creencias y Leyendas (2 referencias): Humboldt (40) nos proporciona un sin fin de anécdotas acerca de los cocodrilos y las creencias supersticiosas que se tenía acerca de su fiereza. Según los habitantes de las zonas cercanas a ríos y caños, los caimanes, y en menor grado las Babas, eran temidos como animales extremadamente peligrosos y hasta con instintos asesinos que únicamente esperaba la oportunidad de atacar a su presa por el simple gusto de exterminarla. Hoy en día no se tienen muchos datos al respecto, sin embargo no hay que olvidar que en la época de los viajes de Humboldt, las poblaciones de caimanes eran numerosas lo que podría aumentar la competencia por el alimento y la irritabilidad de los individuos.

#### 6.- SUGERENCIAS DE ESTUDIO (18 referencias):

En todos los trabajos presentados se sugieren nuevas líneas de investigación necesarias para completar conocimientos acerca de las especies de cocodrilos de nuestro país. Además, los trabajos de Hamilton (39) y de Mondolfi (50) sugieren de manera muy detallada tópicos de investigación referidos especialmente a Ecología y Manejo de poblaciones en vida libre y en cautiverio, muchos de los cuales ya se han realizado hoy en día.

#### Conclusiones

Todos los tópicos incluidos en este trabajo han sido estudiados con más o menos detalle en la Baba, mientras que de las demás especies se tiene escasa información debido, principalmente, a la dificultad de la localización de los individuos. Del género Crocodylus se están haciendo actualmente investigaciones con animales en cautiverio y en vida libre. El género Paleosuchus es el menos estudiado.

De las enfermedades y, en general, de las causas de mortalidad natural de estas especies no se dispone de mucha información. Las técnicas de investigación son muy parecidas en todas las referencias consultadas, pero de radiotelemetría no se tiene realmente ninguna información para las especies venezolanas.

El manejo y los aspectos económicos han sido dos de los tópicos más recientes en los estudios de Babas mientras que de las demás especies se ha tratado principalmente el tema de conservación, ya que, o son especies en extinción (género Crocodylus) o sus poblaciones son suficientemente escasas (Paleosuchus) como para que ameriten la implementación de este tipo de medidas.

Acerca de la distribución en el tiempo de los estudios que se han realizado en Venezuela (fig. 1) podemos concluir que es a partir de la década de los 70 cuando se comienzan realmente las investigaciones con las diferentes especies de cocodrilos venezolanos. Se observa una clara tendencia a intensificar estos estudios en los últimos años.

#### Bibliografía

1. Anónimo. 1970. Veda total de la baba y caimanes por períodos indefinidos. Artículo publicado en El Nacional, Martes 11 de Agosto de 1970.
2. Anónimo. 1973. Comercialización de la baba. Artículo publicado en El Universal, Jueves 5 de Julio de 1973.
3. Arocha Piñango, C.L., y S. Gorzula. 1975. A naturally-occurring inhibitor in the blood-clotting mechanism of Caiman crocodilus. *Herpetologica* 31 (4): 419-420.
4. Arocha Piñango, C.L., y S. Gorzuela. 1976. Hemostasis en el Caiman crocodilus. CONICIT. II Seminario sobre Chiguire (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus) Maracay, 1-4 Dic. 1976. Programa y resúmenes.
5. Arocha Piñango, C.L., S. Gorzula y A. Ojeda. 1982. The blood clotting mechanism of Spectacled Caiman Caiman crocodilus. *Molecular Physiology*. 2:161-170.
6. Ayarzagüena, Jose. 1980. Ecología del Caiman de Anteojos o Baba (Caiman sclerops) en los Llanos de Apure, Venezuela. Tesis Doctoral, Universidad Complutense, Madrid, España. (En Prensa Doñana Act. Vert.) 21 pp.
7. Belda, Antonio. (En preparación). Estudio de la utilización de los desechos de la explotación de la Baba (Caiman crocodilus) como recurso alimenticio para su crianza. Proyecto de Tesis, área de Biotecnología. División de Ciencias Biológicas. Universidad Simón Bolívar.
8. Benedico, M. del C. 1976. Informe sobre la Cacería Comercial del Chiguire (Hydrochoerus hydrochaeris) y de la Baba (Caiman crocodilus) en Venezuela. II Seminario sobre Chiguire y Babas. Maracay 1-4 Dic. 1976. 1976. Programas y resúmenes.
9. Blohm, Tomás. 1948. Observaciones sobre los caimanes traídos del río Orinoco en abril de 1946. *Mem. Cien. Nat. La Salle*. VIII (22): 129-132.
10. Blohm, Tomás. 1973. Conveniencia de criar crocodilidos en Venezuela con fines económicos y para prevenir su extinción. Simposio Internacional sobre Fauna silvestre y Pesca Fluvial y Lacustre Amazónica. 26 Nov. 1 Dic. 1973, Manao, Amazonas, Brasil. 33 pp.

11. Blohm, Tomás. 1974. Breve descripción de investigaciones llevadas a cabo en cuanto a babas (Caiman crocodilus) en Venezuela entre Septiembre de 1973 y Agosto de 1974. Seminario sobre el Chiguire (Hydrochoerus hydrochaeris) y la Babilla (Caiman crocodilus). Bogotá, Colombia 20 al 31 de Agosto de 1974.
12. Blohm, Tomás. 1982. Husbandry of Orinoco crocodiles (Crocodylus intermedius) in Venezuela. Ponencia presentada en el 5th. Working Meeting of the Crocodile Specialist Group the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 12-16 August 1980. Florida State Museum, Gainesville, Florida.
13. Brazaitis, P. y M. Watanabe. 1982. Los Crocodilidos en Venezuela. Un recurso natural renovable no aprovechado. Ponencia presentada en el 5th. Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 12-16 August 1980. Florida State Museum, Gainesville, Florida.
14. Brazaitis, P. y M. Watanabe. (Ed.). 1984. Newsletter: Editor's comments Survival Service Commission Crocodile Specialist Group de la IUCN Vol. 3, N. 1. February, 1984.
15. Carreño, Y. Pablo. 1971. Criaderos artificiales de babas sugiere investigador zoológico. Artículo publicado en El Universal. Jueves 3 de Junio de 1971.
16. Carreño, Y. Pablo. 1972. Criadero de babas, Artículo publicado en Estampas, suplemento dominical de El Universal. Mayo de 1972.
17. Castroviejo, J., C. Ibáñez y F. Braza. 1976. Datos sobre la alimentación del Babo o Caimán Chico (Caiman sclerops) en los llanos de Venezuela. Conicit. II Seminario sobre Chiguire (Hydrochoeris hydrochaeris) y Babas (Caimán crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes
18. Castroviejo, J., C. Ibáñez y F. Braza. 1977. Datos sobre la alimentación del babo. (Caiman crocodilus) en los llanos de Venezuela. Resúmenes del VII Congreso Latinoamericano de Zoología. Tucumán, Argentina: 67.
19. D'Andria, Bianca. 1980. Estructuración de un modelo matemático sobre la dinámica poblacional de la Baba. (Caiman crocodilus) con miras a su posible explotación comercial. Trabajo Especial de Grado. Dpto. de Ciencias Ambientales. Div. Ciencias Biológicas. Universidad Simón Bolívar.
20. Donoso Barros, Roberto 1965. Contribución al conocimiento de los cocodrilos de Venezuela. Physis, 25 (70): 387-400.

21. Donoso Barros, Roberto. 1966a. Contribución al conocimiento de los cocodrilos de Venezuela (continuación) *Physis* 26 (71): 15-32.
22. Donoso Barros, Roberto. 1966b. Contribución al conocimiento de los cocodrilos de Venezuela. (conclusión) *Physis* 26. (72): 263-274.
23. FUDENA (sin fecha). ¡A salvar el caimán!. Fudena informa. Boletín noticioso de la Fundación para la Defensa de la Naturaleza (FUDENA).
24. Godshalk, Robert, E. 1976. Contribución al conocimiento del ciclo de vida del Caiman c. crocodilus. Parte II, : Epoca de lluvia. Conicit. II Seminario sobre Chiguirees (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus) Maracay, 1-4 Dic. 1976. Programa y resúmenes.
25. Godshalk, Robert, E. 1978. El Caimán del Orinoco, Crocodylus intermedius en los Llanos Occidentales Venezolanos, con observaciones sobre su distribución en Venezuela y recomendaciones para su conservación. Informe Final mimeografiado para FUDENA, 26 pp.
26. Godshalk, R.E. 1982. The habitat and distribution of Paleosuchus in Venezuela. Ponencia presentada en 5th. Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 12-16 August 1980. Florida State Museum, Gainesville, Florida.
27. Godshalk, R.E. 1982. Status and conservation of Crocodylus intermedius in Venezuela. Ponencia presentada en el 5th. Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 12-16 August 1980. Florida State Museum, Gainesville, Florida.
28. Gorzula, S., C.L.A. Piñango y C. Salazar. 1974. Coagulación y fibrinólisis en el Caiman sclerops (baba) en su hábitat natural. Ponencia presentada en la VII Jornada Nacional de Hematología y Transfusión. Hospital Veterinario de Los Andes 20-24 de Noviembre de 1974.
29. Gorzula, S. 1975. Conserving and studying the Caiman in Venezuela. The Herptile. The Journal for the reptile and amphibian enthusiastic. Edition N. 6: 26-32.
30. Gorzula, S. 1976a. Identificación rápida y tentativa del Caiman crocodilus y Paleosuchus. Conicit. II Seminario sobre Chiguirees (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes.

31. Gorzula, S. y D. Rendón. 1976b. Ecología del Caiman crocodilus en la Guayana Venezolana. Conicit. II Seminario sobre Chiguire (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes.
32. Gorzula, S., C.L.A. Piñango y C. Salazar. 1976. A method of obtaining blood by venipuncture from large reptiles. Copeia N.4:838-839.
33. Gorzula, S. y C.L.A. Arocha Piñango. 1976. Estudio comparativo de tromboplastinas de siete especies animales. Ponencia presentada en la VIII Jornada Nacional de Hematología y Transfusión. Biblioteca Pública. Barquisimeto 18-22 de octubre 1976.
34. Gorzula, S. 1977. The ecology of the spectacled caiman in the Venezuelan Guayana. Joint annual meeting of the Herpetologists' League and the Society for the Study of Amphibians and Reptiles. Lawrence, Kansas, 7-13 August 1977. Resumen.
35. Gorzula, S. 1978. An ecological study of Caiman crocodilus crocodilus inhabiting savanna lagoons in the venezuelan Guayana. Oecología (Berl.) 35 (1): 21-34.
36. Gorzula, S. y C.L.A. Arocha Piñango. 1981. Thromboplastic activity with particular reference to reptiles. Molecular Physiology. 1:173-177.
37. Gorzula, S. 1984. Proposal for a photographic method for size estimates of crocodilians. Herpetological Review, 5 (2) 38-39.
38. Gutiérrez, Saúl (en preparación). Estudio sobre la utilización de la Baba como recurso alimenticio para consumo humano. Proyecto de Tesis, área de Biotecnología. División de Ciencias Biológicas, Universidad Simón Bolívar.
39. Hamilton, L.S., J. Steyermark, J.P. Veillon y E. Mondolfi. 1976. Conservación de los Bosques Húmedos de Venezuela. Consejo de Bienestar Rural. Caracas, Junio 1976. 181 pp.
40. Humboldt, Alexander de., et Aimé Bompland. 1805-1832. Voyage aux régions équinoxiales du Nouveau Continent, faites en 1799, 1801, 1802, 1803, 1804, Vols. I-XXXV N. Maze París.
41. Lang, J.W. 1977. Thermal Ecology and Social Behaviour of Caiman crocodilus in the llanos of Venezuela. Progress report to the National Zoological Park, Smithsonian Institution. Red Data Book.
42. Maness, S.J. 1976. Contribución al conocimiento del ciclo de vida del Caiman crocodilus. Parte I: Epoca de sequía. Conicit. II Seminario sobre Chiguire (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes.



43. Maness, S. J. y Godshalk. 1976. El Género Crocodylus en Venezuela. Conicit. II Seminario sobre Chiguirees. (Hydrochoerus hidrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4. Dic. 1976. Programa y resúmenes.
44. Maness, S. J. 1982. Status of Crocodylus acutus, Caiman crocodilus fuscus and Caiman crocodilus crocodilus in Venezuela. Ponencia presentada en la 5th. Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 12-16 August 1980. Florida State Museum, Gainesville, Florida.
45. Marcellini, Dale L. 1979. Activity patterns and densities of Venezuelan Caiman. (Caiman crocodilus) and Pond Turtles (Podocnemis vogli). Vertebrate Ecology in the Northern Neotropics, John Eisenberg (Ed.). The National Zoological Park, Smithsonian Institution Press, Washington, D.C. 263-271.
46. MARNR. 1982. Aprovechamiento racional de la Baba o Babo. Caiman crocodilus L. DGSAA. DGSIA. 14 pp.
47. Medem, Federico. 1983. Los Crocodylia de Sur América, Vol. II Universidad Nacional de Colombia y Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales "Francisco José de Caldas", COLCIENCIAS, Bogotá, Colombia 270 pp.
48. Medina, Carmen Julia. 1976. Crocodylians from The Late Tertiary of northwestern Venezuela: Melanosuchus fisheri sp. nov. Breviora, (438): 1-13.
49. Mondolfi, Edgardo. 1965. Nuestra Fauna. El Farol. (214): 2-13.
50. Mondolfi, Edgardo. 1974. Proyecto de reestructuración de los Servicios y Programas de Fauna Silvestre del Ministerio de Agricultura y Cría. Consejo de Bienestar Rural, Caracas, Junio de 1974. 120 pp.
51. Montiel, N., S. Gorzula y C.L. Arocha Piñango. 1976. Parámetros hematológicos del Caiman crocodilus. Ponencia presentada en la VIII Jornada Nacional de Hematología y Transfusión. Biblioteca Pública, Barquisimeto 18-22 de Octubre 1976.
52. Morillo, P., C.M. 1982. Observaciones sobre mantenimiento y cría de Crocodylus intermedius. Zoología Neotropical. Actas del VIII Congreso Latinoamericano de Zoología. P.Salinas Ed. II: 1443-1444.
53. Ojasti, Juhani. 1963. Havaintoja Orinokon alueen luonnosta ja sen ekologisista piirteistä. Luonnon Tutkija 67:137-146. Eripainos.
54. Ojasti, Juhani. 1972. La fauna silvestre produce (separata del libro "La Ciencia en Venezuela, U. Carabobo 1970). Oficina de Divulgación Agrícola. Ed. Div. Fauna DRNR MAC 22 pp.

55. Ramírez, F.J., C. Salazar, S. Gorzula y C.L. Arocha Piñango. 1974. Valores hematológicos de reptiles en su hábitat natural. Ponencia presentada en la VIII Jornada Nacional de Hematología y Transfusión. Hospital Veterinario de Los Andes 20-24 de Noviembre 1974.
56. Ramírez, F., C.L. Arocha Piñango, S. Gorzula, C. Salazar y D. Rondón. 1975. Hematología del Caiman crocodilus (Baba). Acta Científica Venezolana. 26 (1) 27-28.
57. Ramírez, F., C.L. Arocha Piñango, S. Gorzula y N. Montiel. 1976. Estudio Hematológico del Caiman crocodilus. Conicit. II Seminario sobre Chiguirees (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes.
58. Ramírez, F., C.L. Arocha Piñango, N. Montiel y S. Gorzula. 1978. Elementos figurados, hemoglobina y proteínas de la sangre en el Caiman crocodilus. (Linneaus). Acta Científica Venezolana. 29: 268-273.
59. Ramírez, Y., C.C. Castillo y S. Gorzula. 1977. Conservation. Proyecto venezolano sobre cocodrilos (Venezuelan crocodile project). Herp. Review. 8 (4): 130.
60. Ramos S. y C. Villarroel. 1975. Un modelo lineal para la estimación de la relación talla-peso en babas (Caiman crocodilus) de la población localizada en el módulo experimental de Mantecal. Acta Científica Venezolana. 26 (1): 27.
61. Ramos, S. y E. Pereyra. 1975. Valores calóricos de la biomasa de la baba (Caiman crocodilus). Acta Científica Venezolana 26 (1): 27.
62. Ramos Oropeza, Santiago. 1975. Evaluación calorimétrica a nivel individual en Caiman crocodilus (Linneaus 1758) de la población localizada en el módulo experimental de Mantecal, Estado Apure, Venezuela. Trabajo especial de Grado, Escuela de Biología, Fac. Ciencias, Universidad Central de Venezuela. 88 pp.
63. Ramos Oropeza, S. y J. Pacheco, 1976. Notas preliminares sobre la dinámica energética de Caiman crocodilus (baba), en los módulos de Apure. Conicit. II Seminario sobre Chiguirees (Hydrochoerus hydrochaeris) y Babas (Caiman crocodilus). Maracay, 1-4 Dic. 1976. Programa y resúmenes.
64. Ramos S., S. Daniellewski y G. Colomine. 1981. Contribución a la ecología de los Vertebrados Acuáticos en Esteros y Bajíos de Sabana Modulada. Boletín de la Sociedad Venezolana de Ciencias Naturales. XXV. (139): 79-104.
65. Rivero Blanco, Carlos. 1968. El Caimán y su valiosa piel. Líneas (136) 9-13.

66. Rivero Blanco, Carlos. 1970. Situación de la Baba y los Caimanes efectos de la explotación comercial. Recomendaciones para el manejo de las especies. Foro sobre Protección y Fomento de la Fauna Silvestre. SVCN, Caracas, 12 pp.
67. Rivero Blanco, Carlos. 1973. Ensayo monográfico sobre los Hábitos Reproductivos de la Baba o Jacare-tinga, Caiman crocodilus en los llanos de Venezuela y las posibilidades de manejo en semicautividad, con sugerencias sobre las posibles aplicaciones de la metodología de manejo al Caiman Negro o Jacare-acu Melanosuchus niger de las cuencas del Amazonas y Río Negro. Simposio Internacional sobre Fauna Silvestre y Pesca Fluvial y Lacustre Amazónica. 26 Nov. 1 Dic. 1973, Manaus, Amazonas, Brasil. 36 pp.
68. Ribero Blanco, C. 1974. "Cuántos caimanes quedan? Artículo publicado en La Escena Ecológica de El Nacional, Domingo 29 de Diciembre de 1974.
69. Rivero Blanco, C. 1974. Hábitos reproductivos de la Baba en Los Llanos Venezolanos. *Natura* (52): 24-29.
70. Rodríguez, Gustavo. (En preparación). Efectos de las variables densidad y tipo de dieta sobre la tasa de crecimiento en cautiverio de la baba (Caiman crocodilus) durante el primer año de vida. Proyecto de Tesis, área de Ecología. División de Ciencias Biológicas. Universidad Simón Bolívar.
71. Romero G. 1983. Distress call saves a Caiman c. crocodilus hatching in the Venezuelan Llanos. *Biotrópica* 15 (1): 71.
72. Romero, Rafael A. (en preparación). Estudio de los efectos de algunas variables químicas, físicas y ecológicas sobre la biología del nido de la Baba (Caiman crocodilus).
73. Seijas, Andrés Eloy. 1979. Aspectos fundamentales sobre la alimentación y metabolismo de Caiman crocodilus y su relación en la comunidad acuática dentro del Módulo Experimental de Mantecal, Estado Apure. Trabajo Especial de Grado. Escuela de Biología, Facultad de Ciencias, Universidad Central de Venezuela. 123 pp.
74. Seijas, Andrés Eloy y S. Ramos. 1980. Caracterización de la dieta de la Baba. Caiman crocodilus, durante la estación seca en las sabanas moduladas del Estado Apure, Venezuela. *Acta Biol. Venez.* 10 (4): 373-389.
75. Staton, Mark y J.R. Dixon. 1975. Studies on the dry season biology of Caiman crocodilus crocodilus form the venezuelan llanos. *Mem. Soc. Cienc.Nat. La Salle.* 35 (101): 237-266.
76. Staton, Mark y J. R. Dixon, 1977. Breeding biology of the Spectacled Caiman (Caiman crocodilus crocodilus) in the venezuelan llanos. *U.S. Fish & Wildl. Serv. Wildl. Res. Rep.* (5): 1-21.

77. Staton, M. (Comp.). 1978. A list of crocodilian specimens in major herpetological collections of the United States. Copyright 1978 by Mark A. Staton. P.O. Box 37336 Houston, Texas 77036.
78. Torriani, H. 1973. Posibilidades de recría del cocodrilo enano negro y del perro de agua amazónico. Monografía. Simposio Internacional sobre fauna silvestre y pesca fluvial y lacustre amazónica. Informes de conferencias, cursos y reuniones N 26. Manaus-Amazonas. Brasil. 2 VIII-D-1 a VIII-D-8.

M A T R I Z

	REF. Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
HABITAT							+		+	+					+					+	+	
RELACIONES CON OTRAS ESPECIES							+														+	+
COMPORTAMIENTO INDIVIDUAL							+		+	+									+			+
COMPORTAMIENTO SOCIAL							+			+					+							+
AMBITO DOMESTICO							+															+
REPRODUCCION							+		+	+	+				+	+	+				+	+
DINAMICA DE POBLACION							+															
CRECIMIENTO Y CLASES DE EDAD							+		+	+					+	+						+
DIETA							+	+	+	+									+	+		+
ENERGETICA INDIVIDUAL																						
ENFERMEDADES Y PARASITOS							+															+
DEPREDAADORES Y MORTALIDAD							+														+	+
FISIOLOGIA, ANATOMIA				+	+	+	+	+							+							+
SISTEMATICA Y DISTRIBUCION							+															+
TECNICAS DE TRAMPEO							+															
TECNICAS DE MARCAJE							+															
TECNICAS DE RADIOTELEMETRIA																						
OTRAS TECNICAS DE ESTUDIO								+														
MANEJO Y CONSERVACION		+						+	+	+	+	+	+	+	+	+	+	+				+
ASPECTOS ECONOMICOS			+					+			+	+	+									+
DIVULGACION			+	+																	+	+
CREENCIAS Y LEYENDAS																						
SUGERENCIAS DE ESTUDIO							+			+												+

M A T R I Z (Continuacion)

REF. Nos.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41			
HABITAT	+	+		+	+	+	+		+	+	+			+	+						+	+		
RELACIONES CON OTRAS ESPECIES	+	+								+												+	+	
COMPORTAMIENTO INDIVIDUAL											+	+	+		+	+						+	+	
COMPORTAMIENTO SOCIAL	+	+		+	+					+					+	+						+	+	
AMBITO DOMESTICO							+	+															+	
REPRODUCCION	+	+		+			+				+				+	+							+	
DINAMICA DE POBLACION						+	+	+		+													+	+
CRECIMIENTO Y CLASES DE EDAD	+	+					+	+		+					+	+							+	
DIETA	+	+								+	+				+	+							+	
ENERGETICA INDIVIDUAL																							+	
ENFERMEDADES Y PARASITOS																+								
DEPRIDADORES Y MORTALIDAD										+						+							+	
FISIOLOGIA, ANATOMIA	+	+								+	+	+		+	+		+	+				+	+	
SISTEMATICA Y DISTRIBUCION	+	+		+	+					+													+	
TECNICAS DE TRAMPEO																								
TECNICAS DE MARCAJE										+	+				+	+								
TECNICAS DE RADIOTELEMETRIA																								
OTRAS TECNICAS DE ESTUDIO							+	+														+	+	
MANEJO Y CONSERVACION					+	+	+															+	+	
ASPECTOS ECONOMICOS																						+		
DIVULGACION				+																			+	
CREENCIAS Y LEYENDAS																							+	
SUGERENCIAS DE ESTUDIO											+			+	+							+		

M A T R I Z (Continuacion)

REF. Nos. 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61

HABITAT	+	+		+	+	+				+											
RELACIONES CON OTRAS ESPECIES						+		+													
COMPORTAMIENTO INDIVIDUAL	+			+		+														+	
COMPORTAMIENTO SOCIAL	+					+					+										
AMBITO DOMESTICO						+	+														
REPRODUCCION	+					+	+				+		+							+	
DINAMICA DE POBLACION	+	+	+	+		+														+	
CRECIMIENTO Y CLASES DE EDAD						+	+				+		+						+	+	+
DIETA						+	+				+	+							+	+	
ENERGETICA INDIVIDUAL																				+	
ENFERMEDADES Y PARASITOS							+													+	+
DEPREDAADORES Y MORTALIDAD						+	+														
FISIOLOGIA, ANATOMIA							+			+			+	+	+	+	+			+	
SISTEMATICA Y DISTRIBUCION		+	+				+	+													
TECNICAS DE TRAMPEO																					
TECNICAS DE MARCAJE																					
TECNICAS DE RADIOTELEMETRIA																					
OTRAS TECNICAS DE ESTUDIO																					
MANEJO Y CONSERVACION							+			+	+	+	+							+	
ASPECTOS ECONOMICOS							+			+			+								
DIVULGACION							+			+											
CREENCIAS Y LEYENDAS																					
SUGERENCIAS DE ESTUDIO							+	+			+		+							+	

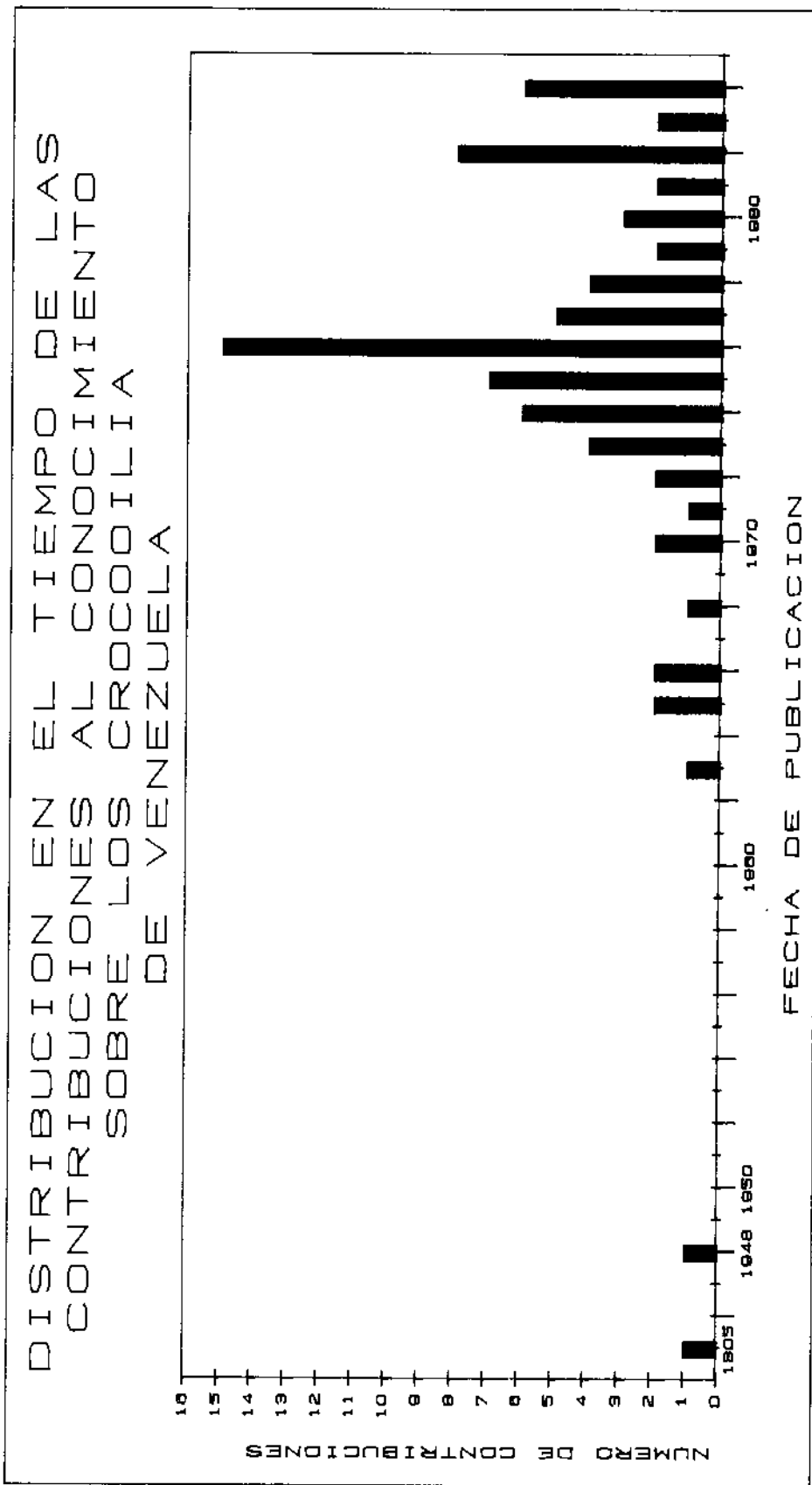
M A T R I Z (Continuacion)

REF. Nos. 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78

	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
HABITAT	+	+	+	+	+			+			+	+	+				+
RELACIONES CON OTRAS ESPECIES		+		+	+			+		+	+		+	+			+
COMPORTAMIENTO INDIVIDUAL									+		+	+		+	+		+
COMPORTAMIENTO SOCIAL			+	+					+	+				+	+		
AMBITO DOMESTICO									+		+			+	+		
REPRODUCCION					+	+			+					+	+		+
DINAMICA DE POBLACION					+	+								+	+		
CRECIMIENTO Y CLASES DE EDAD	+				+	+			+	+				+	+		+
DIETA	+	+							+	+				+	+	+	+
ENERGETICA INDIVIDUAL		+	+	+										+			
ENFERMEDADES Y PARASITOS											+						
DEPREDAADORES Y MORTALIDAD					+				+	+	+			+	+		+
FISIOLOGIA, ANATOMIA					+				+	+	+	+		+	+	+	+
SISTEMATICA Y DISTRIBUCION					+									+	+		+
TECNICAS DE TRAMPEO														+	+	+	
TECNICAS DE MARCAJE									+					+	+		
TECNICAS DE RADIOTELEMETRIA																	+
OTRAS TECNICAS DE ESTUDIO									+		+						
MANEJO Y CONSERVACION					+	+	+	+	+	+				+			+
ASPECTOS ECONOMICOS					+	+			+	+							
DIVULGACION					+				+								
CREENCIAS Y LEYENDAS					+												
SUGERENCIAS DE ESTUDIO					+	+	+	+						+	+		



FIG. 1



SITUACION ACTUAL DE LAS POBLACIONES DE BABAS Y BABILLAS  
(Caiman crocodilus) EN LA REGION NORTE-COSTERA DE VENEZUELA

Andrés Eloy Seijas  
Servicio Nacional de Fauna Silvestre  
Ministerio del Ambiente y de los Recursos Naturales Renovables  
- MARNR -  
Apartado 184. Maracay, Venezuela

SUMMARY

Numerous localities along the northern coast of Venezuela were visited between January and August, 1984. Counts of Caiman crocodilus greater than one year old were related to the distance travelled during the censusing. The maximum number observed was 196.6 individuals/Km in a small sector of the Sanare river. In the other localities the values varied from 0.2 to 26.6 individuals/Km. Where this species coexists with Crocodylus acutus the observed population densities of Caiman crocodilus were low. It is considered that the population levels of spectacled caimans in this region are satisfactory, and may even have been favoured on the one hand by the drastic reduction in numbers of Crocodylus acutus, and on the other hand by the construction of dams and other artificial habitats.

## Introducción

En contraste con el interés creciente que se ha evidenciado por el estudio de la baba (Caiman crocodilus) en los llanos occidentales de Venezuela, las poblaciones de esta especie en el resto de el país ha sido objeto de una escasa atención científica. En la región norte-costera de Venezuela, además de las referencias históricas sobre la existencia de babas (Appun, 1961; Humboldt, 1975), existen algunas referencias más recientes (Donoso-Barros, 1965; Maness, 1982; Medem, 1983). En éstas se señalan a las poblaciones de la Cuenca del Lago de Maracaibo como pertenecientes a la sub-especie C. c. fuscus, la cual extendería su distribución, hacia el este, hasta el río Yaracuy. Las poblaciones del resto de la región norte-costera pertenecerían a la sub-especie C.c. crocodilus.

Las poblaciones de babas, o babillas como se les conoce en el Estado Zulia, de la región norte-costera de Venezuela, probablemente no sufrieron un impacto tan acentuado como el que produjo la intensa explotación comercial de esta especie en la mayor parte del resto del país (Medem, 1983), con excepción de las de la Cuenca del Lago de Maracaibo, las cuales soportaron una extracción de cuya magnitud no existen datos (Medem op.cit.) pero que con seguridad fue muy alta, ya que todavía persiste una actividad clandestina que eventualmente es conocida cuando se producen decomisos como el efectuado por la Zona 5 del MARNR, en Maracaibo, en el año 1982 y consistente en 616 cueros de babillas.

## Localidades Visitadas y Metodología

Este trabajo fue realizado en diversas localidades de la región norte-costera de Venezuela, entendiéndose por ésta a toda la región de las cuencas hidrográficas del Lago de Maracaibo y del Mar Caribe. Los lugares fueron visitados con el objeto principal de determinar la situación actual de las poblaciones del caimán de la costa, Crocodylus acutus, (Seijas, este volumen). Estas localidades, consistentes principalmente en ríos, represas y áreas de manglares, están ubicadas en los Estados Zulia, Falcón, Yaracuy, Miranda y Anzoátegui.

La metodología seguida para el reconocimiento de los sitios visitados es, en términos generales, la descrita en el trabajo antes citado, sólo que aunque muchas localidades fueron recorridas tanto de día como de noche, sólo se consideró el número de C. crocodilus mayores de un año contados de noche.

Las distancias recorridas en varias de las localidades fue calculada posteriormente con la ayuda de un curvómetro y cartas topográficas a escalas de 1:250.000, 1:100.000 y 1:25.000. El número de C. crocodilus contados se relacionó con la distancia recorrida.

Para aquellas localidades donde no fue posible calcular las distancias recorridas, sólo se presentan los resultados de los conteos realizados, con algún comentario sobre la situación de las poblaciones de babas.

## Resultados

El número de C. crocodilus mayores de un año contados a lo largo de las orillas (perímetro) de los embalses o en los ríos y caños visitados, aparece en las Tablas 1 y 2, respectivamente. El perímetro total de la represa de Tulé es de 58,2 km, pero sólo se recorrió aproximadamente la mitad de éste. En la represa de Socuy el perímetro total calculado es de 112,3 km, habiéndose recorrido solamente un tercio del mismo.

El valor más alto de individuos por kilómetro corresponde al río Sanare, el cual es un pequeño curso de agua de corriente intermitente, donde el pequeño sector inspeccionado representa uno de los sitios que conserva agua todo el año.

En los ríos inspeccionados por sectores (Tocuyo, Aroa, Yaracuy y Neverí) la densidad de C. crocodilus es mayor en los sectores más cercanos a la desembocadura y disminuye aguas arriba; situación que es inversa a la que se presenta con Crocodylus acutus en los tres primeros de estos ríos (Tablas 2 y 3).

El número de individuos por kilómetro en los ríos El Cristo, Unare y Caño El Eneal son los más altos, si se exceptúa a los del río Sanare, y superan incluso a la relación Ind/km obtenida al considerar a C. crocodilus y C. acutus de manera conjunta en aquellos cuerpos de agua donde estas especies coexisten.

Otras localidades visitadas fueron el río Limón-Gran Eneal en el Estado Zulia; la Laguna de Jatira y el Parque Nacional Morrocoy, en el Estado Falcón y los canales de Río Chico y la Laguna de Tacarigua en el Estado Miranda. Algunos detalles sobre estas localidades y otras donde no se observaron babas, aparecen en Seijas (este volumen).

En el río Limón y el Gran Eneal se puede considerar a C. crocodilus como escaso, ya que aunque los lugareños afirman que éste existe, no se observó ningún ejemplar durante la corta visita realizada. En la Laguna de Jatira, por el contrario, este crocodílido es muy abundante, aunque no se pudo establecer la relación entre el número de babas contadas (27 babas el 11-2-84) con la distancia recorrida, al no haber podido precisar esta última. En el Parque Nacional Morrocoy se observó sólo una baba, en las cercanías del Caño El León, en aguas con una salinidad de 25 partes por mil. En los canales de agua salobre de Río Chico han sido observadas hasta siete babas pero se puede considerar a éstas escasas, al igual que en la Laguna de Tacarigua donde esta especie está restringida a los caños y ríos que drenan hacia ella.

Datos del autor (Seijas, sin publicar) tomados en la Laguna La Estrella durante la ejecución de estudios en las Ciénagas de Juan Manuel, al sur del Lago de Maracaibo (Seijas, 1984), muestran 24 babillas contadas en media hora de recorrido nocturno en un bote a velocidad mínima.

## Discusión

En trabajos recientes (Maness, 1982, Medem, 1983) se ha discutido brevemente la situación de las poblaciones de Caiman crocodilus fuscus en Venezuela. Esta subespecie, de acuerdo a Medem (op.cit.) tiene una distribución que va desde la cuenca del Lago de Maracaibo hasta el río Yaracuy. Los resultados que se discuten en este artículo provienen de observaciones realizadas en esta área de distribución, pero también en localidades ubicadas hacia el este de la región norte-costera de Venezuela, en la cual existiría otra subespecie de baba, C. c. crocodilus. Sin embargo no se ha querido, al presentar los resultados, hacer ningún tipo de separación por subespecies, por dos razones: en primer lugar, porque no existen suficientes investigaciones que establezcan la distribución y características de las poblaciones de babas en la región, y por lo tanto de sus afinidades y diferencias, y en segundo lugar, porque la región donde se ha realizado el estudio ha sido la mayormente afectada por el desarrollo urbanístico e industrial del país, lo que ha significado una modificación importante de muchos hábitats naturales y la creación de ambientes favorables para la expansión de esta especie, lo que ha podido producir cambios en su distribución original al facilitar, o limitar, la invasión y el intercambio con individuos de otras localidades.

Todos los lugares visitados se encuentran dentro del área de distribución histórica del caimán de la costa, Crocodylus acutus, especie que constituía el motivo principal del estudio. Esto determinó que se ignoraran muchos sitios donde se sabía de la existencia de babas pero donde había poca o ninguna probabilidad de encontrar C. acutus. En este caso se tiene a las ciénagas de Curarí, en Falcón y a la Laguna de Campoma en el Estado Sucre. Por otra parte, algunas localidades muy extensas o inaccesibles no pudieron ser reconocidas, como es el caso de la mayor parte del sur del Lago de Maracaibo, donde se sabe de la existencia de importantes poblaciones de C. crocodilus (Medem, 1983; Seijas, 1984). Entre el río Yaracuy y Cabo Codera, en el Estado Miranda, no fue revisada ninguna localidad. Entre estas localidades sólo se conoce el registro histórico de Appun (1961) quien señala babas en el río San Esteban en Puerto Cabello.

A pesar de que no fueron visitadas todas las localidades donde existe C. crocodilus en la región norte-costera de Venezuela, el área reconocida se puede considerar como representativa de los distintos hábitats que ésta ocupa en la región y, de acuerdo al análisis de los resultados, se puede concluir que las babas y babillas no sólo son abundantes, sino que en algunos sitios ha venido incrementando sus poblaciones por la creación de represas y cuerpos de agua artificiales que favorecen su expansión, y por la eliminación de un competidor tan importante como C. acutus.

Los datos que se presentan en este trabajo sirven de apoyo a la idea de que C. crocodilus ha venido ocupando de manera progresiva el nicho que ha dejado vacío C. acutus (Medem, 1983). Para varias de las localidades visitadas existen datos o referencias sobre la existencia de poblaciones remanentes de este cocodrilo (Seijas, este volumen).

Estos datos aparecen en la Tabla III y muestran como en aquellos lugares donde existen poblaciones de relativa importancia de C. acutus, las poblaciones de babas se encuentran en niveles bajos y a medida que las poblaciones C. acutus disminuyen, las de C. crocodilus adquieren mayor relevancia.

La competencia entre ambos crocódilidos parece impedir el desarrollo de grandes poblaciones en los sitios donde coexisten, ya que al considerar la densidad (expresada en individuos por kilómetros) de ambos reptiles considerados en conjunto (Tabla 3), la misma es baja si se compara con la que existe para babas en lugares como Tulé, Socuy, Cumaripa y el río Unare, en los cuales no existen datos confiables sobre la existencia de C. acutus.

Lo único que actualmente parece limitar la expansión de C. crocodilus, es la existencia de factores ecológicos adversos, como podría ser la salinidad de las aguas, ya que aunque se ha encontrado individuos de esta especie en aguas salobres, siempre ha sido en números muy bajos. El incremento de las poblaciones de babas podrían hasta constituir un obstáculo al tratar de implementar planes de recuperación del caimán de la costa en algunas localidades.

Las cifras que se discuten en este trabajo fueron obtenidas en reconocimientos nocturnos a lo largo de los primeros ocho meses del año 1984. Algunos factores como clima, fase de la luna, hora, etc. no se mantuvieron constantes lo cual podría haber influido sobre el resultado de los contajes tal como sucede en otras localidades (Glastra, 1983; Seijas, 1984b). No obstante, las mismas podrán servir de punto de partida y comparación para el desarrollo de futuras investigaciones sobre C. crocodilus en la región nortecostera de Venezuela.

#### Agradecimientos

A David Gerardo Cordero y Ramón Rivero, quienes me asistieron de una manera eficiente durante el desarrollo de las distintas fases de este trabajo.

#### Bibliografía

- Appun, K.F. 1961. En Los Trópicos Ed. Universidad Central de Venezuela. Caracas. 519 p.
- Humboldt, A. 1775. Del Orinoco al Amazonas. Viaje a las Regiones Equinocciales del Nuevo Continente. Edt. Labor. Barcelona. 429 p.
- Donoso-Barros, R. 1965. Contribución al Conocimiento de los Cocodrilos de Venezuela. Physis, 25 (70): 287-400.
- Glastra, R. 1983. Notes on a Population of Caiman crocodilus crocodilus. Depleted by Hide Hunting in Surinam. Biol. Conservation. 26:149-162.

- Maness, S. 1982. Status of Crocodylus acutus, Caiman crocodilus fuscus, and Caiman crocodilus crocodilus in Venezuela. En Crocodiles, IUCN Publ. (NS): 177-120.
- Medem, F. 1983. Los Crocodylia de Sur América. Vol. II. Edt. Carrera 7a. Ltda. Bogotá. 270 p.
- Seijas, A. E. 1984a. Estudio Faunístico Preliminar de la Reserva de Fauna Silvestre de las Ciénagas de Juan Manuel, Aguas Blancas y Aguas Negras, Estado Zulia. MARNR. Serie Informes Técnicos DGIIA/IT/147. 84 p.
- Seijas, A.E. 1984b. Estimaciones Poblacionales de Babas (Caiman crocodilus) en los Llanos Occidentales de Venezuela. MARNR Serie Informes Técnicos. DGIIA/IT/165. 23 p.
- Seijas, A.E. (Este volúmen). Situación Actual del Caimán de la Costa. (Crocodylus acutus) en Venezuela.

TABLA 1

NUMERO DE CAIMAN CROCODILUS MAYORES DE UN AÑO, CONTADOS  
EN CINCO REPRESAS DE LA REGION NORTE-COSTERA DE VENEZUELA

Localidad	Distancia Recorrida (Km)	Nº Individuos contados	Ind/Km	Fecha
Represa de Tulé (Estado Zulia)	29,1	240	8,2	15 y 17-6-84
Represa de Socuy (Estado Zulia)	37,4	191	5,1	16-6-84
Represa de Pueblo Viejo (Estado Zulia)	30,3	60	2,0	13-6-84
Represa de Tacarigua (Estado Falcón)	15,0	63	4,2	25-4-84
Represa de Cumaripa (Estado Yaracuy)	32,0	276	8,6	20-6-84

Nota: La "Distancia Recorrida", se refiere al perímetro interno de estos embalses. En las represas de Pueblo Viejo, Tacarigua y Cumaripa, los recorridos abarcaron todo el perímetro. En los embalses de Tulé y Socuy la distancia recorrida sólo representó la mitad y la tercera parte, respectivamente, de los perímetros de estos cuerpos de agua.



TABLA 2

NUMERO DE CAIMAN CROCODILUS MAYORES DE UN AÑO, CONTADOS EN RIOS Y CAÑOS DE LA REGION NORTE-COSTERA DE VENEZUELA

Localidad	Distancia Recorrida (Km)	Número Individuos Contados	Ind/Km	Fecha
<u>Estado Zulia</u>				
Río El Cristo	4,0	46	11,5	18-6-84
<u>Estado Falcón</u>				
Río Sanare	0,3	59	196,6	29-4-84
Río Tocuyo				
Sector A.	11,0	23	2,1	23-8-84
Sector B.	5,5	4	0,7	23-8-84
Río Aroa				
Sector A.	14,6	52	3,6	26-1-84
Sector B.	36,6	37	1,0	22-8-84
<u>Estado Yaracuy</u>				
Caño El Eneal	3,0	66	22,0	25-1-84
Río Yaracuy				
Sector Boca Eneal-Limoncito	3,3	27	8,3	25-1-84
Sector B.	6,0	7	1,2	16-5-84
Sector D.	13,2	3	0,2	7-8-84
<u>Estado Anzoátegui</u>				
Río Unare	25,0	658	26,3	25-3-84
Río Neverí				
Sector Pte.Sucre Pte.La Volca	5,3	11	2,1	19-7-84
Sector INOS-Puente Naricual	14,8	13	0,9	23-7-84

Nota: Los sectores mencionados para los ríos Tocuyo, Aroa y Yaracuy, aparecen señalados en la Figura 1.

TABLA 3

NUMERO DE INDIVIDUOS DE MAS DE UN AÑO, DE CAIMAN CROCODYLUS Y CROCODYLUS ACTUS  
 EN LOCALIDADES DE LA REGION NORTE-COSTERA DE VENEZUELA DONDE AMBAS ESPECIES  
 COEXISTEN

Localidad	Distancia Recorrida (Km)	<u>C. crocodilus</u>		<u>C. acutus</u>		Ambas especies	
		Nº Ind.	Ind/Km	Nº Ind.	Ind/Km	Nº Ind.	Ind/Km
Represa de Pueblo Viejo	30,3	60	1,98	31	1,02	91	2,96
Represa de Tacarigua	15,0	63	4,20	4	0,27	67	4,47
Río Tocuyo. Sector A	11,0	23	2,09	8	0,73	31	2,82
Río Tocuyo. Sector B	5,5	4	0,73	9	1,64	13	2,36
Río Aroa. Sector A	14,6	52	3,56	11	0,75	63	4,30
Río Aroa. Sector B	36,6	37	1,01	56	1,53	106*	2,90
Río Yaracuy. Sector B	6,0	7	1,16	21	3,50	28	4,70
Río Yaracuy. Sector D	13,2	3	0,23	35	2,65	43*	3,26

\* Estas cifras incluyen a individuos observados para los cuales no se pudo establecer si se trataba de Caiman crocodilus o Crocodylus acutus.

LA ECOLOGIA Y EL ESTADO ACTUAL DE LOS ALIGATORIDOS  
DE LA GUAYANA VENEZOLANA

Stefan Gorzula  
División de Cuencas e Hidrología  
CVG Electrificación del Caroní, C.A.  
Apartado 62413, Caracas

y

Alfredo Paolillo O.  
Instituto de Zoología Tropical  
Universidad Central de Venezuela  
Apartado 47599 Chaguaramos 1041-A  
Caracas

SUMMARY

Three species of alligatorids are found in the Venezuelan Guiana region, whose geographical distributions cover most of this zone. Caiman crocodilus occurs in a variety of aquatic habitats, with mean densities of 23.42 individuals (older than two years)/kilometer of shore-line in lagoons and 2.52 individuals/kilometer in riverine habitat. Paleosuchus trigonatus is apparently restricted to riverine habitats with mean densities of 0,79 individuals/kilometer. The lack of ecological data for Paleosuchus palpebrosus does not permit an objective analysis for this species. Localities for Caiman crocodilus and Paleosuchus palpebrosus were registered upto altitudes below 400 meters. Paleosuchus trigonatus, however, were found upto 1,300 meters. There is no evidence, at the present time, of any significant negative impact by man on these species in the Venezuelan Guiana. In fact, it is considered that cattle ranching activities have produced an increase in the available habitat in the case of Caiman crocodilus.

## Introducción

Después de la progresiva disminución de los Crocodylidae en Venezuela, la familia Alligatoridae está sujeta a cierta presión humana en determinadas regiones del país. Desde este punto de vista, se hace indispensable conocer las bases ecológicas de las especies involucradas.

La Región Guayana de Venezuela ofrece varias ventajas para el estudio de los aligatóridos, debido a los niveles bajos de población humana, a las restringidas posibilidades de acceso y a los extensos habitats que aún se encuentran en estado natural.

En este trabajo estamos considerando a la Región Guayana de Venezuela desde un punto de vista biogeográfico y su delimitación comprende, aproximadamente, la "Subregión Meridional" de Roze (1966), la cual incluye el Territorio Federal Amazonas, el Estado Bolívar, el Territorio Federal Delta Amacuro, la región oriental del Estado Monagas y el extremo sureste del Estado Sucre.

El propósito de este trabajo es el de suministrar un resumen diagnóstico sobre los aspectos poblacionales más resaltantes de los aligatóridos en dicha región y su significado en el contexto ecológico.

## Material y Métodos

La base evaluativa de la distribución geográfica de los aligatóridos en la región ha sido fundamentada en: (1) la revisión de los ejemplares depositados en colecciones venezolanas (Estación Biológica de Rancho Grande, EBRG; Museo de Biología de la Universidad Central de Venezuela, MBUCV y Museo de Historia Natural La Salle, MHNLS; (2) la información recopilada en algunas colecciones internacionales (American Museum of Natural History, AMNH; University of Illinois Museum of Natural History, UIMNH y United States National Museum, USMN; (3) el análisis crítico de los datos suministrados por autores previos y (4) nuestras observaciones de campo. Se han eliminado de toda consideración las localidades previamente reportadas basadas en referencias orales no comprobadas por el investigador, como la mayor parte de las localidades de Godshalk (1982) para Paleosuchus. También se ha prescindido de las localidades que no hacen alusión a la fuente de origen, como algunos datos de Medem (1983) para Caiman crocodilus y de informaciones erróneas como la presencia de Paleosuchus palpebrosus en Uruguay, basada en una confusión de Medem (1983) al emplear el reporte de Paleosuchus trigonatus en esa región, hecho por Roze (1958).

En la actualidad no existe una metodología estandarizada para realizar censos de Crocodylia. Gorzula (1978), sin diferenciar entre adultos, sub-adultos y crías, expresó densidades poblacionales de Caiman crocodilus en términos de "caimán/m<sup>2</sup> de laguna permanente" y "caimán/m<sup>2</sup> de laguna temporal", señalando que la superficie disponible para esta especie se reduce a una décima parte durante la estación seca de la zona bajo estudio. Este estimado es apto para lagunas donde se sospecha que toda la superficie es utilizable por los Crocodylia. Sin embargo, en lagos grandes y ríos donde los Crocodylia están restringidos a la orilla, la densidad poblacional debería expresarse en base al número de "individuos/kilómetro lineal de orilla". Debe hacerse énfasis en que en ríos angostos y riachuelos las poblaciones de cada orilla no están separadas entre sí, pero el ancho "crítico" aún es desconocido.

Para la finalidad de este trabajo se presentan densidades poblacionales calculadas en base a individuos observados y por lo tanto son densidades que muy probablemente subestiman las densidades reales. La mayoría de los conteos fueron nocturnos, ya que las especies estudiadas muestran mayor actividad durante la noche. Las cifras presentadas excluyen individuos menores de dos años, es decir, agrupaciones ("pods") de juveniles o crías. En el caso de conteos en base a superficie de habitat, se convirtió cada cifra en una densidad lineal, con la premisa que cada cuerpo de agua fuese circular. Cuando se indica un tipo de habitat "río completo" (Tabla 3) se hace alusión a que fueron incluidos aligatóridos de ambas orillas del río en el censo. En el caso de "orilla" se refiere a que el censo corresponde a una sola ribera del río.

#### Sinopsis de las Especies

En la Región Guayana de Venezuela, los aligatóridos están representados por tres especies conocidas, Caiman crocodilus (Baba común, Baba blanca, Baba amarilla), Paleosuchus palpebrosus (Babo negro, Babo morichalero) y Paleosuchus trigonatus (Babo negro), aunque Donoso-Barros (1966a, 1966b) incluyó una cuarta especie Melanosuchus niger.

Sobre la presencia de Melanosuchus niger en Venezuela deben hacerse algunas aclaratorias importantes. En la cita original de la especie para el país, Donoso-Barros (1966a) afirmó que la única localidad segura era el Río Negro y señaló que el único ejemplar venezolano que estudió procedió del sur del Cocuy (1966b). Es evidente la ambigüedad e imprecisión del mencionado autor con respecto a la procedencia exacta del ejemplar. En las colecciones de Venezuela (y aparentemente del resto del mundo, a juzgar por la información dada por Medem, 1983) no existe ningún ejemplar venezolano de la especie y puede ser estimado que el ejemplar de Donoso-Barros acaso procedió de Brasil, pues Cocuy también es el nombre de un pueblo del Río Negro en territorio brasileño. Si el mencionado Cocuy estaba referido a la localidad venezolana, el sitio de colección de todas maneras parece haber sido brasileño, pues el sur de dicha localidad corresponde ya a la frontera entre ambos países. La existencia de Melanosuchus niger en Venezuela no ha podido ser confirmada por nosotros hasta el presente, a pesar de los esfuerzos de campo invertidos durante varios años en el Territorio Federal Amazonas y en el Estado Bolívar, incluyendo ríos como el Negro y el Cuyuní, en los cuales podría presumirse su presencia, tomando en cuenta la distribución de la especie en Brasil y Guayana reseñada por Medem (1983).

En vista de estas consideraciones, recomendamos aceptar que Melanosuchus niger es una especie que hasta el momento no se conoce de Venezuela, si bien su presencia en este país no debe ser descartada del todo. El presente trabajo, en consecuencia, se referirá exclusivamente a los géneros Caiman y Paleosuchus en la Región Guayana de Venezuela.

#### Distribución Geográfica

Se han obtenido 68 localidades para Caiman crocodilus, 12 para Paleosuchus palpebrosus y 24 para Paleosuchus trigonatus, distribuidas en las hoyas orinoquense y atlántica de Guayana (ver Anexo). Otras 5 localidades para Paleosuchus palpebrosus y una para P. trigonatus en el resto del país se han incorporado al análisis de la distribución, tomando en cuenta la carencia de información sobre este género en Venezuela.

En general, las tres especies siguen patrones similares, estando presentes desde el Alto Orinoco hasta su desembocadura en el Delta y áreas de influencia atlántica (Figuras 1, 2 y 3). No obstante, la visión actual de la distribución geográfica continúa siendo fragmentaria y se hacen obvias ciertas regiones en las cuales no se dispone de casi ningún dato:

- a) La comprendida entre la porción izquierda de la cuenca del Río Caroní (Estado Bolívar) y la cuenca del Río Sipapo (Territorio Federal Amazonas).
- b) El Delta del Río Orinoco (Territorio Federal Delta Amacuro) y regiones vecinas a la costa atlántica (Estados Sucre y Monagas).
- c) Todas las regiones altas en las cuencas de los ríos Caroní y Caura (Estado Bolívar), Ventuari y Alto Orinoco (Territorio Federal Amazonas).

#### Habitat

El habitat más frecuentemente utilizado por Caiman crocodilus en la región es de tipo lagunar (natural o artificial; Tabla 1). Es realmente difícil ubicar un ambiente de este tipo que no esté habitado por la especie en las sabanas del norte del Estado Bolívar, donde inclusive es encontrada ocasionalmente en charcos temporales producidos por las lluvias (Gorzula, 1978). Los ríos que atraviesan sabanas y bosques también son ambientes habitados por C. crocodilus y en ellos ocasionalmente puede ser simpátrica con ambas especies de Paleosuchus. En tales casos, Caiman crocodilus casi siempre es menos abundante, pero se ignora si esta proporción o la simpatria misma son estables durante los dos períodos estacionales. Aunque la Tabla 2 sugiere que Caiman crocodilus es una especie de tierras bajas, debe ser tomado en consideración que actualmente existe una desproporción en cuanto al esfuerzo de campo desde el punto de vista altitudinal, la cual favorece a las tierras bajas. Esta suposición se ve soportada por una localidad de C. crocodilus en el Río Kukenán (Estado Bolívar; ver Anexo), el cual drena en una cota altitudinal mínima de 800 metros.

Tanto Paleosuchus palpebrosus como P. trigonatus ocupan principalmente los cursos de agua de la región, incluyendo desde grandes ríos hasta pequeños morichales y quebradas; cuerpos de agua artificiales también son ocasionalmente habitados (Tabla 1). Pueden ser simpátricos, aunque lo más frecuente en nuestras observaciones ha sido la situación contraria. Medem (1967) se refirió a este fenómeno y a las diferencias en abundancia relativa de estas especies en distintos habitats de la Amazonia de Colombia. La afirmación de que estas especies en habitan en zonas de agua torrentosas y en los ríos grandes en zonas de raudales (Medem, 1967) no es del todo cierta, al menos en la Guayana Venezolana. Este tipo de habitat suele ser ocupado por P. trigonatus, pero la especie también está presente en caños pequeños de aguas tranquilas. Según nuestras evidencias, entre estas especies parece existir una separación parcial de habitats a nivel altitudinal, pues P. trigonatus alcanza al menos elevaciones de hasta 1.300 metros en la Gran Sabana (Estado Bolívar), mientras P. palpebrosus parece restringirse a alturas

bastante inferiores (Figura 4). Sin embargo, Medem (1981) registró un ejemplar de P. palpebrosus a 750 metros de altura en Colombia y la Región Guayana de Venezuela aún no ha sido suficientemente cubierta desde este punto de vista, todo lo cual sugiere que el uso altitudinal del habitat aún no es bien conocido aquí.

#### Estimaciones de Densidades Poblacionales

Los resultados para las estimaciones de densidades poblacionales se presentan en la Tabla 3. De las tres especies de aligatóridos conocidas para la Guayana Venezolana, Paleosuchus palpebrosus aparentemente es tan escasa y restringida a habitats aún no muy bien definidos que resulta imposible discutir respecto a su densidad poblacional. De las dos especies restantes, Caiman crocodilus muestra densidades poblacionales mayores que Paleosuchus trigonatus. Al expresar las densidades de Caiman crocodilus en habitats lagunares como densidades "lineales" puede apreciarse que en este habitat la especie alcanza su densidad máxima.

Aún cuando las densidades reportadas están basadas en individuos observados, se considera que estas cifras se acercan a las densidades verdaderas de las poblaciones estudiadas. A través de varios años de experiencia de campo se ha llegado a las conclusiones siguientes:

- a) Los conteos nocturnos deben realizarse durante noches nubladas, sin lluvia y cuando la luna es poco evidente.
- b) En los habitats lagunares los conteos deben realizarse durante los principios de la estación lluviosa, cuando las babas están plenamente utilizando las orillas que aún no han sido cubiertas por el resurgimiento de la vegetación marginal.
- c) Los ambientes ribereños deben censarse cuando el nivel del agua es suficientemente bajo como para permitir una visión ininterrumpida de la orilla.

En estas estimaciones individuos menores de dos años fueron excluidos. Estamos de acuerdo con Magnusson (1983) con respecto a las estimaciones de densidades poblacionales en Crocodylia tienen poco sentido si no se sabe la distribución de edades en la población. Para tratar de desarrollar una metodología con esta finalidad, Gorzula (1984) ha propuesto un método fotográfico para la estimación de los tamaños corporales en este grupo.

#### El Efecto Humano sobre los Aligatóridos

En esta sección se consideran seis interacciones básicas del hombre con los aligatóridos:

1. Cacería Comercial: Desde el año 1973 hasta septiembre de 1984 los aligatóridos de la Guayana Venezolana no han estado sujetos a una explotación comercial legal. Gorzula (1978) consideró posible que la ausencia aparente de dos clases de edades de Caiman crocodilus en la zona de El Manteco (Estado Bolívar) podía motivarse a la cacería comercial durante los años 1972 y 1973. Tenemos reportes no confirmados de exportaciones ilegales de cueros de Crocodylia desde el Territorio Federal Delta Amacuro hacia Trinidad y Guayana.

2. Cacería de Subsistencia por Indígenas: Referencias antropológicas alusivas al papel de los aligatóridos en el Territorio Federal Amazonas (Hames, 1979; Lizot, 1979) indican que la importancia de los mismos como especies de sustento no es homogénea. Según Hames (op. cit.), los aligatóridos constituyen el renglón más importante de la dieta relacionada con la cacería de animales silvestres (30% del peso total de las especies cazadas) entre los indios Ye 'kwana del Río Padamo, durante un estudio de 216 días efectivos de cacería. En el mismo lapso, los aligatóridos solamente representaron el 2% del total para los Yanomamo en la misma localidad. Sin embargo, el peso total de las especies aligatóridas cazadas puede alcanzar valores más elevados en otras localidades habitadas por la etnia Yanomamo (un sexto lugar entre catorce renglones de cacería estudiados por Lizot, op. cit.). Según Hames (op. cit.), la apreciable diferencia entre Ye 'kwana y Yanomamo respecto al valor que le asignan a los aligatóridos como piezas de consumo, se explica por el mayor contacto de la primera tribu con la población criolla (lo que permite que empleen tecnologías de cacería más efectivas) y por sus típicos hábitos de cacería fluvial.

Registros mensuales de la cacería de fauna silvestre realizada en una población de 350 indígenas de la etnia Pemón en el Estado Bolívar, mostraron 30 aligatóridos cazados durante 36 meses representando 2,5% del peso total de la cacería (Ojasti, Febres y Cova, en prensa).

3. Cacería de Subsistencia por Criollos: A pesar de haber viajado ampliamente en la Región Guayana durante unos diez años, ninguno de los dos autores ha visto carne de aligatóridos de venta en las ciudades y pueblos de esta zona, ni ha encontrado dicho alimento servido en restaurantes o casas particulares. En las zonas más alejadas, los aligatóridos son piezas para campesinos, mineros, madereros e indios transculturados. Aunque este tipo de cacería usualmente es ejercida por necesidad y facilidad y no por especial predilección, bajo ciertas circunstancias se ha observado cacería de aligatóridos con una intensidad de hasta un ejemplar diario.

4. Cacería Etnozoológica: Ciertas especies de reptiles están sujetas a una cacería ocasional por parte de los campesinos del Estado Bolívar para la fabricación de "remedios". Entre ellas figuran el mato de agua (Tupinambis nigropunctatus), empleado contra el dolor de muelas y empenzoñamientos; la morrona (Amphisbaena alba) para reumatismo y el caimán de Orinoco (Crocodylus intermedius), cuyos huevos se solicitan para el asma. Sin embargo, no tenemos informaciones ni parecen existir usos parecidos en el caso de los aligatóridos.

5. Modificación de Habitat: La destrucción de habitats naturales que afectarían a los aligatóridos en la Región Guayana puede considerarse inexistente, con excepción de la creación del Lago de Guri, cuyo fin es la producción de hidroelectricidad. El lago existe desde 1969 e inundó unos 800 km<sup>2</sup> de sabanas y bosques al alcanzar la cota 216. Indudablemente, el lago eliminó numerosos ambientes lagunares y ribereños, los cuales seguramente albergaban poblaciones de aligatóridos. Muestreos realizados en varios puntos de la orilla del lago han indicado que esta orilla ha sido colonizada por Caiman crocodilus. Un solo conteo nocturno dio una densidad poblacional de 3,75 individuos/km de orilla. Para 1986 se prevee que el lago alcanzará la cota final de 270 msnm y tendrá una superficie de 4.300 km<sup>2</sup>. La orilla del nuevo lago tendrá unos 2.167 kilómetros, sin incluir las orillas de más de 100 islas, las cuales variarán en superficie desde unas hectáreas hasta más de mil. Si el



nuevo lago es biológicamente semejante al primero su orilla albergará varios miles de Caiman crocodilus. Por lo tanto, resulta poco claro si el efecto neto del Lago de Guri sobre los aligatóridos ha sido del todo negativo.

La mortalidad de aligatóridos causada por la construcción de carreteras interrumpiendo sus rutas migratorias ha sido cuantificada parcialmente por Gorzula y Medina-Cuervo (datos inéditos). Desde Mayo 1979 hasta Julio 1980 los mencionados autores registraron 2 individuos muertos de C. crocodilus en la carretera Ciudad Guayana-Upata (56 kilómetros), durante 79 recorridos de ida y vuelta, 19 individuos muertos en la carretera Upata-Terecay (68 kilómetros), durante 199 recorridos sencillos y 5 individuos muertos en la carretera Terecay-El Manteco (16 kilómetros), durante 99 recorridos sencillos. Sin embargo, la mayoría de estos individuos aparentemente provenían de lagunas artificiales adyacentes a las carreteras creadas durante la construcción de las mismas.

Las intervenciones humanas relacionadas con actividades agropecuarias en la región sabanera y zonas adyacentes del Estado Bolívar, han producido numerosos ambientes acuáticos (tapones, reservorios, lagunas de rebalse, y lagunas de préstamo), las cuales han sido colonizadas por aligatóridos (principalmente Caiman crocodilus). Se sospecha que durante este siglo dichas actividades han propiciado un aumento significativo de los aligatóridos en esta zona.

6. Actitud Cotidiana hacia los Aligatóridos: Ya que las tres especies de aligatóridos presentes en la Región Guayana son relativamente pequeñas y generalmente no causan molestias a los lugareños ni a sus animales domésticos, la actitud general de la gente es de una apreciable indiferencia. Gorzula (1978) reportó un caso de un niño de 12 años que fue atrapado por un Caiman crocodilus y cuyas heridas requirieron 50 puntos de sutura. Este accidente ocurrió en una laguna de préstamo al lado de la alcabala de la Guardia Nacional del pueblo. Es significativo que nadie trató de matar a la baba y la gente continuó bañándose periódicamente en este cuerpo de agua. Este ejemplo constituye una prueba evidente de la actitud indiferente de los lugareños hacia los aligatóridos.

#### La Protección Legal de los Aligatóridos en Venezuela

Las tres especies de aligatóridos reportadas para la Guayana Venezolana están incluidas en la Lista Oficial de Animales de Caza (Ministerio de Agricultura y Cría - Recursos Naturales Renovables, Resolución 5-276, 13-11-70). Sin embargo, tanto Paleosuchus palpebrosus como P. trigonatus se encuentran en situación de veda por tiempo indefinido (Ministerio del Ambiente y de los Recursos Naturales Renovables, Resolución Nº 95, 25-11-79).

El Territorio Federal Amazonas y el Territorio Federal Delta Amacuro han sido excluidos de la cacería experimental de Caiman crocodilus, permitida hasta el presente en la región llanera (Ministerio del Ambiente y de los Recursos Naturales Renovables, Resolución 445, 14-12-82).

Respecto a la conservación de habitats naturales, más de 23 millones de hectáreas se encuentran bajo régimen especial en la Guayana de Venezuela. (Figura 4). No es el propósito de este trabajo discutir a fondo el contenido de la legislación de tales áreas. Sin embargo, a continuación se definen los conceptos fundamentales de las tres categorías básicas:

1. PARQUES NACIONALES: "las regiones establecidas para la protección y conservación de las bellezas escénicas naturales y de la flora y la fauna de importancia nacional, de las que el público pueda disfrutar mejor al ser puestas bajo vigilancia oficial" (Gaceta Oficial de Venezuela 20643, 13-11-43).
2. RESERVAS NACIONALES: "Las regiones establecidas para la conservación y utilización, bajo vigilancia oficial, de las riquezas naturales, en las cuales se dará a la flora y la fauna toda protección que sea compatible con los fines para los que son creadas estas reservas". Gaceta Oficial de Venezuela 20643, 13-11-43).
3. ZONAS PROTECTORAS: Artículo 19 de la Ley Forestal de Suelos y Aguas (Gaceta Oficial 1004E, 26-1-66) "En las zonas declaradas protectoras por disposición de la Ley o por Decreto Ejecutivo, no se podrá efectuar labor de carácter agropecuario o destrucción de vegetación sino en los casos previstos por el Reglamento y con sujeción a las normas técnicas que determine el Ministerio de Agricultura y Cría. En el Reglamento se determinará además la forma como podrán ser utilizadas las zonas protectoras para instalaciones de utilidad pública".

#### Discusión

Algunos autores (Medem, 1967; Magnusson, 1982) se han referido a conteos puntuales de aligatóridos en la Amazonia de Colombia y Brasil, respectivamente. A pesar de que la Región Guayana de Venezuela puede ser considerada como componente de la Amazonia (en el sentido amplio del término biogeográfico), las aproximaciones de las densidades poblacionales de las tres especies estudiadas en este trabajo no pueden ser directamente comparadas con las cifras indicadas en esos trabajos. Esto es debido a las distintas metodologías y a las variaciones de los habitats, que como se sabe se traducen en diferencias de la abundancia poblacional en este grupo.

La baja densidad poblacional humana en el Territorio Federal Amazonas (0,12 habitantes/km<sup>2</sup>, CODESUR 1979) hace pensar que la presión global de mortalidad ejercida sobre Caiman y Paleosuchus no es muy importante, aunque extinciones o disminuciones de estos grupos en zonas fluviales muy próximas a los asentamientos indígenas son conocidas (Hames, 1979). En el norte del Estado Bolívar el impacto neto de las actividades humanas parece haber aumentado el habitat disponible para los aligatóridos, en particular Caiman crocodilus.

En resumen podemos decir que Caiman y Paleosuchus en la Región Guayana de Venezuela no muestran síntomas de peligro respecto a su situación poblacional y futura sobrevivencia, siempre y cuando esa vasta región continúe enfrentando el mismo tipo de desarrollo humano y económico que hasta el presente.

## Agradecimientos

Los autores agradecen a las siguientes personas e instituciones por su contribución en el Desarrollo del presente trabajo: Alí Acuña, Eduardo Alvarez, Carmen Luisa Arocha de Piñango, Luis Arredondo, Lionel Arteaga, José Ayarzagüena, Atilano Azuaje, Luis Balbás, Oreste Balbás, Charles Brewer Carías, Randy Calender, Jimmy Capriles, Julio Cerda, Ramón Elosegui, Asterio Farrera, Saúl Fayola, Doña Sofía Fernández, Carlos Galán, Joseva Gorbea, Manuel Guzmán, Donald Hoffmeister, Gerardo Hoogesteijn, John Hutchins, John Junor, Ventura León, Glenda Medina Cuervo, Francesco Misticoni, Kendal Mitchell, Jesús Morales, Carlos Morillo, Klaus Muller, Juhani Ojasti, Pedro Piñate, Apacacio y Erika Quintero, Desiderio Rendón, Ricardo Riveroll, Ramón Rivero, F. Sayalero, José Miguel Tagliafico, Carlos Todd, Rudi Tuffino, Gerardo y Karen Van Dulken, José Vargas, Paulisto William y Richard Zweifel; Departamento de Medicina Experimental del Instituto Venezolano de Investigaciones Científicas, Consejo Nacional para Investigaciones Científicas y Tecnológicas (subvención CONICIT SI 0168), División de Fauna y Zona 10 del Ministerio del Ambiente y de los Recursos Naturales Renovables, Fundación para el Desarrollo de las Ciencias Físicas, Matemáticas y Naturales, División de Desarrollo Social y Cultural de la Corporación Venezolana de Guayana y División de Cuencas e Hidrología de CVG Electrificación del Caroní, C.A., Servicio de Fauna Silvestre (MARNR).

## Bibliografía

CODESUR (1979)

Atlas de la Región Sur.  
Ministerio del Ambiente y de los Recursos Naturales Renovables.  
Caracas, Venezuela: 1-67.

Donoso-Barros, R. (1966a)

Contribución al conocimiento de los cocodrilos de Venezuela  
(continuación).  
Physis XXVI (71): 15-32.

Donoso-Barrios, R. (1966b)

Contribución al conocimiento de los cocodrilos de Venezuela  
(conclusión).  
Physis XXVI (72): 263-274.

Godshalk, R. (1982)

The habitat and distribution of Paleosuchus in Venezuela.  
Proc. 5th. Working Meeting of the Crocodiles Specialist Group  
(IUCN), Gainesville, Estados Unidos: 31-38.

Gorzula, S.J. (1978)

An Ecological Study of Caiman crocodilus crocodilus Inhabiting  
Savanna Lagoons in the Venezuelan Guayana.  
Oecologia (Berl.) 35: 21-34.

Gorzula, S. (1984)

Proposal for a photographic method for size estimates of  
crocodilians.  
Herpetological Review 15 (2): 38-39.

- Hames, R. (1979)  
A comparison of the efficiencies of the shotgun and bow in Neotropical forest hunting.  
Human Ecology 7 (3): 219-252.
- Lizot, J. (1969)  
On food taboos and Amazonian cultural ecology.  
Curr. Anthropol. 20 (1): 150-151.
- Magnusson, W. (1982)  
Biological aspects of the conservation of Amazonian crocodiles in Brasil. Proc. 5th. Working Meeting of the Crocodiles Specialist Group.  
(IUCN), Gainesville, Estados Unidos: 108-116.
- Magnusson, W.E. (1983)  
Size Estimates of Crocodylians.  
J. Herpetol. 17: 86-88.
- Medem, F. (1967)  
El género "Paleosuchus" en Amazonia.  
Atas do Simpósio sobre a Biota Amazonica, vol. 3 (Limnología): 141-164.
- Medem, F. (1981)  
Los Crocodylia de Sur América. Volumen I (Los Crocodylias de Colombia).  
COLCIENCIAS, Bogotá, Colombia: 1-354.
- Medem, F. (1983)  
Los Crocodylia de Sur América (Volumen II).  
Universidad Nacional de Colombia y COLCIENCIAS.  
Bogotá, Colombia: 1-270.
- Ojasti, J., Febres G. y Cova, M. (en prensa)  
Consumo de fauna por una comunidad indígena en Estado Bolívar, Venezuela. IX Congreso Latinoamericano de Zoología.  
Arequipo. Perú, 1983.
- Roze, J.A. (1958)  
Resultados zoológicos de la expedición de la Universidad Central de Venezuela a la región de Auyantepui en la Guayana Venezolana, abril de 1956. 5. Los reptiles del Auyantepui, Venezuela, basándose en las colecciones de las expediciones de Phelps-Tate, del American Museum of Natural History, 1937-38, y de la Universidad Central de Venezuela, 1956.  
Acta Biol. Venez. 2 (22): 243-270
- Roze, J.A. (1966)  
La Taxonomía y Zoogeografía de los Ofidios de Venezuela.  
Edic. Biblioteca de la Universidad Central de Venezuela: 1-343
- Schmidt, K. (1928)  
Notes on South American Caimans  
Field Mus. Nat. Hist. Publ. (zool. ser.), Publ. 252, XII (17): 205-231.

TABLA 1

Cantidad de Localidades Discriminadas por Tipo de Habitat para las Especies de Aligat6ridos en la Guayana de Venezuela (seg6n Datos de Campo de los Autores).

Habitat	<u>Caiman</u> <u>crocodilus</u>	<u>Paleosuchus</u> <u>palpebrosus</u>	<u>Paleosuchus</u> <u>trigonatus</u>
R6os (incluye ca6os y morichales con curso de agua)	12	2	12
Lagunas naturales (incluye morichales con agua represada)	9	-	-
Terrestre (ambiente como sabana o bosque alejado del agua)	13	3	1
Grandes lagos artificiales (con centenares de hect6reas)	7	-	-
Lagunas artificiales (pr6stamo de carreteras y tapones)	15	-	-
Construcciones humanas (piscinas y otros sitios de construcci6n)	-	2	-
Total	<u>56</u>	<u>7</u>	<u>13</u>

TABLA 2

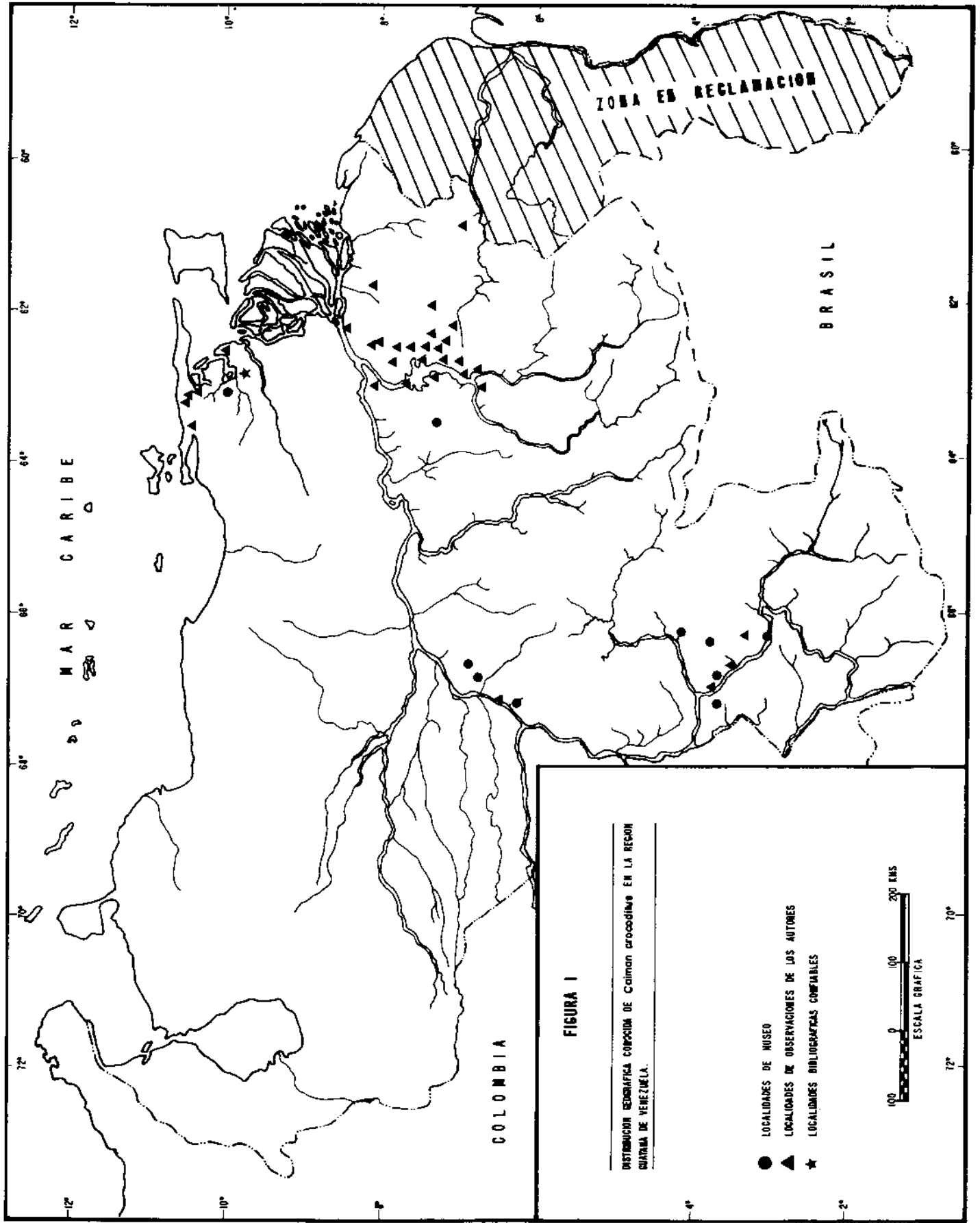
Cantidad de Localidades Discriminadas por Altitud para las Especies de Aligat6ridos en la Guayana de Venezuela (seg6n Datos de Campo de los Autores)

Especie	Altitud (metros sobre nivel del mar)													
	0 a 100	101 a 200	201 a 300	301 a 400	401 a 500	501 a 600	601 a 700	701 a 800	801 a 900	901 a 1000	1001 a 1100	1101 a 1200	1201 a 1300	
<u>Caiman</u> <u>crocodilus</u>	8	2	39	1	-	-	-	-	-	-	-	-	-	
<u>Paleosuchus</u> <u>palpebrosus</u>	5	1	2	1	-	-	-	-	-	-	-	-	-	
<u>Paleosuchus</u> <u>triconotus</u>	2	6	-	1	-	-	-	-	6	-	-	-	1	

TABLA 3

Densidades Poblacionales de Aligat6ridos en la Guayana Venezolana.

Numero Observado	Tipo de Censo	Habitat	Area de Habitat (Ha.)	Densidad por 6rea (N/Ha.)	Longitud de Habitat (km)	Densidad lineal (N/km)
<u>Caiman crocodilus</u>						
5	nocturno	laguna	0,50	10,00	0,25	20,00
15	nocturno	laguna	3,00	5,00	0,61	24,59
25	nocturno	laguna	3,00	8,33	0,61	40,98
3	nocturno	laguna	0,50	6,00	0,25	12,00
2	nocturno	lago	0,20	10,00	0,16	12,50
5	nocturno	laguna	0,10	50,00	0,11	45,45
3	nocturno	laguna	0,10	30,00	0,11	27,27
12	nocturno	laguna	1,00	12,00	0,35	34,29
7	nocturno	laguna	2,00	3,50	0,50	14,00
8	nocturno	laguna	1,00	8,00	0,35	22,86
4	nocturno	laguna	2,00	4,00	0,50	8,00
TOTAL	89	--	13,40	6,64	3,80	23,42
7	nocturno	r6o (completo)	--	--	10,00	0,70
15	nocturno	orilla de lago	--	--	4,00	3,75
2	nocturno	riachuelo	--	--	0,20	10,00
12	nocturno	morichal	--	--	0,08	150,00
TOTAL	36	--	--	--	14,28	2,52
<u>Paleosuchus palpebrosus</u>						
4	nocturno	r6o (completo)	--	--	2,00	2,00
<u>Paleosuchus trigonatus</u>						
3	diurno	r6o (completo)	--	--	0,50	6,00
4	diurno	r6o (completo)	--	--	8,00	0,50
3	diurno	r6o (completo)	--	--	1,00	3,00
4	diurno	r6o (completo)	--	--	15,00	0,27
16	nocturno	r6o (completo)	--	--	10,00	1,60
3	nocturno	ca6o	--	--	0,40	7,50
3	nocturno	r6o (orilla)	--	--	9,00	0,33
4	nocturno	r6o (orilla)	--	--	14,00	0,29
3	nocturno	r6o (completo)	--	--	5,20	0,58
3	nocturno	r6o (completo)	--	--	14,70	0,20
TOTAL	46	--	--	--	77,80	0,79



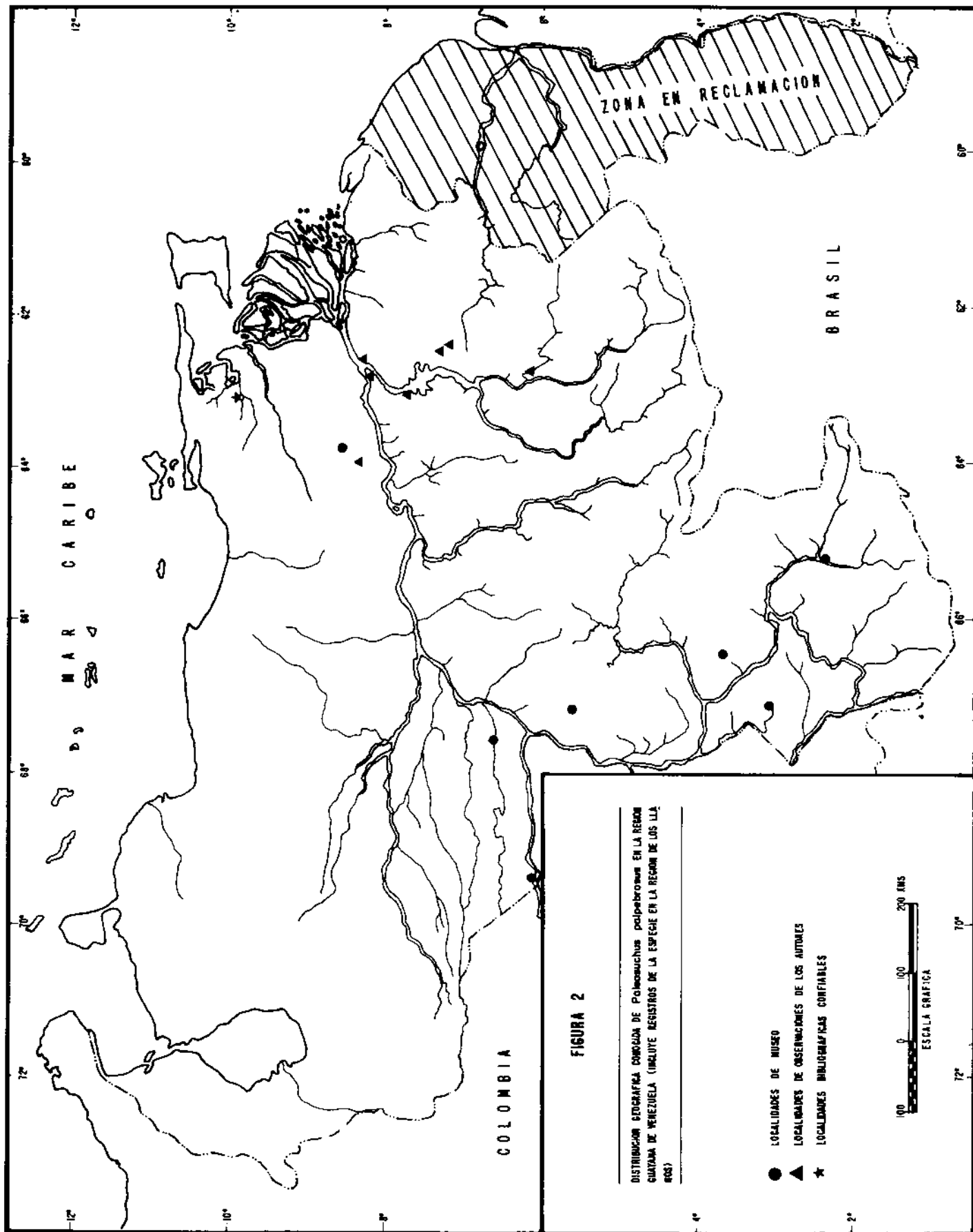


FIGURA 2



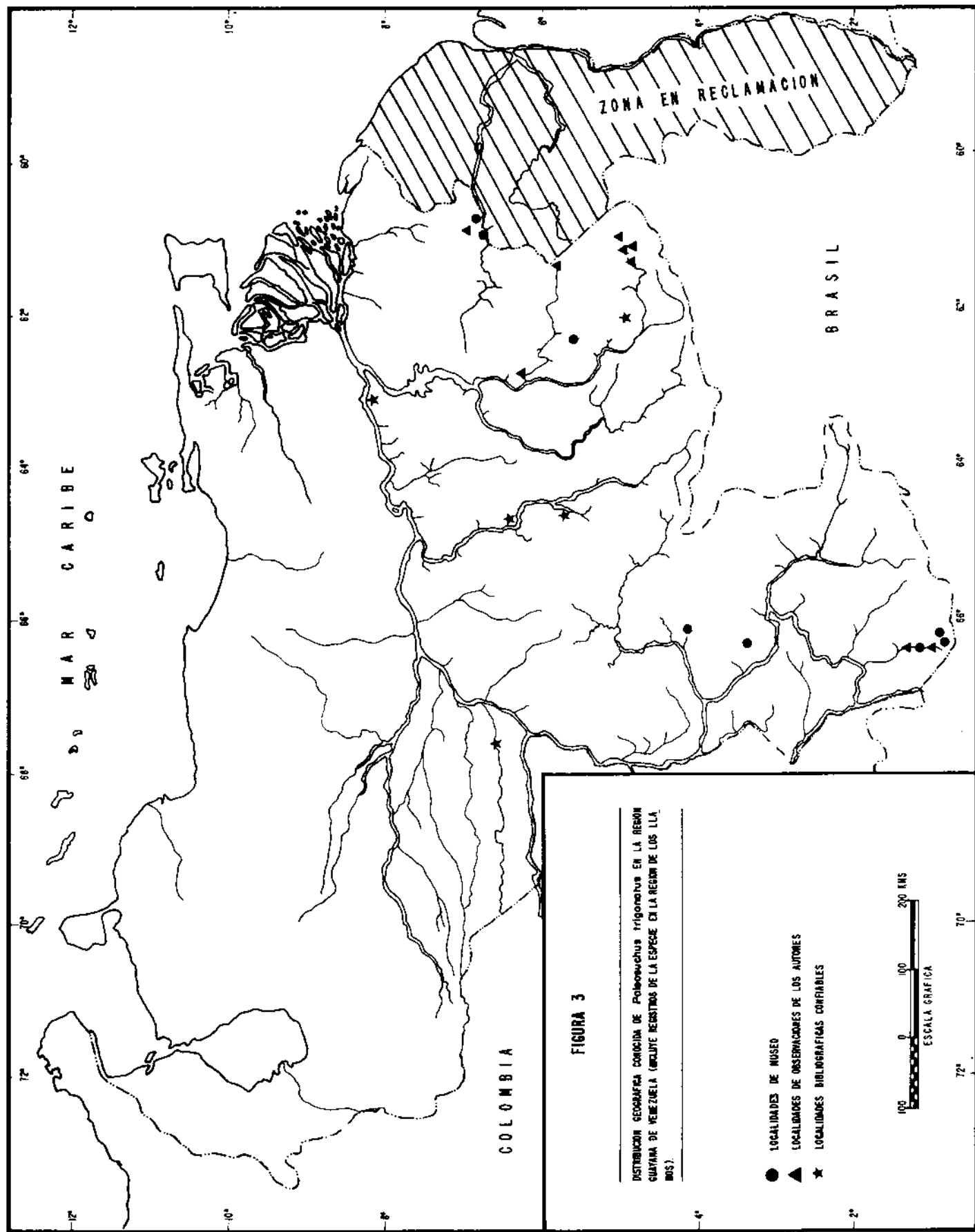
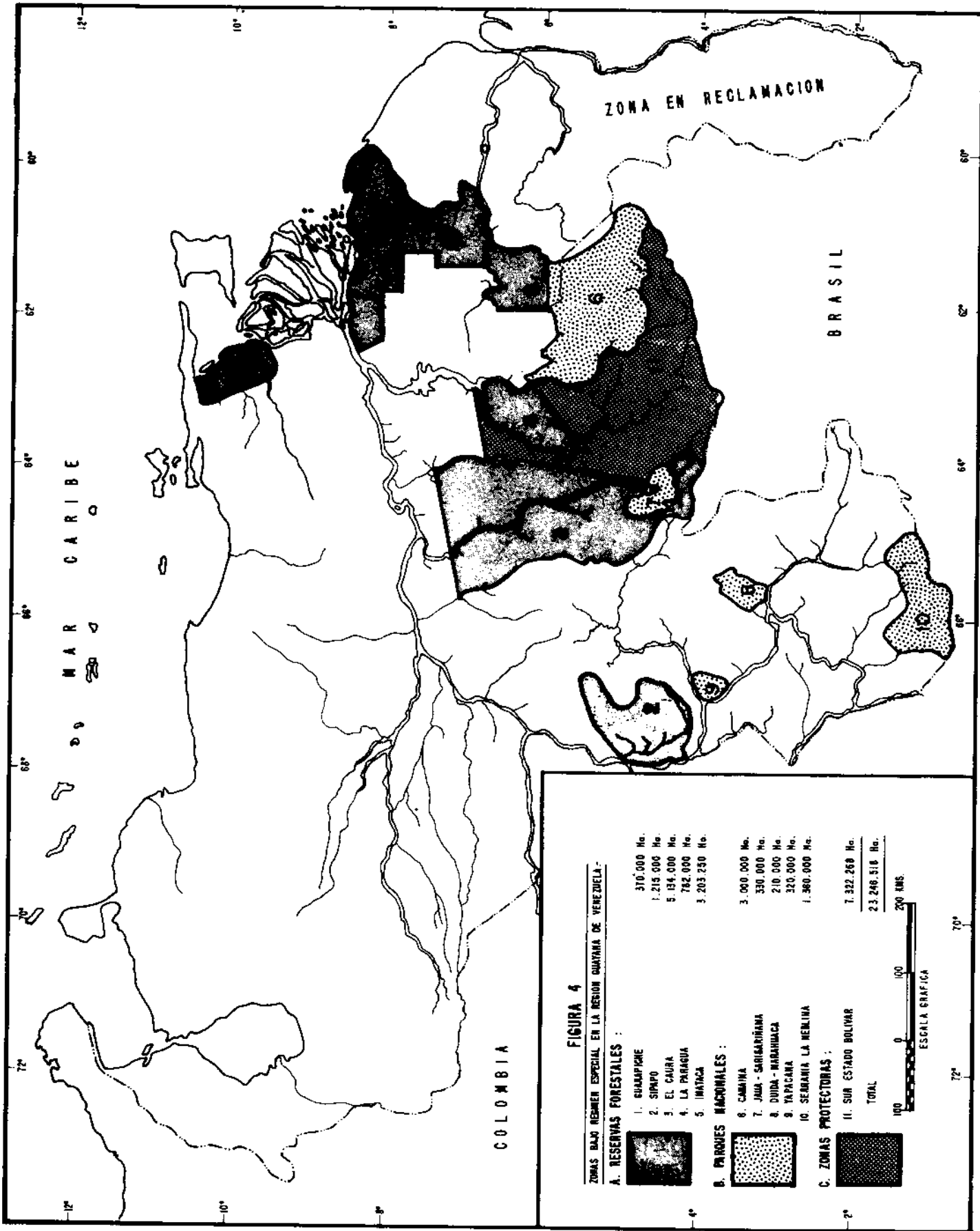


FIGURA 3

DISTRIBUCION GEOGRAFICA CONOCIDA DE *Polioptila trigonatus* EN LA REGION GUAYANA DE VENEZUELA (INCLUYE REGISTROS DE LA ESPECIE EN LA REGION DE LOS LLAIBOS).

- LOCALIDADES DE MUSEO
- ▲ LOCALIDADES DE OBSERVACIONES DE LOS AUTORES
- ★ LOCALIDADES BIBLIOGRAFICAS CONFIABLES



ANEXO:

Lista de las localidades para los géneros Caiman y Paleosuchus en la región Guayana de Venezuela (incluye las de Paleosuchus para la región llanera).

Caiman crocodilus

ESTADO BOLIVAR: Caño Maniapure (EBRG 4); Caño Tortuga (EBRG 11-19); Laguna marginal del Río Kukenan, Gran Sabana (EBRG 54-55); Boca de Parguaza, 06°26'N-67°09'W (MBUCV 193-194); Río Orinoco (UIMNH 91588-91589); 20 km W del Hato San José, La Paragua, 06°49'N-63°29'W (USNM 217260); Hato El Torete, Morichal Tirigua (MHNLS = \* ); Paviche, 07°19'N-62°44'W; Piedadpa, 07°23'N-62°33'W; Bombas Negras, 07°19'N-62°42'W; El Paraíso, 07°31'N-62°31'W; Terecay, 07°28'N-62°33'W; Hato Horizonte, 07°24'N-62°30'W; Hatos Las Maracas y El Diamante, 07°15'N-62°26'W; Hato La Yeguera, 07°22'N-62°23'W; Sistema Lagunar de Mapurite, 07°21'N-62°31'W; Villa Beina, 07°21'N-62°34'W; Hato Kamarapia, 07°20'N-62°26'W; Hato Milendri, 07°22'N-62°29'W; Río Botanamo, 06°54'W-60°55'W; Río Supamo, 06°59'N-62°23'W; Río Grande, este de El Palmar, 08°06'N-61°42'W; 30 km W de El Callao, 07°20'N-62°01'W; El Plomo, 06°55'N-62°50'W; Carretera San Félix/Upata km 25, 08°12'N-62°31'W; Carretera San Félix/Upata km 38, 08°04'N-62°29'W; 4 km al sur del km 70 vía Guri, 08°09'N-62°58'W; Danto Manchado, 07°24'N-62°52'W; Calceta del Perro, 07°05'N-63°43'W; Quebrada San Lufs, 07°14'N-62°45'W; Isla Periquera, 06°49'N-63°03'W; 8 km W de Periquera, 06°50'N-63°07'W; Sabana Calceta Larga, 07°16'N-62°35'W; 3 km sur casa Miguelón, 07°23'N-62°52'W; Sabana de Peñas Negras, 06°58'N-62°54'W; Cerro "W", 07°45'N-62°58'W; Hato Pele El Ojo, 07°52'N-62°42'W; Pele El Ojo Winche, 07°52'N-62°44'W; El Guácimo, 07°30'N-62°43'W; El Juajual, 07°18'N-62°37'W; Carretera Upata/El Manteco km 29 y 30, 07°49'N-62°30'W; Carretera Upata/El Manteco km 32, 07°47'N-62°30'W; Carretera Upata/El Manteco km 37, 07°45'N-62°31'W; Carretera Upata/El Manteco km 40 al 42, 07°43'N-62°32'W; Carretera Upata/El Manteco km 44 y 46, 07°41'N-62°33'W; Carretera Upata/El Manteco km 51 y 52, 07°38'N-62°32'W; Carretera Upata/El Manteco km 56, 07°35'N-62°32'W; Carretera Upata/El Manteco km 62 y 63, 07°32'N-62°32'W; Carretera Upata/El Manteco km 76 y 78, 07°24'N-62°32'W; Carretera Upata/El Manteco km 80 y 82, 07°22'N-62°32'W.

ESTADO MONAGAS: Caripito, 10°08'N-63°06'W (MBUCV 3713).

ESTADO SUCRE: Caño Ajíes, 4 km aguas abajo de Ajíes, 10°29'N-63°04'W; Vuelta Larga, sur de Guaraunos, 10°34'N-63°07'W; 4 km norte de Cariaco, 10°32'N-63°33'W; Caño La Brea, 10°12'N-62°48'W; Represa El Pilar, 10°35'N-63°14'W; Río San Juan (Donoso-Barros, 1965).

TERRITORIO FEDERAL AMAZONAS: Caño Yureba, 04°03'N-66°01'W (EBRG 1516-1517); Caño Cotua, Yacapana, 03°40'N-66°50'W (EBRG 1657); Caño Caname, 03°33'N-66°56'W (EBRG 1799, MBUCV 7030 ); Trucoapure, Río Orinoco, 03°01'N-66°17'W (EBRG 1800); Cerro Cucurito, Caño Yagua, 03°36'N-66°34'W (MBUCV 7031 ); Boca del Caño Perro de Agua, 03°46'N-67°02'W; Boca del Caño Yagua, 03°32'N-66°46'W; Río Puruname, 03°25'N-66°18'W.

TERRITORIO FEDERAL DELTA AMACURO: Caño Araguabisi, 09°21'N-60°56'W (MHNLS 994); Cerca de Los Guayos, 09°02'N-60°54'W (MHNLS 873); Morichal (UIMNH 35483); Castillos de Guayana, 08°31'N-62°25'W.

Paleosuchus palpebrosus

ESTADO ANZOATEGUI: Rfo Caris, 08°48'N-64°16'W (MHNS = \* ); Paso Bajito, Rfo Moquete, 08°35'N-64°13'W.

ESTADO APURE: Rfo Cinaruco, 06°32'N-67°32'W (EBRG 1054-1056); Caño Cararabo, Cararabo, Rio Meta, 06°08'N-69°19'W (MBUCV 7032-7033).

ESTADO BOLIVAR: Guri, Rfo Tocomita, 07°46'N-63°06'W; Ciudad Guayana, Venalum, 08°18'N-62°49'W; El Manteco, 07°21'N-62°32'W; Hato El Diamante, 07°15'N-62°27'W; Granja Santa Bárbara, 4 km este de San Félix, 08°23'N-62°37'W; Campamento Rudi, Ucaima, 06°14'N-62°47'W.

ESTADO SUCRE: Rfo San Juan, 10°10'N-63°04'W (Donoso-Barros, 1966a).

TERRITORIO FEDERAL AMAZONAS: Caño Atacavi, 03°06'N-66°53'W (EBRG 1794, MBUCV 7034); Cerro Cucurito, Caño Yagua, 03°36'N-66°34'W; Gavilán, 40 km sureste de Puerto Ayacucho, 05°34'N-63°22'W (EBRG 1795); Laguna de las Vacas, Mavaca, 02°30'N-65°10'W (MBUCV 2164-2165).

TERRITORIO FEDERAL DELTA AMACURO: La Barra (MHNS 984)

Paleosuchus trigonatus

ESTADO APURE: Rfo Cinaruco (Godshalk, 1982).

ESTADO BOLIVAR: Auyantepui (fide datum museo MBUCV 3063, Rfo Uruyen entre Kamarata y Guayaraca com.pers. del colector, Pedro Trebbau); San Martín de Turumbán, Rfo Cuyuní, 06°43'N-61°05'W (MHNS 7683); Rfo Botanamo, 3 km de la desembocadura en el Cuyuní, 06°52'N-60°52'W (MHNS 7682); Rfo Botanamo, 10 km río arriba, 06°54'N-60°55'W; La Escalera, km 135 carretera El Dorado/Santa Elena de Uairén, 05°54'N-61°25'W; Campamento Rudi, Ucaima, 06°14'N-62°47'W; Pratawaga, Rfo Kukenán, 04°55'N-61°23'W; Campo Alegre, Rfo Kukenán, 04°55'N-61°12'W; Campamento Wiski, Rfo Yuruaní, 04°58'N-61°15'W; Rfo Yuruaní, aguas abajo del sitio de planta eléctrica, 05°03'N-61°07'W; Rfo Yuruaní, aguas abajo del Puerto, 05°01'N- 61°09'W; Quebrada de Jaspe, 04°56'N-61°06'W; Angostura (Lichtenstein y von Martens, 1856 [citados en Medem, 1983]; Schmidt, 1928); Chimantá-tepui (Steyermark, 1955 [citado en Medem, 1983]); Rfo Caura (Medem, 1983); Rfo Erebato (Godshalk, 1982).

TERRITORIO FEDERAL AMAZONAS: Alto Ventuari (Donoso-Barros, 1966a); Caño Yureba, 04°03'N-66°01'W (EBRG 1510-1515, 1796-1797); Rfo Puruname, 03°25'N-66°18'W (EBRG 1551-1552); Rfo Barfa, 01°17'N-66°27'W (MBUCV 2163); Alto Rfo Barfa, 01°05'N-66°25'W (MBUCV 7035-7036, AMNH = \* ); Rfo Mawarinuma, 6 km del Campamento "La Neblina", 00°50'N-66°12'W (MBUCV 7037, AMNH = \* ); Rfo Mawarinuma, Campamento "La Neblina", 00°54'N-66°13'W (AMNH = \* ); Caño Agua Blanca, Rfo Mawarinuma, 00°49'N-66°07'W (MBUCV 7038); Caño Yagua, 03°32'N-66°46'W.

(\* = muestra depositada, registro desconocido)

"BABOS EN BATEAS" UNA MANERA DE PARECERSE AL ALLIGATOR DE FLORIDA

Carlos Rivero Blanco  
Y  
Bianca D'Andria  
CRB Ecólogos Consultores, C.A.  
Apartado 80531, Caracas 1080-A  
Venezuela

SUMMARY

The existence of circular or semi-circular depressions used apparently for resting by Caiman crocodilus along the shores of some streams in eastern llanos of the State of Barinas, Venezuela, is reported. The shape and dimensions are described, as well as its use by the caimans. Comments are made on the possible relation between the crocodilian habit and the "Gator Hole" building activities of the Alligator mississippiensis in its marsh environment. We presume, that these depressions, are used by the caimans for simply resting, or possibly catching prey within the enclosed space which might work as a trap.

Durante un viaje a los pantanos de Florida, en 1972, en compañía de Edwin Froelich, pudimos visitar y observar un "Alligator Hole", una especie de hondonada construida por individuos de la especie Alligator mississippiensis.

Este hueco, hondonada o cráter es hecho por los machos en su hábitat de pantanos y con el tiempo llega a adquirir grandes dimensiones. La tierra, sacada por el animal al hacer el hueco y agrandarlo, es acumulada a su alrededor y forma una especie de muro o camellón que mantiene sobre el nivel de inundación, dando el aspecto de un cráter circular.

Según Ehrenfeld (1975), el alligator comienza a abrir el hueco utilizando sus mandíbulas para arrancar la vegetación y sus patas, vientre y cola para apartar hacia las orillas el fango suave que forma el piso del pantano. El animal no sólo mantiene el hueco abierto sino que lo agranda constantemente. Con el tiempo, uno de estos "Alligator Holes" puede tener un diámetro de más de siete metros y una profundidad de unos dos metros. Estas hondonadas, conforman uno de los pocos lugares que mantienen agua durante la sequía anual del pantano. Es durante esta época, cuando más valor tienen para la variada fauna que se refugia en ellos. Sin el constante mantenimiento por parte del alligator, estas hondonadas se colmatarán rápidamente y pierden su condición de refugio para numerosas especies de invertebrados y vertebrados de la zona.

Luego de nuestra experiencia en Florida, nos pareció curioso que no se hubiese reportado ningún comportamiento similar para las especies de crocodilidos suramericanos. La manifestación etológica más cercana pareciera ser la estivación, sobre la cual Medem (1981) ha hecho algunos comentarios.

Caiman (género) la estivación se manifiesta en enterrarse en el barro de lagunas y otros cuerpos de agua que se van secando durante la época más cruda del verano.

Crocodylus acutus: construye cuevas o madrigueras subterráneas de grandes dimensiones. Una de ellas, descubierta en el río Palenque, en Colombia, estaba constituida por una cámara de ocho metros y medio de diámetro y dos entradas, una superficial y otra subacuática. En las zonas de manglares, las cuevas son hechas bajo las raíces y hojarasca.

Crocodylus intermedius: esta especie aprovecha las cárcavas horizontales hechas por la corriente en los barrancos de los ríos. Los caimanes profundizan estas cárcavas y las convierten en cuevas según observaciones de los lugareños.

Melanosuchus niger: según los indios Yecunas, esta especie solía estivar en el fango de las lagunas y en el monte debajo de la hojarasca.

Paleosuchus palpebrosus y P. trigonatus: No se ha observado estivación propiamente dicha, sino más bien cuevas o madrigueras cuyas entradas se encuentran por debajo del agua y quedan destapadas en verano. Suelen llegar a tener hasta más de tres metros de largo y en el fondo son más anchas.

Durante repetidos viajes al Hato Mata de Bárbara, en el Estado Barinas, durante los últimos meses secos del presente año, (febrero y marzo) pudimos observar como semana tras semana, los caños y lagunas se secaban, permitiendo ver ejemplos claros de lo que Medem (op. cit.) ha reportado como comportamiento de estivación para Caiman.

Durante varios vuelos en helicóptero realizados con la finalidad de hacer ensayos de censos fotográficos pudimos observar, además, unas curiosas hondonadas de forma circular formando parte, unidas o separadas de las orillas de los caños La Aguada (LO 68 33' y LN 8 10') y San Miguel (LO 68 33' y LN 8 05'). En estas Hondonadas circulares había agua y se pudieron observar varias babas en su interior. Aquellas hondonadas alejadas del borde de los caños estaban secas, y no observamos evidencias de ningún animal en su interior. El aspecto aéreo de estas hondonadas es el de cráteres perfectamente circulares que nos traen a la memoria la descripción de las "Bateítas" de Aguirre (Cruxent, 1950), y decidimos, entonces, llamarlas con el mismo nombre.

Durante un vuelo del 24 de marzo, fotografiamos y medimos tres bateítas en las playas del Caño San Miguel (Tabla 1).

TABLA I  
Dimensiones de las "Bateítas" del Caño San Miguel

ANCHO ENTRADA	30 cm.	no	no	
ANCHO BATEA	160 cm.	200 cm.	130 cm.	
LARGO BATEA	170 cm.	200 cm.	130 cm.	
LARGO TOTAL	210 cm.	200 cm.	130 cm.	
PROFUNDIDAD	14 cm.	15 cm.	7.5 cm.	
TEIM. AGUA	31 C	31 C	31 C	
TEMP. CAÑO	30 C	32 C	30 C	
TEMP. AIRE	35 C	35 C	35 C	
HORA	16.16	16.50	17.15	

Las bateítas secas son prácticamente inconspicuas cuando se camina por la orilla de estos caños. Aquellas que ya no forman parte del borde pero todavía tienen agua tienen forma de pozos circulares y son más fáciles de ver. Las que están formando parte del borde del caño lucen como muescas semicirculares o como sacos con una entrada en forma de cuello angosto que las comunica con el agua del caño.

Desde el aire, las bateítas secas aparecen conformando un patrón de cráteres a lo largo de las marcas paralelas del cambiante nivel del agua y las que todavía tienen líquido se ven con mayor facilidad. El ruido y el movimiento del helicóptero, al acercarse, invariablemente alerta y asusta a las babas que se encuentran en el agua de las bateítas, provocando su huida hacia el agua del caño.

La relación entre las babas y las bateítas puede tratar de interpretarse a la luz de las siguientes observaciones (1) Las babas han sido observadas, en repetidas ocasiones, dentro del agua de las bateas (hasta dos individuos a la vez) y (2) La forma circular y el tamaño de las bateítas parecen guardar una relación proporcional con el tamaño de las babas.

Dos preguntas surgen de las anteriores observaciones: 1. ¿Son las babas las que hacen las bateas? y 2. ¿Cuál es la utilidad de las bateas para las babas?

La primera pregunta es muy interesante, ya que aunque no se ha visto a ningún individuo construyendo las bateas, sabemos que en su conjunto, los cocodrilidos suramericanos son capaces de remover tierra e incluso excavar y habitar profundas cuevas, bien sea aprovechando la existencia de alguna cárcava natural o trabajando desde un principio (Medem, Op.Cit). Además, el antecedente del "Alligator Hole" nos muestra que un pariente cercano de las babas es capaz de hacer cráteres de más de siete metros de diámetro e impactar de tal modo los pantanos donde vive como para ser un factor ecológico de gran importancia en la creación y el mantenimiento de hábitat para sí y para otras especies de plantas y animales. Según Mago Leccia (Com. Pers.) no se conoce, para la zona, que un pez pudiera hacer semejantes cráteres en el fondo o en las márgenes de los caños. Habría que hacer las observaciones pertinentes para poder asegurar que las babas construyen las bateas.

La utilidad de las bateas puede tener alguna relación con aspectos como el de servir temporalmente como trampa para pescar, como lugar de reposo o, como lugar para refrescarse. Nosotros tratamos de excavar en una de las bateas secas, pero no encontramos ningún indicio de que alguna baba hubiere quedado sepultada en el fango en su interior.

La práctica de construir bateas, si es que es cierto que son las babas las que lo hacen, no ha sido reportada anteriormente debido a la dificultad para apreciar su presencia desde una perspectiva cercana al suelo. Creemos que este fenómeno sea más común que lo que a primera vista parece y que se pueda estudiar detenidamente.

En conclusión, nos encontramos ante ciertos indicios de que la baba es capaz de construir pequeñas hondonadas o bateas, un comportamiento en cierto modo parecido al del Alligator mississippiensis cuando construye sus "Gator Holes". De hecho, se han observado numerosas bateas en dos caños de la zona oriental de Barinas (Venezuela) siendo usadas por individuos de la especie en aparente actitud de descanso. Se presume que dichas bateas pueden servir para atrapar a invertebrados o vertebrados acuáticos, para descansar o refrescarse.

#### Bibliografía

- Cruxent, J.M. 1950. Las Bateas de Aguirre. Mem. Soc. Cien. Nat. La Salle. X (27): 175-186.
- Ehrenfeld, David W. 1975. The Alligator: Landscape Architect of the Everglades. In: Our Magnificent Wildlife Reader's Digest. 178-179.
- Medem, Federico. 1981. Los Crocodylia de Colombia. In: Los Crocodylia de Sur América, Colciencias Vol. I, 354 pp.



CENSOS DE  
Caiman crocodilus  
UNA VARIACION METODOLOGICA

Carlos Rivero Blanco  
Y  
Bianca D'Andria  
CRB Ecológos Consultores, C.A.  
Apartado 80531, Caracas, 1080-A  
Venezuela

SUMMARY

This contribution presents partial comparative results of spectacled cayman counts made visually during the night and photographically during the day from a helicopter and from the shores of small lagoons and rivers in the eastern llanos of the State of Barinas, Venezuela. A method for measuring the length of individual caymans using aerial photography was also devised-

## Introducción

El manejo de una población de Caiman crocodilus requiere conocer el número de individuos y las clases de edad que la componen. Se han utilizado combinaciones de diferentes técnicas para la realización de censos o estimaciones del número de individuos de una población (Chabrek, 1966; Woodward y Marion, 1977, Gorzula, 1984).

Con la intención de realizar un censo de Caiman crocodilus en lagunas artificiales y en caños de un hato en los llanos orientales del Estado Barinas, Venezuela, tratamos de comparar tres modalidades: 1.- Fotografía aérea desde un helicóptero. 2.- Fotografía a nivel del suelo, desde la orilla y, 3.- Contaje visual nocturno.

Para determinar el tamaño individual, recurrimos a una combinación de fotografía aérea y medición por proyección, mediante el uso de escalas de referencias colocadas en las playas de aseo o flotando en el agua de las lagunas.

Para el primer caso se utilizó como referencia una tabla de madera de dos metros de largo dividida en secciones de 20 x 10 centímetros. Estas secciones fueron pintadas con los colores rojo y blanco alternadamente. En las lagunas se utilizó una tabla de anime con un patrón cuadrado de 10 x 10 centímetros, marcados también con colores contrastantes.

Se efectuaron vuelos paralelos y sostenidos a 40 m. de altura sobre los caños donde se encontraban los animales (Eastman, 1971). Las secuencias fotográficas se hicieron con una cámara motorizada de 35 mm., utilizando una lente de 100 mm. Una vez procesadas, las secuencias de fotos se proyectaron sobre papel, procediendo así a marcar, a lápiz, los individuos que se veían tanto en tierra como en el agua. En el caño en el cual se colocó la escala de dos metros se tomó la medida proyectada con un compás y se construyó una escala que se usó para medir cada animal.

Las fotos tomadas en las lagunas se proyectaron de la misma forma, creando una escala de medición en base a la placa de anime flotante. En este caso sólo era posible registrar el tamaño de la cabeza de los animales ya que era la única parte flotante sobre el agua. Gorzula (1984) describe un método para calcular el tamaño de los individuos utilizando la razón largo cabeza/largo hocico, comparable a su vez con la talla del cuerpo (SVL) del animal.

En el caso de lagunas a punto de secarse, logramos hacer fotografías en las que todo el cuerpo de los animales era visible pudiendo, al menos, apreciar la relación cuerpo-cabeza con cierta facilidad.

## Resultados

1. En la situación de campo específica para este trabajo, el conteo aéreo mediante el uso de helicóptero y cámara motorizada parece ser apropiado, rápido y preciso pero costoso.

2. Si comparamos los conteos a) aéreo fotográfico motorizado, b) terrestre diurno fotográfico y c) conteo nocturno de una misma laguna, observamos que (a) y (c) permitieron ver y contar más animales que (b), y que (c) es mucho más práctico y más barato que (a) y (b).

3. Si el conteo nocturno se hace con una cámara provista de flash, seguramente permitirá afinar el método ya que se podrán contar los ojos con la calma que provee el laboratorio, como en el caso del censo fotográfico diurno terrestre o aéreo.

4. La estimación del tamaño de los animales en las lagunas, mediante el uso de la escala flotante fue un rotundo fracaso, debido a que la altura a que volamos varió de una foto a otra y a que los animales no estaban precisamente en el centro, cerca de la escala.

5. La estimación del tamaño de los animales en el caño, mediante la escala de dos metros en tierra no ha sido comenzada, y se prevee que habrá cierta dificultad en medir todos los individuos debido a que el ángulo de posición no coincide siempre en ser perpendicular al ángulo de vuelo.

### Conclusión

Aunque no definitivos, los resultados de esta contribución tienden a mostrar como es más útil, barato y preciso un censo pedestre nocturno con la ayuda de fotografía y flash, si se compara con la aplicación de la misma técnica en horas del día, bien sea a pié o en helicóptero. En cualquiera de los casos el conteo se hace en un ambiente de laboratorio, mediante la proyección de las diapositivas sobre el papel en el que se marcan con un lápiz los individuos contados. Esta técnica, es sólo practicable en aquellas lagunas en las que no existe vegetación flotante que obstruya la vista.

### Bibliografía

- Chabreck, Robert. 1966. Methods of determining the size and composition of Alligator populations in Louisiana. Proc. 12th Ann. Conf. S.E. Assoc. Game & Fish Comm: 105-112.
- Eastman Kodak Company 1971. Photography from Lightplanes and Helicopters. Kodak Publication N. M-5 CAT 147 5144 Rev. 1974: 1-25.
- Gorzula, Stefan. 1984. Proposal for a photographic method for size estimates of crocodylians. Herpetological Review 15 (2): 38-39.
- Woodward, Allan R. y Marion R. Wayne. 1977. An evaluation of factors affecting night light counts of Alligators. Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 291-302.

ESTUDIO DEL CRECIMIENTO EN CAUTIVERIO DE LA BABA,  
CAIMAN CROCODILUS, DURANTE SUS PRIMEROS MESES DE VIDA

Gustavo Rodríguez Arvelo  
Y  
Michael D. Robinson  
Departamento de Biología  
Universidad Simón Bolívar  
Sartenejas, Baruta, Estado Miranda  
Venezuela

SUMMARY

This paper analyzes the results of the growth of 250 Spectacled Caimans (Caiman crocodilus) raised in captivity during their first five months of life. Special attention was given to the effects that diet and density have on the growth of young caimans. The variable density had a very clear influence on the growth rate; however, the effects of the type of diet on the growth was less clear. The mortality was 8%. We calculated growth rates, correlations among variables, etc. We analyze methods and results and contrast them with those reported by other authors. Finally an economic analysis is presented (the bone and meat flour seems to be the most favorable and economic diet), and we propose several suggestions and models of commercial exploitation.

## Introducción

La cría de crocodilidos en cautiverio se viene ensayando desde hace un siglo con Aligatores (Alligator mississippiensis) en los Estados Unidos. Actualmente los resultados de largos años de experiencia han redundado en beneficio en granjas especializadas en la cría de Aligatores a escala comercial (Chabreck, 1967; Joanen y Mc Nease, 1971, Mc Nease y Joanen, 1981). También se ha ensayado la cría en cautiverio de otros crocodilidos como Crocodylus niloticus (Pooley, 1970).

En Venezuela hace algunos años surgió la idea de criar crocodilidos en cautiverio, pero realmente han sido pocos los resultados que se han obtenido hasta el momento. Para el caso de la Baba (Caiman crocodilus) y la Baba marrón (C.c. fuscus) hay cierta experiencia previa con algunos ensayos hechos en cautiverio (Blohm, 1973; Rivero Blanco 1974; Pachon, 1982). También existen estudios de tipo ecológico que tratan sobre hábitos alimenticios y reproductivos de la baba (Staton y Dixon, 1975, 1977; Gorzula, 1978; Seijas y Ramos 1980; Ayarzagüena, 1980). Datos obtenidos en estos trabajos junto con datos aportados por la larga experiencia en Aligatores fueron los que sirvieron de bases teóricas esenciales para el diseño de este experimento.

Este trabajo pretende aportar más información a la ya existente sobre el tema de cría de crocodilidos en cautiverio, y trata de un análisis de los resultados obtenidos de la observación del crecimiento de babas durante sus primeros meses de vida. Se tiene como parte fundamental del experimento, un análisis de los efectos que ejercen dos variables de control: dieta (tipo de alimento) y densidad (Número de individuos/unidad de espacio) en la variable de estudio: crecimiento.

Este trabajo cuenta con el apoyo económico de FUDENA. El trabajo fue realizado como parte de un proyecto conjunto entre estudios ecológicos y biotecnológicos que se adelantan en la Universidad Simón Bolívar para evaluar la factibilidad de instalar un criadero de babas a escala comercial, y cuenta con la Tutoría académica del Profesor Michael Robinson (USB), quien es además autor del diseño experimental original, y tuvo a su cargo la coordinación general de este y de los demás trabajos. Los Dres. C. Rivero, S. Gorzula, A. Seijas, y J. Ojasti, aportaron ideas y recomendaciones, así como también L. Pierichi y E. Eljuri en la parte de análisis estadístico. El Ing. Carlos Anglade proporcionó la infraestructura básica y ofreció su Hato como lugar para los estudios biológicos. El Sr. Iván Darío Maldonado permitió la recolección de los huevos de baba en su Hato. Deseo también agradecer al personal de FUDENA y en especial a Cecilia Blohm. A mis padres, a mis compañeros, y en general a todas las personas que ayudaron y colaboraron en la realización de este trabajo.

## Materiales y Métodos

Diseño experimental: El punto básico del diseño experimental es la evaluación de los efectos que ejercen las variables de control (dieta y densidad), en el crecimiento (longitud total, longitud corporal y peso). Para ello se ensayaron 3 dietas y 3 densidades (diseño 3 x 3).

Sitio de estudio: Este trabajo se realizó en el Hato "Los Arrecifes", propiedad del Ing. Carlos Anglade. El hato está ubicado en el Estado Guárico, a 40 Kms. de Guardatinajas (9°3' Norte, 68° 15' Oeste).

Recolección e incubación de los huevos: Los huevos fueron recolectados de 25 nidos de baba obtenidos directamente de la naturaleza, 20 de estos nidos se obtuvieron del Hato "El Frío" en el Estado Apure, los cinco restantes se obtuvieron del propio hato de estudio. Los huevos fueron incubados en un cuarto aislado donde se mantenían condiciones controladas (30 °C y 95% de humedad relativa). Como sustrato para colocar los huevos se utilizó el mismo material con que estaban hechos los nidos. En total se incubaron 523 huevos durante 2 meses.

Cuidado y marcaje de los recién nacidos, mediciones: A medida que iban naciendo los individuos, se colocaban en poncheras con agua en el mismo cuarto de la incubación. Los individuos se marcaban cortando escamas de la cresta caudal simple, esto permitía identificarlos mediante un código binario; también se recortaron dedos de las patas anteriores como indicativo del N° de tratamiento a que serían sometidos.

A cada baba recién nacida se le tomó un registro de su fecha de nacimiento, el nido del cual provenía y sus respectivas medidas:

- Longitud total (LT): medida ventralmente desde la punta del hocico hasta la punta de la cola ( $\pm 1$  mm).
- Longitud corporal u hocico-ano (LHA): medida ventralmente desde la punta del hocico hasta el borde anterior de la cloaca ( $\pm 1$  mm).
- Peso (P): medida con una balanza ( $\pm 1$  gr).

Estas mediciones se repitieron mensualmente para todas las babas.

Diseño de los zocriaderos (alimentación, cuidados). Se utilizaron 250 babas para los zocriaderos, el resto (216) se soltaron en una de las lagunas del hato.

Se tenían 10 estanques separados para los recién nacidos, los cuales se situaron la borde de una de las lagunas permanentes. Los individuos se pasaban a los estanques después de uno a cinco días de nacidos.

Siguiendo el diseño experimental se colocaron las 250 babas repartidas entre las 10 jaulas. Las tres densidades ensayadas fueron:

- 1.- 15 individuos en  $1,2 \text{ m}^2$ , es decir  $0,08 \text{ m}^2/\text{indiv.}$
- 2.- 26 individuos en  $1,2 \text{ m}^2$ , es decir  $0,046 \text{ m}^2/\text{indiv.}$
- 3.- 35 individuos en  $1,2 \text{ m}^2$ , es decir  $0,034 \text{ m}^2/\text{indiv.}$

Las tres dietas ensayadas fueron:

- 1.- Dieta a base de insectos de la sabana atraídos a las jaulas con luz eléctrica.
- 2.- Dieta a base de alimento comercial (Perrarina).
- 3.- Dieta a base de peces de río y vísceras de res (principalmente pulmón), finamente picados.

En total se tenían nueve tratamientos. Se tenía una jaula por tratamiento, más una jaula adicional donde se mantenían 22 individuos de repuesto, estos individuos eran usados para reemplazar aquellos que murieran en los distintos tratamientos, de manera de mantener constante las densidades durante el transcurso del experimento. Debido a límites de espacio y de individuos no se pudo hacer duplicados de los tratamientos.

Para la escogencia de las densidades y el diseño de las jaulas, se siguieron recomendaciones de trabajos hechos con Aligatores y con babas (Chabreck, 1967; Joanen y Mc Nease, 1971, 1976; Coulson 'et al, 1973; Blohm, 1973; Chirivi Gallego, 1973; Alvarez del Toro, 1974; Mc Nease y Joanen, 1981). En estos trabajos también se habla de que los requerimientos de espacio de Aligatores mantenidos en cautiverio aumentan exponencialmente a medida que crece el animal. Tomando esto en cuenta, en el diseño del experimento se incluyó una segunda etapa donde todos los individuos fueron pasados a jaulas mayores con un espacio cuatro veces mayor (una densidad cuatro veces menor que la inicial). Este traspaso de los individuos se hizo a partir del cuarto mes.

En cuanto a las dietas ensayadas hubo necesidad de hacer algunas modificaciones durante el transcurso del experimento (ver resultados). No se dieron suplementos vitamínicos; solamente se daba un complemento de calcio en forma de conchas de molusco trituradas, que se vende como alimento para pollos. Este suplemento se les daba a los de la dieta a base de carne, ya que la carne roja no contiene casi calcio (Bothwell, 1962). Este elemento es vital para los crocodilidos (Coulson et al, 1973), y es fácilmente asimilable para la baba en forma de estas conchas, ya que las mismas constituyen parte de su dieta natural (Chirivi Gallego, 1973).

Las jaulas de la primera etapa medían  $1,2 \text{ m}^2$  de área total. En el centro tenían un estanque de 30 cm. de profundidad y un área aproximadamente igual a la mitad del área total. Las paredes eran de tela metálica y el techo era de una malla plástica (de invernadero) que dejaba pasar 20% de luz. Las jaulas recibían suficiente sol durante las primeras horas de la mañana y las últimas de la tarde, pero se evitaba el fuerte sol de mediodía, además se disponía de un pequeño compartimiento de sombra total donde las babas se podían refugiar. Se colocaron cuatro bombillos de 100 w c/u para los tratamientos con dieta de los insectos, la luz se dejaba prendida durante cuatro horas/noche. El agua se transportaba a las jaulas mediante una bomba de gasolina, directamente de la laguna. El agua de los estanques se cambiaba todos los días, previamente limpiado el pozo y sus alrededores. El alimento se les daba ad libitum (tanto como ellos quisieran comer), una vez al día. El alimento se les ponía en un solo plato por jaula, bajo sombra. Las jaulas de la segunda etapa eran similares, sólo que con un área cuatro veces mayor.

Babas crecidas en condiciones silvestres: Durante los meses que duró el trabajo se hicieron varios muestreos nocturnos alrededor de la laguna grande donde se soltaron las 216 babas marcadas. Las babas capturadas también eran medidas y pesadas.

Análisis estadístico de los datos: El análisis de los datos se realizó con la ayuda de un microsistema EPSON QX-10. Se usó el programa de Dbase II y un paquete estadístico (Northwest Analytical Statpak). Se usaron programas de regresión, análisis de Varianza, etc. En las comparaciones de medias y ANOVA se usaron siempre intervalos de confianza de 95% ( $P = 0,05$ ).

### Resultados y Discusión

Se hicieron observaciones generales de las babas mantenidas en cautiverio durante 10 meses. Pero para el análisis estadístico de los datos de crecimiento se usaron sólo los cinco primeros meses, debido a que algunas perturbaciones externas al experimento (fuga de un grupo de babas de las jaulas cuando comenzó el período de lluvias) alteraron las variables de control.

Eclosión: Se obtuvo una eclosión de 90%, todos los individuos nacieron sanos, algunos tenían todavía parte del vitelo presente, pero éste se reabsorbía en uno o dos días. Más detalles sobre la incubación y eclosión se pueden encontrar en el trabajo de R. Romero (1984).

Todas las babas fueron pesadas y medidas al nacer, se obtuvieron los siguientes resultados:

	Media	Varianza
Longitud total (mm)	22,8	0,84
Longitud corporal (mm)	10,9	0,12
Peso (gr)	39,7	14,2

Valores similares han sido obtenidos por diversos autores (Staton y Dixon, 1977; Ayarzagüena, 1980). Estas dimensiones dependen un poco de la localidad geográfica y la época de postura (Staton, 1976).

Alimentación: Las babas que se mantenían en las tres jaulas con dieta de insectos (en su mayoría coleópteros, ortópteros y lepidópteros) se alimentaron perfectamente durante mes y medio, es decir, hasta el final del período de lluvias (Diciembre de 1983), cuando decreció rápidamente la actividad y la biomasa de éstos. A pesar de los esfuerzos hechos (aumentando la superficie reflectora, la intensidad de la luz, y el tiempo que se dejaron prendidos los bombillos), no se logró atraer suficientes insectos. Por esta razón fue necesario cambiar esta dieta por carne-pescado-calcio. Esta modificación, por supuesto, constituye una fuente de error que enturbia los resultados del experimento en términos de diferencia de crecimiento respecto a las otras dietas.

Las babas que se mantenían a base de carne y pescado se alimentaron muy bien desde el principio. El sistema usado para alimentarlos fue similar al usado por otros autores (Blohm, 1973; Rivero Blanco, 1974): se arrojaban pedazos pequeños de pulmón (que flotan) en la superficie del agua de manera que aprendieran a comerlo, después se les pondría el alimento fuera del agua. Al momento de alimentarse las babas siempre originan una especie de conmoción general produciendo sus llamadas características. Un fenómeno observado fue que en todos los tratamientos habían siempre algunas babas (las más grandes) que impedían a las demás acercarse a obtener el alimento, es esta una de las razones por las que siempre habían babas subalimentadas. Este hecho se veía aún



más acentuado en las densidades altas. Este efecto tal vez se hubiese podido reducir distribuyendo el alimento en varias fuentes separadas por estanque, y por supuesto la otra alternativa hubiese sido redistribuir los animales en atención al tamaño (Chabreck, 1967; Chirivi Callego, 1973; Blohm, 1973), pero para fines de este experimento, hacer esto hubiese alterado las densidades, que era una de las variables de control.

Durante el experimento se ensayaron varios tipos de carne. La que más se usó en todo momento por ser la de menor costo fue el pulmón (bofe), el cual se conservaba mediante salado. El calcio (conchas de moluscos) resultó ser un complemento perfecto para las babas y tuvo muy buena aceptación. Se ensayó también con víceras de babas beneficiadas del mismo hato, hubo muy buena aceptación. Este resultado puede ser de gran importancia a la hora de instalar criaderos de babas de uso extensivo donde se usen ciclicamente los desechos del beneficio de la baba para alimentar a las babas mantenidas en cautiverio. Futuros estudios podrían incluir si hay diferencias de crecimiento con los distintos tipos de carne. Un hecho bastante notable fue que en los últimos meses de estudio se notó un porcentaje bastante alto de babas subalimentadas en los tratamientos de carne-pescado, esto puede haber sido debido a dos razones:

- Las babas posiblemente presentaron un rechazo a la carne salada.
- Dado que no fue posible mantener una proporción adecuada de pescado en esta segunda dieta debido a la dificultad de conseguir peces frescos durante los meses de sequía, esto puede haber producido un efecto negativo para el crecimiento de las babas, que necesitan la vitamina D, proveniente del pescado. Sin embargo no se vieron los síntomas típicos de raquitismo (deficiencia de Vit. D) en reptiles (Chirivi Gallego, 1973).

Las babas que se pensaban mantener con Ferrarina no mostraron interés en comer dicho alimento en ningún momento, pese a todo los esfuerzos hechos, tales como probar distintos tipos (granulada y expandida), y tratar incluso de inducir la alimentación forzada.

Resultados similares han sido obtenidos con Aligatores (Joaney y Mc Nease, 1971, 1976). La explicación de la baja aceptación a este alimento puede ser el hecho de que estos animales, por ser de hábitos carnívoros, posiblemente no lo reconozcan como comestible, o tengan dificultades en asimilar los componentes vegetales, que se encuentran presentes en todos estos alimentos comerciales. Un resultado muy diferente fue obtenido al cambiar esta dieta (y sustituir todas las babas de esta dieta por un stock nuevo) por harina de carne y hueso, la cual tiene hasta 45% de proteína animal cruda y no contiene complementos vegetales. La aceptación de esta harina fue total en todo momento. El sistema seguido para alimentarlas fue usando primero trozos de carne picados, rociados con esta harina, poco a poco se fue aumentando la cantidad de harina, hasta que en un mes, la proporción era casi exclusivamente harina. La harina era mezclada con agua de manera de producir una pasta y siempre se dejó algo de trozos de carne para dar consistencia a la pasta, de otra forma las babas tenían dificultad en comerla al no poderla manipular, ya que los alimentos "pastosos" no constituyen parte de su dieta natural.

Se sugiere para futuros trabajos, ensayar también con mezclas de dietas (ejm: pescado con harina de carne y hueso), para evitar posibles problemas (ejm: deficiencias vitamínicas), que de hecho se han encontrado en Aligatores al aplicar monodietas por tiempo prolongado (Mc Nease y Joanen, 1981).

Sólo hubo un tratamiento (babas que comían carne, a densidad baja) donde las babas no se quisieron alimentar en ningún momento. Todas las babas de este tratamiento estaban subalimentadas, no llegando ninguna a pesar más de 100 gr. Las razones de este extraño fenómeno se desconocen, pero se sospecha que puede haber sido por factores congénitos (de nacimiento) ya que todas estas babas provenían de un mismo nido y las y las medias de las dimensiones para estas babas fueron las menores de todas (21 cm. y 37,7 gr). También está el hecho de que pasaron varios días desde que nacieron estas babas, hasta que comenzaron el tratamiento; esto tal vez haya afectado algún período crítico en la vida de las babas. Todos los esfuerzos hechos para hacer comer a estas babas resultaron en vano. Debido a este hecho, estas babas no fueron incluidas en los análisis estadísticos.

Crecimiento: Se calcularon medias y varianzas de los tres parámetros medidos (LT, LHA, y P) para todos los tratamientos, para cada mes de medición. Se calcularon también tasas de crecimiento. Resulta imposible exponer en este trabajo todos los resultados obtenidos, por lo que se expondrán sólo los resultados globales.

Se calculó una regresión lineal entre LT y LHA para todas las babas y todas las mediciones, se obtuvo el siguiente resultado:

$$LT = 2,19.LHA - 0,12 \quad (1140 \text{ puntos})$$

El coeficiente de correlación fue  $r = 0,97$  lo que indica una muy alta correlación entre estos parámetros. Datos similares han sido obtenidos por Staton y Dixon (1975). Para los demás cálculos estadísticos no se usó el parámetro LHA, sino solamente LT y P. Las mediciones de LHA fueron usadas solamente para extrapolar el valor de LT (en función de esta regresional, para babas que habían perdido parte de la cola en peleas, para estas babas se usó el valor de LT extrapolado, no el real. También se calcularon regresiones lineales, exponenciales, logarítmicas y de raíz cúbica, para observar cual describe mejor la correlación entre LT y P, los resultados fueron:

$$X = LT, Y = P \quad (900 \text{ puntos}).$$

$$Y = 6,62X - 113,2 \quad r = 0,88$$

$$Y = 3,16.e^{0,11x} \quad r = 0,90$$

$$3- \quad Vy = 0,15X - 0,17 \quad r = 0,92$$

$$\text{Log}Y = 3,08\text{log}X - 5,98 \quad r = 0,92$$

Como puede observarse, todas las correlaciones dieron bastante altas. Aunque las mejores vienen siendo Vy y LogY, resultados similares han sido obtenidos con la baba (Staton y Dixon, 1975); Vanzolini y Gomes, 1979) y con Aligatores (Joanen y Mc Nease, 1976). El hecho de que

este tipo de regresiones definen bien la correlación entre estas variables, es una reafirmación de una observación generalizada de que el peso en Crocodilidos aumenta exponencialmente en función de la longitud y en función de la edad (hasta cierta edad) (Dowling y Brazaitis, 1954; Chabreck y Joanen, 1979), dato de gran importancia a la hora de pensar en edad y tamaño definitivo para beneficiar una baba. El hecho de que la regresión lineal para estos primeros cinco meses haya dado relativamente alta ( $r = 0,88$ ) nos indica que probablemente en las primeras etapas todavía no se haya "disparado" el crecimiento exponencial, esto tal vez ocurra después del primer año.

Al comparar las varianzas obtenidas entre todas las mediciones, se obtiene que las varianzas han crecido de manera desproporcionada a medida que transcurre el tiempo. Este hecho es una consecuencia de no poder reclasificar los animales en atención al tamaño y de que hayan babas que impidan la alimentación de otras. Este es un efecto perjudicial para cualquier plan de manejo, pues la consecuencia es que aumenta la varianza, el número de babas subalimentadas y eventualmente, la mortalidad.

La mayor uniformidad (menor varianza) se obtuvo en los tratamientos a base de insectos (en los meses en que hubo insectos), esto es seguramente debido a que en estos tratamientos, al caer insectos en la superficie del agua, todas las babas tienen más o menos la misma probabilidad de obtener alimento y por lo tanto el crecimiento es bastante parejo. Este hecho nos podría dar un indicio en apoyo de la teoría de que alimentos distribuidos en varias fuentes por jaula producen mayor uniformidad de tamaños que un solo plato por jaula. Probablemente en estos tratamientos, la principal fuente de variación de tamaño era de tipo genético (de nacimiento). Este efecto genético se podría reducir a un mínimo poniendo individuos nacidos de un mismo nido, por jaula. De hecho las varianzas eran mucho menores en los tratamientos donde las babas provenían de un mismo nido.

Se hicieron varios Anovas de una sola vía para determinar la presencia de efectos de las variables de control en las tasas de crecimiento. Los Anovas se calcularon independientemente para tasa de crecimiento en P y en LT.

Para la primera prueba de hipótesis:

H0: No existe efecto de la densidad.

H1: Existe efecto de la densidad.

Se obtuvo como resultado que para todas las mediciones se puede rechazar la hipótesis nula (H0) que dice que las medias de las tasas de crecimiento son iguales ( $P < 0,05$ ). Podemos afirmar entonces, que la densidad es un factor definitivo para afectar las tasas de crecimiento, en babas mantenidas en cautiverio. Siendo mayor el crecimiento a menor densidad. Este efecto se observó desde el primer mes, y está presente en los tres grupos de dietas.

Si consideramos que en términos económicos, la densidad ideal es la máxima densidad que se puede mantener sin que se vea afectado el crecimiento de las babas en cautiverio, entonces de este resultado se desprende

que esta densidad ideal debe ser menor o igual que la menor de las densidades ensayadas en este experimento ( $0,08 \text{ m}^2/\text{individuo}$  para babas recién nacidas). Particularmente opinamos que en futuros estudios se deberían ensayar densidades menores y aplicar metodologías que reduzcan al mínimo la varianza de tamaños por jaula (factor íntimamente ligado a la densidad), estos métodos incluirían: individuos de un mismo nido por jaula, varias fuentes de alimento por jaula, y reclasificación en atención al tamaño. Se esperaría de esta forma conseguir tasas de crecimiento máximas en cautiverio. Es de hacer notar la importancia de patrones comportamentales (ejm: agresividad, etc) en la escogencia de densidades adecuadas para el cautiverio. El criterio para elegir la densidad "ideal" también dependería del tipo de estrategia de explotación que se desee emplear, es decir si se desea mantener pocos individuos creciendo a un ritmo máximo, o se desea mantener muchos individuos (densidad alta), creciendo poco (ver "Modelos de explotación" en las conclusiones).

Para la segunda prueba de hipótesis:

H0: la dieta no afecta el crecimiento.

H1: la dieta afecta el crecimiento.

Se obtuvo como resultado que se puede rechazar la hipótesis nula (H0) ( $P < 0,05$ ) a partir del segundo mes. Es decir que existen diferencias de crecimiento entre babas sometidas a las distintas dietas. Siendo la dieta de harina de carne y huesos donde se encontró el máximo crecimiento.

Este resultado puede que no sea muy confiable debido a varias perturbaciones que han ocurrido durante el experimento, que han alterado el control de la variable dieta. Entre otras están: el cambio de dieta de las babas que estaban sometidas a la dieta de insectos, el hecho de no haber podido mantener una proporción adecuada de pescado en la dieta de carne-pescado, el posible rechazo de la carne salada, dificultad de llevar la carne en dos ocasiones, lo que causó un ayuno de 3 o 4 días en las babas sometidas a esta dieta. A pesar de esto se sospecha que si debe haber una diferencia de crecimiento entre las distintas dietas, como de hecho se ha encontrado el Aligatores (Mc Nease y Joanen, 1981).

Aunque no hubiesen diferencias de crecimiento, de todos modos resulta positivo el hecho de que hayan crecido por igual, babas mantenidas con harina de carne y hueso que cuesta 2 Bs/kg, y babas alimentadas con vísceras de res que cuesta 6 Bs/kg, siendo la harina, además, de más fácil mantenimiento y transporte.

Lastasas de crecimiento máximas se obtuvieron en el tratamiento N<sup>o</sup> 6 (babas alimentadas con harina de carne y hueso, a densidad baja) (Fig. 1 y 2). Las babas que más crecieron alcanzaron un promedio de 2,7 y 3,0 cm/mes, y 29,3 gr/mes (Fig. 3 y 4). Datos similares aunque un poco más bajos (2,5 cm/mes) han sido obtenidos con la baba por otros autores (Blohm, 1973; Rivero Blanco, 1974) y con la baba marrón (Pachón, 1982). Son alentadores estos datos de crecimiento ya que nos dan idea de que existe una potencialidad bastante alta de crecimiento en cautiverio que se puede explotar al máximo usando condiciones apropiadas (dieta y densidad). Según algunos modelos y estimaciones, manteniendo tasas de crecimiento en cautiverio similares a éstas, se pueden llevar a las babas, en tres años, a tallas comercialmente explotables (1,20 mts) (D'Andria, 1980; Pachon, 1982).

Una observación interesante fue que durante el primer mes, las tasas de crecimiento en longitud fueron mucho mayores que para el resto de los meses. Esto puede explicarse en parte por una observación hecha de que las babas recién nacidas tienen un "factor de estiramiento" que puede estar presente o no, cuando está, puede llegar hasta 2,5 cm en la primera semana o 3 cm en los primeros 15 días. Este hecho se vió bastante claro en numerosas babas que fueron medidas varios días después de nacidas sin haber iniciado todavía el tratamiento. En general se observaba este incremento en longitud, acompañado por una pérdida de peso, por lo que no se le puede llamar crecimiento. Este fenómeno tal vez se podría explicar como una adaptación ecológica de las babas para alcanzar una talla máxima en sus primeros períodos de vida, en pro de su adecuación y supervivencia, y el hecho de estar presente o no podría depender de factores genéticos, época del año, tamaño de los huevos, y otros factores relacionados con la estrategia reproductiva y de supervivencia de la baba, como lo cita Staton (1976).

Otro fenómeno encontrado fue que durante los meses de sequía, las tasas de crecimiento, en general, se redujeron notablemente, siendo de 2 o 2,5 cm/mes para las babas que más crecían, y muchas babas perdieron peso durante estos meses. Una posible explicación de esto podría ser un período de estivación natural, posiblemente relacionado con cambios hormonales al llegar la época de sequía. Este hecho es ya bastante conocido en Aligatores mantenidos en cautiverio en climas templados (Chabreck y Joanen, 1979) y que también ha sido visto en la baba marrón por Pachón (1982) quien encontró también reducción en las tasas de crecimiento y pérdidas de peso de hasta 10% durante los meses de sequía.

Enfermedades, mortalidad: No se encontraron enfermedades evidentes durante el transcurso del trabajo, solamente se observó un porcentaje alto de individuos subalimentados (22% del total de babas). Se cree que la causa principal de esto debe haber sido la alta densidad, aunque también pueden haber contribuido otros factores (sobre todo entre las que se alimentaban con carne), tales como: deficiencias vitamínicas, rechazo a la carne salada, rechazo a la monodieta.

Se calcularon % de mortalidad e individuos subalimentados para todos los tratamientos, y se encontró que existe un efecto claro de la densidad siendo máximo (35%) en las densidades bajas. Se encontró que entre las distintas dietas este % fue menor en los grupos que comían harina.

La mortalidad total, sin incluir 15 babas que murieron por un accidente (desecamiento de un pozo), fue de 8% durante los cinco primeros meses, la causa principal era subalimentación. Se estima que este % puede llegar a ser mucho menor, e incluso llevarse a 0% si se extreman las precauciones y se usan condiciones ideales (de dieta y densidad). Con todo, este % de mortalidad resulta sumamente bajo si lo comparamos con los obtenidos para babas en la naturaleza, para su primer año de vida, que es el año crítico debido a la alta predación, hambre y desecamiento de los pozos; diversos autores han reportado % de mortalidad entre 70 y 90% para el primer año (Rivero Blanco, 1974; Staton, 1976; Ayarzagüena, 1980; MARNR, 1982). El hecho de poder mantener una mortalidad tan baja, al eliminar los factores que la producen, prácticamente justifica el mantenimiento en cautiverio, aunque sólo sea por un año.

Comportamiento: El comportamiento agresivo de las babas en cautiverio fue una de las observaciones más notables. La agresividad es un factor muy importante en la distribución del alimento, y en propiciar el stress en las jaulas, que puede ser un factor negativo en el crecimiento. Se sospecha que este stress producido por peleas, etc. puede haber sido una de las principales razones del bajo crecimiento encontrado en las densidades altas. Resultados similares se han encontrado con Aligatores sometidos a densidades altas (Chabreck, 1967).

Las llamadas o sonidos típicos en las babas son muy importantes a la hora que se entrega la comida, pues alertan al resto del grupo de la presencia de alimento. Algo se ha estudiado sobre sistemas de comunicación en babas al natural, Gorzula (1978) ha encontrado que tanto estas llamadas, como secreciones en las glándulas almizcleras son de gran importancia para mantener cohesión en el grupo y como manera de solicitar ayuda (distress calls). La efectividad de estas llamadas puede alcanzar dimensiones insólitas, como se observó en varias ocasiones en que una baba de aproximadamente 1,30 mts. (presumiblemente una hembra), salía de la laguna cercana a las jaulas, durante la noche, atendiendo al llamado de los habitos enjaulados, y comenzaba a producir un sonido similar. Cuando los habitos oían esta llamada, aumentaban su algarabía comunicativa y hacían esfuerzos desesperados por salir de las jaulas saltando las paredes, cinco babas lograron escapar de esta forma. Después de esto fue necesario tomar medidas para auyentar a la baba grande.

Otro hecho interesante se observó cuando se reinició el nuevo período de lluvias (mayo de 1984), muchas babas comenzaron a escapar de las jaulas de manera incontrolada y sin haber dado señas de querer hacerlo en meses anteriores. Una posible explicación de este hecho sería que las babas atendían a sus instintos migratorios, que precisamente se desencadenan en las épocas de lluvia, y hacían esfuerzos desesperados por escapar de las jaulas.

Se necesitan más estudios sobre observaciones de comportamiento ya que pueden ser de gran utilidad a la hora de diseñar los zocriaderos y las técnicas de alimentación, mantenimiento, etc.

Discusión sobre metodología y fuentes de error: El sistema de marcaje usado fue bastante útil y no hubo regeneración de escamas durante los meses de trabajo. Las fuentes de error a la hora de hacer las mediciones eran pocas, en general se resumían al hecho de que el peso de una baba podía ser muy distinto al momento de medirse si habían comido hacia poco o no. Un factor que puede haber afectado a los tratamientos fue el uso de babas de reemplazo.

Crecimiento en condiciones silvestres: En total se pudieron capturar 12 babas durante los meses de muestreo nocturno en la laguna grande del ható, de las cuales, sólo dos estaban marcadas. Se presume que la mortalidad debe haber sido sumamente alta, además de que no se contó con medios adecuados para hacer un buen muestreo. Se calculó una tasa de crecimiento (en LT y P) para las dos babas marcadas y dieron resultados muy parecidos (1,8 cm/mes y 8 gr/mes). También se calculó una regresión lineal LT-P con las 12 babas capturadas, obteniéndose:

$$P = 9,34LT - 210 \quad r = 0,98 \quad (12 \text{ puntos})$$

El crecimiento en condiciones silvestres ha sido estudiado por otros autores (Staton y Dixon, 1975; Gorzula, 1978; Ayarzagüena, 1980), y en general no se han obtenido valores demasiado diferentes a los obtenidos aquí (a pesar de ser una muestra bastante pequeña). Al comparar los resultados obtenidos con los de las babas mantenidas en cautiverio saltan a la vista tres hechos importantes:

- La tasa de crecimiento en LT para las babas crecidas al natural, es mayor que la media global para las babas mantenidas en cautiverio, pero es bastante menor que las tasas en los tratamientos donde hubo máximo crecimiento.
- La tasa de crecimiento en P para las babas al natural es menor que la media para las babas mantenidas en cautiverio.
- La relación P-LT es mucho menor para las babas crecidas al natural.

A pesar de que el número de babas capturadas fue bastante bajo, si basta para generalizar que las babas crecidas en la naturaleza tienden a ser "largas y flacas", o lo que es lo mismo, las babas mantenidas en cautiverio tienden a engordar más relativamente. Este efecto puede ser debido a que las babas que crecían en cautiverio, por tener poca actividad locomotiva (no tienen necesidad de moverse para procurarse el alimento), tienden a acumular más calorías en los tejidos. Resultados similares se han encontrado en Aligatores mantenidos en cautiverio, los cuales tienden a pesar 10% más que Aligatores de la misma longitud, crecidos en la naturaleza (Coulson et al, 1973; Joanen y Mc Nease, 1976; Mc Nease y Joanen, 1981). Estos resultados pueden ser sumamente positivos en términos económicos, de mantenerse este fenómeno.

Aunque no se hayan obtenido diferencias muy notables en cuanto al crecimiento en longitud, en cautiverio, y al natural, es posible que este efecto resulte más aparente después del segundo año de crecimiento. Se requiere más experimentación al respecto.

Análisis de aspectos económicos: En esta sección no se discutirá sobre gastos de infraestructura, (jaulas, personal, etc), sino solamente gastos de alimentación.

El gasto por alimento durante cinco meses fue el siguiente:

Alimento	Kg.	Bs/Kg	Costo total (Bs.)
Harina de carne y hueso	120	2	240
Vísceras (bofe)	265	6	1.680
Conchas de moluscos	10	4	40
<b>Costo por animal:</b>			
		Bs/mes	Bs/animal/mes
Dieta de harina de carne y hueso		48	0,63
Dieta de carne-pescado-calcio		344	2,26

A simple vista se puede deducir que la dieta de harina resulta mucho más económica. Si a esto sumamos el hecho de que esta harina probablemente esté produciendo mejor crecimiento y que es un alimento de fácil mantenimiento y transporte, resulta en definitiva que es esta la dieta más recomendable hasta los momentos. Habría que ver en futuros estudios si no se presentan problemas por aplicar monodieta por tiempo prolongado.

El gasto por alimento fue aumentando progresivamente a medida que transcurrían los meses, ya que la cantidad de alimento consumido es proporcional al peso del animal. En Aligatores han encontrado que consumen entre 10 y 25% de su peso/semana (Joanen y Mc Nease, 1977; Mc Nease y Joanen, 1981) y convierten entre 40 y 50% del alimento consumido (peso seco) en tejido, según el tipo de dieta. En este estudio no se pudo calcular la conversión (peso de alimento consumido/peso de animal ganado) debido a que no se llevó control de alimento suministrado y alimento dejado. Este dato es de suma importancia para cualquier estudio económico (costo/beneficio) y por lo tanto se recomienda que se hagan estudios futuros de este tipo, probando con distintas dietas y mezclas de dietas.

Es obvio que los costos de manutención aumentan exponencialmente a medida que crecen las babas, ya que el peso también aumenta exponencialmente. Algunos modelos estiman que resulta rentable la manutención en cautiverio de la baba hasta tres años (D'Andria, 1980), pero deberán hacerse más estudios para reforzar esta afirmación.

### Conclusiones

Conclusiones sobre el crecimiento: -La variable de control densidad, afecta definitivamente el crecimiento, siendo este mayor, a menores densidades. La densidad ideal sería la máxima densidad que se puede mantener sin resultar afectado el crecimiento. Se estima que esta densidad debe ser menor o igual a 12,5 individuos/m<sup>2</sup> (0,08 m<sup>2</sup>/indiv.) para babas en sus primeros meses de vida. -La variable de control dieta, probablemente esté afectando el crecimiento. Se requiere más experimentación y probar con distintos tipos de dietas. -El máximo crecimiento se alcanzó con babas alimentadas con harina de carne y huesos, a densidad baja (0,08 m<sup>2</sup>/individuo). -Factores que reduzcan la varianza en el crecimiento (ejm: varias fuentes de alimento, y babas de un mismo nido por jaula), resultan positivos para el crecimiento en cautiverio. -Las tasas de crecimiento máximas (2,7 y 3,0 cm/mes) resultaron relativamente altas y parecen alentadoras para un plan de explotación en cautiverio. -Las babas crecidas en cautiverio tienden a engordar más (mayor peso para una longitud dada) que las babas crecidas al natural. -Existe un "factor de estiramiento" (incremento en longitud) durante los primeros 15 días de vida, que puede estar presente o no. Hubo reducción en las tasas de crecimiento durante los meses secos, posiblemente debido a estivación natural. -El porcentaje de mortalidad fue de 8%. El % de mortalidad e individuos subalimentados fue mayor en las densidades altas, y nulo en las densidades bajas.

Conclusiones sobre alimentación: -La dieta a base de insectos no se puede mantener durante todo el año, en todo caso se podría usar como complemento de otras dietas durante los meses lluviosos. -El alimento comercial Ferrarina no es útil para alimentar babas durante sus primeros meses de vida. -Las vísceras de res, vísceras de baba, peces frescos, y harina de carne y hueso tienen buena aceptación por parte de las babas. -Las babas probablemente rechazan la carne que ha sido salada. -Un complemento de calcio en forma de conchas de moluscos tiene buena aceptación. -Factores desconocidos (incluyendo quizás congénitos) pueden determinar que algunas babas se hallen renuentes a alimentarse en cautiverio. -Factores comportamentales (ejm: agresividad, comunicación)



determinan patrones en la distribución del alimento y deberán tomarse en cuenta a la hora de diseñar los zocriaderos.

Conclusiones de aspectos económicos: -La dieta de harina de carne y hueso parece ser la más adecuada y rentable, ya que se pueden mantener animales a 0,63 Bs/mes durante los primeros meses, y es de fácil mantenimiento y transporte. -De mantener las tasas de crecimiento obtenidas, se cree que se pueden mantener babas en cautiverio durante dos o tres años, a bajo costo. Se requiere más experimentación al respecto.

Algunas recomendaciones para la implantación de zocriaderos: -Usar densidades bajas. -Tratar de poner individuos provenientes de un mismo nido por jaula para reducir la variabilidad, y reagrupar en atención al tamaño cada cierto tiempo. -Alimentar a las babas cada dos días, y usar varias fuentes de alimento por jaula. -Alimentar a las babas con vísceras de res, o de babas beneficiadas, pescado fresco, o harina de carne y hueso, y usar conchas de moluscos como complemento de calcio e insectos durante los meses lluviosos. -Usar carne y pescado refrigerado, no salado. -Picar los trozos de carne y pescado lo más fino posible. -Tener una fuente continua de pescado (ejm: cultivo de cachamas). -Usar mezclas de dietas (ejm: pescado con harina de carne y hueso) (evitar monodietas). -Para el diseño de las jaulas, usar paredes lisas y altas (más de 1,5 mt. de altura), para evitar escapes.

Proposición de modelos de explotación: Lo primero que hay que determinar es el tipo de estrategia que se desea usar: a) Mantener pocos individuos, bien alimentados, a altas tasas de crecimiento en cautiverio. b) Mantener muchos individuos en cautiverio, sin importar que el crecimiento sea igual o menor que en la naturaleza, con tal de eliminar la alta mortalidad del primer año.

Si se dispone de suficiente infraestructura (espacio, capital, fuentes de alimento), se podría seleccionar la alternativa a), y mantener pocas o muchas babas hasta que alcanzaran un tamaño comercial (ejm. en tres años). Cada año se podría recoger un nuevo stock de huevos, o hasta se podría probar la reproducción en cautiverio mediante inseminación artificial, etc. Se podría implementar una procesadora de carnes y cueros y alimentar a las babas mantenidas en jaulas con los desechos del beneficio de las babas. Como fuente adicional se podría disponer de cultivos de cachamas. Esta sería la alternativa que daría más independencia de la naturaleza. Si se dispone de poco capital o espacio para los zocriaderos, y en cambio se tienen cuerpos de agua naturales o artificiales (ejm: tapas recientes), se podría seleccionar la alternativa b), y mantener las babas por solo un año, para luego soltarlas, y tener suficientes babas para cosechar de la naturaleza cuando alcancen un buen tamaño. Se repetiría el ciclo todos los años sin peligro de agotar el recurso. Existen infinidad de variantes y mezclas entre modelos. Se espera que futuros experimentos aporten más datos útiles para acercarse cada vez más a un modelo de explotación de babas en cautiverio, que sea factible de realizar.

Sugerencias para futuros temas de estudio: Estudiar los efectos de distintas dietas y mezclas de ellas en el crecimiento (ejm: carne, peces, harinas de carne y huesos y de pescado). Probar si se pueden usar insectos capturados durante el invierno, y secados al sol, para alimentar a las babas durante los meses secos. Buscar la densidad "ideal", mediante ensayo y error, o extrapolación. Estudiar el efecto de la

distribución del alimento en el crecimiento. Estudiar el comportamiento. Estudiar el crecimiento por más de un año en condiciones de cautiverio controlado. Estudiar los cambios hormonales. Estudiar la conversión de alimentos y contenidos nutricionales. Estudios económicos (costo/beneficio) por tamaños de babas.

#### Bibliografía

- Alvarez del Toro, M. 1974. Los Crocodylia de México. IMERNAR. México.
- Ayarzaguena, J. 1980. Ecología del Caimán de Antejos o Baba (Caiman crocodilus L.) en los Llanos de Apure, Venezuela. Manuscrito, Tesis para optar al grado de Doctor en Ciencias Biológicas. Universidad Complutense de Madrid: 1-216.
- Blohm, T. 1973. Conveniencia de criar Crocodilidos en Venezuela con fines económicos y para prevenir su extinción. Simposio Internacional sobre Fauna Silvestre y Pesca Fluvial y Lacustre Amazónica. Manaus, Brasil. 32 pp.
- Bothwell, D. 1962. The great outdoor book of Alligators. Great Outdoor Publishing Co. St. Petersburg, Fla.
- Coulson, T., Coulson, R., Hernández, T. 1973. Some observations on the growth of captive alligators. Zoologica. 58:47-52.
- Chabreck, R. 1967. Alligator Farming Hints. La. Wild Life and Fisheries Comm., New Orleans. Mimeografía.
- Chabreck, R. y Joanen, T. 1979. Growth rates of American Alligators in Louisiana. Herpetologica, 35 (1) 1979, 51-57.
- Chirivi Gallego, R.H. 1973. Contribución al conocimiento de la Babilla o Yacaré Tinga (Caiman crocodilus) con notas sobre su manejo y otras especies de Crocodylia Neotropicales. Simposium Intern. sobre Fauna silvestre y Pesca fluvial y lacustre. Manaus, Brasil.
- D'Andria, B. 1980. Estructuración de un modelo matemático sobre la dinámica poblacional de la Baba (Caiman crocodilus) con miras a su posible explotación comercial. Trabajo especial de grado. Universidad Simón Bolívar, 149 pp.
- Dowling, H. y Brazaitis, P. 1954. Size and Growth in captive Crocodilians, Int. Zoo. YB. 6: 265-270.
- Gorzula, S. 1978. An ecological study of Caiman crocodilus inhabiting savanna lagoons in the venezuelan Guayana. Oecología 35 (1): 21-34.
- Joanen, T. y Mc Nease, L. 1971. Propagation of the American alligator in captivity. Proc. Southeastern Assoc. Game and Fish commissioners Conf. 25: 106-116.
- Joanen, T. y Mc Nease, L. 1976. Culture of immature American alligators in controlled environmental chambers. Proc. World Mariculture Soc. 7: 201-211.
- Joanen, T. y Mc Nease, L. 1977. Artificial incubation of Alligator eggs and post hatching culture in controlled environmental chambers. Proc. World mariculture Soc. 8: 483-489.
- Mc Nease, L. y Joanen, T. 1981. Nutrition of Alligators. Alligator Production conference. Gainesville, Florida.

- MARNR (Ministerio del Ambiente y de los Recursos Naturales Renovables). 1982. Aprovechamiento racional de la Baba o Babo, Caiman crocodilus L. Folleto. 14 pp.
- Pachon, E. 1982. Algunos aspectos relativos a la Conservación y Manejo de los Crocodylia en Colombia. INDERENA. Documento presentado ante el II Curso sobre la investigación, manejo y conservación de Cocodrilos. Gainesville, USA.
- Pooley, T. 1970. Crocodile rearing in Zululand. *Animals (London)* 24: 1-15.
- Rivero Blanco, G. 1974. Hábitos reproductivos de la Baba en los Llanos Venezolanos. *Natura (52)*: 24-29.
- Romero, R. 1984. Estudio de algunas variables bióticas y abióticas del nido de la Baba, Caiman crocodilus, con la finalidad de evaluar la factibilidad de una incubación artificial. Trabajo Especial de Grado. Universidad Simón Bolívar.
- Seijas, A. E. y Ramos, S. 1980. Caracterización de la dieta de la Baba, Caiman crocodilus, durante la estación seca en las sabanas moduladas del Estado Apure, Venezuela. *Acta. Biol. Venez.* 10 (4): 373-389.
- Staton, M. y Dixon, J. 1975. Studies on the dry season biology of Caiman crocodilus crocodilus from the Venezuelan Llanos. *Mem. Soc. Cienc. Nat. La Salle.* 35 (101): 237-266.
- Staton, M. y Dixon J. 1977. Breeding Biology of the Spectacled Caiman (Caiman crocodilus crocodilus) in The Venezuelan Llanos. *U.S. Fish & Wildl. Serv. Wildl. Res. Rep.* (5): 1-21.
- Staton, M. 1976. Notes on The ecology of young Babas (Caiman crocodilus) from the Venezuelan Llanos. II Seminario sobre Chiguire y Babas. Maracay. Venezuela. 17 pp.
- Vanzolini, O. y Gomes, N. 1979. Notes on the Ecology and Growth of Amazonian Caimans (Crocodylia, Alligatoridae). *Papeis Avulsos de Zool.* 32 (17): 205-216. Sao Paulo, Brasil.

#### Figuras

1. Gráfica de crecimiento (LT/edad) hasta cinco meses, para el tratamiento 6. (Harina de carne y huesos, densidad baja).
2. Gráfica de crecimiento (P/edad) hasta cinco meses, para el tratamiento 6.
3. Gráfica de crecimiento (LT/edad) para la baba que más creció en cinco meses.
4. Gráfica de crecimiento (P/edad) para la baba que más creció en cinco meses.

Fig. 1.

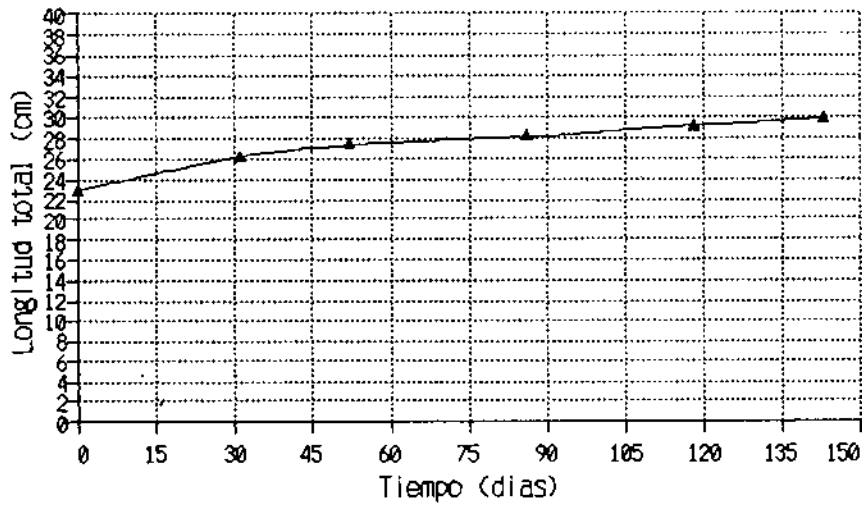


Fig. 2.

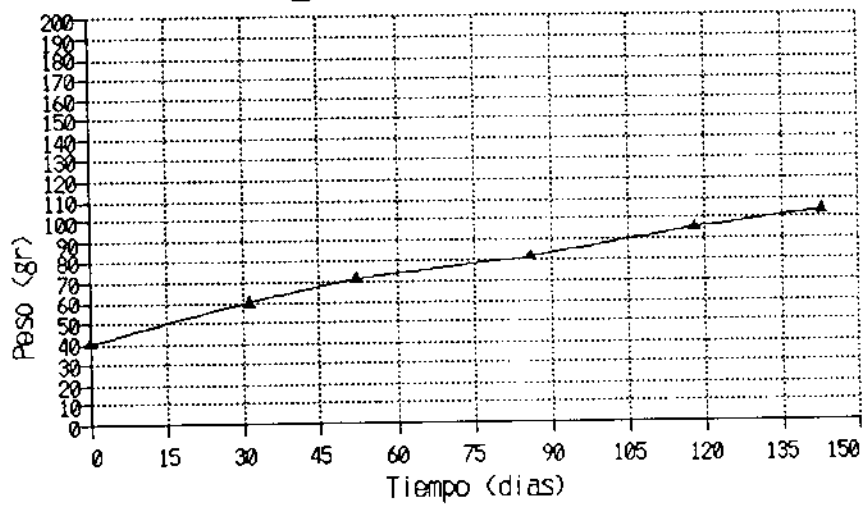


Fig. 3.

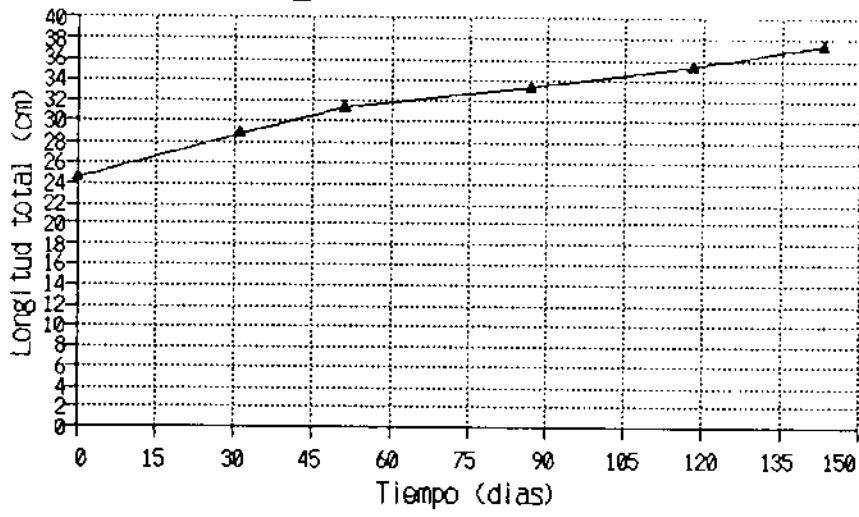
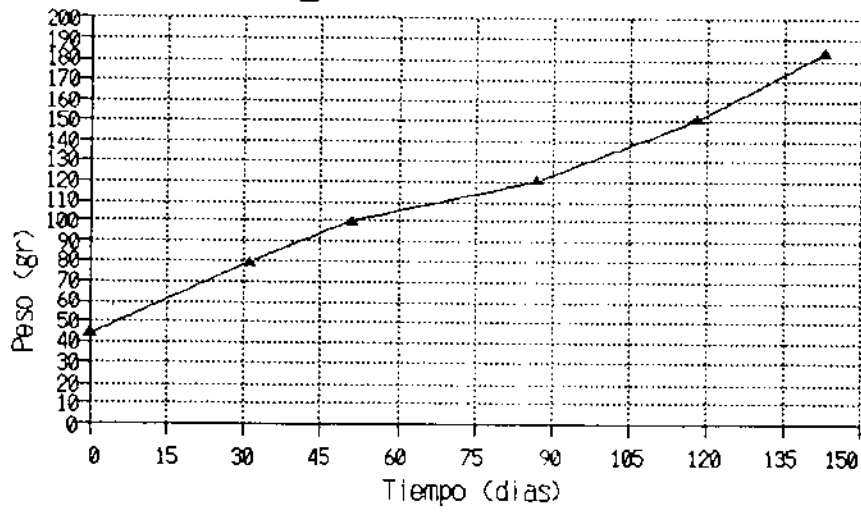


Fig. 4.



UN CASO DE CAQUEXIA EN UNA BABA (Caiman crocodilus) DEL  
ZOOLOGICO LAS DELICIAS DE MARACAY, ESTADO ARAGUA, VENEZUELA

E.O. BOEDE  
Zoológico Las Delicias  
Instituto Nacional de Parques  
Las Delicias-Maracay, Estado Aragua

M.E. PARRAGA  
Hospital Veterinario Dr. Rafael Cabello  
Facultad de Ciencias Veterinarias  
Universidad Central de Venezuela  
El Limón - Estado Aragua

N. SANCHEZ DE BOEDE  
Facultad de Ciencias Veterinarias  
Universidad Central de Venezuela  
El Limón - Estado Aragua

N. MEDINA DE LOPEZ  
Instituto de Investigaciones Veterinarias  
FONAIAP, Las Delicias - Maracay

H. CASTAÑO  
Instituto de Investigaciones Veterinarias  
FONAIAP, Las Delicias - Maracay

### SUMMARY

With the objective of contributing to the development of diagnostic methods for use in the clinical treatment of crocodilides kept in captivity, a study was made of a 15-year old male kept with eight others in an exhibition pen in the zoo. Data were collected on the animal's clinical history and examination, and blood samples taken for hematological studies. In order to establish hematological reference standards, blood samples were also taken from the eight other animals. Clinical examination of the affected animal showed lethargy, lesions in different parts of the body and signs of dehydration. Blood analysis showed leucopenia ( $11 \times 10^3/\text{ul}$ ; baseline values:  $12-31 \times 10^3/\text{ul}$ ) due to a lymphopenia ( $2 \times 10^3/\text{ul}$ ; baseline values:  $4-16 \times 10^3/\text{ul}$ ) and eosinopenia ( $0.1 \times 10^3/\text{ul}$ ; baseline values:  $0.6-2 \times 10^3/\text{ul}$ ). Hemoglobin over the superior baseline value ( $10 \text{ gm/dl}$ ; baseline values:  $6.5-9.8 \text{ gm/dl}$ ); VGM and HGM slightly raised (VGM:  $475 \text{ fl}$ ; baseline values:  $299-362 \text{ fl}$ ; HGM:  $144 \text{ pg.}$ , baseline values:  $83-115 \text{ pg}$ ). The animal was slaughtered and the following results found on post-mortem examination: hydropericard and gastroliths. As microscopic findings: Hialinization of the cardiac miofibrilles and fatty degeneration of the liver. Pseudomona aeruginosa was isolated from heart, liver lung and kidney tissues. An attempt to isolate leptospire from the kidney gave negative results. Negative results were also obtained from test for gastrointestinal and blood parasites. All these findings took us to the diagnostic of cachexia from inanition, due to hierarchy and territoriality problems between the caimans.

## Introducción

La explotación irracional a nivel mundial de los crocodílidos en general, ha llevado a peligro de extinción a muchas especies, por lo que en la actualidad se hacen esfuerzo por balancear los factores que influyen sobre su dinámica poblacional. Hoy en día las babas (Caiman crocodilus) abundan en algunas zonas de Venezuela y en otras donde anteriormente habitaban ha sido parcialmente extinguida (Seijas, comunicación personal, 1984).

Los trabajos que se llevan a cabo actualmente en varios países consisten mayormente en reproducir crocodílidos en cautiverio, reintroduciendo un cierto porcentaje de las crías al estado silvestre en zonas protegidas como parques nacionales, reservas de fauna y haciendas conservacionistas. Otro porcentaje de estas crías se utilizan para la explotación de su cuero y carne.

El mantener animales de estas especies bajo sistema de explotación extensivos e intensivos, acarrea problemas sanitarios que deben ser estudiados para poder tomar las adecuadas medidas profilácticas y mantener animales saludables, logrando su óptimo crecimiento y reproducción.

Con la finalidad en primer lugar de tratar de establecer un sistema que facilite el diagnóstico de enfermedades en estas especies, y en segundo lugar recopilar datos clínicos y patológicos de crocodílidos mantenidos en condiciones de cautiverio, se efectuó un estudio de la población de 9 babas del Zoológico de Las Delicias en Maracay.

## Materiales y Métodos

**Animales:** Una baba (C. crocodilus) de aproximadamente 15 años de edad, macho, con signos de caquexia, fue evaluada clínicamente. Paralelamente, 8 animales clínicamente normales (5 hembras y 3 machos 5 años) que cohabitaban en el mismo ambiente fueron considerados como controles.

**Dieta:** Las babas son alimentadas 3 veces por semana una vez al día con ratones blancos, pollo picado crudo y carne de burro picada. Debido a problemas de jerarquía entre los animales, la comida es colocada en forma dispersa en una zona del estanque.

**Ambiente:** El área de exhibición ocupada por las babas consta de un estanque con una superficie de 58.32 m<sup>2</sup>., con 0.35 m. de profundidad y con una capacidad aproximada de 20 m<sup>3</sup>. de agua. La zona de tierra firme es de aproximadamente 96.48 m<sup>2</sup>. de superficie con áreas soleadas y parcialmente sombreadas.

**Condiciones climáticas:** La recolección de los datos se realizó durante el mes de abril de 1984. La temperatura media de la zona es de 24.6°C.

**Evaluación del animal problema:** La baba con signos de caquexia se le practicó un examen clínico, exámenes hematológicos y fue posteriormente sacrificada. Se realizaron exámenes histopatológicos, bacteriológicos y parasitológicos.



Hematología: La recolección de sangre en el animal enfermo se practicó después del degollamiento, conservándose en tubos EDTA (Vacutainer -R-, Becton-Dickinson, Rutherford, NJ). Previo al degollamiento se efectuaron varios intentos de recolectar la muestra por venipuntura de los vasos caudales, vena yugular, arteria carótida y por punción cardíaca, los cuales resultaron infructuosos. Al resto de los animales (n=8 controles) se les recolectó sangre por amputación de la porción distal de uno de los dedos de cualquiera de los cuatro miembros, a nivel de la unión de la falange terminal y la uña (Frye, 1977), seguido de un masaje por espacio de 3 a 5 min. Se utilizó este método por su semejanza con el utilizado en la baba problema (traumático), además de ser sencillo y práctico. Esto fue realizado con la finalidad de establecer valores controles de referencia. Frotis: la tinción de los extendidos de sangre se realizó con colorante de Wright. Contaje celular: primeramente se realizó un contaje total de células nucleadas (eritrocitos, leucocitos, plaquetas y células no identificables o núcleos libres) utilizando la metodología previamente descrita (Schalm et al, 1975) para el contaje total de glóbulos blancos con el diluyente de Truck. La dilución empleada fue de 1:100. El contaje diferencial relativo (porcentaje) de células nucleadas (eritrocitos, leucocitos, plaquetas, células no identificables o núcleos libres) se realizó a través del frotis teñido, para lo cual se contaron un total de 600 células. El mismo principio fue utilizado para establecer el diferencial relativo de leucocitos (neutrófilos, linfocitos, monocitos, eosinófilos, heterófilos y basófilos) con la excepción de haber sido consideradas solo 100 células. Los valores absolutos de cada total de células nucleadas al igual que cada total de los diversos tipos de leucocitos, fueron posteriormente calculados en función de los respectivos valores relativos.

El volumen globular medio (VGM), la hemoglobina globular media (HGM) y la concentración de hemoglobina globular media (CHGM) fueron calculados como previamente se ha descrito (Schalm et al, 1975).

Para la determinación de la hemoglobina se utilizó un kit el cual se basa en el método de la cianometahemoglobina. El hematocrito se determinó por el método de microhematocrito (Schalm et al, 1975).

El frotis sanguíneo fue evaluado para evidenciar hemoparásitos. La baba enferma se sacrificó mediante desangrado por degollamiento. Se efectuó la evaluación macroscópica de los órganos de la cavidad toraco-abdominal. Para los exámenes histopatológicos se tomaron muestras de corazón, pulmón, riñón e hígado y se conservaron en formol (10%). También se tomaron muestras de los órganos previamente nombrados para estudios bacteriológicos, los cuales se efectuaron siguiendo una metodología de aislamiento de gérmenes aeróbicos exclusivamente. Las muestras se procesaron de acuerdo a métodos standards previamente descritos (King, 1972). Para el aislamiento de Leptospira del riñón se efectuó cultivo en medio de Fletcher. El cultivo fue incubado a 30°C durante 6 semanas luego de las cuales se inocularon hamsters por vía intraperitoneal. Al cabo de 20 días se sembraron los riñones de los hamsters en medio de Fletcher. Los cultivos se observaron periódicamente por espacio de seis semanas.

Parasitología: El contenido intestinal fue sometido a un lavado en un tamiz N° 100, con la finalidad de visualizar parásitos adultos en el tamizado (microscopio estereoscópico), (Unitest System, Bio-Dynamics, Indianapolis, Indiana - Standard Test-Sieve, ASTM 11-70). (Morales y Pinto,

1977), además se efectuó un examen de Willis para la observación de huevos de parásitos. Se hizo un frotis del raspado de la mucuosa intestinal para poner en evidencia posibles parásitos adheridos a ella. Los estudios histopatológicos, microbiológicos y parasitológicos fueron realizados en el Instituto de Investigaciones Veterinarias (FONAIAP, CENIAP, Ministerio de Agricultura y Cría, Maracay).

### Resultados

**Historia y Examen Clínicos:** La baba problema presentó: letargia, anorexia, pérdida de peso, heridas en el hocico y cuello, además signos de deshidratación como fueron escamas secas y ojos hundidos. La temperatura corporal fue de 34.5°C. Es necesario señalar que al animal le faltaban varias falanges en algunos de sus miembros, desde su llegada al zoológico hace 12 años. La temperatura promedio de las babas controles fue de 33.8°C. (rango 33.6-34.0°C.).

**Hematología:** Los valores hematológicos controles obtenidos en este trabajo se presentan en la Tabla I conjuntamente con los de la baba enferma. Los promedios y rangos controles para cada parámetro fueron establecidos utilizando siete babas clínicamente normales de las 8 inicialmente consideradas, debido a que una de ellas presentó hematozoarios. Los valores hematológicos hallados en el animal enfermo revelaron: leucopenia (disminución de leucocitos) debida a una moderada linfopenia (disminución de linfocitos) y a una moderada eosinopenia (disminución de eosinófilos); hemoglobina por encima del valor superior del rango VGM y HGM ligeramente aumentadas. El frotis resultó negativo a hemoparásitos.

**Histopatología:** Como hallazgos macroscópicos post-mortem se observó: contenido líquido mal oliente, de color achocolatado, además de gastrólitos en la cámara anterior del estómago, los cuales ocupaban una cuarta parte de la capacidad del mismo. Es necesario señalar que la apariencia macroscópica de la mucuosa estomacal era normal. Los cuerpos extraños consistían en: un trozo de aluminio, una pequeña copa de plástico, una semilla de mamón y varias piedras. Además se observó hidropericardio. Los únicos hallazgos microscópicos significativos fueron degeneración grasa del hígado e hialinización de las miofibras cardíacas. El resto de las muestras de vísceras remitidas presentaron una histología normal.

**Bacteriología:** Pseudomona aeruginosa fue aislada de hígado, corazón, pulmón y riñón. El intento de aislamiento de Leptospira a partir de riñón fue negativo.

**Parasitología:** Todos los procedimientos efectuados con el propósito de observar parásitos y/o huevos gastrointestinales dieron resultados negativos.

### Discusión

Independientemente del caso clínico que se persigue abordar, existe un mínimo de procedimientos que debería seguir el clínico preocupado (Tasker, 1976). Esto tiene como finalidad evitar en retrospectiva los errores cometidos por omisión. De acuerdo a este punto de vista la base de datos iniciales debe incluir historia clínica, examen físico y de laboratorio.

En la exhibición de babas en el "Zoológico Las Delicias" permanecían dos machos adultos de aproximadamente el mismo tamaño, el macho problema de 1.80 m. de largo total (LT) con 30 kg. pv y el macho dominante de 1.75 m. LT con 36 kg. pv, conjuntamente con otros dos machos de menor tamaño (1 y 1.5 m LT) y cinco hembras (de un promedio de 1.4 m. LT). Entre estos dos machos de mayor tamaño existían continuos enfrentamientos quedando siempre en desventaja y herida la baba problema, esto ocurría por la falta de espacio suficiente que hubiese permitido la fuga de la baba intimidada. Paulatinamente esta última dejó de entrar al estanque, llegando al extremo, dos meses antes de ser sacrificada, de permanecer en el mismo sitio en una actitud letárgica fuera del agua, sin alimentarse. El otro macho considerado por nosotros como el dominante se comportaba normalmente. En C. crocodilus, en condiciones silvestres no ocurren peleas sino intimidaciones del macho dominante sobre los demás machos, los cuales pueden huir o sumergirse en el agua. En ocasiones el macho dominante logra morderles la punta de la cola en la huida. Esto ocurre especialmente en la época reproductiva (Staton y Dixon, 1977).

Según Blake (1974) una causa de pelea en Crocodilus niloticus en cautiverio ocurre en el momento de la alimentación. Esta causa es descartada como motivo de enfrentamiento en el grupo de babas estudiado, ya que el alimento se les suministra esparcido en una zona del estanque y nunca se observaron peleas a la hora de la alimentación. La causa de enfrentamiento entre estos dos animales se debió a problemas de jerarquía y territorialidad. Una conducta similar es descrita por Joanen y Mc Nease (1979) en Alligator mississippiensis en cautiverio, donde explican lo inadecuado de mantener dos machos dominantes en un estanque. En esta especie la mayor causa de mortalidad en cautiverio son las peleas.

La metodología para el examen físico que se sigue en mamíferos no es valedera en reptiles. En estas especies la observación tiene mucha importancia no así la auscultación ni la persecución (Fowler, 1980).

Las temperaturas tomadas en los animales controles a una misma hora del día (11:00 - 12:00 h) oscilaron entre 33.6-34.0°C. La baba enferma, que permanecía fuera del agua a toda hora del día, mostró una temperatura 0.5°C. por encima del valor superior del rango (34.5°C). Staton y Dixon (1975) reportaron temperaturas máximas de 33°C en C. crocodilus, tomadas estas durante la época de sequía en el llano venezolano. Por el contrario, Wallach y Boever (1983) refieren como temperatura corporal máxima óptima en A. mississippiensis 35°C. y una temperatura alta crítica de 39°C.

En los reptiles se ha dicho que no pueden variar su temperatura por mecanismos propios, por lo tanto no pueden producir fiebre (Reichenbach-Klinke, 1977). Este autor observó que en caso de malestares o infecciones en lagartos, estos buscan sitios con temperaturas más elevadas, tratando de lograr un mejoramiento de su estado físico.

En el transcurso del trabajo se utilizaron varias técnicas para la obtención de sangre en animales mayores de 1 m LT. La utilizada en el animal enfermo, el degollamiento, no deja de ser una técnica con muchas desventajas: 1) conlleva el sacrificio del espécimen; 2) imposibilita como consecuencia el seguimiento de la enfermedad y la apreciación de la efectividad del tratamiento aplicado. En nuestro caso fue necesario usar este método en vista de que los intentos por usar otras técnicas como fueron: la punción cardíaca, de los vasos yugulares y arteria carótida, fueron infructuosos.

El segundo método usado en el trabajo, la amputación de la porción distal de uno de los dedos de cualquiera de los miembros posteriores (Fowler, 1978; Frye, 1977), resultó tener varias ventajas: 1) práctico; 2) sencillo; 3) requiere un mínimo manejo del animal, considerando que los animales de este estudio superaban los 20 kg pv. Las desventajas son: 1) por ocasionar trauma vascular se producen artefactos como son cambios en la morfología normal de algunas células sanguíneas y disminución del número de plaquetas por activación de los procesos de coagulación; 2) obtención de pequeños volúmenes de sangre; 3) afecta la estética del animal, sobre todo en extracciones de sangre seriada. Frye (1977) recomienda esta técnica para la obtención de sangre en pequeños reptiles, lográndose extraer hasta 0.5 ml. de sangre. En el presente estudio obtuvimos hasta 1.0 ml. de sangre.

Es importante señalar que existen otras técnicas más indicadas como por ejemplo: punción cardíaca (babas juveniles); punción de la vena yugular, arteria carótida y/o vasos caudales (en animales de mayor tamaño) (Frye, 1977; Gorzula 1976). Pudimos comprobar que en animales mayores de 20 kg pv. se necesitan agujas para anestesia epidural con más de 2.5 pulgadas de longitud y de calibre 20, que resistan la penetración de la piel y la gran masa muscular, para poder así lograr la punción de los vasos caudales. Más aún, algunos autores (Brazaitis y Watanabe, 1982) han reportado el uso de ultrasonido para lograr una pronta canalización de los vasos sanguíneos, evitando así repetidas punciones y traumatismo tisular.

Actualmente no existen trabajos referidos a valores hematológicos de babas en cautiverio. Se realizó un intento de establecer valores controles de referencia para comparar los obtenidos en la baba afectada motivo de este trabajo.

El gran problema con que cuenta la hematología de aves y reptiles es que el núcleo de los eritrocitos no es destruido por los diluyentes usados en el conteo de leucocitos de mamíferos (Blain, 1929; Saint Girons, 1970). A pesar de esto han existido reportes que señalan el uso de estos diluyentes en la hematología de aves (Magath e Higgins, 1934). Quizás uno de los primeros intentos realizados para tratar de obviar este problema (Blain, 1928) fue establecer una relación numérica eritrocitos: leucocitos a través del frotis teñido (método indirecto). Debido a la no disponibilidad del diluyente adecuado (diluyente de Shaw) (Otis, 1964) y a la urgencia de procesar la muestra de la baba problema, nos llevó a la utilización de diluyentes de sangre de mamíferos y como consiguiente métodos indirectos para la realización de los conteos celulares. Nosotros estamos conscientes que estos métodos indirectos cuentan con un gran margen de error. Es así como por ejemplo Magath e Higgins (1934) señalan un coeficiente de variación de un 19.6% en el método indirecto empleado para establecer el total de leucocitos. Está de más señalar que el método más exacto para el conteo celular en aves y reptiles es el método directo (Blain, 1928; Quay, 1974).

La influencia de las variaciones climáticas y/o ambientales sobre los valores hematológicos de reptiles es muy controversial (Duguay, 1970; Ramírez et al, 1975; 1978). La realización de este trabajo ocurrió a una misma hora del día, durante una misma época del año y en un período corto de tiempo, por lo que consideramos que estas variables no afectaron los resultados.

Por otra parte algunos autores coinciden en señalar que no existe diferencia significativa en los valores hematológicos establecidos entre machos y hembras en algunas especies de reptiles incluyendo al C. crocodilus (Engbretson y Hutchinson, 1976; Ramírez et al, 1978). La tabla I representa los datos combinados de 3 machos y 4 hembras (rangos controles).

Al comparar los resultados previamente establecidos (Ramírez et al, 1978) en animales no parasitados de la misma especie con aquellos obtenidos en el presente estudio, podemos señalar que muchos de sus promedios se encuentran dentro de nuestros rangos controles (Tabla I), tales como índices eritrocíticos (VCM, HCM, CHCM), número de glóbulos rojos y blancos, hemoglobina y hematocrito. A diferencia, el número promedio de plaquetas (machos 159.000/ul, hembras 164000/ul) se encuentra muy por encima del valor superior de nuestro rango. Con respecto al diferencial de blancos, podemos decir que solo se asemeja en los rangos porcentuales de monocitos, segmentados y basófilos. A diferencia del trabajo de Ramírez et al (1978) en el presente estudio no se encontraron formas jóvenes de neutrófilos.

En el conteo diferencial de leucocitos de este trabajo se consideran los siguientes tipos celulares: linfocitos, monocitos, neutrófilos, basófilos, eosinófilos y heterófilos. Frye (1978) ha señalado esta clasificación como válida en la hematología de reptiles. En la actualidad no existe una unidad de criterios al respecto. Por ejemplo Sain Girons (1970) no considera en su clasificación a los heterófilos, y por el contrario cita en su lugar al azurófilo. Reportes más recientes (Mateo et al, 1984) sobre el A. mississippiensis concluyen que son 5 los tipos celulares de la serie blanca: linfocitos, monocitos, basófilos, eosinófilos y heterófilos. Esta última especie de crocodilidos es quizás de la cual se tiene mayor información hematológica (Duguy, 1970; Frye, 1978). De acuerdo a valores hematológicos previamente establecidos para estos animales, tales parámetros como hemoglobina (5.9-12.0 g/dl, Frye, 1978), hematocrito (20-30% - Frye, 1978-), número de glóbulos rojos ( $6.18-14.8 \times 10^5/\text{ul}$  -Duguy, 1970; Frye, 1978;  $3.84 \pm 8.7 \times 10^5/\text{ul}$  -Mateo et al, 1984), número de heterófilos (54.7% -Mateo et al, 1984), son similares a los establecidos en el presente estudio. Por el contrario datos referentes al número total de glóbulos blancos ( $6.4-10.2 \times 10^3/\text{ul}$  -Frye, 1978;  $6.4 \pm 2.9 \times 10^3/\text{ul}$  -Mateo et al, 1984), se encuentran por debajo del valor inferior de nuestro rango. (Ver tabla I).

El número de glóbulos rojos, el hematocrito y la hemoglobina de la baba enferma estuvo comprendido dentro del rango control (Tabla I). Clínicamente la baba presentó signos de deshidratación lo que nos conduce a pensar la posibilidad de una anemia enmascarada por una hemoconcentración. La clarificación de este punto hubiese estado dada por una hiperproteinemia o por un incremento de la gravedad específica de la orina (Tasker, 1978) valores ambos con los cuales no contamos.

No encontramos una explicación al incremento del VGM y HGM. De haber significado este incremento una respuesta a una probable anemia (y como consecuencia al aumento del número de formas jóvenes de eritrocitos) el incremento del VGM creemos que hubiese estado relacionado con el decremento del CHGM (Searcy, 1976). Este último valor resultó estar comprendido dentro del rango control.

TABLA I

	<u>CONTROLES</u>		<u>BABA PROBLEMA</u>
	<u>RANGO</u>	<u><math>\bar{X}</math></u>	
Hcr (%)	23 - 33	28	33
Hb (g/dl)	6.5 - 9.8	8.5	10
Plaquetas	2.200 - 20.340	10.620	0
GR (cel x 10 <sup>5</sup> /ul)	7 - 11	9	7
VGM (fl)	299 - 362	327	475
HGM (pg)	83 - 115	98	144
CHGH (g/dl)	27 - 34	30	30
GB (cel x 10 <sup>3</sup> /ul)	12 - 31	23	11
NEUT (cel x 10 <sup>3</sup> /ul)	0 - 2	0.8	0.4
(%)	0 - 8	4	4
LINF (cel x 10 <sup>3</sup> /ul)	4 - 16	11	2
(%)	32 - 73	47	19
MON <sub>x</sub> (cel x 10 <sup>3</sup> /ul)	0 - 1	0.4	0
(%)	0 - 5	1	0
EOS (cel x 10 <sup>3</sup> /ul)	0.6 - 2	1	0.1
(%)	2 - 13	6	1
HET (cel x 10 <sup>3</sup> /ul)	5 - 18	9	7
(%)	21 - 64	39	70
BAS (cel x 10 <sup>3</sup> /ul)	0 - 2	0.7	1
(%)	0 - 11	4	11
cel no ident. (cel x 10 <sup>3</sup> /ul)	13 - 55	25	35
cel nuc totales (cel x 10 <sup>3</sup> /ul)	740 - 1.145	931	740

El valor absoluto en el diferencial de células blancas se ha venido considerando durante mucho tiempo en la medicina veterinaria de mayor significación en la interpretación clínica del leucograma (Schalm et al, 1975). La baba afectada presentó en el hemograma leucopenia debido a una linfopenia y a una eosinopenia (Ver Tabla I). La interpretación previa del leucograma se efectuó en función de los valores absolutos. En mamíferos domésticos, linfopenia y eosinopenia usualmente son reflejos de un stress sistémico de enfermedad (i. e. corticoides endógenos) (Prasse y Duncan, 1976). En este caso hemos extrapolado datos existentes en la interpretación clínica del leucograma de mamíferos domésticos a reptiles, debido a que en la actualidad carecemos de datos exclusivos de esta especie. Debemos también señalar que el leucograma no es un arma diagnóstica per-se. Debe tratar de interpretarse a la luz del examen clínico (Prasse y Duncan, 1976).

Como es bien sabido en el transcurso del proceso de coagulación (en este caso generado por trauma vascular producido por degollamiento o por resección de una porción del dedo) las plaquetas juegan un papel activo en la formación del trombo conjuntamente con algunos glóbulos blancos y fibrina (Harker, 1974). Luego de adherirse a la pared vascular, las plaquetas liberan sustancias activas (i.e. ADP) que también contribuyen a la formación del coágulo hemostático (Dodds, 1980). Es por estas razones que el conteo de plaquetas realizado en el presente estudio, no es representativo del número de plaquetas en sangre circulante. Además es lógico suponer que la morfología de las células sanguíneas se vería afectada en el intento de recolectar sangre posterior a la injuria vascular, al ocurrir su extravasación a través de una red constituida por el trombo. La presencia de un gran número de núcleos libres y/o células no diferenciadas constituyen una desventaja de los métodos de recolección de muestra de sangre empleados.

Como ha sido anotado por varios autores (Scherpner, 1980; Fowler, 1978; Gorzula, comunicación personal, 1984; Staton y Dixon, 1975), la presencia de piedras, semillas y palos es común hallazgo en elevado porcentaje de autopsias de crocodilidos en condiciones silvestres.

La función de los gastrolitos (cuerpos extraños en el estómago) no ha sido aún dilucidada. Gorzula (comunicación personal, 1984) considera que posiblemente estos ayudan a triturar los alimentos más duros como pequeños mamíferos y crustáceos. Gorzula (1978) señala una mayor incidencia de gastrolitos en los animales que contenían en sus estómagos huesos, peces grandes y cangrejos, que en aquellos que presentaban restos de alimentos más blandos, como renacuajos y pequeños anfibios. Por el contrario, otros autores no están de acuerdo en señalar esta función, ya que consideran que el estómago de los crocodilidos no se asemeja al estómago muscular de las aves, debido a que su pared es distensible y no tiene revestimiento interno cuticular, por lo tanto no puede tener función abrasiva (Fowler, 1978). Scherpener (1980) considera que los gastrolitos brindan estabilización en el agua. Igualmente Brazaitis (1969) plantea el cambio en la gravedad específica causado por estos artículos no digeribles, permite al animal permanecer sumergido en el fondo de fuertes corrientes de agua. Por lo tanto podemos señalar que la presencia de cuerpos extraños en estómago es definitivamente cuestionable.

Si la relación con algún proceso fisiológico no ha podido ser establecida, la presencia de gastrolitos pudiera correlacionarse con pica o malasia, especialmente si los animales han pasado largos períodos de inanición, como en la época de sequía.

Lo que pudiera parecer fisiológico en animales en estado silvestre, se transforma en un problema patológico en animales en cautiverio (Wallach y Boever, 1983). Es así como los objetos extraños (gastrolitos) encontrados en crocodilidos mantenidos bajo estas condiciones, son reflejo del contacto de estos animales con el hombre (i.e. pelotas, monedas, botellas de vidrio), y que debido a su forma, tamaño o material causan daño al tracto gastrointestinal, originando diversas sintomatologías, como desde regurgitación, y abultamiento corporal hasta la muerte.

En el caso particular de la baba autopsiada en el presente trabajo, no puede afirmarse que lo encontrado en el estómago sea un hallazgo patológico, en vista de que la mucosa estomacal no mostraba cambios macroscópicos, y su sintomatología no coincide con la encontrada en estos casos. No podemos descartar la posibilidad de que la baba problema, haya ingerido estos cuerpos extraños, debido a que el macho dominante por problemas de territorialidad no permitía su libre acceso al alimento. Esto no se podrá rebatir hasta que se compruebe la base fisiológica de la ingestión de cuerpos extraños.

Los hallazgos histopatológicos macroscópicos de hidropericardio y microscópicos de degeneración grasa del hígado e hialinización de las miofibras cardíacas han sido previamente asociados a procesos de desnutrición (Jubb y Kennedy, 1973). Con respecto a la degeneración grasa, existen autores que la señalan como común hallazgo en autopsias de tortugas y lagartos, no así en otros reptiles (Klos y Lang, 1976).

Pseudomonas sp han sido aisladas tanto de reptiles enfermos como en los clínicamente sanos (Beehler y Sauro, 1983; Klos y Lang, 1976; Wallach y Boever, 1983). (Jacobson, 1980) anota el aislamiento de Pseudomonas asociada a Trichosporum, en hematomas atribuidos a combates macho-macho en lagartos, en los que esta bacteria produce una septicemia con pocos signos clínicos discernibles. Entre esotos señala: escamas hemorrágicas, letargia, anorexia y convulsiones antes de morir. Además existen otros reportes (Jacobson, 1980; Klos y Lang, 1976; Reichenbach-Klinke, 1977; Wallach y Boever, 1983) que asocian las Pseudomonas con estomatitis ulcerosa, pneumonías y absesos en varias especies de reptiles.

En el caso de la baba problema se logró aislar Pseudomona aeruginosa de corazón, pulmón, riñón e hígado. Esta bacteria pudiera haber entrado por las heridas que presentaba el animal en varias partes del cuerpo, y debido al stress (Duponte et al, 1978) a que estaba sometido, consiguieron paulatinamente pasar a la sangre y de allí a los órganos donde fue aislada (Reichenbach-Klinke, 1977). El caracter patológico de su aislamiento en estos órganos es cuestionable, ya que no hubo hallazgos histopatológicos que así lo evidencien.

Muchos estudios han comprobado que mamíferos silvestres actúan como reservorio de leptospiras (Carrillo et al, 1972; Clark et al, 1961; Ferris et al, 1957; Santa Rosa et al, 1975; Wisseman et al, 1955). Estudios bacteriológicos y serológicos en reptiles demuestran que estos aparentemente también actúan como reservorio de leptospiras (Ferris et al, 1961; Klos y Lang, 1976; Mazzonelli y Jelambi, 1980; Reicehbach-Klinke, 1977).



infectándose al ingerir animales de presa (i.e. roedores) infectados (Wallach y Boever, 1983). Esto nos motivó a tratar de hacer un aislamiento en la baba problema, el cual resultó negativo. Debemos señalar que no se realizaron exámenes serológicos.

Los exámenes parasitológicos realizados a la baba motivo del presente estudio resultaron negativos, a pesar de que numerosos autores anotan la existencia de una gran variedad de parásitos gastrointestinales, del tejido conectivo y hemoparásitos en estas especies (Fowler, 1978; Khan et al, 1980; Klos y Lang, 1976; Marcus, 1977; Marinkelle, 1981; Reichenbach-Klinke, 1977; Wallach y Boever, 1983).

### Conclusiones

1. La historia y examen físicos son de utilidad limitada en el diagnóstico clínico de enfermedades en crocodilidos. Sin embargo, la observación del comportamiento del animal y su relación con sus congéneres fue de gran importancia en la evaluación clínica del caso. Los exámenes complementarios (i.e. hematología) fueron de gran utilidad en el presente estudio, y progresivamente, a medida que se realicen nuevos reportes irán adquiriendo una mayor importancia diagnóstica.
2. La técnica de obtención de sangre por amputación de la porción distal de uno de los dedos de los miembros posteriores, resultó ser la técnica más sencilla en animales de gran talla.
3. Los métodos indirectos para conteo celular no son realmente representativos de la constitución corpuscular de la sangre, porque son valores relativos.
4. La razón por la cual el animal estudiado tenía gastrolitos no fue determinada. Aconsejamos evitar el acceso de las babas a objetos nocivos extraños dentro de la exhibición o estanque, por la tendencia todavía no justificada de estos animales a ingerirlos. Por el contrario si podemos concluir que estos gastrolitos no influyeron en el cuadro clínico estudiado.
5. El carácter patológico de la Pseudomona aeruginosa en los órganos donde fue aislada es cuestionable, debido a que no hubo hallazgos histopatológicos que así lo evidenciaran.
6. El diagnóstico al que se llegó en el caso estudiado fue el de caquexia por inanición, la cual fue causada por problemas de jerarquía y territorialidad entre esta baba y la dominante. Por eso se recomienda evitar tener más de un macho adulto en un área restringida (exhibición o estanque).
7. Podemos señalar las siguientes recomendaciones para el manejo de problemas sanitarios en explotaciones de crocodilidos: a) recopilar una buena información con respecto a la historia clínica; b) observar el comportamiento del animal enfermo y su relación con el resto del grupo; c) aislamiento; d) practicar un examen clínico completo y tomar las muestras necesarias para exámenes de laboratorio (serología, química sanguínea, hematología, bacteriología, parasitología); e) diagnóstico,

tratamiento; f) en caso de no responder al tratamiento, o en caso de deterioro o muerte, practicar la necropsia y recolectar muestras para exámenes histopatológicos, bacteriológicos y parasitológicos; g) tomar las medidas profilácticas requeridas con el resto del grupo.

#### Bibliografía

- Beehler, B.A. Sauro, A.N. Aerobic bacteria isolates and antibiotic sensitivities in a captive reptile population. Proc. of the American Assoc. of Zoo Vet., Tampa, Florida, pp.198-201, 1983.
- Blain, D. A direct method for making total white blood counts on avian blood. Proc. Soc. Exper. Biol. Med. 25:594-596, 1928.
- Blake, D.K. The rearing of crocodiles for commercial and conservation purposes in Rhodesia. Rhodesia Sci. News 8:321-322, 1974.
- Brazaitis, P. The occurrence and ingestion of gastroliths in two captive crocodilian. Herpetológica. 25:63-64, 1969.
- Brazaitis, P. Watanabe, H. The doppler, a new tool for reptile and amphibian hematological studies. J. Herpetol. 16:1-6, 1982.
- Burke, T.J. Infectious diseases of reptiles. En: Zoo and Wild Animal Medicine, ed. Fowler, pp. 134-137. I.B. Saunder Co., Philadelphia, 1978.
- Carrillo, C.G., Meyers, D.M. Szyfres, B. Bataviae group leptospirae isolated from armadillos in Argentina. Trop. geogr. Med. 24:377-381, 1972.
- Clark, L., Kressie, J.; Marshak, R.; Hollister, Ch. Natural occurrence of Leptospira icterohemorrhagiae infection in the common muskcat (Odantra zibethicus zibethicus) a preliminary report, (mimeo). 1961.
- Doods, W. J. Hemostasis and coagulation. En: Clinical Biochemistry of Domestic Animals, ed. Kaneko, pp. 672-673, 3rd. ed. Academic Press, New York, 1980.
- Duguy, R. Numbers of blood cells and their variation. En: Biology of Reptilia, ed. Gans, pp. 93-100, vol. 3. Academic Press, London, 1970.
- Du Ponte, M.; Nakamura, R. M.; Chang, E.M. Activation of latent Salmonella and Arizona organisms by dehydration in red-eared turtles (Pseudemys scripta-elegans). Am. J. Vet. Res. 39 529-530, 1978.
- Engbretson, G.A.; Hutchinson, V.H. Erythrocyte count hematocrit and hemoglobin content in the lizard Liolaemus multiformis. Copeia 1: 166, 1976.

- Evans, H.E. Introduction and anatomy. En: Zoo and Wild Animal Medicine, ed. Fowler, p. 94. W.B. Saunders Co., Philadelphia, 1978.
- Ferris, D.H.; Hanson, L.E.; Alberts, J.C.; Calhoun, J.C.; Marlowe, R. Epizootiological studies on *Leptospira* in Illinois. I. Serological test on Illinois deer in 1957, (mimeo) 1957.
- Ferris, D.H.; Rhoades, H.E.; Hanson, L.E.; Galton, M.; Mansfield, M.E. Research into the nidality of *Leptospira ballum* in campestral host including the hog-nosed snake (*Heterodon platyrhinus*). Cornell Vet. 51: 405-419, 1961.
- Fowler, M.E. Restrain and Handling of Wild and Domestic Animals, P. 288. Iowa State University Press, Iowa, 1978.
- Fowler, M.E. Respiratory disease in reptiles. En: Current Veterinary Therapy VI, ed. Kirk, pp. 633-637. W.B. Saunders Co., Philadelphia, 1980.
- Frye, F.L. Hematology of captive reptiles (with emphasis on normal morphology). En: Current Veterinary Therapy VI, ed. Kirk, pp. 792-798. W.B. Saunders Co. Philadelphia, 1977.
- Gorzula, S.; Arocha-Piñango, C.L.; Salazar, C. A method of obtaining blood by venipuncture from large reptiles. Copeia 4: 838-839, 1976.
- Gorzula, S. An ecological study of *Caiman crocodilus crocodilus* inhabiting savanna lagoons in the venezuelan Guayana. Oecología 35: 21-34, 1978.
- Harker, L.A. Hemostasis Manual, p. 37. F.A. Davis Co., Philadelphia, 1974.
- Jacobson, E. Infectious diseases of reptiles. En: Current Veterinary Therapy VII, ed. Kirk, pp. 625-633. W.B. Saunders Co., Philadelphia, 1980.
- Joanen, T.; Mc Neas, L. Culture of the american alligator. International Zoo Yearbook 19: 61-62, 1979.
- Jubb, K.V.; Kennedy, P.C. Pathology of Domestic Animals, 2nd. ed., vol. 1 y 2. Academic Press, New York, 1970.
- Khan, R.A.; Forester, D.J.; Goodwin, T.M., Ross, C.A. A haemogregarine from the american alligator (*Alligator mississippiensis*). J. Parasitol. 66: 324-328, 1980.
- King, E. The identification of unusual pathogenic gram negative bacteria, United States Department of Health, Education and Welfare. Public Health Service, Center for Disease Control. Atlanta, Georgia, 1972.
- Klos, H.G.; Lang, E.N. Zootierkrankheiten. Verlag Paul Parey, Berlin, 1976.
- Magath, T.N.; Higgins, G.M. The blood of the normal duck. Folia Haematol. 51: 230-241, 1934.

- Marcus, L. Parasitic diseases of captive reptiles. En: Current Veterinary Therapy VI, ed. Kirk, pp. 801-806. W.B. Saunders Co., Philadelphia, 1977.
- Marinkelle, C.J. Oswaldofilaria medemi n.sp. (Nematoda: Filaroidea) from the smooth fronted caiman, Paleosuchus trigonatus from Colombia. Rev. Biol. Trop. 29 (1): 5-10, 1981.
- Mateo, M.R.; Roberts, E.D.; Enright, F.M. Morphologic, cytochemical, and functional studies of peripheral blood cells of young healthy american alligators (Alligator mississippiensis), Am. J. Vet. Res. 45: 1046-1053, 1984.
- Mazzonelli, J.; Jelambi, F. La leptospirosis bovina en el trópico venezolano. Gaceta Veterinaria, (Buenos Aires) XLII: 356, 1980.
- Morales, G.A.; Pinto, L.A. Manual de diagnóstico Helminológico en rumiantes. Gremerca Editores, Aragua, 1977.
- Otis, V.S. Leucocyte and erythrocyte diluent for reptilian blood cell counts. Copeia 1: 252-254, 1974.
- Prasse, K.W.; Duncán, J.R. Clinical interpretation of leykocyte abnormalities. Vet. Clin. North Am. 6: 581.
- Quay, W.B. Leucocyte and erythrocyte diluent for reptilian blood cell counts. Copeia 1: 252-254, 1974.
- Ramírez, F.J.; Arocha-Piñango, C.L.; Gorzula, S.; Salazar C. Haematology of Amphisbaena alba Linnaeus. British J. Herpetol. 5: 627-628, 1975.
- Ramírez, F.J.; Arocha-Piñango, C.L.; Montiel, N.; Gorzula, S. Elementos figurados, hemoglobina y proteínas de la sange en el Caiman crocodilus Linn. Acta Cient. Venezolana, 29:268-273, 1978.
- Reichenbach-Klinke. Krankheiten der Reptilien. Gustav Fischer Verlag, Stuttgart, 1977.
- Santa Rosa, C.A., Sulzer, C.; Giorgi, W; da Silva, A.S.; Yanaguita, R.M.; Lobao, A. Leptospirosis in wild life Brazil: Isolation of a new serotype in the pyrogenes group. Am. J. Vet. Res. 36: 1363-1365, 1975.
- Saint Girons, M.C. Morphology of the circulating blood cells. En: Biology of Reptiles, ed. Gans, pp. 73-91. vol. 3, Academic Press, London, 1970.
- Schalm, O.W.; Jain, N.C.; Carrol, E.J. Veterinary Hematology, 3rd. ed. Lea Febiger, Philadelphia, 1975.
- Scherpner, C. Die krokodile. En: Grzimeks Tierleben Vol. 6, ed.Grzimek, pp. 128-147. Deutschen Taschenbuch, Verlag, Munchen, 1980.

- Searcy, G.P. The differentail diagnosis of anemia. Vet. Clin. of North America 6: 567-580, 1976.
- Soifer, F. Parasitic diseasses of reptiles. En: Zoo and Wild Animal Medicine, ed. Fowler, pp. 138-143. W.B. Saunders Co., Philadelphia, 1978.
- Staton, M.; Dixon, J. Studies on the dry season biology of Caiman crocodilus from the venezuelan llanos. Memoria de la Sociedad de Ciencias Naturales La Salle XXXV: 237-265, 1975.
- Staton, M.; Dixon, J. Breeding biology of the espectacled caiman, Caiman crocodilus crocodilus, in the venezuelan llanos. Wildl. Res. Report. 5: 3-7, 1977.
- Tasker, J.B. A problem oriented approach to laboratory diagnosis. Vet. Clin. of North America 6: 515-522, 1976.
- Wallach, J.D.; Boever, W.J. Diseases of Exotic Animals Medial and Surgical Management, p. 1006. W.B. Saunders Co., Philadelphia, 1983.
- Wisseman, C.L.; Traub, R.; Gochenour, W.S; Smadel, J.E.; Lancaster, W.E. Leptospirosis of man and animals in urban, rural and jungle areas of southeast Asia. Am. J. Trop. Hyg. 4: 29-40, 1955.

SITUACIÓN ACTUAL DEL CAÍMAN DE LA COSTA, Crocodylus acutus,  
EN VENEZUELA

Andrés Eloy Seijas Y.  
Servicio Nacional de Fauna Silvestre  
Ministerio del Ambiente y de los Recursos Naturales Renovables  
Apartado 184. Maracay, Venezuela

SUMMARY

Numerous localities within the historical range of Crocodylus acutus were visited along the coast of Venezuela, in order to collect information about the status of this species. The presence of C. acutus was confirmed in only 14 of these localities, with a total of 293 crocodiles greater than one year old being seen. Only 35 of the individuals observed were considered to be adults. On the basis of the presence of nests hatchlings it was estimated that at least 22 reproductively active females existed in the areas visited. A discussion is made with regard to the possibility of recuperating this species in Venezuela.

## Introducción

La situación de las poblaciones del caimán de la costa, Crocodylus acutus, en Venezuela ha sido reseñada en algunos trabajos recientes (King, Cambell y Moler, 1982; Maness, 1982; Medem, 1983). No obstante, estos trabajos no han contado con la actividad de campo suficiente para establecer con mayor precisión la ubicación y el estado actual de las poblaciones de este cocodrilo en el país. Con esta finalidad se ha venido haciendo, desde el año 1980, un reconocimiento de numerosas localidades de la región costera de Venezuela, actividad que está inscrita dentro de los programas básicos del Servicio Nacional de Fauna Silvestre del Ministerio del Ambiente y de los Recursos Naturales Renovables (MARNR). Este esfuerzo, cuyos logros iniciales fueron presentados por Seijas y Caballero (1981), cobró un mayor impulso a partir de noviembre de 1983. La información que aquí se presenta es sólo un resumen de las observaciones hasta ahora realizadas. Una publicación más detallada, que incluya algunas proposiciones de manejo para la recuperación de esta especie, habrá de ser publicada posteriormente.

## Localidades visitadas y metodología

Se visitó la mayor parte de las localidades específicamente señaladas en la literatura (Medem 1983; Donoso-Barros 1966) y aquellas para las cuales se tenía información por parte de turistas, pescadores, prensa u otras fuentes, sobre la existencia de C. acutus.

La metodología empleada para el reconocimiento de las localidades visitadas consistió en recorridos diurnos y/o nocturnos, utilizando para ello, la mayor parte de las veces, un bote de aluminio de 12 pies y un motor fuera de borda de 6,15 o 25 HP. Se recabó información sobre esta especie y sus hábitats: señales sobre su supervivencia, huellas, nidos, principales factores que amenazan su supervivencia, etc. Para el reconocimiento nocturno se empleó una potente lámpara conectada a una batería de automóvil de 12 voltios. El encandilamiento de los animales permite acercárseles lo suficiente como para hacer una estimación de sus tamaños o para su captura, a mano o con lazos, y la toma de medidas más precisas previas a su marcaje y liberación. Para el conteo de los animales en cada localidad se discriminó entre crías (C. acutus menores de un año) e individuos mayores de un año, destacando entre estos últimos a los adultos. La presencia y localización de las crías y nidos, se tomó como criterio para estimar el número mínimo de hembras reproductivamente activas en cada lugar.

La longitud de los ríos y el perímetro de los embalses y lagunas se calculó por medio de un curvímetro y cartas geográficas a distintas escalas: desde 1:25.000 hasta 1:250.000. El número máximo de caimanes observados para cada localidad se relacionó con estas longitudes.

## Resultados

Gran parte de la región costera venezolana, excluyendo todo el litoral del Distrito Federal, fue visitada durante la realización del presente trabajo. Sólo en 14 de los sitios recorridos fue

posible comprobar la existencia de C. acutus. El número máximo de animales de más de un año que pudo ser contado, para todas las localidades, alcanza la cifra de 293 ejemplares. En la Tabla 1 aparecen los valores para cada localidad, y la relación entre el número de animales y las longitudes recorridas.

Un total de 207 individuos de C. acutus, incluyendo crías, fueron capturadas. El mayor de estos animales era de 1.500 mm de longitud total (Tabla 2). De estos cocodrilos, 36 fueron retenidos para la realización de un ensayo de cría en cautividad.

Sólo 35 de los caimanes observados en las distintas localidades fueron considerados adultos, y se estimó, en base a la presencia de nidos y crías, que existen al menos 22 hembras reproductivamente activas. (Tabla 3).

En la Tabla 4 aparecen las localidades para las cuales no fue posible comprobar, o negar, la existencia de C. acutus, indicándose el tipo de reconocimiento realizado, la fecha, y la fuente que señala la existencia de esta especie en el lugar.

A continuación se hace una breve descripción de las localidades para las que se pudo comprobar la existencia de caimanes y se señalan aquellas características o aspectos relevantes que pudieran estar amenazando la supervivencia de esta especie.

**EMBALSE DE PUEBLO VIEJO:** Presa sobre el río Pueblo Viejo, ubicada a unos 20 km de la ciudad de Lagunillas, en el Estado Zulia. Esta obra fue construida en el año 1960. Dista 30 km, en línea recta, del Lago de Maracaibo y está situada a una altura aproximada de 60 metros sobre el nivel del mar, cubriendo una superficie de 1.000 ha. El área es de acceso limitado y está parcialmente protegida por la Guardia Nacional. Para la fecha de la visita, 13 de junio de 1984, los niveles del embalse estaban muy bajos, provocado por la fuerte sequía que afectaba la zona y no se encontró vegetación acuática en los bordes de la presa. Estos factores parecen estar afectando a la pequeña población de C. acutus presente en el lugar, ya que la mayor parte de los animales capturados, particularmente las crías, parecían muy flacas. La siembra del pez Cichla ocellaris, parece haber provocado un desequilibrio ecológico que pudiera estar afectando a los caimanes allí presentes.

**EMBALSE DE TACARIGUA:** Presa sobre el caño El Cauce, a unos 4 km. de la población de Boca de Tocuyo, en el Estado Falcón. La represa tiene por finalidad suministrar agua para riego y consumo humano de poblaciones vecinas. Algunas fincas que rodean el embalse han deforestado hasta el borde mismo del agua, lo cual elimina a estas áreas como posibles lugares para la nidificación de C. acutus.

**LAGUNA DE JATIRA:** En realidad también es un embalse y está conectado con el anterior (Embalse de Tacarigua) por un estrecho canal de unos 300 metros de largo. Es más pequeño que el embalse de Tacarigua y de aguas más someras y con mucha vegetación acuática, lo cual dificulta su recorrido. En reconocimiento nocturno de una pequeña parte de esta laguna, el 11 de febrero de 1984, sólo se observó a dos caimanes, ambos adultos. No obstante, cinco adultos



observados en un pozo de unos 500 m<sup>2</sup>. ubicado a una distancia de 200 metros de la laguna, deben provenir de la misma. Allí, los días 30 de septiembre y 12 de noviembre de 1982, se capturaron 41 crías y se comprobó la existencia de, al menos, tres nidos. El pozo fue secado en 1983 para regar tierras cercanas, desconociéndose el destino de todos los animales.

**RIO TOCUYO:** Es uno de los ríos más largos que desembocan en la Costa Caribe de Venezuela. Sólo los últimos 16,5 km. fueron recorridos. En ese sector los bordes están muy intervenidos, los cultivos llegan hasta la orilla y la mayor parte de las fincas toman el agua directamente del río. Los agricultores, además, arrojan con frecuencia los barbechos al cauce. En el recorrido realizado el 23 de agosto de 1984, se observaron caimanes juveniles y subadultos, pero tan sólo una cría.

**CUARE:** Ubicado en el Estado Falcón al sur de la población de Chichiriviche. En este lugar existe un refugio de fauna silvestre con una superficie de 11.825 ha., mayormente representada por un golfete -Cuare- rodeado de manglares y unas salinas de inundación temporal. En recorridos nocturnos de junio y septiembre de 1981; enero de 1982 y febrero de 1984, han sido observados un máximo de dos cocodrilos, ambos adultos, en la boca del caño Guacabana. En febrero de 1984 se observó las huellas de un adulto en las ciénagas de El Buquillo. En agosto de 1982, unos muchachos destruyeron un nido recién construido en las cercanías de la casa del refugio.

**MORROCOY:** El Parque Nacional Morrocoy, en el Estado Falcón, tiene una superficie de 32.090 ha., mayormente constituidas por una intrincada red de canales e islotes de manglares. En el lugar existe una creciente presión y aprovechamiento turístico. El lugar ha sido visitado en recorridos parciales por los sectores de Cayo Punta Brava, Caño El León, Ensenada de Morrocoy e Isla de Pájaros. Sólo en Punta Brava e Isla de Pájaros han sido observados caimanes. No se han localizado nidos ni crías.

**RIO AROA:** Ubicado en el Estado Falcón. Ha sido inspeccionado en toda su longitud desde el punte de Palma Sola hasta su desembocadura. El río está muy intervenido en ambos márgenes; particularmente hacia la desembocadura, donde existen casas a la orilla misma de éste. En el sector Palma Sola-La Caracara se observaron siete crías, muy dispersas unas de las otras, una de ellas estaba debajo del propio puente de Palma Sola. Existe una fuerte presión sobre los caimanes por parte de los pobladores, debido a los supuestos o reales daños que ocasionan a los animales domésticos. En enero de 1984 obtuvimos información sobre la muerte de tres cocodrilos subadultos, matados por un lugareño.

**RIO YARACUY:** La mayor parte de este río corre por el Estado Yaracuy y a partir de la población de La Hoya, marca el límite entre este estado y el Estado Carabobo. El río corre a través de una extensa zona dedicada a la agricultura, principalmente caña de azúcar, para terminar en una amplia faja de terreno, de unas 5.000 ha., que conforman un delta: zona de ciénagas, pantanos y albúferas de difícil penetración.

El sector recorrido abarca la mayor parte del río que va desde el puente de Santa María, a 70 km en línea recta desde la costa, hasta su desembocadura; con la excepción del sector entre el puente de El Peñón y la desembocadura del río Marcano. Los recorridos se realizaron los días 23, 24 y 27 de enero; 16 y 17 de mayo y 7 y 8 de agosto de 1984. Sólo en el trayecto que va desde Limoncito (VENEZUELA) hasta la desembocadura no se observaron C. acutus.

**RIO MARCANO:** Este es un pequeño afluente del río Yaracuy. Es muy angosto, poco profundo y cubierto de vegetación acuática en su mayor parte. El río es usado para sacar agua y regar cultivos cercanos. Fue visitado el 7 de diciembre de 1983.

**TURIAMO:** Esta localidad se refiere principalmente a una pequeña laguna de agua salobre ubicada hacia el extremo nor-occidental de la bahía del mismo nombre, en el Estado Aragua. El lugar ha sido visitado 14 veces desde el mes de agosto de 1980, hasta junio de 1984. En tres oportunidades: 1980, 1983 y 1984, se han conseguido nidos, el de este último año fue depredado por humanos. En ciertas oportunidades los caimanes abandonan la laguna y se dirigen hacia el cercano río San Miguel, en la misma bahía. Esta localidad puede ser considerada bastante protegida, en primer lugar por estar ubicada dentro del Parque Nacional Henri Pittier, y en segundo lugar por la presencia cercana de una base naval, lo cual restringe el ingreso de personas al área. No obstante se sabe de la muerte de tres ejemplares, subadultos y adultos, entre los años 1979 y 1980.

**LOS TOTUMOS-LAGUNA GRANDE:** En las cercanías de Cabo Codera, al noreste del Estado Miranda. El área consiste principalmente en lagunas y canales rodeados de manglares. En algunos lugares poco profundos existen praderas de Thalassia. Los caimanes han sido observados también en el mar, a unos 100 metros de la orilla. El sitio ha sido visitado en dos oportunidades: Julio de 1982 y agosto de 1983. No se han encontrado nidos ni crías.

**CANALES DE RIO CHICO:** Situados cerca de la ciudad del mismo nombre en el Estado Miranda. Allí existe una serie de canales naturales y artificiales usados con fines turísticos y recreativos, principalmente para la práctica del skí acuático. Esta localidad ha sido visitada en cuatro oportunidades: julio de 1982, agosto de 1983; y marzo y julio de 1984. Existe, al menos, una pareja de adultos, ya que se han conseguido crías y nidos sucesivamente los años 1983 y 1984.

**LAGUNA DE TACARIGUA:** Ubicada en el Estado Miranda. Esta es una laguna costera bordeada de manglares en su mayor parte, se encuentra protegida por la figura de parque nacional y posee una superficie de 18.400 ha. Ha sido recorrida parcialmente en dos oportunidades en agosto de 1983 y julio de 1984. Se observaron caimanes en los caños Hondo, San Nicolás y Pirital; en los dos últimos lugares hay evidencias, nidos y crías, de la existencia de un mínimo de tres hembras adultas. Uno de los nidos en el Caño Pirital, fue depredado por humanos en 1984.

RIO NEVERI: Este río, muy sinuoso y de aguas relativamente tranquilas, atraviesa, en su último tramo, a la ciudad de Barcelona, en el Estado Anzoátegui. Los recorridos realizados los días 10 y 23 de julio de 1984, abarcaron desde Puente Sucre, en el centro de la ciudad, hasta el puente de la población de Naricual. Sólo se observaron C. acutus, algunos de ellos crías, entre el sector cercano a la planta de la Cervecería Polar y el puente La Volca. De acuerdo a algunos jóvenes que habitan en la población de Naricual, también existen caimanes en los ríos Naricual y Araguaita. En los primeros meses de 1984, tres caimanes, uno de ellos mayor de 2.50 metros, murieron en manos de pobladores de la zona.

### Discusión

La explotación comercial a gran escala del caimán de la costa se inició en Venezuela en el año 1929, aproximadamente. Esta ocurrió de manera simultánea a la explotación del caimán del Orinoco. Crocodylus intermedius y a niveles tan altos que para mediados de 1940 ambas especies se podían considerar escasas, (Medem, 1983; Mondolfi, 1965). No obstante, no existen cifras que permitan conocer con exactitud, y ni siquiera con aproximación, el número de C. acutus cosechados durante esos años. Tampoco se saben las localidades principales donde se realizó esta actividad. De acuerdo a informaciones obtenidas de lugareños y concedores de algunas de las localidades visitadas, se desprende que la explotación fue particularmente importante al sur del lago de Maracaibo, en el río Yaracuy y en la laguna de Tacarigua.

Inmediatamente después de haber finalizado el aprovechamiento comercial, no se realizaron estudios que permitieran establecer la situación exacta en que habían quedado las poblaciones de C. acutus. Los resultados obtenidos en este trabajo no permiten, por lo tanto, hacer comparaciones y poder establecer si ha habido, o no, alguna recuperación de las poblaciones diezmadas. El único valor que puede ser comparado no permite ser optimista. Maness (1982) contó 23 de estos cocodrilos en el Refugio de Fauna Silvestre de Cuare en 1975. Durante la realización del presente trabajo este refugio fue visitado en cuatro oportunidades en los años 1981, 1982 y 1984 siendo dos (2) la cifra máxima de cocodrilos observados.

La presión directa sobre las poblaciones de C. acutus no ha cesado. El valor de su piel, las supuestas propiedades curativas de su grasa, el carácter mágico que se le asigna a sus colmillos, su real o infundada amenaza sobre el hombre y los animales domésticos, etc., ha significado un permanente incentivo para la persecución y muerte de estos animales. Sin embargo, la principal y más preocupante amenaza sobre esta especie es la destrucción de hábitats. En muchas de las localidades visitadas se desarrollan actividades agrícolas y otros tipos de actividad humana en la orilla misma de los cuerpos de agua, lo cual viola disposiciones vigentes en la Ley Forestal de Suelos y Aguas. Esto afecta a los lugares utilizados por C. acutus para la construcción de sus nidos. Por otra parte, las áreas de manglares han venido soportando una creciente presión por parte de urbanizadores, para convertirlos en centros de recreación que terminan, a la larga, con las poblaciones de esta especie.

La cifra de 293 animales de más de un año, contada en las localidades visitadas, puede considerarse como conservadora por dos razones: en primer lugar, porque todavía quedan algunas localidades por visitar o insuficientemente muestreadas, como es el caso de los ríos Tocuyo, Aroa y Yaracuy, toda la región sur del lago de Maracaibo y otras, para las cuales existen algunas referencias históricas y recientes sobre la existencia de este cocodrilo (Laiz-Blanco, 1979; Medem, 1983; Seijas, 1984); y en segundo lugar, porque no todos los animales que ocurren en una zona pueden ser vistos o contados. Con la cifra estimada de 22 hembras reproductivamente activas, se puede hacer un cálculo de la población de estos reptiles en las 14 áreas mencionadas. Este cálculo se basa en observaciones para otras especies de *Crocodylia* (Chabreck, 1966) y ha sido usado por Ogden (1978) para estimar las poblaciones de *C. acutus* en el Estado de Florida en los Estados Unidos. De acuerdo a los criterios usados por estos autores, las hembras adultas que nidifican cada año constituyen entre el 4 y 5% de la población. Si estos valores fueran ciertos para estos reptiles en Venezuela, la población en las áreas visitadas estaría entre 440 y 550 individuos de más de un año, cifra que debe ser tomada con mucho cuidado ya que en este caso no se tiene una población de *C. acutus*, sino múltiples y pequeñas poblaciones aisladas. Futuros estudios podrían permitir una mayor aproximación a la realidad.

La situación de *C. acutus* en Venezuela es crítica, pero no irreversible. La recuperación de sus poblaciones, sin embargo, sólo será posible con la puesta en práctica de un programa de protección y manejo a largo alcance. La sólo política proteccionista, necesaria en todo caso, no sería suficiente.

El freno a la acelerada destrucción de habitats; la recuperación de las zonas protectoras de ríos y represas; la formación de una opinión pública favorable a la recuperación de esta especie (especialmente en las zonas donde ella existe) a través de una eficiente campaña educativa, debe estar acompañada de medidas más energéticas y rápidas, como podría ser la cría en cautividad y por un tiempo prudencial (por ejemplo un año) de animales recién nacidos capturados en el campo, o incluso iniciar este proceso con la incubación de huevos. Este procedimiento elimina, o disminuye, la mayor parte de los factores que provoca una gran mortalidad de los animales en esta etapa. Al término del año los cocodrilos serían liberados en una proporción en el sitio de origen y otros serían para repoblar áreas donde los niveles poblacionales son muy bajos o, incluso, donde esta especie haya desaparecido. Existen antecedentes de este tipo de manejo con *Crocodulus niloticus* (Blake, 1974) con resultados satisfactorios.

La superación de la situación crítica en que se encuentran las poblaciones de *C. acutus* en Venezuela, requiere de la realización de un esfuerzo que, en principio, debería partir de organismos públicos interesados, pero que debería involucrar de alguna manera a toda la colectividad. Sólo así será posible restaurar los valores culturales, científicos, ecológicos y económicos de esta especie.

### Agradecimientos

Son numerosas las personas que colaboraron con la realización de este trabajo, particularmente en la fase de campo, entre ellas la mayor parte del personal de Servicio Nacional de Fauna Silvestre. No obstante, quiero destacar la valiosa participación de Ramón Rivero y Gerardo Cordero, quienes me asistieron en las últimas etapas del proyecto.

### Bibliografía

- Casler, C. y J. Lira. 1983. Estudio Faunístico de los Manglares del Sector Los Olivitos. MARNR. Serie Informes Científicos Zona 5/IC/50. 39 pp.
- Blake, D. K. 1974. The Rearing of Crocodiles for Commercial and Conservation Purposes in Rhodesia. The Rhodesia Science News 8 (10): 315-324.
- Chabreck, R. 1966. Methods of Determining the size and compositions of Alligator Population in Louisiana. Proc. 20th. Annual Conf. S.E. Game and Fish Comm. 20: 105-112.
- King, F.W.; H. W. Cambell y P.E. Moler. 1982. Review of the Status of the American Crocodile. In: Crocodiles. IUCN Publ. (New Ser.): 84-89.
- Laiz-Blanco, J. 1979. Conservación del Ecosistema "Isla de Aves", con Especial Enfasis en el Control y Marcaje de la Tortuga Verde (Chelonia mydas) y de las Aves Residentes y Migratorias. Fundación para la Defensa de la Naturaleza. FUDENA. 82 pp.
- Maness, S. 1982. Status of Crocodylus acutus, Caiman crocodilus fuscus, and Caiman crocodilus crocodilus in Venezuela. In Crocodiles. IUCN Publ. (New Ser.): 117-120.
- Medem, F. 1981. Los Crocodylia de Sur América. Vol. 1. Los Crocodylia de Colombia. Edt. Carrera 7a. Ltda. Bogotá. 354 pp.
- Medem, F. 1983. Los Crocodylia de Sur América. Vol. II. Edit. Carrera 7a. Ltda. Bogotá. 270 pp.
- Mondolfi, E. 1965. Nuestra Fauna. El Farol, (214): 1-12.
- Ogden, J. C. 1978. Status and Nesting Biology of the American Crocodile, Crocodylus acutus, (Reptilia, Crocodylidae) in Florida. J. Herpetol. 12 (2): 183-195.
- Seijas, A. 1984. Estudio Faunístico Preliminar de la Reserva de Fauna Silvestre de las Ciénagas de Juan Manuel, Aguas Blancas y Aguas Negras, Estado Zula. Serie Informes Técnicos DGIIA (MARNR)/IT/147. 84 pp.

Seijas, A. y L. Caballero. 1981. El "Status" Poblacional del Caimán de la Costa (Crocodylus acutus) en Venezuela. (Resumen). Acta Cient. Venez. 32. (Supl. 1). p. 81.

Venezuela. 1977. Reglamento de la Ley Forestal de Suelos y Aguas.

TABLA 1

NUMERO MAXIMO DE CROCODYLUS ACUTUS MAYORES DE UN AÑO, OBSERVADOS EN LAS DISTINTAS LOCALIDADES VISITADAS

Localidades	Distancia Recorrida (Km)	Nº veces visitada	Nº máximo Observado	ind/km.	Fecha
Pueblo Viejo	30,25	1	31	1,02	13-6-84
Laguna de Jatira	--	3	5	--	27-9-82
Represa de Tacarigua	15,00	2	4	0,27	25-4-84
Río Tocuyo					
Sector A	11,00	1	8	0,72	23-8-84
Sector B	5,50	1	9	1,63	23-8-84
Cuare	25,00	5	2	0,08	19-1-82
Morrocoy	--	4	5	--	8-11-82
Río Aroa					
Sector A	14,60	1	11	0,75	26-1-84
Sector B	36,60	1	56	1,53	22-8-84
Río Yaracuy					
Sector A	17,00	2	34	2,00	24-1-84
Sector B	6,00	3	21	3,50	17-5-84
Sector C	13,30	1	21*	1,58	8-8-84
Sector D	13,20	1	35	2,65	7-8-84
Río Marcano	--	1	3	--	7-12-84
Turiamo	4,90	14	18	3,67	3-4-84
Los Totumos- Laguna Grande	--	2	4	--	19-8-83
Río Chico	--	3	6	--	18-8-83
Lag. Tacarigua	--	2	16	--	17-8-83
Río Neverí	3,75	1	4	1,07	23-7-84

\* Recorrido Diurno.

293

TABLA 2

NUMERO DE INDIVIDUOS DE CROCODYLUS ACUTUS CAPTURADOS EN  
DISTINTAS LOCALIDADES DE VENEZUELA

Localidades	450mm.	450 mm.	1.000 x	1.500 mm
Pueblo Viejo	5	8	1	
Embalse de Tacarigua	6	2	-	
Laguna de Jatira	41	-	-	
Río Tocuyo	1	3	-	
Morrocoy	-	3	-	
Río Aroa	4	1	-	
Río Yaracuy	36	6	-	
Turiamo	42	2	5	
Río Chico	12	2	-	
Laguna de Tacarigua	17	3	-	
Río Neverí	6	1	-	
Totales	170	31	6	= 207

Nota: Los individuos de menos de 450 mm de longitud total son crías, es decir, animales menores de un año.



TABLA 3

NUMERO DE ADULTOS OBSERVADOS Y NUMERO MINIMO DE HEMBRAS REPRODUCTIVAMENTE ACTIVAS DE CROCODYLUS ACUTUS, EN LAS DISTINTAS LOCALIDADES VISITADAS

Localidad	Adultos	Nº mínimo ♀ Reproduc. Activas	Observaciones
Pueblo Viejo	1	2	Crías muy dispersas
Laguna de Jatira	5	3	Tres nidos en 1982
Represa de Tacarigua	2	1	Crías en 1984
Río Tocuyo. Sector A	-	1	Una cría en 1984
Cuare	2	1	Un nido en 1982
Morrocoy	1	-	
Río Aroa. Sector B	3	3	Crías muy dispersas
Río Yaracuy. Sector A	5	-	
Sector B	1	1	Una nidada en 1984
Sector C	3	-	Visitada en el día
Sector D	2	3	Crías muy dispersas
Río Marcano	1	-	
Turiamo	4	1	Un nido los años 1980,1983,1984
Los Totumos- Laguna Grande	2	-	
Río Chico	1	1	Nidos en 1983 y 1984
Laguna de Tacarigua	1	3	Nidos y crías en 1983-84
Río Neverí	1	2	Crías muy dispersas
	35	22	

TABLA 4

LOCALIDADES VISITADAS DONDE NO SE OBSERVARON INDIVIDUOS NI SEÑALES  
SOBRE LA PRESENCIA DE CROCODYLUS ACUTUS

Localidad y Fecha de la Visita	Tipo de Reconocimiento D = diurno: N = Nocturno	Fuente
Estado Zulia-Cocinetas (Marzo 1983)	D. y N. Total	Medem, 1981
Ríos Limón y Gran Eneal (Abril 1984)	D. y N. Parcial	Lugareños
Represa Socuy (Junio 1984)	N. Parcial (1/3)	Lugareños
Represa Tulé (Junio 1984)	N. Parcial (1/2)	Lugareños
Río El Cristo (Junio 1984)	N. Total Navegable (4 Km)	Lugareños
Los Olivitos (Marzo 1983)	D. y N. Parcial	Casler y Lira, 1983
Sipallare (Julio 1984)	D. Parcial	Lugareños
Estado Falcón-Caño El Doce (Febrero 1984)	D. Parcial	
Río Araguaita (Febrero 1984)	D. Parcial	
Estado Yaracuy-Caño El Eneal (Septiembre 1981 y Enero 1984)	N. Total Navegable (3 Km)	
Represa Cumaripa (Junio 1984)	N. Total (32 Km)	Lugareños
Estado Miranda Bahía de Guayacán-Laguna La Reina (Julio 1982)	N. Total	
Estado Anzoátegui-Río Unare (Marzo 1984)	N. Sector Clarines-La Boca	Lugareños
Estado Sucre Río Cariaco y Manglares Aledaños (Julio 1984)	N. Total	Donoso-Barros, 1966
Laguna de Chacopata (Julio 1984)	Entrevista con Pescadores	
Golfo de Paria (Febrero 1983)	D. Parcial	Donoso-Barros, 1966
Estado Monagas Reserva Forestal de Guarapiche (Febrero 1983)	D. y N. Parcial	

\* En "Fuente" aparece la referencia más reciente que señala la presencia de C. acutus para una determinada localidad. No obstante, la mayor parte de los lugares fueron visitados por existir información de lugareños, o por encontrarse en el área de distribución histórica de la especie.

CENSO AEREO DE CAIMANES (CROCODYLUS INTERMEDIUS) EN EL RIO  
TUCUPIDO (PORTUGUESA, VENEZUELA) CON OBSERVACIONES SOBRE  
SU ACTIVIDAD DE SOLEAMIENTO

Cristina Ramo y Benjamín Busto  
Universidad Nacional Experimental  
de los Llanos Occidentales "Ezequiel Zamora"  
Guanare - Venezuela

SUMMARY

A crocodile (Crocodylus Intermedius) population was found along the Tucupido river in Portuguesa state, Venezuela. This river originates in the piedmont of the Andes at approximately 1200 meters above sea level, and empties into the Guanare river. A dam is being constructed on the Tucupido river next to the dam of the adjacent Bocono river, the combined dams will be able to flood an area of about 13,000 hectares.

The Tucupido river was observed from an airplane five times at different hours of the day from the bridge of the Guanare-Barinas road until the river is approximately 300 meters above sea level. Sixty-six crocodiles were counted during the five flights. Of these, 32 were shorter than 2 meters in length, 26 were between 2 and 3 meters, and one was longer than 3 meters. These sightings representant least nineteen individuals, 5 between the bridge and the dam and 14 above the dam.

A bimodal pattern of basking activity was found, with maximum basking at 10 a.m. and a second peak at 4 p.m.

## Introducción

El Caimán del Orinoco (*Crocodylus intermedius*), es una especie cuya distribución se encuentra restringida a la cuenca del río Orinoco, desde el Delta Amacuro en Venezuela hasta el río Guavaire en Colombia (Medem, 1983).

El alto valor comercial de su piel, provocó una explotación intensiva hace algunas décadas. Por esta razón, las poblaciones de esta especie disminuyeron drásticamente, hasta tal punto, que actualmente está considerada en peligro de extinción (Blohm, 1973; Rivero-Blanco, 1974; Godshalk y Sosa 1978; Medem, 1981, 1983).

Los datos más recientes acerca del estado poblacional de esta especie en Venezuela, han sido aportados por Godshalk y Sosa (1978-1982) quienes durante un censo efectuado en los Llanos Occidentales, observaron indicios de 273 individuos en los ríos Guanare, Portuguesa, Cojedes, Tinaco, San Carlos, Capanaparo, Riecito, Cinaruco, Meta y Orinoco. Posteriormente, en 1981, Franz et. al. (en prensa), en un reconocimiento aéreo, encontraron una población importante en el río Caura (Bolívar) cerca del Salto Pará.

En la figura 1 se señala la distribución del Caimán del Orinoco en Venezuela.

Las primeras observaciones sobre caimanes en el río Tucupido, son cuatro ejemplares: un macho de 1,20 m. de longitud, capturado el 2 de noviembre de 1980 por D. Taphorn y G. Ríos, una hembra de 2,56 m. capturada el 24 de enero de 1981 por R. Sánchez y dos juveniles de poco tiempo, uno de 36,5 cm. y otro que no se midió, capturados el 24 de mayo de 1981 por R. Sánchez. Estos caimanes se mantienen en cautiverio en las instalaciones de la Universidad Nacional Experimental de los Llanos Occidentales "Ezequiel Zamora" (UNELLEZ) en Guanare.

Posteriormente en julio de 1982, realizando un reconocimiento a pie por la orilla del río, pudimos observar un ejemplar de aproximadamente 2,5 m. soleándose en el borde. Más tarde, el 23 de septiembre de 1982, sobrevolando una parte del Tucupido, tuvimos la oportunidad de avistar 6 caimanes.

Todos estos datos evidenciaban la existencia de una población importante, además la presencia de juveniles recién nacidos indicaba que era una población con parejas que se estaban reproduciendo activamente. Esta información nos llevó a plantear la realización de un censo aéreo ya que era imposible hacerlo por lancha, debido a las condiciones del río.

## Descripción del Area

El río Tucupido nace en las cercanías de la fila Cerro Negro, a 1.200 msnm, aproximadamente. Antes de desembocar en el río Guanare, recorre las siguientes formaciones vegetales: Bosque Premontano

Semideciduo, Bosque Tropical Siempreverde, Sabanas con Chaparros y Bosque Tropical Semideciduo (Ministerio del Ambiente y de los Recursos Naturales Renovables -MARNR- 1982), recibiendo agua de diversas quebradas (Riquera, Higuerones, Los Baños, Las Carpas y Los Hierros).

El clima de la zona se caracteriza por tener dos estaciones bien marcadas; una lluviosa, (junio a octubre) en la que ocurre el 80% de la precipitación anual, y otra seca (diciembre a marzo). Esta estacionalidad influye mucho en el caudal del río, que es de régimen pluvial. Los gastos medios del mes más húmedo y más seco, son respectivamente de 50,7 m<sup>3</sup>/s y 0 m<sup>3</sup>/s (Ministerio de Obras Públicas -MOP- 1976). En la época de lluvias el agua es turbia debido a los sedimentos que arrastra, pero en la época seca, el agua es clara, ya que casi no hay corriente. En su curso alto, el lecho es pedregoso, para dar paso, en su curso medio, a un lecho pedregoso que alterna con grandes pozos y playas arenosas. Al llegar al puente en la vía Guanare-Barinas, han desaparecido los cantos rodados y el lecho del río es arenoso.

Los caimanes se detectaron en los grandes pozos en una sección del río entre el puente y la cota aproximada de los 300 msnm.

Actualmente el Ministerio del Ambiente y de los Recursos Naturales Renovables -MARNR- está construyendo una represa, con fines agrícolas y de electricidad, 10 km. aguas arriba del puente, que acumulará agua hasta un nivel máximo de 267 msnm, esta represa se conectará con la del río Boconó (ya finalizada) por un canal de 700 m. de largo y la superficie máxima de ambas será de aproximadamente 13.000 hectáreas (MOP, 1976) (Fig. 2).

#### Metodología

Para los vuelos se utilizó una avioneta CESSNA 170, en la que iban dos observadores. El censo se realizó en el mes de diciembre de 1982. En esta época el río estaba bastante seco y el agua era clara pudiéndose distinguir los caimanes con facilidad.

Se sobrevoló cinco veces el río Tucupido, desde el puente situado en la carretera Guanare-Barinas, hasta donde se convertía en un torrente y los caimanes dejaban de aparecer, invirtiéndose de 20 a 30 minutos en el recorrido. Los vuelos se realizaron a distintas horas del día (09:40 a 10:10, 10:56 a 11:20, 13:00 a 13:20, 16:07 a 16:32 el 7 de diciembre y 08:15 a 08:39 el 8 de diciembre) con objeto de determinar el patrón de soleamiento.

Cuando se divisaba un caimán, se estimaba su tamaño, incluyéndolo en alguna de las categorías siguientes: < 2m., 2-3 m., y > 3 m. Se anotaba si estaba dentro del agua o soleándose, y el tipo de sustrato donde se encontraba (arena o piedra). Los caimanes eran reconocibles desde el aire por la forma alargada de su cabeza. Por este método Franz et al. (en prensa), estiman que los caimanes menores de un metro, no son visibles.

## Resultados

Durante los cinco vuelos efectuados, se observaron 66 caimanes de los cuales 32 (54,24%) eran menores de 2 metros, 26 (44,07%) estaban entre los 2 y 3 metros, y sólo uno (1,69%) era mayor de 3 metros (Tabla 1).

Se censó un máximo de 19 caimanes distintos, 5 se situaban entre el puente y la represa, y 14 aguas arriba de la misma. Por lo general se encontraban en los pozos más profundos, 27 (77,14%) en secciones donde el río presentaba un lecho arenoso y 8 (22,86%) en donde el lecho era pedregoso. No obstante dentro de esta última cifra sólo se observó un ejemplar soleándose sobre un sustrato pedregoso, el resto, (7 caimanes) estaban sobre este sustrato pero dentro del agua.

El mayor número de caimanes, (16 ejemplares) se observó durante el segundo y tercer censo, (entre 09:40 y 11:20), tanto dentro del agua como soleándose.

En cuanto a la actividad de soleamiento, los datos se exponen en la fig. 3. Los caimanes comienzan a salir del agua, a medida que el sol va calentando el ambiente; a las 10, se observa un máximo en el número de ejemplares que están fuera del agua y después este número descendiendo bruscamente; entre las 11 y las 14:00 horas, la mayoría se encontraba en el agua, y a las 16:00 horas se producía otro máximo en el soleamiento, menos acusado que el primero. Este patrón bimodal es parecido al encontrado para la Baba (Caiman crocodilus) en los Llanos, durante la época seca (Ayarzagüena, 1980; Staton y Dixon, 1975; Marcellini, 1976), y para el Cocodrilo del Nilo (Crocodylus niloticus) (Cott, 1961) (Figura 3). El sobrecalentamiento en las horas centrales del día, hace que los animales retornen al agua, para regular su temperatura.

Con el fin de obtener más datos acerca de su comportamiento, nos instalamos cerca de un pozo en el que se soleaban cinco ejemplares. Durante las tres horas y cuarto que permanecimos ocultos observándonos, sólo se pudieron distinguir sus cabezas sobre la superficie del agua, tan sólo un ejemplar pequeño salió a solearse durante algunos minutos. Esta actitud de desconfianza hacia el hombre, probablemente ha sido la que los ha preservado, ya que el área es frecuentemente visitada por cazadores, que conocen la existencia de caimanes en el río.

En este mismo pozo se observaron algunas babas, pero mientras los caimanes se encontraban en la parte más profunda, estas se situaban en las aguas someras. Observamos también como un caimán intentó atrapar aunque sin éxito, una iguana, que estaba sobre las ramas en el borde del río.

### Impacto de la Represa sobre los Caimanes

Es indudable que la construcción de la represa, provocará cambios sustanciales en los hábitats acuáticos. Por el momento no sabemos cómo afectarán estos cambios a la población de caimanes situada aguas arriba de la misma. La consecuencia más inmediata es la

inundación de las playas del río, utilizadas tanto para el soleamiento como para efectuar la puesta. Hay evidencias de que, en condiciones adversas, los caimanes pueden construir sus nidos en tierra gredosa, así T. Blohm encontró un nido de estas características en las márgenes del embalse de Camatagua (T. Blohm, com.per.) y F. Medem (1981) reporta como un caso excepcional, un nido de caimán en el Alto Ariporo (Casanare, Colombia) donde no existen playas arenosas, y las orillas son de greda y cascajo. Este nido estaba construido con ramas secas y hojarascas amontonadas, y contenía 43 huevos.

Por otra parte, el mayor volúmen de agua, y los cambios originados en la densidad y composición de las poblaciones de peces, afectarán de alguna manera los hábitos alimenticios de los caimanes.

Pudiera ocurrir una migración hacia la cabecera del río, pero lo estimamos poco probable, ya que en esa parte, el río presenta un lecho pedregoso y carece de grandes pozos donde los caimanes podrían encontrar refugio, otra posibilidad, sería la migración aguas abajo a través de las compuertas de la represa.

Si esta población reacciona bien a las nuevas condiciones ambientales podría extenderse a través de las orillas, de las 13.000 has. que van a quedar inundadas.

#### Conclusiones

Los resultados de este trabajo constituyen un aporte adicional al conocimiento actual del estado de Crocodylus intermedius. El hecho de que se haya localizado una población en el piedemonte, hace pensar en la posibilidad de que queden reductos más o menos importantes de esta especie en otros ríos de esta zona.

Por otra parte, el reconocimiento aéreo se revela como un método eficaz para obtener datos de densidad relativa, aumentando las posibilidades de localización de nuevas poblaciones en lugares inaccesibles por lancha.

En cuanto a la mejor época para realizar los vuelos, sería el comienzo de la época seca, cuando las aguas hayan bajado y no sean turbulentas. Y a fin de obtener los mejores resultados, se recomienda que los censos se efectúen en días soleados entre las 09:30 y 11:30h.

#### Agradecimientos

Queremos agradecer a la UNELLEZ, el financiamiento de los vuelos, sin el cual la realización de este trabajo no hubiera sido posible. Asimismo queremos manifestar nuestro reconocimiento a Stewart Reid, magnífico piloto, a Graciela Mínguez por mecanografiar el texto, a Roberto Escalona por la realización de las figuras, y por último al Dr. Stephan Gorzula por la revisión del manuscrito.

## Bibliografía

- Ayarzaqueña, J. (1980). Ecología del Caimán de anteojos o baba (Caiman crocodilus L.) en los Llanos de Apure, Venezuela. Tesis Doctoral, Facultad de Ciencias Biológicas de la Universidad Complutense de Madrid, 216 p.
- Blohm, T. (1973). Conveniencia de criar crocodílicos en Venezuela, con fines económicos y para prevenir su extinción. Simposio Internacional sobre Fauna Silvestre y Pesca Fluvial y Lacustre Amazónica. Manaus, Brasil.
- Cott, H.S. (1961). Scientific results of an inquiry in to the ecology and economic status of the Nile Crocodile (Crocodylus niloticus) in Uganda and Northern Rhodesia Trans. Zool. Soc. London, 29 (4): 211-535 p.
- Franz, R., S. Reid y C. Puckett (en prensa). The discovery of a population of Orinoco Crocodile, Crocodylus intermedius, in Southern Venezuela. Informe sin publicar.
- Godshalk, R. (1982). Status and Conservation of Crocodylus intermedius in Venezuela. Proc. 5th Work Mtg. CSG, SSC, IUCN Publ., New Series, 39-53 p.
- Godshalk, R. y E. Sosa (1978). El caimán del Orinoco. Crocodylus intermedius, en los Llanos Occidentales Venezolanos con observaciones sobre su distribución en Venezuela y recomendaciones para su conservación, informe presentado a FUDENA (WWF). Caracas, 84 p.
- Marcellini, D.L. (1979). Activity patterns and densities of Venezuelan Caiman (Caiman crocodilus) and Pond Turtles (Podocnemis vogli). En: Vertebrate Ecology in the Northern Neotropics. J.F. Eisenberg Ed. Smithsonian Institution. Washington, 263-271 p.
- Medem, F. (1981). Los Crocodylia de Suramérica. I. Los Crocodylia de Colombia. COLCIENCIAS. Bogotá. 354 p.
- Medem, F. (1983). Los Crocodylia de Suramérica. II. Venezuela, Trinidad, Tobago, Guayana, Suriname, Guayana Francesa, Ecuador, Perú, Bolivia, Brasil, Paraguay, Argentina y Uruguay. Universidad Nacional de Colombia y COLCIENCIAS. Bogotá 270 p.
- Ministerio del Ambiente y de los Recursos Naturales Renovables. MARNR. (1982). Sistemas Ambientales Venezolanos. Proyecto VEN/79/001. Mapa de vegetación actual de Venezuela. Caracas, 231 p.
- Ministerio de Obras Públicas -MOP- (1976). Programa Guanare-Masparró: Plan de Desarrollo. República de Venezuela, Decreto 107, 134 p.



Rivero Blanco, C. (1974). Hábitos Reproductivos de la Baba en los Llanos de Venezuela. *Natura* 52: 24-29 p.

Staton, M.A. y J.R. Dixon (1975). Studies on the dry season biology of Caiman crocodilus crocodilus from the Venezuelan Llanos. *Mem. Soc. de Cienc. Nat. La Salle*, 35 (101): 237-265 p.

#### Indice de Tablas y Figuras

Tabla 1. Número y tamaño de los caimanes observados, actividad y tipo de sustrato sobre el que se encontraban.

Figura 1. Distribución de Crocodylus intermedius en Venezuela.

Localidades donde se han encontrado caimanes (tomado de Medem, 1983).

Ríos con las principales poblaciones de caimán conocidas:

1. Río Cojedes (Godshalk y Sosa, 1978)
2. Río Capanaparo ( " " " )
3. Río Cinaruco ( " " " )
4. Río Meta ( " " " )
5. Río Caura (Franz et al., en prensa )
6. Río Tucupido (Ramo y Busto, este trabajo)

Figura 2. Embalse de los ríos Boconó y Tucupido. La represa del río Boconó ya está finalizada, la del Tucupido está en construcción.

Figura 3. a) Patrón de soleamiento del caimán en el río Tucupido. Patrón de soleamiento de la baba en los llanos según datos de:

- b) Ayarzagüena (1980)
- c) Staton y Dixon (1975)
- d) Marcellini (1979)
- e) Patrón de soleamiento del cocodrilo del Nilo según Cott (1961)

TABLA 1

NUMERO Y TAMAÑO DE LOS CAIMANES OBSERVADOS,  
ACTIVIDAD Y TIPO DE SUSTRATO SOBRE EL QUE  
SE ENCONTRABAN

Hora	Número Caimanes	T a m a ñ o				Actividad		Sustrato		
		2	2-3	3	?	en el agua	soleándose	arena	piedra	?
08:15 a 08:39	5	4	1	-	-	4	1	4	1	-
09:40 a 10:10	16	3	5	1	7	5	11	11	-	5
10:56 a 11:20	16	7	9	-	-	13	3	5	-	11
13:00 a 13:20	14	9	5	-	-	12	2	3	4	7
16:07 a 16:32	15	9	6	-	-	9	6	4	3	8
TOTAL	66	32	26	1	7	43	23	27	8	31

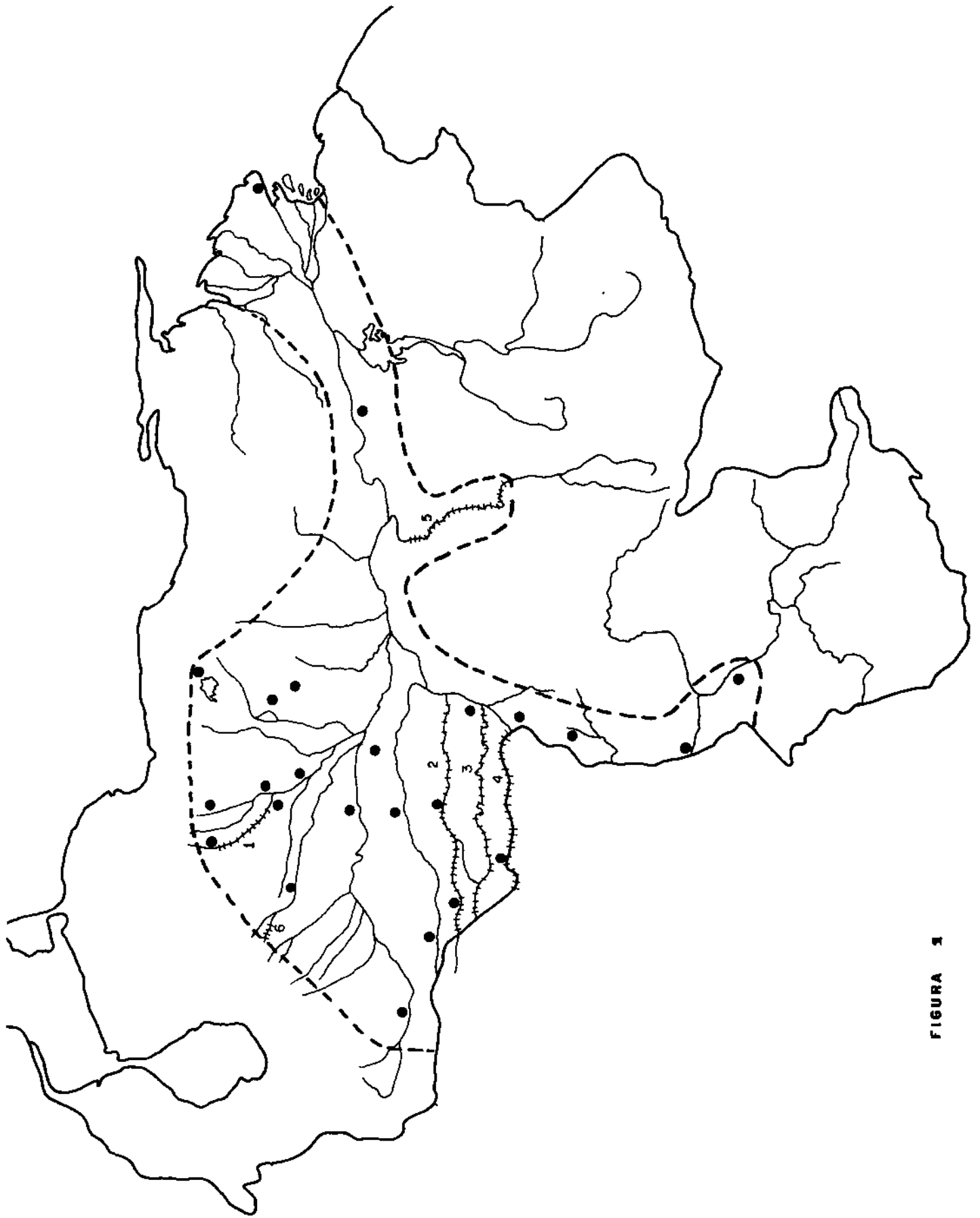


FIGURA 1

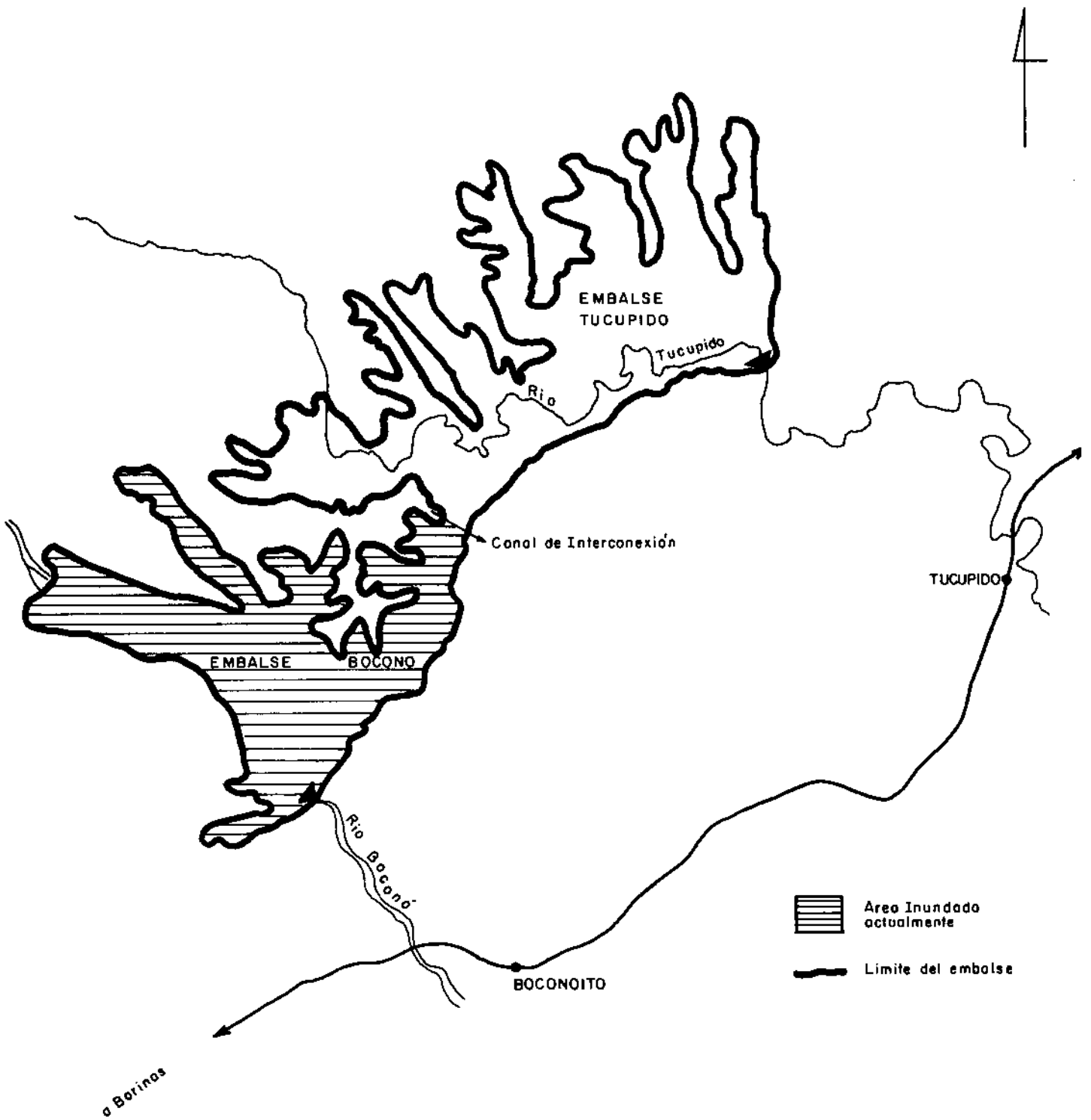


FIGURA 2

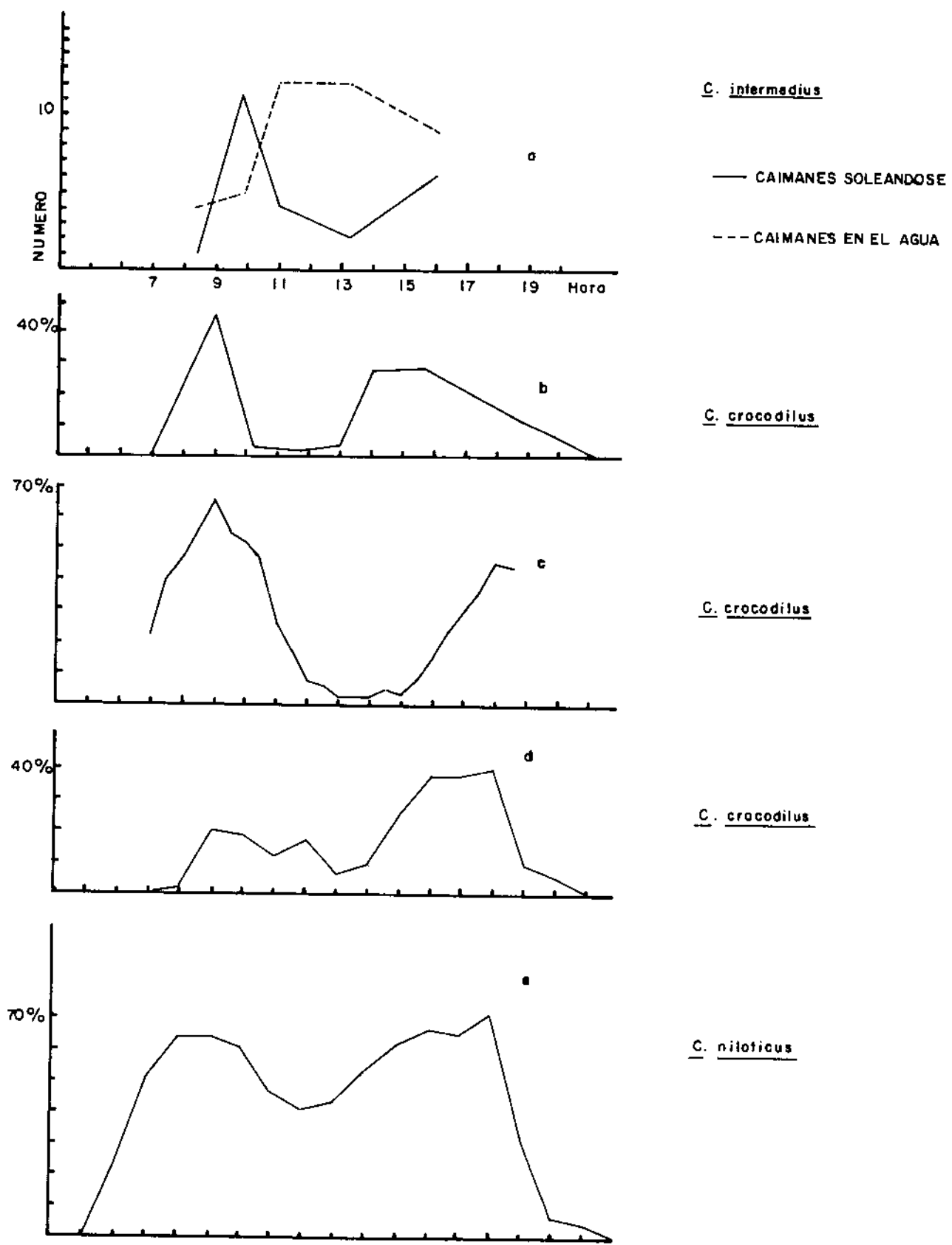


FIGURA 3

CAPTIVE REARING OF ORINOCO CROCODILES ON HATO  
MASAGUARAL - VENEZUELA

John Thorbjarnarson and  
Tomás Blohm  
Hato Masaguaral Crocodilian Center  
Apartado 69, Caracas 1010-A

Introduction

Hato Masaguaral, an 7.500 ha cattle ranch/wildlife preserve is located in the central llanos of Guarico State, Venezuela. The ranch has been the site of a significant amount of biological research since 1944. Work has covered a wide variety of topics including botany, studies of invertebrates,, and a great deal of work on vertebrate ecology, including studies of the spectacled caiman (Caiman crocodilus). (Staton and Dixon, 1975-1977, Marcellini 1979). To date, over 85 scientific publications have resulted from work on Hato Masaguaral).

Recently, through the initiative and financial support of Tomás Blohm, Hato Masaguaral has also become the site of a captive breeding and rearing program for Orinoco Crocodiles, a critically endangered species once commonly found in the riverine habitats of the llanos. The principal goal of the program reintroduction schemes. The work at Hato Masaguaral is being jointly supported by the IUCN Crocodile Specialist Group, the Fundación para la Defensa de la Naturaleza (FUDENA), the New York Zoological Society and the Florida State Museum.

Captive Breeding of Orinoco Crocodiles

The Orinoco Crocodile, Crocodylus intermedius, has recently been recognized as one of the worlds 12 most endangered animals (SSC 1985). Once widespread throughout the Orinoco river drainage the crocodile was hunted to near extinction in both Colombia and Venezuela during the period 1920-1950. Since then a combination of poorly understood factors has prevented population recovery and today populations have continued to decline to an extremely critical level.

In Venezuela recent concern for the continued survival of the species has spurred new interest in developing an effective conservation program for the crocodile. One applicable management alternative is captive rearing and re-introducing crocodiles into protected areas to speed population recovery while it is reorganized that captive breeding in and of itself, is no solution for ensuring the survival of viable populations, a well managed program of habitat protection, properly enforced wildlife regulations and crocodile reintroductions can effectively revitalize decimated crocodilian populations. The model program in India has demonstrated the potential for this type of program with Crocodylus porosus, C. palustris and Gavialis gangeticus (Singh, 1984).

The captive breeding program for the Orinoco crocodile represents a part of an overall program, spearheaded by the Comisión de Crocodílicos of FUDENA for the rehabilitation of crocodile populations in Venezuela. By working together with other private and governmental organizations such as the Universidad Nacional Experimental de los Llanos Occidentales "Ezequiel Zamora" (UNELLEZ), the Fundación La Salle, the Instituto Universitario de Tecnología de Yaracuy, the Sociedad Conservacionista Audubon de Venezuela, and the Ministerio del Ambiente y de los Recursos Naturales Renovables, FUDENA hopes to create an effective national program for the 5 crocodylian species native to Venezuela. The major goals of this program are to develop and initiate recovery plans for the two species of crocodiles (C. intermedius, C. acutus), and to ensure the proper management of the more abundant spectacled caiman (Caiman crocodilus).

Captive breeding of Orinoco crocodiles has been problematic in the past. Very few specimens of C. intermedius are in captivity (Blohm 1973) and many of these were housed under, suboptimal conditions. The first captive breeding was accomplished in 1974 at Cachamay Park, near Puerto Ordaz in Venezuela. (Ramírez et al 1977) when 2 females produced a total of 56 young. Since then Orinoco crocodiles have bred on Hato El Frío, owned by Dr. Iván Darío Maldonado (Apure State) and on Hacienda Refugio de Fauna El Paraíso owned by Tomás Blohm (Aragua State) (Blohm 1982).

#### Hato Masaguaral

The establishment in 1984 of the captive breeding operation on Hato Masaguaral grew out of an urgent need to provide a stock of crocodiles for reintroduction, as well as a desire to develop standardized husbandry techniques which then could be applied to other projects in Venezuela. As work progressed, studies were expanded to include wild and captive populations of the spectacled caiman, as well as an educational and training role. The principal goals of the current work at Hato Masaguaral are;

- 1) Provide a stock of crocodiles for reintroduction into protected areas and other breeding purposes.
- 2) Develop appropriate, low cost husbandry techniques.
- 3) Experiment with the feasibility of ranching Caiman.
- 4) Investigate the population ecology of Caiman with the aim of developing management recommendations to ensure sustainable utilization.
- 5) Provide a center for training Venezuelan students and biologists in crocodylian management and research techniques.
- 6) And disseminating technical information on captive rearing.

Concerning the captive breeding of Orinoco crocodiles, work has progressed steadily since the arrival of the first breeding pair in October 1984. This pair had been kept at Refugio de Fauna El Paraíso since early 1978, where they produced 13 hatchlings in 1980. The current stock includes 5 adult crocodiles (2 male, 3 female) as well as 9 subadult females nearing maturity.

The breeding pair first established immediately began courtship activity (Oct. Dec. 1984). The female oviposited on 14 Feb. 1985. After an incubation period of 86 days, the female was observed opening the nest and carrying 18 hatchling crocodiles to the water (11 May 1985). The young were left in the adults. Eleven were removed in September 1985 and are currently being reared in concrete tanks.

Along with the hatchling crocodiles, hatchling Caiman are being pen reared to examine the economic feasibility of ranching Caiman.

Facilities at the breeding center currently consist of a dormitory/laboratory building, four 25 m. x 25 m. crocodile breeding pens, a large (80 m. x 25 m.) natural enclosure for adult Caiman, 7 concrete hatchling pens and a food preparation and autopsy shed. Water for the concrete tanks is supplied by windmill to a 10,000 liter water storage system.

Additional breeding enclosures and hatchling and grow-out pens will be built during dry season.

Besides its function as a captive breeding and rearing center, work at the Masaguaral Center is aimed at a number of other topics. Training is being offered to Venezuelan students biologists, National Guard officers and civil servants in the Fauna Service and National Parks departments. For the past two years, Hato Masaguaral has served as the site of a training course in Wildlife management and research techniques, taught by Dr. R. Rudran of the Smithsonian Institution. This course will again be taught in 1986. Plans are also being made to offer a short course dealing specifically with crocodilians. Training in captive propagation and research techniques for several Venezuelan students from the Instituto Universitario de Tecnología de Yaracuy has already begun.

The project has benefited greatly from support and technical advice of a number of individuals: Peter Brazaitis (New York Zoological Society), David Blake (National Parks Dept.) and Dr. F. Wayne King (Florida State Museum and Chairman of the GSG/SSC/UICN).

Future plans call for continuing the work already underway, and also initiating studies of wild populations of Orinoco crocodiles. Perhaps, the highest priority item is to undertake a series of systematic status surveys combined with research into the ecology of these wild populations. The greatest problem that now faces the crocodile rearing program



and the future survival of the species is the lack of protected habitat, and adequate enforcement of existing wildlife regulations. With the cooperation of the Ministerio del Ambiente y de los Recursos Naturales Renovables, and the National Guard, it is hoped that adequate protection of the crocodile can be achieved.

#### REFERENCES

- Blohm, T. 1973. Conveniencia de criar crocodílicos en Venezuela con fines económicos y para prevenir su extinción. Proc. Simp. Internl. Fauna Silv. Pesca, Fluv. Lacus, Amaz. Manaus: 1-33.
- Blohm, T. 1982. Husbandry of Orinoco Crocodiles (Crocodylus intermedius) in Venezuela. Crocodiles IUCN Publ. N.S. ISBN 2-8032-209- x 267-285.
- Marcellini, D. 1979. Activity patterns and densities of Venezuelan Caiman (Caiman crocodilus) and pond turtles (Podemnemis Vogli) P-263-271. Vertebrate Ecology in the Northern Neotropics (J.F. Eisenberg, ed.). Smithsonian Institution, Washington D.C.
- Ramírez, Y. C.C. Castillo and S.J. Gorzula - 1977. Proyecto Venezolano sobre Cocodrilos. Herp. Review 8 (4): 130.
- SSC, 1985 Species Survival Commission Newsletter Nº 5. Gland Switzerland.
- Singh, L.A.K. 1984. Situation Report: India Central Crocodile breeding and management Project. Crocodiles IUCN Publ. N°S. ISBN 2-99032-905-1 P. 165-170.
- Staton, M.A. and Dixon 1975. Studies on the dry season biology of Caiman crocodilus crocodilus from the Venezuelan Llanos. Mem. Soc. Cienc. Nat. La Salle 35 (101): 237-266.
- Staton, M.A. and Dixon 1977. Breeding biology of the Spectacled Caiman, Caiman crocodilus crocodilus in the Venezuelan Llanos Dep. Int. Fish Wildl. Serv., Wildl. Pes. Rept. 5.

THE COMPILATION OF A CROSS-INDEXED TROPICAL  
BIBLIOGRAPHY FOR THE AMERICAN ALLIGATOR  
A STUDY OF TRENDS IN THE LITERATURE CONCERNING AN ENDANGERED SPECIES

I. Lehr Brisbin, JR., Savannah River Ecology Laboratory  
P. O. Drawer E, Aiken, South Carolina 29801, USA

Charles A. Ross, Department of Vertebrate Zoology  
National Museum of Natural History  
Smithsonian Institution  
Washington, D.C. 20560, USA

M.C. Downes, 17 Allen's Road, Heathmont  
3235, Victoria, Australia

and

Brad Gammon, Savannah River Ecology Laboratory  
P. O. Drawer E. Aiken, South Carolina 29801, USA

Like any other field of natural science, the conservation and management of the world's crocodylians require ready access to the published literature and data bases available for the various species of concern. Since many crocodylian biologist frequently work afield in underdeveloped or remote areas of the world, obtaining access to such literature and data resources can often be a severe problem.

Over the past few years, the National Environmental Research Park (NERP) program of the University of Georgia's Savannah River Ecology Laboratory (SREL) has compiled and published cross-indexed working bibliographies on topics of relevant environmental interest to several of the laboratory's research programs (Felly and Smith 1975; Jackson, 1981; Smith et al., 1982). The compilation of each of these bibliographies involved obtaining copies of each of the references listed and reading each in sufficient detail to allow it to be classified as to subject matter, into one or more categories of particular importance to research on that particular species. These references are then filed by accession numbers which allow the retrieval of listings of all references containing information on any one or combination of one or more topics. This report describes the compilation of a similar cross-indexed bibliography for the American alligator (Alligator mississippiensis). An overview of recent research on the American alligator conducted at the SREL during the 1960's and 1970's, has been published elsewhere (Brisbin, 1982).

This bibliography for the alligator, at nearly a final stage of editing, now contains 2695 titles, with each reference having been obtained, verified, read and classified as to subject matter, into 28 categories as listed in Table 1. This compilation covers the world literature from the mid-1700's through the spring of 1984. The compilation of this bibliography was based in turn, on an update of an earlier bibliography of 995 titles on the alligator, which

had been compiled and published in a similar format (Murphy, Brown and Brisbin, 1978).

The compilation of two successive bibliographies of the world literature for the alligator permits a comparison of the frequencies with which various topics have been covered by the references in these two collections. Furthermore, comparisons of these frequencies with similar frequencies calculated for only those articles published from 1980-1984, provide a unique opportunity to compare changes of patterns of topic coverage over time. As indicated in Figure 1, there has been a noticeable shift over a 6-year period (1978 through 1984) in these patterns of topic coverage. In the initial bibliography (Murphy, Brown and Brisbin, 1978), a skewed pattern (Figure 1) indicated that the majority of the topics were dealt with by only a few papers each, while only a few of the categories received extensive coverage in the literature. This skewed pattern of relatively few common topics and many rare ones was gradually reversed through the updating of the 1978 bibliography and the addition of more references to form the present 1984 compilation. As indicated in Figure 1, those references published since 1980 showed an even more equitable distribution, with most of those categories which had received only rare coverage in the 1978 compilation now being addressed in the literature with a much more greater frequency.

The trends over time in the frequency of coverage of each of the specific categories are indicated in Table 1. This data shows clearly that the two topics of "Internal Anatomy" and "General Physiology" dominate the early literature on the American alligator, being addressed by 38.5% and 27.4% of all of the references cited in the 1978 bibliography. The wide coverage of these two topics reflects the intense scientific interest that crocodylians apparently engendered in the early days of biological research, as a "missing link" between the anatomical and physiological complexity of the more primitive reptiles on the one hand, and the more advanced birds on the other. Being one of the most easily obtained species of crocodylian, the American alligator thus became a common subject for treatment in texts and other studies of both comparative anatomy and comparative physiology of the vertebrates.

The decline of alligator numbers in the wild was first noted by naturalists as early as the beginnings of the 20th century, and by the 1940's - 1950's, the first signs were becoming apparent in the general world literature, that alligator population numbers in the wild were declining to seriously low numbers. Subsequently, with an official recognition of this problem and the resultant listing of the American alligator as an endangered species in 1966, a marked change became apparent in the subject matter dealt with by the world literature on this species. This undoubtedly resulted from a combination of two factors: (1) as alligator numbers became low in the wild and legal restrictions were imposed against their being taken, it became difficult or impossible to obtain specimens for use as subjects of studies in comparative anatomy or physiology, and the common caiman (Caiman crocodilus), whose use was not so restricted, began to replace the alligator as a subject of such

studies; (2) the official listing of the alligator as an endangered species made it easier for researchers to obtain support for studies in those areas which provided the information needed to more effectively conserve and manage wild alligator populations. These subject areas, which had been comparatively neglected in the early literature, all showed marked increases in frequency of coverage by the world literature (some by as much as 500-600% between the 1978 compilation vs. the 1980-84 citations), and included such topics as: "Habitat", "Conservation and Management", "Population Estimates and Density", "Reproduction", "Mortality and Age Structure" and "Food Habits" (Table 1). Thus, the changes in the patterns of frequency of coverage of the alligator literature over time (Figure 1) are seen to be the result of both diminished use of the species as a subject for laboratory research and a concomitant increase in attention to those topics related to efforts to conserve and manage dwindling wild populations (Table 1).

Although the alligator may be an extreme example of this process, the data presented here clearly show that public awareness and official legal recognition of the plight of an endangered species can have a profound effect on the subject matter covered by that species' published world literature and that moreover, this effect can occur over a relatively short period of time (in the present case, over less than seven years). To the extent that such shifts in subject matter reflect the proportion of research effort that is being expanded in these areas of concern, the data presented here suggest that world conservation programs and legislation are effectively influencing the allocation of research efforts in desired ways to achieve goals of effective management and conservation of endangered wild populations.

#### Acknowledgements

Preparation of this manuscript was supported by the National Environmental Research Park Program of the Savannah River Ecology Laboratory, under a contract (DE-AC09-76SR00819) between the United States Department of Energy and the Institute of Ecology at the University of Georgia. Support was provided to M.C. Downes by the Wildlife Division, Government of Papua New Guinea. Research space for C.A. Ross was made available through the kindness of George Zug and Clyde Jones of the United States Museum of National History. Support was also provided to C.A. Ross by the World Wildlife Fund, U.S.A., the New York Zoological Society and the Office of Endangered Species, United States Fish and Wildlife Service.

#### Literature Cited

Brisbin, I.L., Jr. 1982. Applied ecological studies of the American alligator at the Savannah River Ecology Laboratory: an overview of program goals and design. In: Proc. Fifth Working Meeting of the IUVN/SSC Croc. Spec. Group, F.W. King (ed.). Publ. Intern. Union Conserv Nature and Nat. Res. Gland, Switzerland.

- Felley, J.D. and M.H. Smith. 1975. A Bibliography for the Old-Field Mouse, Peromyscus polionotus Wagner (Cricetidae: Rodentia). Publ. (DEP. NTIS SREL-5) of the Savannah River Ecology Laboratory. Aiken, SC.
- Jackson, J.A. 1981. An Annotated Bibliography of the Red-Cockaded Woodpecker. Publ. (SRO-NERP-8) of the Savannah River National Environmental Research Park. Aiken, S.C.
- Murphy, P.A., C. Brown and I.L. Brisbin, Jr. 1978. Bibliography for the American alligator, Alligator mississippiensis. Publ. of the Savannah River Ecology Laboratory. Aiken, S.C.
- Smith, M.W., C.F. Aquadro, M.H. Smith, R.K. Chesser and W.J. Etges. 1982. A Bibliography of Electrophoretic Studies of Biochemical Variation in Natural Vertebrate Populations. Texas Tech. Press. Lubbock, TX.

Table 1. Categories used to classify references for a cross-indexed topical bibliography for the American alligator.

Category	Frequency of Coverage*	Comments
Habitat	5.1/15.0/23.9	Papers describing habitat and niche requirements for the species. These include the effects of habitat modification on distribution.
Locality and Distribution	6.2/19.0/22.3	Papers that give specific locations that can be used to define the species range.
Growth and Development	12.8/13.0/18.6	Articles dealing with ontogeny and age-specific changes in dimensions and other characteristics, including the effects of habitat and other variables on those characteristics.
Body Composition	9.3/5.4/6.8	Papers that focus on body composition, such as body fat, protein and amino acid levels in the species.
Reproduction	6.5/17.9/26.5	Articles dealing with reproductive characteristics such as sex ratio, clutch size and nesting success.
Mortality and Age Structure	3.6/11.9/19.3	Papers dealing with sources of mortality, degrees of mortality in relation to various factors and the resultant age structures.
Population Estimates or Density	1.9/7.2/14.8	References considering the numbers of alligators in a population or density per unit area.
Genetics	1.0/1.3/1.9	Papers concerning karyotype, gene frequencies, inheritance or genetic similarities of various forms.
Movement Patterns	2.4/6.5/11.7	Papers concerning movement, homing, home range and dispersal in the species.
General Behavior	12.8/13.0/18.6	Papers concerning all behaviors with the exception of movement. These include reproductive behavior.

Table 1. Continued.

Category	Frequency of Coverage*	Comments
General Physiology	27.4/16.7/22.0	Papers concerning all physiological aspects of the species with the exception of metabolism and energetics.
Metabolism and Energetics	3.1/3.9/9.5	References on energy requirements, energy utilization efficiency, and oxygen consumption in the species.
Parasites and Diseases	5.6/6.2/9.8	Papers that identify or describe parasites or diseases affecting the species; also includes information on congenital malformations, injuries and other factors affecting general health.
External Morphology	3.8/16.1/14.8	Papers that include measurements of external dimensions or descriptions of external appearance, including scalation.
Internal Morphology	38.5/25.3/13.3	Papers dealing with attributes of internal morphology, such as internal gross anatomy, cytology and histology.
Taxonomy	3.0/7.7/4.5	Papers concerning species identification, nomenclature, placement of <i>Alligator mississippiensis</i> in higher taxonomic categories and sub-specific designation within the species.
Paleontology	3.0/3.5/4.9	Papers that describe fossil occurrence of <i>Alligator mississippiensis</i> or that evaluate methods for identifying fossils of this species.
Radioecology	1.2/0.7/1.9	Papers that describe radionuclide uptake and cycling, the effects of radiation on alligators or the use of radioisotopes with this species.
Evolution	14.3/19.0/24.6	References that discuss the evolutionary biology of the species, including modes of selection and comparisons with other species.

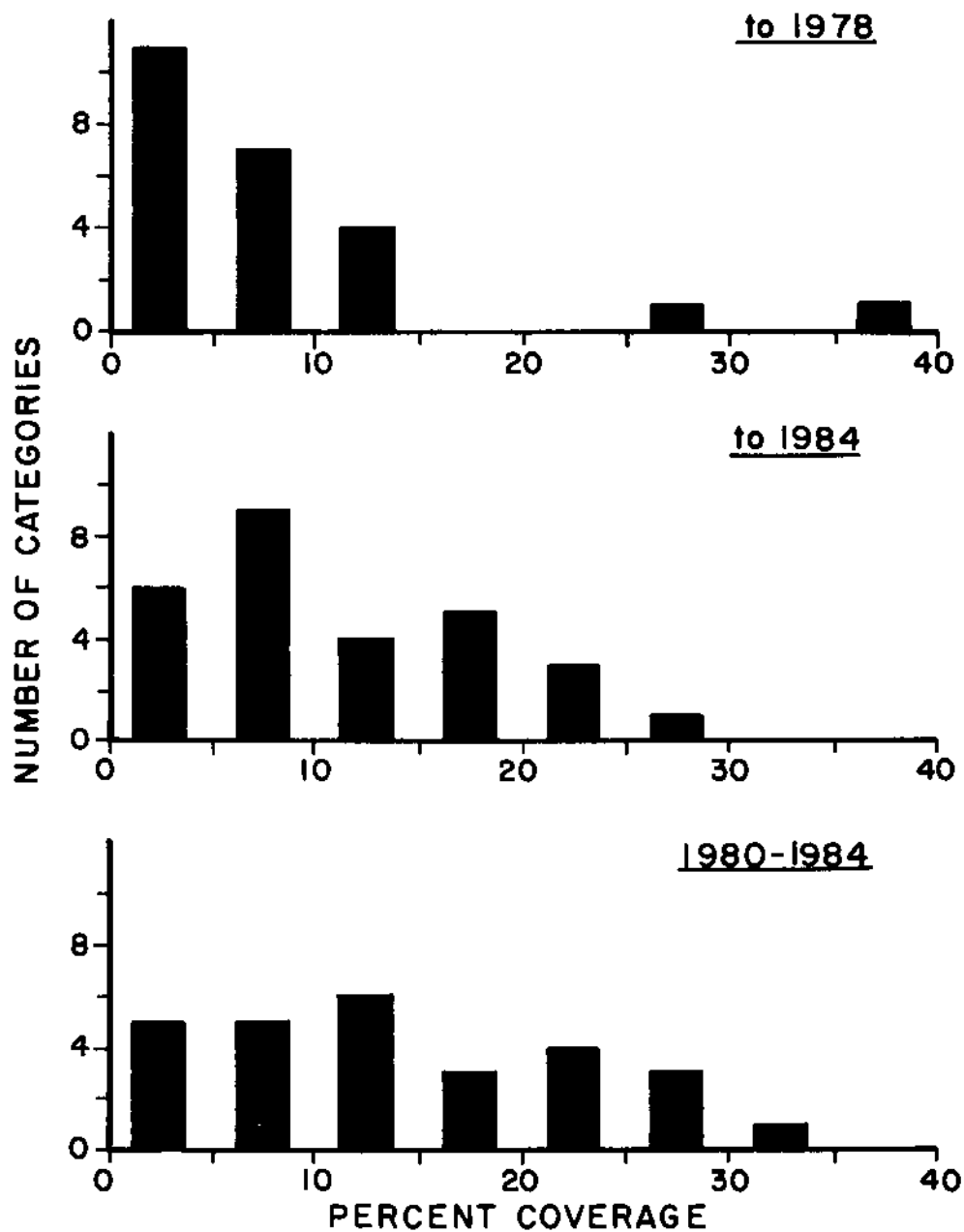
Table 1. Continued.

Category	Frequency of Coverage*	Comments
Dissertations or Theses	Not Calculated	Dissertations or theses written to fulfill degree requirements.
Abstracts	Not Calculated	References which are only abstracts of papers delivered at scientific meetings and not prepared for full-length publication.
Techniques	8.2/21.2/32.6	Papers dealing with specific methods applicable to this species, including capture, handling, husbandry, care in captivity and other specialized techniques. This category also includes catalogs or listings of museum collections of this species, and is also used to designate references dealing with captive animals.
Conservation and Management	4.1/20.6/27.3	References dealing with species preservation, status and management goals and practices.
Food Habits	3.1/11.5/14.4	Papers concerning nutrition, and natural and artificial diets of the alligator.
Reports and Bibliographies	Not Calculated	Limited access papers, not available in the general literature, and lists of references dealing with this species.
Biochemistry	14.1/9.1/13.3	Papers concerning enzymes, enzyme kinetics, hormonal effects and all general biochemical aspects of alligator biology.
Thermal Biology	5.3/9.8/17.4	Papers concerning the effects of temperature on physiology, biochemistry, metabolism and/or behavior.

\*Percent coverage is presented as A/B/C, where A, B and C represent the total number of references which deals with that given category, expressed as percentages of all references listed in: (A) a 1978 bibliography of the American alligator (Murphy, Brown and Brisbin, 1978), (B) A recent update of the 1978 bibliography extending through spring of 1984, and (C) a subset of those references in source (B) published in the 1980's.



Figure 1: Changes over time in the frequencies of subject matter categories which have been covered by given percentages of the published literature for the American alligator. The top figure was compiled from Murphy, Brown and Brisbin (1978) on the basis of 985 categorized references, while the middle figure was based on a 1984 update of that bibliography containing 1695 categorized references. The lower figure was based on a subset of only those references (N=264), published in 1980 or later from the latter (1984) updated bibliography.



FLORIDA ALLIGATOR: ECONOMICS, HARVEST, AND CONSERVATION  
Hines, T., Abercrombie, C., Percival, F. and Woodward, C.  
Wildlife Research Laboratory  
4005 G Main Street  
Gainesville, FL 32601, U.S.A.

Past and Present Status

Throughout much of this century crocodilians have suffered worldwide depletion because of unrestrained commercial harvest and habitat destruction. During the 1950's and 1960's, Florida populations were no exception, and it became necessary to extend full legal protection to the American alligator (Alligator mississippiensis). By the mid-1970's populations were well on their way to recovery-- if indeed they had ever been so depleted as some had feared (Hines 1979)-- and by 1975 Florida Game and Fresh Water Fish Commission offices were receiving 4,000-5,000 nuisance alligator complaints from the public each year (Hines and Woodward 1981).

During the mid-1970's, alligator research and management activities centered around assessing population status (Woodward and Marion 1978; Wood and Humphrey 1983) and developing techniques to handle the nuisance alligator problem (Hines and Woodward 1980, 1981). Soon thereafter more intensive studies of life history and population dynamics began (Dietz and Hines 1980), and by 1981 a definite commitment to investigate sustained yield management had been made.

Alligator Program Direction

Three basic premises eventually came to underlie these investigations. To begin with, we decided that (1) alligators would some day be harvested and that (2) within the constraints of resource conservation, harvest revenue would be maximized. Also, we became absolutely convinced that (3) a portion of the harvest profits should be returned, directly or indirectly, to benefit the conservation of the species. We believe this last consideration is particularly important because although the trade in crocodilian products has long been an economic force worldwide, little inclination or opportunity has hitherto existed for any revenues to be returned to the natural system. The idea of economic feedback from commercial wildlife harvest to the environment has recently become widely recognized in Louisiana (Palmisano et al. 1973), Papua-New Guinea (Rose 1982), and Zimbabwe (Anon. 1982)-- where ongoing crocodilian management programs presently exist. Furthermore, in Florida we have proposed that the concept of value-added conservation be explicitly incorporated in the State alligator management plan.

Research and Management

A purposeful program of commercial exploitation for maximum revenue carries added responsibilities to build a knowledgeable basis for decision making. Consequently, a long-term management-oriented research effort is underway. An alligator population

model is being developed to serve as a guide for research and management. Fully aware that explicit projection models are only as good as the data they include, we have set out to test the harvest concept experimentally.

In 1981 an experimental harvest of 1.2m and larger alligator was initiated in north-central Florida on Orange and Lochloosa Lakes, two areas which contain substantial alligator populations that have been extensively monitored since 1976. The objective of these harvests is to test the effects of specific removal rates and to provide improved data for a population model.

In 1981 the Game and Fresh Water Fish Commission, the Florida Cooperative Fish and Wildlife Research Unit, and the Florida Alligator Farmers' Association initiated a joint project to determine impact of egg and/or hatchling removal on alligator populations. This study is currently in progress on 4 central Florida lakes. Obviously it was designed to complement investigations into the harvest of larger animals.

Full evaluation of these two experimental studies would be premature. Nevertheless, based on these investigations, as well as several life history studies, we have gained insight into the approximate values (monetary and demographic) of various sized alligators. Using this information we have diagrammed the monetary and demographic costs and benefits of a controlled harvest. The objective of our approach is to assist wildlife managers in designing harvest strategies that are economically and ecologically optimal.

#### Egg and Hatchling Harvest: Cost and Value

A helicopter, airboats, and an egg-transport boat are typically employed for egg collection. Nests are located by helicopter, and airboats are guided toward the nests by an airborne observer. Using a helicopter and 3 airboats, we have removed as many as 1,800 eggs in an 8-hour period. Obviously the per-hour costs are quite high, and in some alligator habitats such operations are not practicable.

Collection of hatchlings is most practically accomplished at night, by airboat. Since we generally attempt to take young alligators before they disperse from the nest site, location of nests by helicopter has again proved beneficial. Many nests are inaccessible, and their hatchling pods can not be collected until they move to the open margin of the lake. Because of this delay, our hatchling collection efforts are often protracted over 2-3 months.

Costs for egg or hatchling removal depend upon habitat conditions and alligator population density. Cost per fertile egg have thus far averaged about \$5. For hatchlings, expenses have ranged between \$7.32 and \$12.86 per animal. These figures are based on airboat operating costs of \$10/hr and aircraft time at \$110/hr. For these and subsequent analyses, wages were arbitrarily figured at \$5/hr. In actual operations, some personnel have been paid less; some have been paid much more. It should also be noted that

extensive planning is required to achieve the above level of economic efficiency. Wage costs for planning have not been included in the analyses we report.

The cost to a Florida alligator farm of raising a cohort of alligators to harvestable size has not been accurately determined. Costs are dependent on the number of animals being raised, growth rates, mortality, capital investment, and harvest strategy. For purposes of this discussion, we assume that the farm starts with 1000 hatchlings, raises them to an average total length of 190cm in 4 years, and incurs 10% mortality during those 4 years. Based on discussions with a number of Florida alligator farmers, the per alligator cost of raising 1000 alligators to harvest size was estimated to be \$75-\$125 depending on the operation. Slaughter costs were estimated to be \$30 per animal. Hide and meat marketing costs add another \$10 to cost per animal. Using the above figures, we arrive at the following per-animal costs:

cost of raising alligator to 190 cm	\$ 100
cost of slaughter	30
cost of marketing products	10
cost of collecting hatchling	10
	-----
Total cost	\$ 150

Based from harvest figures from Smith's Alligator Farm in Bell, Florida, a 190cm alligator has a 50cm belly width and yields 7.4 kg of meat. Over the past several years, prices for farm-raised alligator products have averaged \$3.00/cm for hides and \$11.00/kg for meat. Based on these figures, the value of an average 190cm alligator is:

hide (50cm belly width)	\$ 150
meat (7.4kg)	81
	-----
Total value	\$ 231

If one subtracts raising costs from total value, then one can estimate the net value of a wild hatchling to be approximately \$81.

#### Hunter Harvest

The experimental harvest on Orange and Lochloosa Lakes has provided an annual harvest of approximately 330 alligators larger than 1.2m. Check stations have been operated to assure that exact harvest quotas are adhered to, that all necessary biological data are collected from each animal, and that hunter effort is recorded. In addition estimates of per-animal processing time for both meat and hide are documented. Hourly wages and airboat operational costs are figured as above. The average prices are based on \$49.21 per linear meter for hides and \$11.02 per kilogram for meat.

### Hunter Harvest: Cost and Value

It is difficult to evaluate precisely the discrete costs of harvesting adult alligators within particular size-classes. However, analysis of check-station records for our experimental harvest indicates that cost will increase with the size of the target alligator-- and that for animals larger than 3 meters, the rate of increase will be rapid and nonlinear. The approximate value of an average hunter-harvested animal (c. 2.3m) has been about \$200. When the prices for meat and skin have been high, very large animals ( 3.5m) have generated total revenues in excess of \$1000 (Figure 1).

### Value to the Population

In managing the harvest of a wild crocodylian population, it is important to consider which age/size class will become the primary target of exploitation. To make this decision responsibly, one must consider not only the monetary economics of harvest but also the potential value of harvestable animals to the residual population. Any precise evaluation obviously demands rather complete knowledge of crocodylian population dynamics, and we do not presently possess such detailed information for the American alligator. Nevertheless, we can derive a very approximate relationship between alligator age/size and demographic value. Doing so requires us to estimate a large number of alligator population parameters. Most of the values we have used are employed without knowledge of their accuracy. Values for a few parameters have not been observed at all. Rather, they have been estimated through "triangulation" by computer simulations involving a modified Leslie matrix. Another difficulty, perhaps even more serious, is that we do not yet understand the nature of any density-dependent mechanisms by which alligator populations might compensate for harvest. In other words, when you look at our value-to-the-population curve (Figure 2), you should consider its general shape rather than its precise dimensions.

In deriving our curve, we assumed that the only important values were reproductive, and we also assumed that, demographically speaking, males were reproductively irrelevant. The horizontal axis of our graph is demarked by field-identifiable life stages; i.e., it is scaled mostly by size. This somewhat unusual scale was necessary because of our determination to present value as a function of population classes which can be practically targeted for exploitation. In other words, we did not use age as a scale because one cannot reasonably expect commercial hunters to discriminate among animals by age class before harvesting them. (Similar considerations also apply to the determination of sex.).

Basically, then, we developed our value curve to address questions of expected demographic cost upon harvest of a randomly selected animal of length (L). Value was assumed proportional to the number of mature-female-years an alligator could be expected to the population. Or,

$$E(V:C) = K * P(F:C) * (Y:F,C), \text{ where}$$

$E(V:C)$  is the expected value of an animal to the population, given that the animal is a member of age/size class C;

$P(F:C)$  is the probability that an animal is female, given that it is a member of age/size class C;

$E(Y:F,C)$  is the expected number of years an animal will spend as a reproductively mature individual, given that the animal is female and belongs to age/size class C.

We do not have good estimates for the expected value of a mature-female-year. However, for present purposes, this is not important if we can assume that any variation in this expected value is independent of age/size class membership (i.e., if in the above equation we can incorporate this factor into the constant, K). Almost certainly, this is not strictly correct, but our research indicate that any bias introduced into our value curve because of this assumption will be minimal. In any case, this assumption allows us to graph for each age/size class its relative expected value to the population (RELATIVE VALUE); for convenience, we have scaled this variable so that its maximum value is equal to 100.0:

$$\text{RELATIVE VALUE for class C} = 100 * E(V:C) / E(V \text{ max} ).$$

The rough estimates which entered the calculation of our value curve were derived from a number of sources. Percentages of females by size class were taken from Florida experimental harvest data. Survival rates for animals less than 2 years old were estimated from Orange Lake recapture data. Survival rates for immature animals 2 years or older were estimated from size-class distributions of Florida and Louisiana harvests. Annual survival rates for mature animals were arbitrarily set at 0.9. Growth rates for animals less than 2 meters were estimated or extrapolated from Orange Lake recapture data. Growth rates for larger animals were taken from Chabreck and Joanen (1979). Senescence was arbitrarily assumed to occur at 40 years of age.

Again we would emphasize the dangers in focusing intensively on the details of our curve's shape. Nevertheless, the following points seem important to us. First, our value-to-population curve has the basic shape one would expect on general demographic principles. Second, the curve is strongly peaked and exhibits extreme negative skewness. These factors indicate that small animals-- and very large animals, which are almost exclusively males-- are particularly appropriate targets for harvest. For example, one can remove almost 50 hatchlings for the same population cost as taking one 2-meter animal. When this fact is considered along with the economics-of-harvest information presented above, certain alligator exploitation strategies stand out as clearly better than others.

## Discussion

At least 3 sets of information are needed to determine efficiently the appropriate size-class target for commercial exploitation of a crocodilian population (Figures 1, 2, and 3). A potential manager should understand the relationship between size class and expected demographic value to the residual population. Similarly, the commercial worth of individual animals from the various size classes should be approximately known. With this information, one can consider targeting size classes with high commercial-to-demographic value ratios. Among Florida alligators, for example, such ratios are particularly favorable with respect to small and very large animals. There remains, however, one crucial ingredient missing from this calculation. Those of you who are familiar with Florida alligators would quickly point out that a commercial hunter would eventually go bankrupt if he or she hunted exclusively animals over 4 meters. Certainly each animal in that size class would be worth a great deal on the commercial market, and certainly they would all be reproductively expendable males. But there simply are not enough animals that big to make their exclusive pursuit worthwhile in the long run. In other words, a manager planning size-class selective harvesting of a crocodilian population also needs some idea of the relative abundance of size classes (Figure 3);

The information we have sketched in Figures 1, 2, and 3 provide grounds for deciding which size classes are most appropriately targeted for exploitation. This information does not, however, directly address the question of whether crocodilians should be commercially hunted at all. As you might expect, we have debated this most crucial question among ourselves a number of times. And four very general points have emerged from these debates and from our studies of commercial alligator exploitation. First, it is probable that the dynamics of harvested alligator populations are influenced by several factors which we have not yet been able to evaluate. Among these factors are the following: (a) We do not know what compensatory mechanisms might operate in an exploited population. (b) The wariness that develops in hunted crocodilians almost certainly provides some insurance against over-exploitation. (c) Some alligator habitats in Florida are difficult to hunt, and this problem of access also helps preserve some populations from excessive harvest.

Second, sustained-yield exploitation is not universally appropriate even where wild crocodilian populations can withstand substantial harvest. For example, it has been suggested that conservation and wildlife commercialization are incompatible under some socio-economic systems (Hope and Abercrombie, elsewhere in this volume). Furthermore, Magnusson (1984) points out that ranching some less valuable crocodilian species is simply not economically viable. As an absolute minimum, wildlife managers should avoid proposing strategies which imply a net financial drain or exacerbate social tendencies toward natural resource destruction. Therefore, the social economics of any destruction. Therefore, the social economics of any contemplated harvest scheme should be evaluated before significant commitments to sustained-yield management programs are made.

Third, potential demographic value of individual animals varies very substantially by targetable size class. This is far more the case for long-lived species such as crocodilians than for traditionally managed species (e.g., white-tailed deer), and this fact has important harvest implications. For example, despite our imperfect understanding of alligator demography, we can at least be certain that harvest schemes targeting 2m animals will not maximize sustained yield.

Finally, we believe that commercialization of wildlife can enhance conservation only when two conditions are met. (a) Persons involved in exploitation must be encouraged to develop a vested interest in maintaining substantial standing populations together with appropriate habitat. (b) A significant portion of harvest revenues must be returned (directly or indirectly) to species and habitat conservation.

### Conclusion

The potential commercial value of several crocodilian species could finance sustained-yield conservation programs and also generate surplus revenues to address important human needs. However, effective sustained-yield exploitation programs need a sound research base since (for social and biological reasons) crocodilians are particularly vulnerable to overharvest. Today we have outlined initial results of our alligator harvest studies. In Florida, as elsewhere, much work obviously remains to be done. Nevertheless, we hope the present paper will stimulate appropriate discussion.

### References

- Anon. 1982. National parks policy-- conservation of crocodiles in Zimbabwe. *The Zimbabwe Science News* 16:214-215.
- Chabreck, R.H. and T. Joanen. 1979. Growth rates of American alligators in Louisiana. *Herpetologica* 35:51-57.
- Deitz, D.C. and T.C. Hines. 1980. Alligator nesting in north-central Florida. *Copeia* 1980:249-258.
- Hines, T.C. 1979. The past and present status of the alligator in Florida. *Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies* 33:224-232.
- Hines, T.C. and A.R. Woodward. 1980. Nuisance alligator control in Florida. *Wildl. Soc. Bull.* 8(3):234-242.
- Hines, T.C. and A.R. Woodward. 1981. A report on Florida's nuisance alligator program. *Proc. Non-game and Endangered Wildl. Sym. Georgia Dept. of Natural Resourc. Tech. Bull. WL5.* 73-76.
- Magnusson, W.E. 1984. Economics, developing countries, and the captive propagation of crocodilians. *Wildl. Soc. Bull.* 12:194-197.



- Palmisano, A.W., T. Joanen, and L.L. McNease. 1973. An analysis of Louisiana's 1972 experimental alligator harvest program. Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 27:184-206.
- Rose, M. 1982. Crocodile management and husbandry in Papua New Guinea. Proc. 6 Ann. Meet. IUCN.Crocodile Specialists Group. 13pp.
- Taylor, D. and W Neal. 1984. Management implications of size-class frequency distributions in Louisiana alligators populations. Wildl. Soc. Bull. 12:312-319.
- Wood, J.M. and S.R. Humphrey. 1983. Analysis of Florida alligator transect data. Univ. of Florida Coop. Wildl. Resource Unit. Gainesville, Tech. Bull. 5.
- Woodward, A.R., and W.R. Marion. 1978. An evaluation of factors affecting night-light counts of alligators. Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32:291-302.

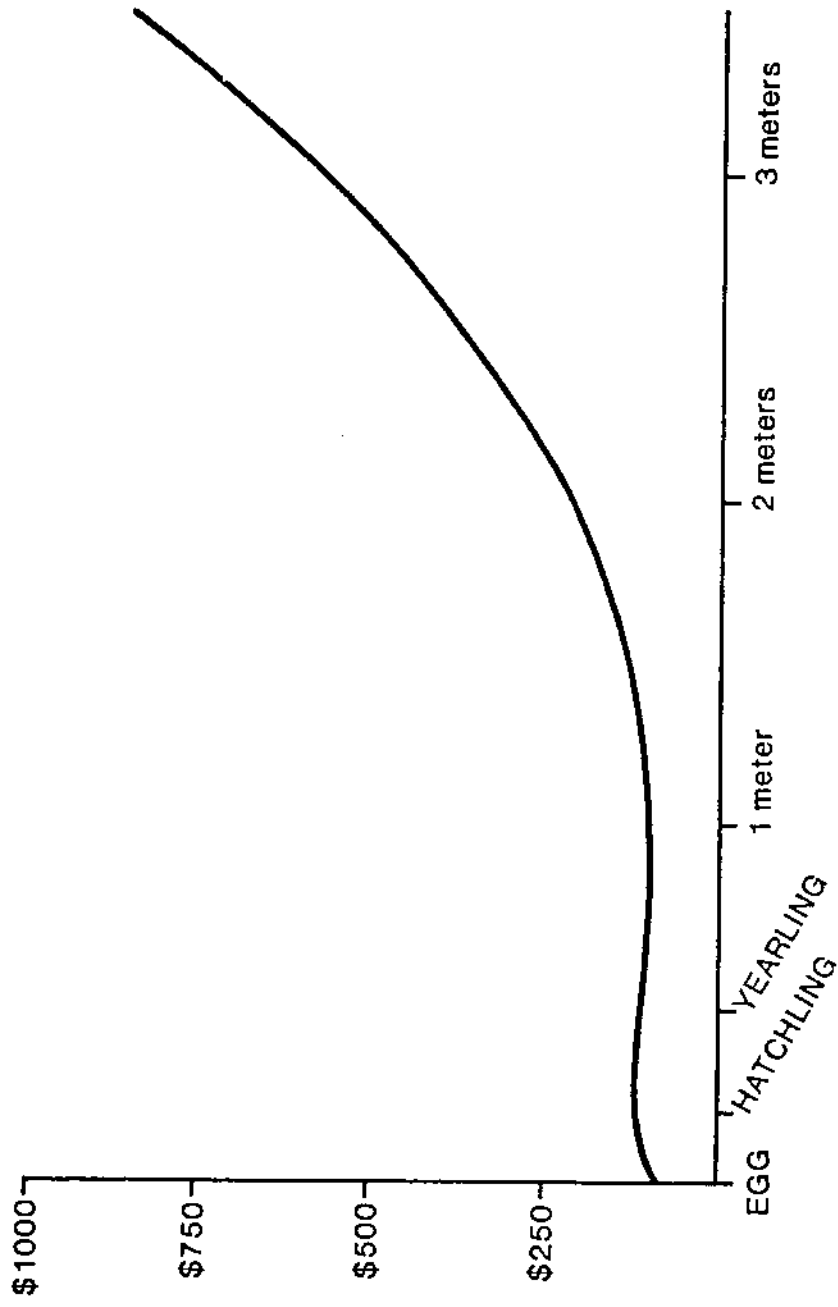


FIGURE 1: MONETARY VALUE BY SIZE CLASS

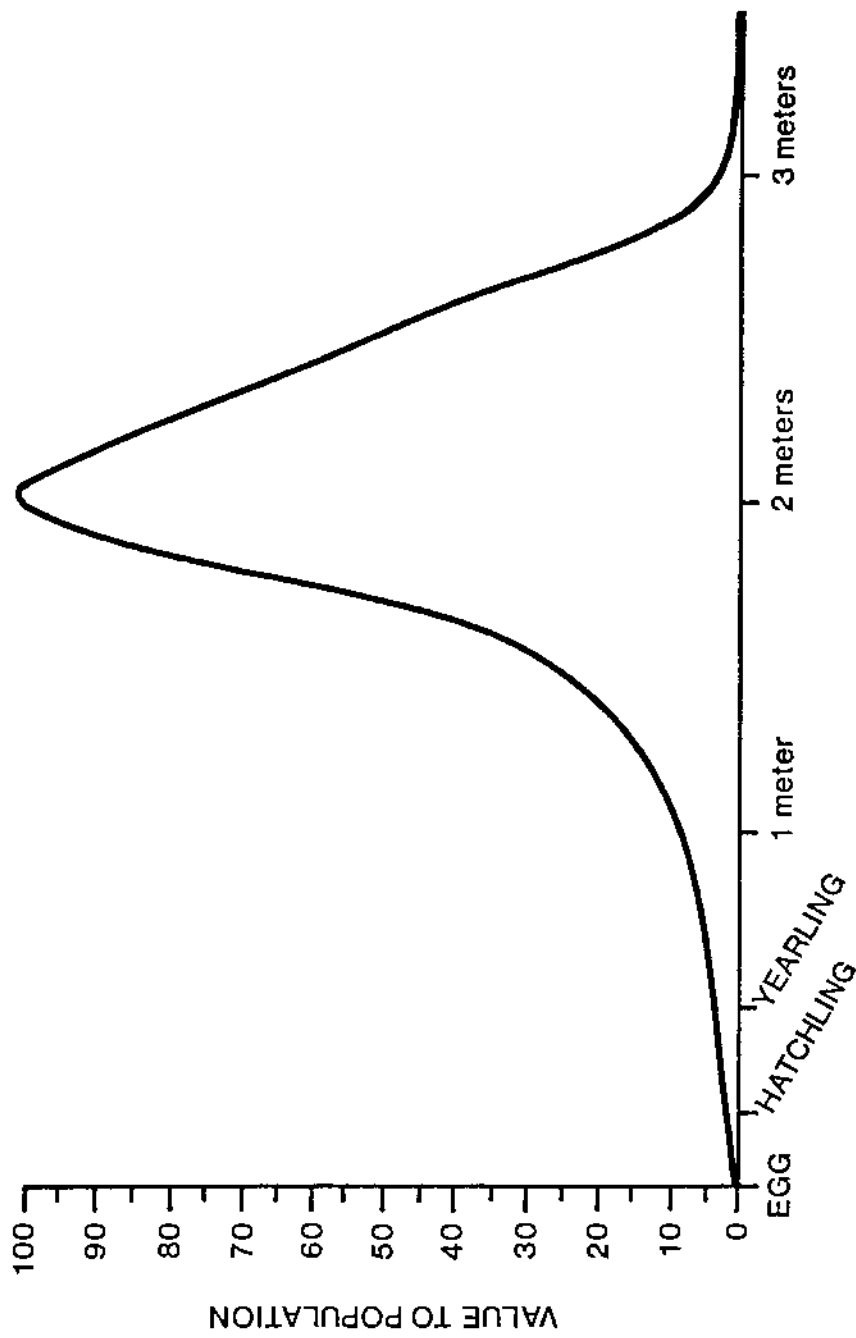


FIGURE 2: EXPECTED VALUE TO POPULATION

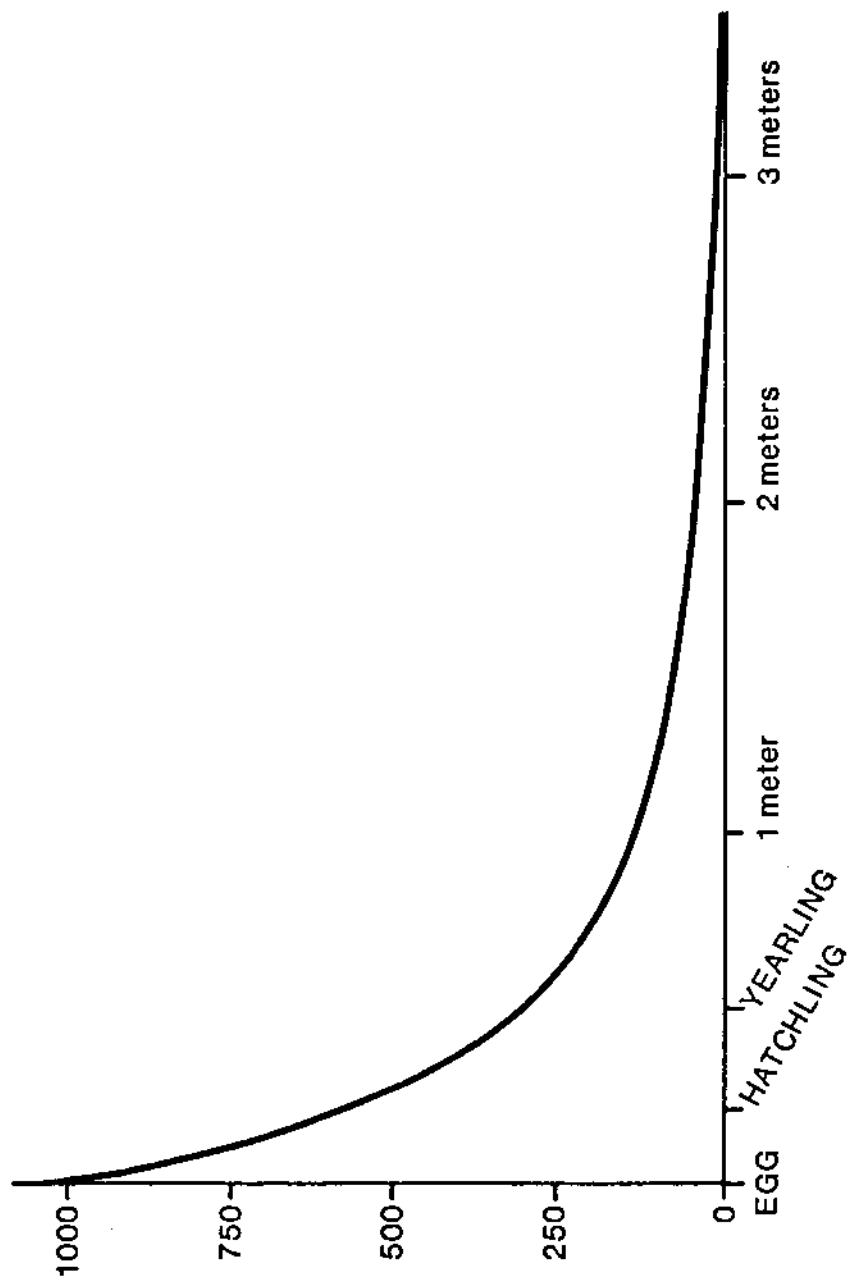


FIGURE 3: RELATIVE ABUNDANCE BY SIZE CLASS

HUNTERS, HIDES, DOLLARS, AND DEPENDENCY: ECONOMICS  
OF WILDLIFE EXPLOITATION IN BELIZE

Christine A. Hope, Department of Sociology, College of  
Charleston, Charleston, South Carolina 29401, USA

Clarence L. Abercrombie\* Department of Sociology, Wofford  
College, Spartanburg, South Carolina 29301, USA

\* Presente Address: Cooperative Fish & Wildlife Research  
Unit 117 Newins-Ziegler

Institute of Food and Agricultural Sciences University  
of Florida - Gainesville, Florida 32611, USA

Introduction

As heirs of nineteenth century progressivism, Western social scientists have until recently argued that Third World nations would achieve much-needed improvements in quality of life through an almost organic process of internal, progressive "development" (Almond and Powell 1966, Pye and Verba 1965, Rostow 1960). However, it is presently difficult to discern any general pattern of natural, progressive development in the tropical countries. Recent critiques of this development theory attribute its failure to its insistence, in extreme, that each nation is, and has been for years, an independent actor on an otherwise empty stage (Frank 1969, Villamil 1979, Wallerstein 1974, 1979). By contrast the critics, or dependency theorists (Wallerstein 1979) emphasize that it is not possible to understand what goes on within a Third World nation until one recognizes the present and historical relationship of that nation to other international actors.

Social scientists applying dependency theory to Third World countries have most often emphasized the effect of colonial policy, trade relations, and programs of economic development on agricultural underdevelopment (e.g. Ashcraft 1973, Franke and Chasin 1980). They argue that Third World agriculture has been shaped by the industrially developed world to benefit the industrially developed world: raising crops for export has been promoted over raising food crops for domestic consumption; cash-crop agriculture has been expanded into ecologically marginal areas; developing foreign markets for agricultural products has been stressed to the detriment of internal markets (Ashcraft 1973, Franke and Chasin 1980, Morgan 1979). Consequently, the people of many Third World countries devote their major energies and resources to providing inexpensive agricultural products (e.g., sugar, bananas, coffee, marijuana, etc.) for the developed world. Thus they end up in debt for more expensive manufactured products and, increasingly, for food to sustain themselves.

We believe that a similar analysis can be applied to the exploitation of wild plant and animal species for commercial export. While conservationists interested in such matters have become increasingly sensitive to the economics (including the international economics) of species preservation or extinction (National Research Council 1983), they have not systematically outlined how resource exploitation in a Third World country can be driven by forces largely exogenous to the national borders. Rather, their analyses have concentrated on the internal dynamics of the resource in question (e.g., Glastra 1983). Often, therefore, native "poachers" are simply defined as the villains in such studies (e.g., Barbour 1976, Loftas 1977, Myers 1978), and there is little investigation of the ways in which the poachers'/hunters' activities are linked to the economies of the developed world.

This report will extend the application of dependency theory to the exploitation of Third World wildlife by considering the specific case of crocodile hunting in Belize. In so doing, we shall show how the underdevelopment process has shaped the ancient human activity of hunting, and we shall discuss the social, economic, and ecological consequences of this type of wildlife exploitation. We contend that the whole process of hunting crocodiles, skinning them, selling, reselling, tanning, finishing, and retailing the hides provides a microcosm of the relationships which exist between the underdeveloped Third World and the rich, historically developed countries.

#### Methods

We gathered the information upon which this report is based during visits to Belize in the summers of 1978, 1979, 1980, 1982, and 1984. As part of our project to assess the status of the wild crocodilian populations in Belize, we talked with hunters and hide dealers throughout the northern two thirds of the country. In some areas, prior contacts led us to informants. Elsewhere we asked people encountered on the road or in other public places for information about "alligators" (The local terminology) and those who hunted them. Data gathered from interviews, along with information obtained from historical documents and from individuals familiar with the international crocodile hide trade, allowed us to construct a reasonably complete picture of commercial crocodile exploitation in Belize.

#### The Belizean Crocodile-Hide Trade

Circa 1980, the crocodile hide business in Belize operated as follows. A rural Belizean, typically poor, hunts at night from a hand-built dorey. Battery-powered handlamps are used to illuminate eye-shines. The experienced hunter ascertains the size of a crocodile and, if the animal is large enough (greater than 1 meter) to bring a reasonable price, kills it with a shotgun. Crocodiles are skinned at a camp close to the place where they were killed. The hides are salted and rolled for transport home; the flesh is discarded.

The hunter carries his croc hides, plus the skins of any spotted cats he may have killed, to a nearby village. Here he sells all the hides to the local hide dealer, usually a storekeeper for whom the hide business is a sideline. In 1980, hunters received \$4-\$5 (all currency figures are in U.S. dollars) per linear foot for crocodile hides. After gathering a supply of hides, the local dealer transports them to a larger city where he sells them to the only man in Belize with a permit to export hides and skins. This exporter, a man of European descent, pays the local dealer \$4-\$7 per foot for the crocodile hides and then resells them to a Belgian holding company for about \$10-\$15 per foot. What happens to the hides next is a still-hidden part of the process, but they have usually been eventually sold to an Italian processing firm that turns them into handbags, belts, and shoes. These products will be purchased by retail firms which, in turn, sell them to persons of the world's upper classes.

A seven-foot crocodile can yield products costing as much as \$2500 retail. Of this \$2500, the hunter would receive about \$35 and the local hide brokers about \$15. Very approximately, the remaining \$2450 is divided among the parties involved in the transport, processing, and sale of crocodilian products as follows; \$30 goes to the foreign broker and transporter, \$65 to the tanner, \$120 to the manufacturing laborers and seamstresses, \$1100 to the manufacturing contractor, and \$1135 to the retailers. To put in another way, 98% of the money derived through the processing of this particular tropical wildlife resource circulates among people in the developed world.

This pattern fits almost perfectly with Braudel's (1976) description of 16th century merchant capital accumulation. As noted above, hides are bought cheap. They pass through a chain of middlemen (who do not disclose the prices for which they will sell the hides) and are eventually processed into expensive luxury goods. Materials which can be sold for high profits in Europe are purchased overseas at prices sufficient to maintain the supply. As we shall see, in the supplying country, money inflow drives resource exploitation to levels which would presumably not otherwise obtain; local surpluses of cash usually go to purchase imported, European goods that are sold at considerable profit. The dynamics of the exchange system are largely external to the supplier area which, over time, is increasingly stripped of its natural resources without appreciable gain.

#### Belize as an Underdeveloped Society

To understand the above process requires some knowledge of Belizean geography and history. Located along the Caribbean coast south of Yucatan, Belize encompasses c. 23000 square kilometers and falls mostly into the tropical moist forest life zone. The country was formerly known as British Honduras; it received complete independence in 1981. Unlike many of its Central American and Caribbean neighbors, Belize is sparsely populated, and much of the land therefore remains available for wildlife exploitation or agricultural development.

Several factors in Belizean history are directly relevant to the country's present pattern of natural resource exploitation. There was relatively little human impact on wildlife from the time of Mayan

population collapse (c. 1000 A.D.) until the 16th century (Forst 1974). However, from the first days of contact, European interest in Belize was aimed very explicitly at the exploitation of natural resources, and by the middle of the sixteenth century, regular logging operations had begun (Ashcraft 1973, Cross 1979, Frost 1974).

Like other Caribbean societies, British Honduras was created, virtually de novo, in response to the needs of the Old World. The particular Old World needs Belize was designed to fulfill involved, almost exclusively, the exploitation of forest resources with minimum capital investment. This was evidenced, for example, in the minimal public works program: because timber was transported almost entirely by water, a system of roads, which could have linked potential internal markets, was not constructed. Furthermore, the general colonial strategy affected the human population very directly. Since early Belize contained too few Amerindians to work the timber harvest, Britain populated her new "colony" with imported West Indian slaves (Ashcraft 1973, Dobson 1973). After emancipation (1834) these persons usually remained as forestry wage laborers (Ashcraft 1973), and, into the present century, many Belizeans would be more properly classified as low-paid work crews than as colonists. With exclusive emphasis placed on forest products, colonial policy actually prohibited the development of agriculture for at least two centuries (Ashcraft 1973). For all these reasons, British Honduras long ago became accustomed to working for money-- and to eating imported food, wearing imported clothing, using imported tools.

These long-term socio-economic patterns have persisted to influence the structure of present-day Belizean hunting. Like subsistence agriculture, subsistence hunting simply could not mature, and the hunting "tradition" of Belize involves exploiting wildlife for its monetary value. Presumably logging crews did occasionally supplement their imported food with forest animals, but in general Belizeans apparently preferred to shoot something they could sell. Perhaps it is significant that the full development of commercial croc hunting occurred at a time (c. 1930) when major forest products (logwood, mahogany, and chicle) were losing value (Colonial Reports); it was simply a case of partial resource-switching. In other words commercial hunting in British Honduras did not grow out of a long-standing subsistence hunting tradition as did commercial fur-trapping in Canada (Lealcock 1954, Martin 1978, Tanner 1979) and commercial elephant-hunting in Africa (Ricciuti 1980); instead, it simply extended the established Belizean practice of using the forest to make money.

### The Hunters

There are certain similarities between some commercial hunters in Belize and the traditional hunters in preliterate societies. These similarities involve mostly wilderness skills and self-identification.



Some Belizean hunters, primarily of the older generation, spend most of the dry season hunting and fishing--and specifically identify themselves as "hunters." Their detailed knowledge of both local and remote hunting areas and their ability to find and evaluate potential game on the basis of minor clues are similar to skills of traditional hunter-gatherers (Jones and Konner 1976, Laughlin 1968, Marks 1976). Like traditional hunters depicted in anthropological descriptions, these "master" Belizean hunters often travel long distances (up to 100 km) and expect to be continuously afield for long periods (often a week or longer). Finally, like hunters in both preliterate (Marks 1976) and highly industrialized societies (Kennedy 1974, Schole *et al.* 1973), these Belizean hunters talk about the intrinsic pleasures of hunt--simply being away from home, out in the wilderness, away from the problems of daily life.

However, there are also a great many part-time hunters in Belize who take an occasional crocodile and who are much less knowledgeable about wild areas and much less committed to the hunting way of life than are the master hunters. These men continue to work at another job (usually wage labor on plantations or on road-building projects) even during the dry season and go hunting after work, on holidays, or when their work takes them into wild areas. They typically hunt only in areas easily accessible by road, and they hunt animals of all types.

Even the master hunters in Belize are different from traditional subsistence hunters in most respects. Some of our informants mentioned hunting with a brother or with their father, but commercial crocodile hunting is for the most part a solitary endeavor. There are no formal organizations of crocodile hunters, and informal contacts between them seem to be rather rare. In our experience, the men who hunt crocodiles are not known for that in their home village and neighborhoods--sometimes not even by their own relatives. Although individual crocodile hunters did reveal a few superstitions about crocodiles and hunting, there was little evidence of shared beliefs, symbols, or ceremonies among the commercial hunters with whom we spoke.

By contrast, traditional subsistence hunting, especially for large animals, is often done by large groups of men and boys, sometimes organized into hunting guilds (Marks 1976). Typically the reputation of each hunter is widely shared community knowledge. Hunting in such societies is often surrounded by a variety of symbol-rich ceremonies and beliefs; preparation for hunting, hunting itself, and sharing the fruits of the hunt frequently provide major organizing from the entire community (Marks 1976, Sackett 1979, Tanner 1979).

In some senses, the Belizean crocodile hunters are classic examples of alienated labor. Some of this is evident in the very language they use. Hunting is referred to as "the job" (as in "I have been doing the job for forty years now"), and potential hunting locations are evaluated on the basis of how much cash they can expect to yield ("I could have a thousand-dollar night there"). Their work is largely a means to an end rather than an end in itself. Unlike hunters in at least some hunting-gathering societies (Jones and Konner 1976), Belizean hunters generally observe animals only in order to learn how to hunt them more efficiently. For example, most are unable to identify and locate crocodile nests or even to distinguish them

from the nests of iguanas. Typically, hunters have direct use only for the money they make from hunting and not for the animal products per se. This is true even for those few hunters who preferentially pursue deer, peccary, or paca; they seldom consume the meat but rather sell it in the larger towns. Crocodile hunters have only vague ideas about where the hides are sent after the local dealer buys them, and little knowledge about the final use of the hides ("What is an alligator skin really good for anyway?"). Without knowledge of world prices and trends (the Belizean middlemen also lack such knowledge), the hunters are not in a position to decide when to hunt intensively and when to cut down on hunting to maximize financial gains. Similarly, hunters have little power to bargain for a better price. In essence, although they have considerable freedom in day-to-day working conditions, they absolutely lack control over the products of their labor.

In traditional hunting-gathering societies, the fruits of a successful hunt are often shared with all members of the community (Leacock 1954, Marks 1976, Sackett 1979). In contrast, little of the money received by Belizean croc hunters finds its way into the "less developed" sectors of the local economy. Interviews indicate that for most Belizeans, hunting is just about a break-even proposition. Many of their earnings, therefore, go to purchase imported goods (batteries, shotgun shells) necessary to support the next hunt. The remaining money is spent partially within the local community and partially for imported food and consumer goods.

#### Consequences to the Resource

The method of resource exploitation introduced by colonialism and carried out by the commercial hunters today probably has ecological consequences as well. Most subsistence hunters understand that they can utilize just so many animals as food, and indigenous subsistence-hunting traditions may include customs and taboos helpful in preventing overexploitation of wildlife (Marks 1976, Rappaport 1968). There is some evidence to suggest that subsistence hunters may (for reasons somewhat more complex than a simple caloric budget) adjust their hunting effort so that returns per unit effort remain constant. Nietschmann (1972), for example, found that when hunting pay-offs dropped below c.0.7kg/hunting-hour, Miskito Indians began to decrease their hunting effort. Smith's (1976) study of three similar-sized "agrovilas" along the trans-Amazon highway is more directly suggestive. Where prey density had been reduced, hunting effort also contracted. Therefore, although total hunting take varied greatly across the villages, take per unit effort remained remarkably constant. Clearly these mechanisms could be important in preserving populations of exploited species.

The stability projected above for a simplified subsistence-hunting model does not necessarily persist in a commercial-hunting system such as the one in Belize. To begin with, there are no obvious upper limits to the amount of cash a hunter might desire to accumulate or spend. Also, the closed-system models which apply to many subsistence hunting situations are fundamentally altered when their feedback loops are intercepted by exogenous information from a larger system. For example, the world economic system may set

new values for prey units, thereby changing the amount of hunting effort a given prey density will motivate. For k-selected animals like crocodilians, such destabilizations are likely to be catastrophic.

### Conclusion

Thus far, a number of forces have combined to preserve the Belizean crocodile population from immediate danger of extinction. The relatively late start of extensive commercial hunting, along with the fact that many areas of the country are still inaccessible by road (an ironic effect of Belize's particular type of underdevelopment) have combined to assure Belize a continuing source of crocodiles in the short term. Intensive crocodile hunting has not involved many people since c. 1982. However, this situation could change rather rapidly if Belize experiences an economic recession with resulting unemployment, if the price of crocodile hides goes up for even a brief period, if good roads are built into presently inaccessible hunting areas, or if there are several long, consecutive dry seasons.

A few countries in the world have begun to experiment with exploiting crocodilians as a long-term source of national income by instituting managed, sustained yield harvest operations (Hines *et al.* 1984) or by establishing farms to rear the animals (Ashley in press, Cardeillac *et al.* 1981. Gee in press, Pose in press). There is little in Belize's past or present to suggest that such projects will take root there. The major buyers of hides have many other sources and, of course, have a stake in keeping the more lucrative parts of the process located in Europe. Local hide dealers are willing to make money off crocodiles while it is convenient, but they can easily shift to other money-making schemes when the crocodiles are gone. They (and the hunters) lack the capital and expertise needed to manage sustained yield exploitation. While the master hunters note the diminishing supply of crocodiles with some regret, the entire historical pattern of resource exploitation in Belize has taught them to make money on whatever they can whenever they can (if they don't get the remaining crocodiles, others will). As in so many other ex-colonial situations, Belize will be left without a resource and with no perceptible gain.

### Literature Cited

- Almond, G. and G.B. Powell. 1966. Comparative politics: a developmental approach. Little, Brown, Boston.
- Ashcraft, N. 1973. Colonialism and underdevelopment: processes of political change in British Honduras. Teachers College Press, New York.
- Ashley, J.D. In press. Overview of alligator farming in the United States. Proceedings of the Sixth Working Meeting of the IUCN Crocodile Specialist Group, Zimbabwe, 1982.

- Barbour, J. 1976. Poachers at work: crocodiles at bay. *International Wildlife* SEP-OCT: 4-11.
- Braudel, F. 1976. Afterthoughts on material civilization and capitalism. (trans. P. Ranum) Johns Hopkins, Baltimore).
- Cardeillac, P., T. Lane, and R. Larsen (eds.) 1981. Proceedings of the first alligator production conference. IFAS, Univ. of Florida, Gainesville.
- Carneiro, R.L. 1970. Hunting and hunting magic among the Amahuaca of the Peruvian montana. *Ethology* 9(4):331-341.
- Colonial Reports, British Honduras, Reports for 1919-1965. His/Her Majesty's Stationery Office, London.
- Cross, M. 1979. Urbanization and urban growth in the Caribbean: an essay on social change in dependent societies. Cambridge Univ. Press, Cambridge.
- Dobson, N. 1973. A history of Belize. Longman Caribbean, London.
- Frank, A. G. 1969. Latin America: underdevelopment or revolution. Monthly Review Press, New York.
- Franke, R.W. and B.H. Chasin. 1980. Seeds of famine; ecological destruction and the development dilemma in the West African Sahel. Allanheld, Osmun, Totowa.
- Frost, M. 1974. A biogeographical analysis of some relationships between man, land, and wildlife in Belize. (British Honduras). Unpublished Ph.D. dissertation, Oregon State Univ.
- Gee, R. In press. Some comparisons between crocodile-farming and crocodile-rearing in Zimbabwe. Proceedings of the Sixth Working Meeting of the IUCN Crocodile Specialist Group, Zimbabwe, 1982.
- Glastra, R. 1983. Notes on a population of Caiman crocodilus depleted by hide hunting in Surinam. *Biological Conservation* 26(2): 149-162.
- Jones, N.B. and J. Konner. 1976. ;Kung knowledge of animal behavior. pp 325-348 in R. Lee and I DeVore (eds.) Kalajari hunter-gatherers: studies of the ;Kung San and their neighbors. Harvard Univ. Press, Cambridge.
- Hines, T., A. Woodward, D. David, M. Delany, P. Moler, and C. Abercrombie. 1984. Alligator Management Plan. Florida Game and Fresh Water Fish Commission Unpublished.
- Kennedy, J.J. 1974. Attitudes and behavior of deer hunters in a Maryland forest. *Journal of Wildlife Management* 38(1):1-8.

- Laughlin, W.S. 1968. Hunting: an integrating behavior system and its evolutionary importance. pp. 304-320 in R. Lee and I. Devore (eds.) *Man the hunter*. Aldine, Chicago.
- Leacock, E. 1954. The Montagnais "hunting territory" and the fur trade. *American anthropological association memoirs*, 56:5. Memoir No 78.
- Loftas, T. 1977. The great ornamental fish rip-off. *International Wildlife* JUL-AUG:28-32.
- Marks, S. 1976. Large mammals and a brave people: subsistence hunters in Zambia. Washington Univ. Press, Seattle.
- Martin, C. 1978. Keepers of the game: Indian-animal relationships and the fur trade. Univ. of California Press, Berkeley.
- Morgan, D. 1979. *Merchants of grain*. Penguin, Harmondsworth.
- Myers, N. 1978. The selling of the zebra. *International Wildlife* JAN-FEB:26-30.
- National Research Council. 1983. Crocodiles as a resource for the tropics. Report of Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board of Science and Technology for International Development, Office of International Affairs. National Academy Press, Washington, D.C.
- Nietschmann, B. 1972. Hunting and fishing focus among the Miskito Indian, Eastern Nicaragua. *Human Ecology* 1(1):41-68.
- Pye, L. and S. Verba (eds.). 1965. *Political culture and political development*. Princeton Univ. Press, Princeton.
- Rappaport, R. A. 1968. Pigs for the ancestors: ritual in the ecology of a New Guinea people. Yale Univ. Press, New Haven.
- Ricciuti, E.R. 1980. The poachers. *Animal Kingdom* FEB-MAR: 25-31.
- Rose, M. In press. Crocodile management and husbandry in Papua New Guinea, 1982. Proceedings of the Sixth Working Meeting of the IUCN Crocodile Specialist Group, Zimbabwe, 1982.
- Rostow, W.W. 1960. *The stages of economic growth: a non-communist manifesto*. Cambridge Univ. Press, London.
- Sackett, L. 1979. The pursuit of prominence: hunting in an Australian aboriginal community. *Anthropologica* 21:(2):223-246.
- Schole, B.J., D.A. Glover, D.D. Sjorgren, and E. Decker. 1973. Colorado hunter behavior, attitudes, and philosophies. *Transactions North American Wildlife Natural Resources Conference* 34:252-264.

- Smith, N. 1976. Utilization of game along Brazil's Transamazon highway. *Acta Amazonica* 6(4):455-466.
- Tanner, A. 1979. Bringing home animals: religious ideology and mode of production of the Mistassini Cree hunters. St. Martin's Press, New York.
- Villamil, J. (ed.) 1979. Transnational capitalism and national development: new perspectives on dependence. Humanities Press, Atlantic Highlands.
- Wallerstein, I. 1974. The modern world-system: capitalist agriculture and the origins of the European world-economy in the sixteenth century. Academic Press, New York.
- Wallerstein, I. 1979. The capitalist world economy. Cambridge Univ. Press, Cambridge.

ALLIGATOR NEST FLOODING IN THE SOUTHERN EVERGLADES:  
A METHODOLOGY FOR MANAGEMENT

Terri Jacobsen and James A. Kushlan  
Institute of Ecology, University of  
Georgia, Athens, Ga. 30602, and  
Department of Biology, East Texas  
State University, Commerce, Tx. 75428

Introduction

The management of natural resources in relatively affluent countries such as the United States is generally uncomplicated by a need for the resource to generate revenue. In areas such as Everglades National Park, located in southern Florida, a preservationist policy is mandated by law, such that the Everglades is viewed as a resource to be managed solely for its perpetuation. The American alligator (Alligator mississippiensis) has an important ecological role in the Everglades (Kushlan 1974) and is fundamental to the continuation of the natural processes governing the marsh ecosystem. In that the alligator is not to be viewed as a harvestable resource, ecological rather than economic criteria are crucial for its survival. Management objectives for the Everglades alligator include the preservation of it's role in the ecosystem, in this way maintaining the Everglades ecosystem for future generations.

During our eight-year study of Everglades alligators, fluctuations in environmental conditions have provided us with opportunities for natural experimentation. Research has focused on describing the responses of the alligator to the primary human influence on the system, that of an altered delivery of surface water into the park. With the construction of extensive deep-water canals throughout the Everglades watershed, which drained surface water and halted overland surface flow, the water now entering Everglades National Park is not only of artificial quality, having by-passed the natural filtering processes available in the marsh system, but the flow is entirely controlled by four flood control gates along the park's northern border (Fig. 1). Of concern to this research are the effects of the timing and extent of water flow on the Everglades wetland ecosystem, and in particular on the alligator.

In this short report we discuss one aspect of our study, the flooding of alligator nests, which reached nearly 100% in two years of the study. Of interest was whether nest flooding was a natural occurrence, and in what frequency and extent it was likely to have occurred prior to the alternation of water flow patterns. We undertook a predictive modeling effort geared toward addressing these questions. Here we summarize the results of our analyses, emphasizing the implications for the management of the Everglades ecosystem. This report abstracts the results of a complete report as yet unreleased by the South Florida Research Center (Superintendent, Everglades National Park, Homestead, Fl. 33030, U.S.A.), in which is contained the detailed statistical analyses that support the conclusions drawn here.

## Methods

Everglades National Park is located in extreme southwestern Florida, USA, and contains about 1.5 million hectares of Everglades habitat, including freshwater marshes, mangrove estuaries, pinelands, hammocks, and open bays. Information on alligator nesting success was collected in a 10-km<sup>2</sup> area in the Shark River Slough, the major drainage area for surface water flow into the park (Fig. 2). Other 10-km<sup>2</sup> areas of marsh distributed along the length of Shark Slough were studied with less intensity, as was the lower end of Conservation Area 3A (Fig. 2). Although most information was collected in the primary study area, this area reflects average relationships among water conditions and alligator nest flooding throughout Shark Slough, a contention demonstrated by the fact that the extent of nest flooding during our study period in the primary study area approximated the average nests flooding in other study areas in the northern and southern parts of Shark Slough.

We determined the number of nests each year from 1975 to 1982 using fixed-wing aircraft, helicopters, and ground searches. In the primary study area, all areas not visible from the air were searched thoroughly on foot to provide complete counts of all nests. These ground searches allowed us to calculate that 13.9 percent of the nests present were not spotted during aerial surveys.

We measured all but five nests built from 1975 to 1982 in the primary study area (n=71). At one nest an aggressive female prevented us from approaching on the ground, and four other nests were not located prior to hatching. Eggs in each measured nest were counted and examined for viability. The time of egg deposition was estimated from eggs collected from each nest using embryological timing criteria developed by Grabowski et al. (in prep.). At each nest visit we noted the habitat of the nest and took several measurements (Fig. 3), including the height of the nest above the prevailing water level at the nest site, the distance from the top of the nest to the top of the egg cavity, and the depth (extent) of the clutch or egg cavity.

From these measurements we calculated the height of the center of the clutch above the water level at the time of measurement. We then expressed the clutch heights as mean sea level elevations in meters (m MSL) to correspond with the units of stage measurement. Water stage data (m MSL) were recorded daily within the primary study area, and we calculated mean stage values from these daily readings. Water conditions varied over the study period and among the study areas. Such water level variability is an inherent characteristic of the Everglades system, and each year provided us with a temporal experiment on the effects of water levels on alligator nesting.

Air temperatures were recorded at the climatological station located along the northern border of the park. We use the midpoint between the recorded minimum and maximum daily temperature to approximate the daily mean temperature.



## Results

NESTING PRODUCTIVITY. Alligators reproduce during a nesting season which is relatively consistent and predictable from year to year. Nesting of the alligator in the Everglades takes place during the boreal summer. From 1975 to 1982, the average date of egg-laying (n=71 nests) was 26 June (s=11 days), with the earliest nesting recorded on 9 June and the latest on 27 July. The average date of egg laying occurred one month after the average beginning of the rainy season as water levels were rising. The nesting season, therefore, seems to reflect a balance in selective pressures. Nesting occurs late enough in the year to coincide with the high ambient temperatures needed for incubation but early enough for hatching to occur before seasonal water levels usually peak, thereby reducing the chances of nest flooding.

Egg deposition generally occurred from late June to early July. The mean laying date differed significantly among the years from 1975 to 1982, and was strongly correlated with spring air temperatures. The mean annual egg-laying date can be predicated by the mean temperature in April and the mean temperature in May-June using the following relationship:  $\hat{Y} = 241.62 - 5.45 X_1 - 2.18 X_2$ , where  $\hat{Y}$  is the estimated laying date expressed as the number of days after May,  $X_1$  is the mean daily air temperature in April ( $^{\circ}\text{C}$ ), and  $X_2$  is the mean daily air temperature in May-June ( $^{\circ}\text{C}$ ). In general, it appears that alligators nest earlier following a warmer spring season and delay nesting in cooler years.

For alligators in the southern Everglades, the average clutch size during our study was 30 eggs (mean=29.7, s=7.52, n=198 nests), and the annual nesting effort from 1975 to 1982 ranged from 16 to 58 percent of the known-breeding females, with an average of 29 percent of the females nesting per year. The clutch size and nesting effort are substantially lower than in Louisiana or North Florida (Joanen 1969, Dietz and Hines 1980, Joanen and McNease 1973). In fact, the annual nesting effort in the Everglades is less than half of what it is in Louisiana. We are studying the possible causes and effects of the lower productivity rate in our ongoing analyses of the population ecology of Everglades alligators.

A lower clutch size means that Everglades alligators have a lower annual reproductive potential than do other populations studied. Given a 25 percent lower clutch size and a 50 percent lower nesting rate, an Everglades alligator appears to produce on average one third as many eggs per year (5.0 viable eggs per mature female per year) as do Louisiana alligators (15.9 viable eggs per mature female per year, Joanen 1969). As a result fewer hatchlings are produced per nest in the Everglades. This may mean that the Everglades alligator population has less ability to buffer the adverse effects of mortality agents effecting nesting success and productivity. A single egg may, therefore, be of a greater value to the stability of the Everglades population than it would be to other populations so far studied. Thus, any factor affecting nesting success would have a relatively greater impact on population levels of Everglades alligators than they would on such other populations.

The single most crucial factor in nest success in the Everglades is nest flooding. The loss of eggs by flooding resulted in an average annual loss from 1975 to 1982 of 27.9 percent (s=37.1 percent) and a median loss of 5.4 percent. In years when little or no nest flooding occurred, water levels did not reach relatively high levels during the summer nesting season. In 1975 and 1977, flooding occurred only in two particularly low-lying nests. In two years when flooding was significant, 1978 and 1982, flooding was attributed to an unnatural increase in water discharge levels.

**PREDICTING AND MANAGING NEST FLOODING.** The ability to anticipate the occurrence and predict the extent of alligator nest flooding would permit appropriate water management decisions by managers of Everglades National Park. To this end, we have developed a method by which we can predict the extent of nest flooding in a given year. For analytical purposes, we define clutch height as the height of the center of the egg cavity. A nest is considered to be flooded if the ambient water level reaches this point. We can predict with ease whether any particular nest will be flooded in any year during our study by comparing its clutch height to any water level. For our model to be predictive outside of the time of our study, however, we would need to know the clutch heights of all nests constructed each year, and this can be done by means of a predictive relationship.

During the study period, we found that clutch heights differed significantly among years ( $F=7.11$ ,  $p=0.001$ ,  $df=7,63$ ), and that we could predict the mean annual clutch height by using the water level during the last two weeks of June, the period when nests construction is occurring ( $Y = 0.663 X + 0.899$ ,  $r=0.951$ ,  $p=0.001$ ,  $n=8$  years). What this relationship implies is that higher water levels during the early summer correlate with higher clutch heights. The mechanism for this appears to be a multivariate response in nest construction. We can account for 92 percent of the variability in clutch heights during our study and can attribute 46 percent to flexibility in the height of the site chosen for nest construction, 43 percent to the height of the eggs within the nest mound, and 2 percent to the height of the mound itself. Thus, under conditions of higher water levels during the nest construction process, alligators appear to be choosing higher sites, placing eggs higher in the nest mound, and to some extent building higher mounds.

With this information we have constructed a model which includes both the linear response to higher water levels and thresholds beyond which alligators are unable to compensate due to the limitations imposed by the low-lying marsh habitat (Fig. 4). Given this model, we can estimate the clutch height of all nests in any year by inputting water conditions characteristic of early summer. Flooding extent can then be determined by examining the maximum water level achieved during the incubation period.

There are at least four uses of such a model that predicts nest flooding. First, the model can be used after a current nesting season to estimate the amount of nest flooding occurring as a result of the highest water levels reached that year. Second, upon anticipating a rise in summer water levels in the park as a result of a management action or a change in upstream water conditions, a manager could predict the impact on alligator nesting success. Third, if critical water levels were derived from computer simulation using hydrologic models, the effects of simulated hydrologic scenarios on alligator reproductive success could be assessed. And fourth, the model permits estimation of historical nest losses, including those that occurred before intensive water management began.

We noted earlier that our model uses data from the primary study area as being indicative of conditions throughout Shark Slough. To support this, we compared the observed nest flooding data in the primary study area with the estimated nest flooding in study areas I and V, located in the northern and southern ends of Shark Slough, respectively (Fig. 2). In one year flooding occurred in all areas, with a 44 percent nest flooding in the primary study area, 79 percent loss of nests in area I, and 25 percent loss of nests in area V. Thus, in years when flooding occurs, results from the primary study area appear to be about average for both upgradient and downgradient areas, and can accurately represent nest flooding throughout Shark Slough.

**HISTORIC NEST LOSSES.** By extending the use of the flooding model to historic period, we can compare and evaluate the recent effects of water management practices. We calculated the estimated nest loss to flooding that occurred historically beginning in 1953, when hydrologic data first became available (Fig. 5). We found that the extent of nest flooding has increased considerably, from an estimated annual loss of 4 percent under natural, historic conditions, to a recent annual loss of 20 percent, rising by a multiple of five times since active water management began in 1971. By our best estimates derived from our model, it seems that nest losses to flooding did not at any time approach 100 percent during the historic period of data available to us. The estimated maximum flooding reached just 33 percent in 1966. The nearly complete flooding of all nests that we observed in 1981 and 1982 was apparently unprecedented during historic time.

What then is the fundamental cause of the water level conditions that flood alligator nests and how have these conditions changed since scheduled water deliveries began in 1971? We approached this question by evaluating the predictability of the Everglades hydrologic system. We found that during the historic period (1953 to 1962), the maximum summer water level, which was the water level that would potentially flood alligator nests, was highly correlated with two variables - water level in the last two weeks of June, and discharge in June and July. Historically, much of the variability in maximum summer water levels could be attributed to antecedent hydrologic conditions that prevailed in each year, and primarily to water levels in late June, which alone accounted for over 86 percent of the variability ( $r=0.928$ ,  $p < 0.001$ ,  $n=10$ ) (Fig. 6). Thus, the maximum water level that occurred during the risk period for

alligator nest was predictable from water conditions during the time of nest construction, the same conditions that correlate significantly with annual clutch heights.

The relationship between water levels during the early summer and the maximum water levels reached during the risk period breaks down after 1971 during the recent water management period (Fig. 6). From 1971 to 1981, the maximum water levels during the incubation period were no longer reliably predictable. Importantly, water level during the last two weeks of June from 1971 to 1981 had no relation to maximum summer water levels. From this analysis several points can be made. First, there was at one time a relationship between water levels during the critical time for initiation of alligator nesting (early summer water levels) and those water levels that threaten flooding of alligator nests (summer maximum water levels). Flooding conditions under contemporary water management practices can no longer be anticipated by water conditions in early summer. The unnatural occurrence of high late summer discharge into Everglades National Park has led to increased nest flooding in recent years, in part through disruption of the natural predictability of the Everglades hydrologic system.

### Discussion

Public opinion of the alligator is important to its preservation, a view that is well-recognized by crocodylian biologists. One population view of the alligator is that its status no longer needs to be a matter of concern. Jacobsen and Kushlan (in prep.), in their review of the alligator's status relative to the management of problem alligators in the park, summarized how legal protection for alligators has loosened considerably in recent years. The current popular view of the alligator's status arises because in recent years most populations have benefitted from legal protection from the Endangered Species Act, and have largely recovered from the effects of hunting and their subsequent decline in numbers. Recovery in parts of Florida has been cited in a request by the State Game and Fresh Water Fish Commission as cause to reduce the alligator's status to "threatened by similarity of appearance", thus bringing alligator management completely under the responsibility of the state. Currently, an experimental harvest program in north Florida reflects the state's intention to manage the alligator as a commercially harvestable resource.

There is a temptation to assume that because alligator populations appear to be resilient in some areas, threats to their continued survival no longer exist. A reclassification of alligators throughout Florida includes populations in southern Florida and in Everglades National Park, where threats continue to exist. The long-term effects of limited alligator production in the wetlands of southern Florida are made evident by contrasting the relative size of the alligator nesting population in areas of the Everglades that have had a history of unnaturally high water conditions, such as the southern end of Conservation Area 3a (Fig. 2), with that in southern Shark Slough, using aerial nest censuses as an index for comparison.

In most years, nesting in the deep water marsh of Conservation Area 3a was very limited. On the average the nesting population there was less than 10 percent of that in the shallower and more typically fluctuating marshes in the park. The lack of production in a large geographical area such as Conservation Area 3a reduces considerably the potential size of the total Everglades alligator population. Should high water regimes become prevalent in the park, we could expect that similar dislocations and reduction of the alligator population would follow. The encroachment and subsequent loss of former willow ponds in nearby Conservation Areas reflect in part the loss of adult alligators there. This inadvertent experiment in water management should provide insight into the future of the alligator population in Everglades National Park if productivity is not maintained at historic levels through proper water management.

In the Everglades, alligators are often seen in artificial ponds and borrow pits in visitor use areas, where concentrations are usually apparent only during dry months. Seasonal numbers reveal little about the biological health of the Everglades alligator population. Even though few animals are being added to the population, the visibility of old adult alligators may distract from what otherwise would be a major concern. Current adverse impacts on the long-term population status of such a long-lived species may take decades to show their effect.

Thus, one should not casually extend reports of alligator population recovery in some parts of Florida to include the status of the alligator in the southern Everglades, and in Everglades National Park in particular. Our studies indicate that alligators in the Everglades marsh may face pressures unusual in other populations. Maintaining an annual pulse of young alligators into the system by avoidance of unnatural nesting failure would seem to be critical to maintaining the adult population. Previous studies modeling hunted crocodylian populations have demonstrated that continual production of young is critical to population stability. In fact, those models show that factors that are detrimental to the production of young have a greater effect on long-term population levels than do factors such as hunting and drought that affect all age classes (Blomberg et al. 1980, Nichols et al. 1979). The long-term effect of nest flooding and the loss of young in the Everglade alligator population must be determined in a similar way. It would seem that these model findings may be particularly relevant in the Everglades, where fluctuating water levels potentially threaten the successful production of young alligators by flooding nests. Consequently, managing to prevent unnatural nest failure is crucial to the long-term survival of the alligator population in the Everglades ecosystem, and should such management not be undertaken one can expect continued deterioration of ecosystem processes in the Everglades.

#### Literature Cited

- Blomberg, G.E.D., C. St. Pierre, K.D. Smith, S.M. Cadell, and S.R. Pett. 1982. Simulated population dynamics of crocodiles in the Okavango River, Botswana. IN Crocodiles Proc. of 5th Working Meeting of Crocodile Specialist Group, Gainesville, Fla.

- Deitz, D.C. and T.C. Hines. 1980. Alligator nesting in north-central Florida. *Copeia* 1980(2):249-258.
- Joanen, T. 1969. Nesting ecology of alligators in Louisiana. Proc. Ann. Conf. Southeast Assoc. Game and Fish Comm. 23: 141-151.
- Joanen, T., and L. McNease. 1973. Developments in alligator research in Louisiana since 1968. Presented at symposium of the American alligator council Winter Park, Fla. 20 p. (mimeo).
- Kushlan, J.A. 1974. Observations on the role of the American alligator (Alligator mississippiensis) in the southern Florida wetlands. *Copeia* 1974: 993-996.
- Nichols, J.D., L. Viehman, R.H. Chabreck, and B. Fenderson. 1976. Simulation of a commercially harvested alligator population in Louisiana. Louisiana State University Center for Agricultural Sciences and Rural Development. 59 p. (mimeo).

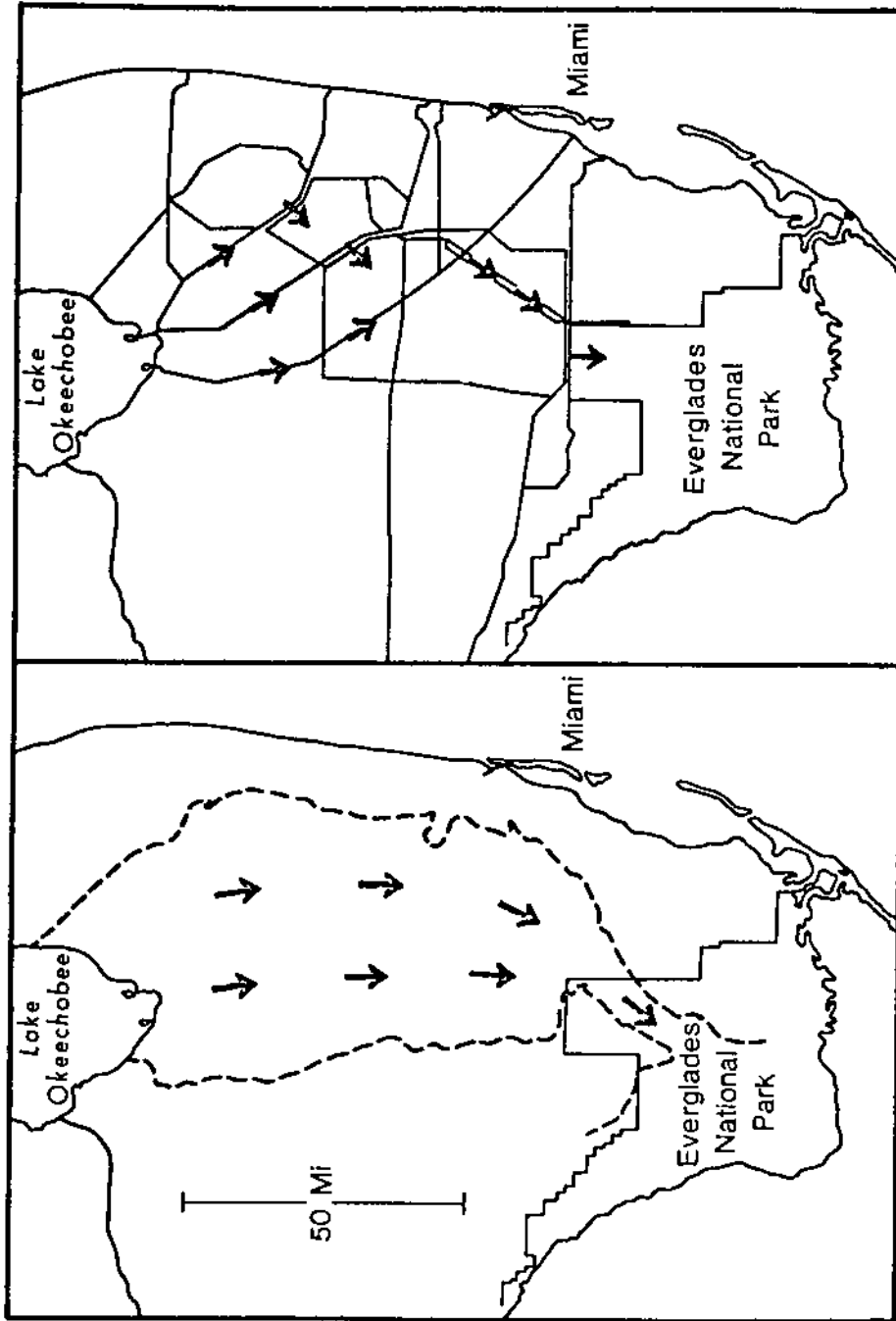


Figure 1: Alteration of water delivery patterns into Everglades National Park due to channelization of Everglades watershed. Left - natural overland flow prior to water management. Right - present situation bypassing natural filtering processes offered by northern marshes and under control of four flood control gates along the northern border of the Park.

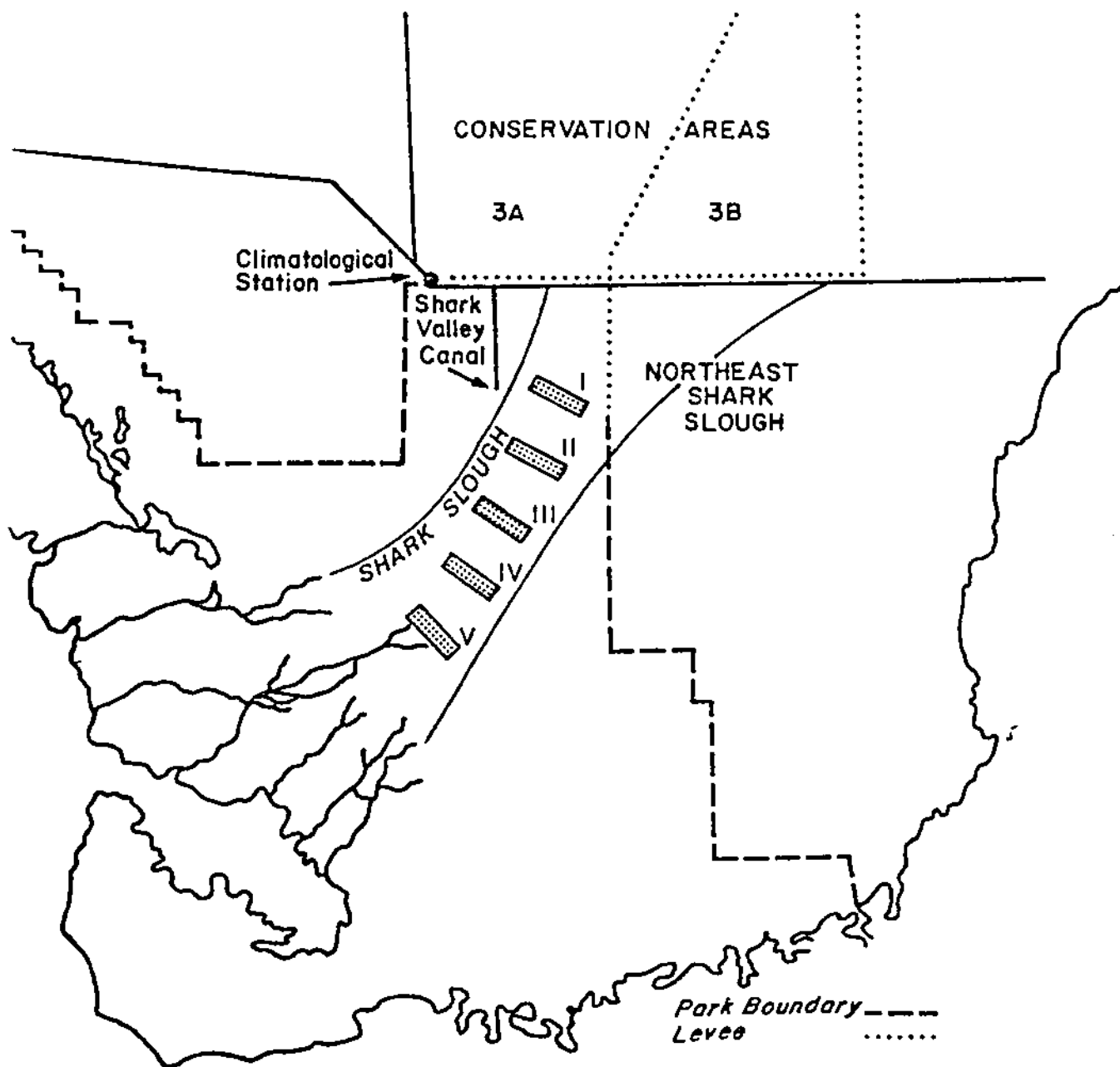


Figure 2: Map of south Florida showing the location of five alligator study areas (numbered rectangles) in Shark Slough, Everglades National Park, and nearby locations. Conservation areas 3A and 3B to the north are separated from Shark Slough in the Everglades National Park by levees.



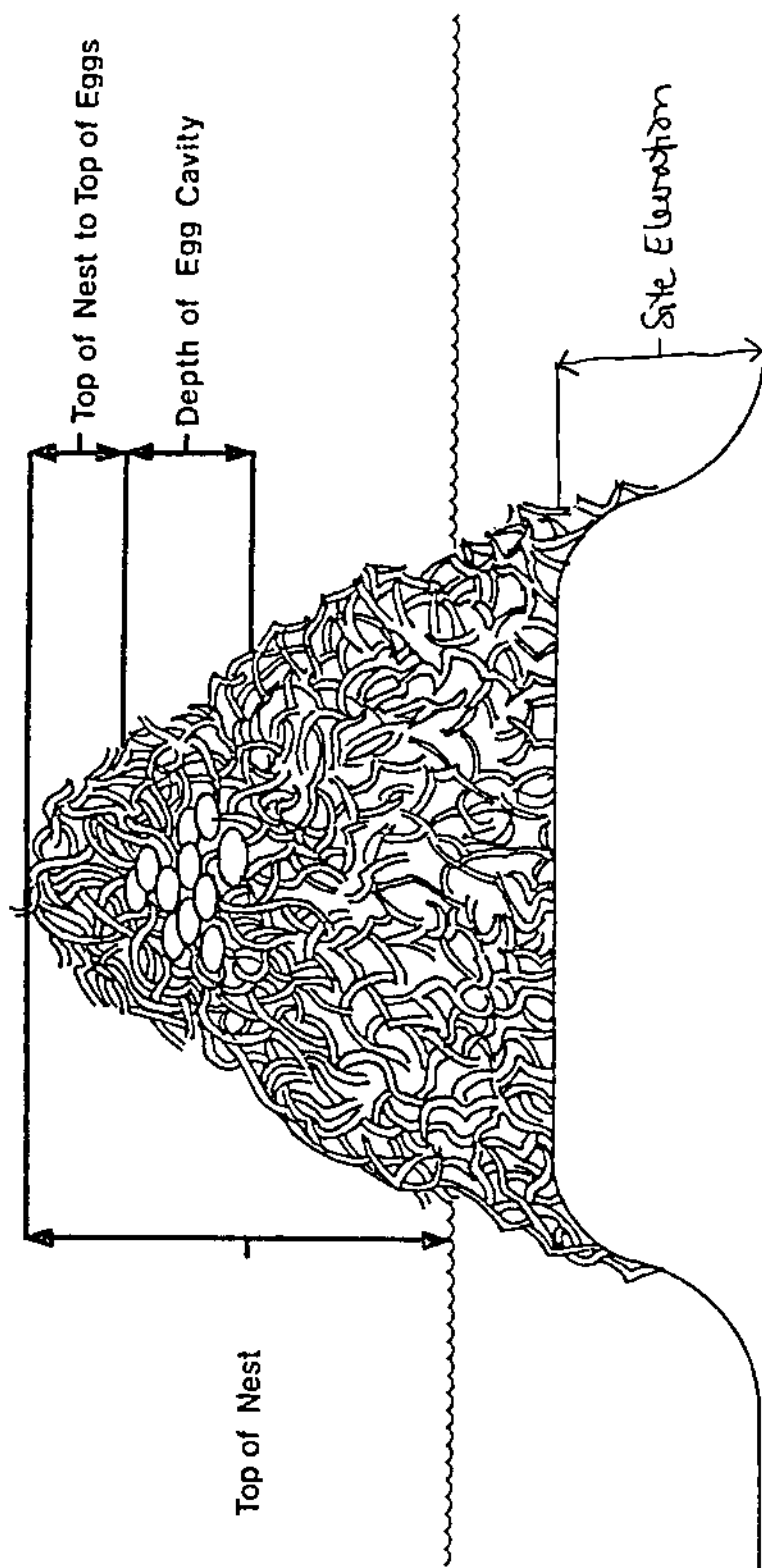


Figure 3: Field measurements typically taken of alligator nests in Everglades National Park including the height of the top of the nest above prevailing water level, the distance from the top of the nest to the top egg in the egg cavity, and the depth (extent) of the egg cavity containing the clutch. All measurements are taken in centimeters.

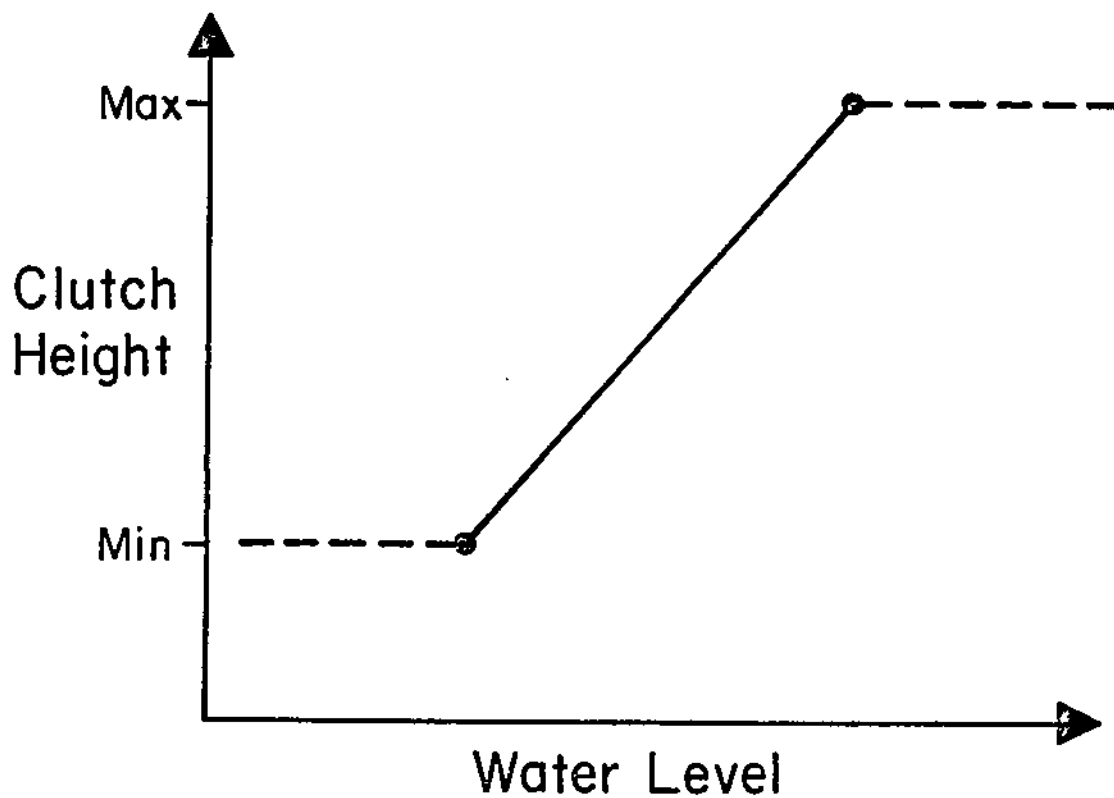


Figure 4: Schematic diagram of nest flooding, illustrating linear compensation in clutch height for water level during the last two weeks of June, bounded by thresholds which delimit the compensatory ability. At the lower threshold, nests are constructed at the level of the marsh, and at the upper threshold at the highest elevation provided by the available habitat.

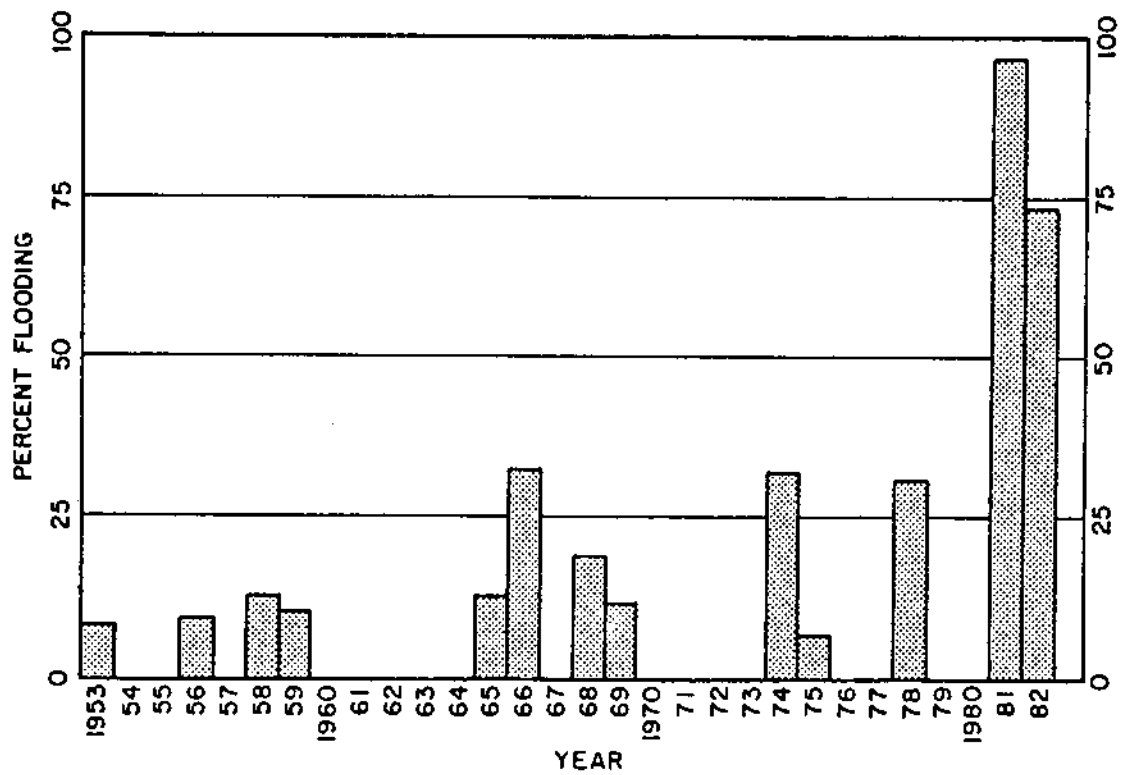


Figure 5: Percent of alligator nests flooded in the Everglades from 1953 to 1982. Values prior to the study period, which began in 1975, were estimated using the nest flooding model. From 1975 to 1982, nest flooding extent was measured in the primary study area. The nearly complete flooding observed in 1981 and 1982 was apparently unprecedented under historic conditions.

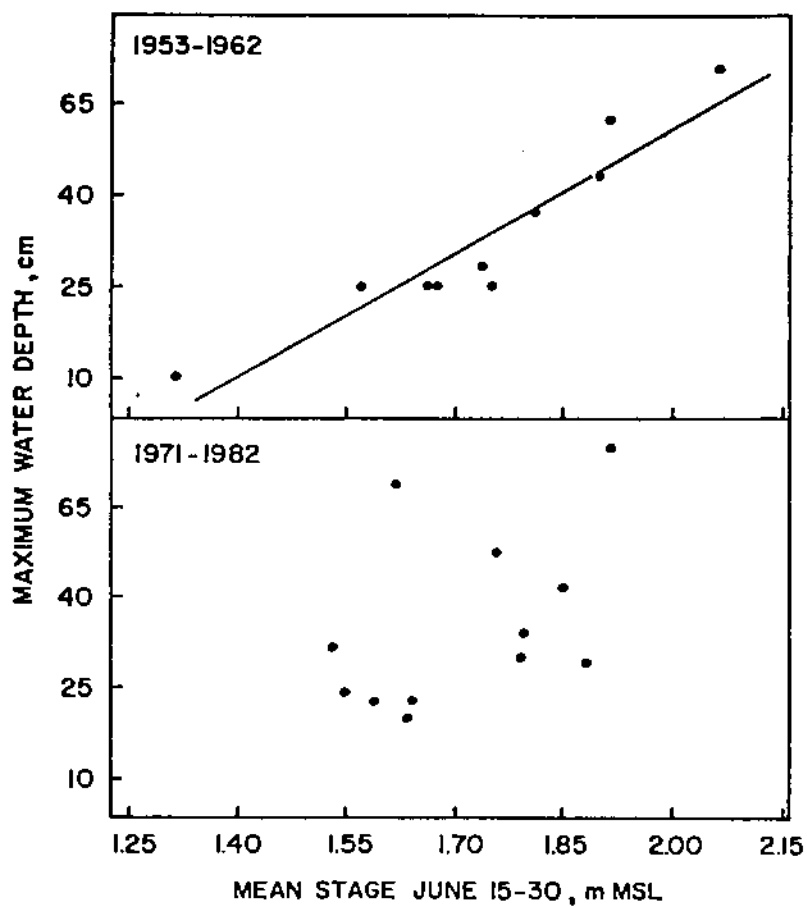


Figure 6: Relation of the maximum water depth (cm) in the primary study area, Everglades National Park, during the estimated incubation period and the mean water level (m MSL) from June 15 to 30. These figures illustrate the breakdown in predictability of the Everglades hydrologic system in recent years. a (top) - Historic period, 1953 - 1962,  $r=0.928$ ,  $p < 0.05$ ,  $n=10$ . b (bottom) - Recent period, 1971-1982,  $r=0.465$ ,  $p < 0.05$ ,  $n=12$ .

## CLASSIFICATION AND POPULATION STATUS OF THE AMERICAN ALLIGATOR

Ted Joanen and Larry McNease  
Louisiana Department of Wildlife and Fisheries  
Grand Chenier, Louisiana 70643, USA

### Introduction

Since passage of the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service designated that the American alligator (Alligator mississippiensis) be placed in three basic classifications: endangered, threatened, or threatened due to similarity of appearance (S/A) throughout its range in the southeastern United States. These categories simply designate status of the animal in relation to its recovery or rate of recovery. Generally, the endangered status indicates a low population within a geographic area, whereas, the threatened status indicates an increasing population well on its way toward recovery. Threatened due to similarity of appearance indicates a recovered population. Other important factors are considered in making these determinations. These include habitat evaluations; state research, management, and enforcement programs; natural mortality factors: utilization; the adequacy of regulatory mechanisms; and miscellaneous other factors. Today, alligators are classified as threatened in 20.3 percent of their range, as endangered in 48.9 percent of their range, and as recovered in 30.8 percent of their range (Table 1). The historic stronghold of the alligator is for practical purposes the 51.1 percent of the range presently classified as recovered (threatened S/A) or threatened. Peripheral range areas and counties with limited habitat (a large percentage of the overall range) will probably retain a restrictive classification status (Table 1). Classification status reviews are periodically conducted by the U.S. Fish and Wildlife Service, usually as a result of state petitions to change the legal status of the alligator. The collection of biological information pertaining to status reviews has greatly enhanced management capability for the alligator.

Since the IUCN/CSG meeting in South Africa in 1982, the U.S. Fish and Wildlife Service reclassified the biological status of the alligator in only one state. The entire State of Texas was reclassified to threatened S/A, effectively returning management authority back to the State.

The American alligator in Florida has been proposed for reclassification from threatened to threatened due to similarity of appearance (Federal Register 20 June, 1984). A final rule, if approved, will change the status of all alligators in Florida to the special category of threatened due to similarity of appearance.

## Population Status by State

Ten states contain alligators in all or parts of the state. In general, alligator populations are increasing throughout the range. Areas on the fringes of the range generally have stable populations and cannot biologically harbor high densities characteristic of states bordering the Gulf of Mexico.

LOUISIANA: The 1984 coastal marsh population, where nest count indices were used to calculate population levels, was projected to be 412,198, an 8.8% increase over the estimate for 1983. Water levels affect the degree of nesting a factor which must be considered when making annual population estimates based on nest transects (McNease and Joanen 1978). Nest count estimates have shown an annual increment of approximately 10.1 percent since initiation of the survey in 1970 (Joanen and McNease 1984). In areas of the state where the nest count method is not feasible, standardized night counts were conducted along established transect lines. Night count data were then applied to population modeling. Louisiana personnel surveyed 13 different areas of the state in 1983, covering a total distance of 93 miles. Alligators per mile averaged 6.0 for the 13 transects; slightly above the range-wide average of 5.4 for the same year (Chabreck 1984). McNease and Joanen (1978) reported available alligator habitat within Louisiana coastal marshes comprise 2.9 million acres, Taylor (1980) reported statewide alligator habitat for non-marsh as 1.1 million acres.

FLORIDA: The U.S. Fish and Wildlife Service is currently reviewing the status of the alligator in the State of Florida. The Service proposes to reclassify the alligator from its present classification of threatened, to threatened due to similarity of appearance under provisions of the Endangered Species Act of 1973. The reclassification proposal presents evidence that the species is not biologically threatened with extinction. Information prepared by Mr. Wendell Neal of the U.S. Fish and Wildlife Service and as advertised in the Federal Register of 20 June, 1984, Vol. 49, No. 120, indicates approximately 6.7 million acres of Florida wetlands are occupied by alligators. A further breakdown of alligator habitat estimated 3.6 million acres of freshmarsh, 1.2 million acres of permanently flooded wooded swamps, 1.7 million acres of lakes, and rivers and streams comprising 200,000 acres. Neal reported some habitat was lost due to drainage and conversion to agricultural use and the construction of levees for flood control projects. Alligator night count data collected before 1977 and compared to night count information collected between 1977-81, by habitat type show increases in number of alligators observed per mile. Florida lakes averaged 11.9 alligators/mile prior to 1977 and 13.8/mile from 1977-81. Florida marshes averaged 11.3/mile prior to 1977 and 13.3/mile from 1977-81. Some general conclusions were obvious when night count data were analyzed: (a) the number of observed alligators/mile demonstrated increases when pre-1977 and post-1977 periods were compared, (b) small, medium, and large size classes were

well represented, indicating survivorship is adequate, (c) alligator populations are well distributed throughout Florida's major habitat types, and finally (d) there were no major shifts in size class composition (Neal 1984).

GEORGIA: A 1984 alligator population survey indicated population increases are occurring in most of Georgia. An analysis of population trends by counties showed that 56 were increasing, 45 were stable, and 1 decreasing. Compared to 1982 surveys, in 102 counties reporting alligator populations, 1984 estimates increased from 1% to as high as 10%. A total of 5,824,000 acres of alligator habitat was reported in the 102 county area (S. Ruckel, personal communication, 1984). Georgia personnel surveyed 12 different areas of the state in 1983, transecting a total distance of 77.7 miles. Alligators per mile averaged 4.4, slightly below the range-wide average of 5.38 in 1983 (Chabreck 1984).

TEXAS: Alligator populations are considered to be stable to increasing. Census data (night counts) on inland habitat and coastal routes, and aerial nest counts reflect a population well over 100,000 alligators of all size classes occur within the Texas range. Night count surveys covering some 32 miles indicated 4.4 alligators/mile. Habitat in Texas is reported to comprise over 3.62 million acres; including 54,400 acres of brackish marsh, 186,240 acres between brackish and fresh marsh, 52,480 acres of fresh marsh, and 3,328,000 acres of inland alligator habitat. The inland habitat is comprised of small inland marshes and bayous, swamps, lakes, ponds, reservoirs, rivers, creeks and ditches. Stream mileage for historical alligator range in Texas is estimated to be 9,649 miles. Alligators currently occur in more than 90% of the historic range in Texas. Although the greatest alligator concentrations in Texas occur in the middle and upper coastal counties, significant populations occur inland in suitable habitat (Thompson et al. 1983).

SOUTH CAROLINA: Of 28 counties containing alligators in South Carolina, 15 reported increasing populations. Increases were estimated to be as much as 5-10 percent. Thirteen (13) counties reported stable to slightly increasing populations (increase 5%) (Tom Murphy, personal communication 1984). The best habitat is associated with the coastal impoundments and marshes comprising approximately 100,000 acres in Georgetown, Charleston, Colleton, and Beaufort Counties. The next tier of counties inland represent moderate to high alligator densities and a significant amount of habitat particularly in Berkeley and Jasper Counties. The amount of suitable alligator habitat from these counties to the fall line diminishes rapidly with generally isolated ponds supporting small populations. South Carolina reports approximately 250,000 acres of alligator habitat statewide (T. Murphy, personal communication 1982). Most nesting (84%) occurred in seven river drainages. The drainages in order of highest nest counts were: the Santee, Cooper, Combahee, Savannah, Ashepoo, Pee Dee, and South Edisto Rivers (Wilkinson 1983).

ARKANSAS: The alligator's range is limited in Arkansas. The trend for Arkansas alligators is a stable to slightly increasing population. Since 1972, the state restocked 2,700 alligators from Louisiana in 40 of 45 counties lying within the historic range of the species. From this restocking effort, successful reproduction has been documented in five counties that were previously void of alligators (S. Barkley, personal communication 1984). Night count data totaling some 56 miles of survey lines indicate 1.25 alligators per mile (Chabreck 1984).

MISSISSIPPI and OKLAHOMA: No current population estimates are available for these states. Mississippi night count data for 75 miles of survey lines indicate an average of 1.00 alligators per mile, well below the range-wide 1983 average of 5.38 alligators per mile. However, this data compares favorably with its neighboring state of Arkansas which recorded 1.25 alligators/miles for 1983 (Chabreck 1984).

Oklahoma reports alligators occurring in only McCurtain County. This small population is characterized as slightly increasing (F. James, personal communication 1984).

ALABAMA: No current population estimates are available for Alabama. Seven night count routes covering 117.5 miles in length were run and averaged 5.2 alligators per mile (Chabreck 1984). However, of the 7 surveys conducted, 4 were run in one coastal country, Baldwin, known for its high alligator population. Excluding this one country, alligators per mile of survey averaged 1.6; comparable with Mississippi and Arkansas's findings.

NORTH CAROLINA: Alligators occurred in low densities on night count survey routes in coastal North Carolina. Highest densities occurred in estuaries of the Cape Fear # 3 Watershed and in lakes of the Neuse Watershed. Alligators were found to be clumped in areas such as military bases, national forests, and private property. Alligator densities decreased by watershed from south to north. No alligators were found north of Albemarle Sound, supporting the belief that this is the northern limit of the alligator's range. The population of visible alligators was reported at 443. The estimate was expanded to an estimated total population size of 1,772. Although there are no recent night count data from survey routes in North Carolina, the sampling design, established in 1979-80, was established with the express purpose of providing baseline data with which to compare the results of future surveys. Now that North Carolina has a nongame and endangered wildlife program, it is hoped that their surveys can be repeated at 3-5 year intervals, so that population trends can be monitored (Phil Doerr, personal communication 1984).

#### Available Alligator Habitat

Since the noticeable increase in alligator populations range wide, states have been evaluating these populations and also classifying alligator habitat (McNease and Joanen 1978, Joanen and McNease 1980, Taylor 1980, Thompson et al. 1983, Wilkinson 1983, Neal 1984). Obvious differences exist in the quality of habitat for alligators and in most cases, habitat has been



classified into 3 distinct habitat types: coastal marshes, inland freshwater rivers, swamps and marshes; and natural man-made lakes. Surveys have shown that alligator populations vary according to habitat type. Also obvious differences may exist in population levels within a single habitat type. McNease and Joanen (1978) found certain ecological features exist in one type and may not exist in the same habitat type just a few miles away. In the coastal marshes of Louisiana, interspersions of land/water ratios and water levels were two important factors that must be taken into consideration when evaluating alligator habitat. Probably the best example of this in Louisiana are dense solid stands of Panicum hemitomon which provide little or no open water, no habitat diversity, and very poor alligator nesting habitat. However, Panicum marshes interspersed with ponds, potholes, and open lakes provide some of the finest nesting habitat to be found on the Louisiana coast.

Inland lakes, both man-made and natural, possess varying degrees of alligator populations. Important factors that must be considered when evaluating these areas as alligator habitat are vegetative cover and water depth. Lakes which seem to provide the best alligator habitat are those which have some open freshwater marshes attached, or those which have vegetative cover extending from the shoreline out into the open water areas.

Freshwater swamps attached to large river systems or lakes probably provide the largest single habitat type within the range of the alligator; however, possess the lowest alligator concentrations when compared to the other habitat types. The exception to this would be swamps which possess imbedded open freshwater marshes of sizeable acreage. Generally, riverine swamps lack the proper interspersions of vegetative cover and land/water ratio of the coastal marsh zone or inland lakes. Riverine systems are also known for their extremes in seasonal water level fluctuations along with extreme currents.

The amounts of alligator habitat (wetlands) reported by 5 states are presented in Table 2. Although any wetland habitat has the potential of being used by alligators, the frequency of use varies considerably. Salt water marshes, large deep open water lakes, and large rivers in Louisiana have been found to be used only occasionally and only by the adult segment of the population. A careful review of the different habitat types along with a better understanding of their value to alligators is of the utmost importance in the management of a resource. Wetlands in themselves do not qualify as alligator habitat, but rather the true estimate of habitat suitability can be measured by studying wetlands which possess distinctive ecological features and comparing this to existing alligator populations.

#### Literature Cited

Chabreck, R.H. 1984. Cooperative surveys of the American alligator in southeastern United States during 1983. Louisiana State Univ., Baton Rouge. 3 pp. Mimeograph.

- Joanen, T., and L. McNease. 1980. Management of the alligator as a renewable resource in Louisiana. IUCN, Survival Service Commission, Crocodile Specialist Group. (In press).
- Joanen, T.L., McNease, G., Perry, D. Richard and D. Taylor. 1984. Louisiana's alligator management program. Proc. Southeastern Assoc. Fish and Wildlife Agencies 38: (In review).
- McNease, L., and T. Joanen. 1978. Distribution and relative abundance of the alligator in Louisiana coastal marshes. Proc. Southeastern Assoc. Fish and Wildlife Agencies 32: 182-186.
- Neal, W. 1984. Endangered and threatened wildlife and plants; proposal to reclassify the legal status of the American alligator in Florida to threatened due to similarity of appearance. Federal Register 49 (120): 25342-25348.
- Taylor, D. 1980. An alligator population model and associated minimum population estimate for non-marsh alligator habitat in Louisiana. La. Dept. of Wildlife and Fisheries. 32 pp. Mimeograph.
- Thompson, B.C., F.E. Potter, Jr., and W.C. Brownlee. 1983. Management plan for the American alligator in Texas. Texas Parks and Wildlife Dept. 41 pp.
- Wilkinson Philip M. 1983. Nesting ecology of the American alligator in coastal South Carolina. S.C. Wildlife and Marine Res. Dept. 113 pp. Mimeograph.

TABLE 1

## Alligator Classification Status by State - September, 1984

	Number of Counties			Total
	Threatened S/A	Endangered	Threatened	
Mississippi		55		55
Alabama		33		33
North Carolina		21		21
Texas	74			74
Arkansas		3		3
Oklahoma		1		1
Georgia		81	21	102
Louisiana	63			63
Florida			64	64
South Carolina		23	5	28
TOTAL	137	217	90	444
Percent	30.8	48.9	20.3	

TABLE 2

## Available Alligator Habitat Reported for Five States

State	Habitat Type	Acreage
Louisiana	Coastal marsh	2,900,000
	Inland wetland*	1,100,000
Florida	Fresh marsh	3,600,000
	Permanently flooded wooded swamp	1,200,000
	Lakes	1,700,000
	Rivers and streams	200,000
S. Carolina	Coastal marshes and impoundments	100,000
	Inland wetland*	150,000
Texas	Coastal marsh	293,000
	Inland wetland*	3,328,000
Georgia	Unclassified wetland	5,824,000

\* Swamps, lakes, ponds, rivers and streams, marshes, reservoirs.

## LOUISIANA'S ALLIGATOR MANAGEMENT PROGRAM

Ted Joanen, Larry McNease, Guthrie Perry, and David Richard  
Louisiana Department of Wildlife and Fisheries, Rt. 1  
Box 20-B, Grand Chenier, Louisiana 70643

and

Louisiana Department of Wildlife and Fisheries  
Minden, Louisiana 71055

### Introduction

Louisiana's first program to manage the alligator on a sustained yield harvest was initiated in 1972. The management program resulted from 15 years of research, dedicated enforcement, and enactment of effective state and federal laws governing the taking, possession, and transportation of alligators and their products. By 1970, such legislation was in effect in Louisiana (Joanen et al. 1981).

Public Law 91-135, known as the "Amended Lacy Act", was passed in December 1969. Lacy Act provisions made it a Federal crime to sell or transport in interstate or foreign commerce any form of wildlife or products made from wildlife taken in violation of the laws of any state or foreign country. In 1970, the Louisiana Legislature enacted Act 550 giving the Department of Wildlife and Fisheries full authority to regulate the alligator in the State. Louisiana law classifies the alligator as a non-game quadruped along with wild fur-bearing animals valuable for their skins or hides. The alligator is, therefore, considered a commercial wildlife species; and Act 550 formed the framework which permitted the implementation of a closely regulated commercial harvest (Palmisano et al. 1973).

Alligators occur throughout the State and populations have demonstrated dramatic increases in recent years. The majority of habitat and the largest segment of the alligator population are found in the southern 1/3 of the State in coastal marsh and cypress tupelo swamps. Due to its value and vulnerability to hunting, the species requires special regulations which must be designed to regulate the harvest of surplus animals yet equally distribute the kill in relation to population levels. A complex system of applications, licenses, tags, and report forms was necessary to implement the management program.

The authors acknowledge A. Ensminger, Chief of Fur and Refuge Division of the Louisiana Department of Wildlife and Fisheries for his unselfish support and overall supervision of a sometimes controversial alligator plan, making it possible for the management and research program to become a reality. The alligator program would not have been successful without the cooperation of many Louisiana Department of Wildlife and Fisheries personnel, primarily employees of the Fur and Refuge, Game, and Enforcement Divisions. The Louisiana State University Department of Experimental

Statistics provided expertise and implementation for a complex monitoring program.

#### Methods and Materials

INVENTORY: Aerial nest censuses have been conducted annually in the coastal marsh zone since 1970 and were used to project alligator population levels (Chabreck 1966, McNease and Joanen 1978). In areas of the State (swamps, and upland lakes and streams) where the aerial nest count method could not be applied, a minimum population estimate for non-marsh areas was used as described by Taylor (1980). Taylor (1980) used data from size class composition of adults taken from night counts and hide measurements to derive these minimum estimates. These data were used for distributing the harvest in proportion to existing populations.

Available alligator habitat within Louisiana coastal marshes comprises 1,178,000 ha (2,900,000 acres) (Chabreck and Linscombe 1978) and is subdivided into 3 major subdivisions according to origin: The Chenier Plain, Sub-Delta, and Active Delta Zones. The Chenier Plain makes up 445,000 ha (1,100,000 acres) and is located in the southwest corner of the State. The Sub-Delta Marsh Zone contains 640,000 ha (1,570,000 acres) and extends from the Vermilion Bay complex to the Mississippi-Louisiana border. The Active Delta comprises 93,000 ha (230,000 acres) and consists of the present Mississippi River Delta.

Each marsh zone is further divided according to salinity and vegetation (Chabreck and Linscombe 1978). The fresh marsh made up 39% of the area or 460,000 ha (1,131,000 acres), intermediate marsh comprised 23% or 271,000 ha (667,000 acres), and the brackish marsh, minus marshes over 10 ppt salinity, comprised 38% or 447,000 ha (1,102,000 acres). Alligators do not normally utilize the saline marsh type, nor brackish marsh 10 ppt salinity, hence 360,000 ha (880,000 acres) of these types were omitted from the survey.

Taylor (1980) reported total statewide alligator habitat for non-marsh areas as 474,000 ha (1,171,000 acres). He further subdivided habitat available into upland streams, swamp streams, cypress tupelo lakes, and cypress tupelo swamps. The latter 2 habitat types were the most important for alligators.

ESTABLISHING HARVEST REGULATIONS: The Louisiana Department of Wildlife and Fisheries authorized 10 seasons for the taking of alligators for the sale of skins between 1972-1983 (Palmisano et al. 1973, McNease and Joanen 1978). The 1st hunt, authorized in 1972, was confined to 1 parish in southwest Louisiana which according to the serial nest survey housed the largest segment of the coastal marsh alligator population. The hunt area was gradually expanded until 1981 when the season was opened statewide (Table 1).

No season was allowed in 1974 as a result of the passage of the Federal Endangered Species Act. After an 18-month delay, caused by delisting requirements of the U.S. Fish and Wildlife Service, Louisiana again initiated its harvest program expanding to a 3 parish area, 1975-1977. Due to limited markets of skins within the United States and the ban on overseas shipment of skins as a result of the Convention on International Trade of Endangered Species (CITES), no season was allowed in 1978. CITES, in March of 1979, allowed the export of skins in international commerce. Along with the CITES action, the U.S. and Wildlife Service delisted an additional 9 coastal Louisiana parishes. As a result the Louisiana Department of Wildlife and Fisheries authorized a regulated harvest in 12 coastal parishes in 1979 and 1980. In 1981, the alligator was reclassified in the remaining 52 parishes as threatened (S/A) and a statewide harvest was authorized.

Harvest strategy (Palmisano et al. 1973) and alligator population features (Chabreck 1966, Taylor and Neal 1984) for marsh habitats were described in detail by Joanen and McNease (1981).

Taylor and Neal (1984) developed a size class frequency distribution model to estimate alligator population features. Night count data were used in conjunction with the model to derive tag allocation features for harvest in non-marsh habitats.

State law prohibited the taking of alligators between the hours of sunset and sunrise and those animals less than 1.2 m (4 feet) in length. Other provisions regulating the taking and shipment of alligators were established by the Department.

Harvest regulations, licensing requirements, tagging requirements, reporting procedure, nuisance alligator control regulations, a successful law enforcement program, and a computer program were established to regulate and monitor the harvest of surplus animals and yet distribute the kill in proportion to the existing populations over the area opened for harvest (Joanen and McNease 1981).

### Result and Discussion

POPULATION SURVEYS: Population estimates in the coastal marsh varied from a low of 134,000 in the drought year of 1971 a high of 520,000 (Table 2). Overall, populations increased dramatically in the Chenier Plain and Sub-Delta Zones from 1970-1983. The Active Delta showed the lowest alligator population of the 3 marsh zones. A comparison of alligator densities from 1979-1983, expressed as ha (acres)/alligator, shows higher population levels in the Chenier Plain Zone. The Chenier Plain averaged 1 alligator: 2.2 ha (5.4 acres), the Sub-Delta 1:3.6 ha (9.0 acres), and the Active Delta 1:10.5 ha (26.0 acres). Population distribution by marsh types on a coastwide basis showed the intermediate marsh type contained the highest alligator densities, 1 alligator to 2.1 ha (5.3 acres). The brackish and fresh marshes were about equal in area; however, population density in the brackish marsh was 1

alligator to 4.1 ha (10.2 acres) and in the fresh marsh 1 alligator to 2.8 ha (6.9 acres) (McNease and Joanen 1978, Joanen and McNease 1981, Unpubl. La. Alligator Census Records, 1980-1983).

The coastwide average annual percentage increase of nests for the period of 1970-1983 was 10.1%. Privately-owned property, 90% of which was hunted, showed an average annual increase in nest production of 11.0% over the 14-year period, 1970-1983. Refuges and wildlife management areas, where only limited hunting occurred, had an average annual increase of 9.7% in nesting for the same period. The average annual increase in the Chenier Plain of southwest Louisiana was 10.4% for the same period. A further analysis of population dynamics in the Chenier Plain demonstrated average annual increases in nest production were considerably greater on 333,550 ha (825,000 acres) of privately-owned property than for 111,375 ha (275,000 acres) of public property.

Air temperature affects the timing of nesting and egg laying activity (Joaanen and McNease, 1979). Nesting occurred in early June for the years with highest March-May temperatures and occurred as late as the 1st week in July when springtime temperatures were the lowest. The above factor must be taken into account when establishing time tables for nest censusing and season dates. Extremes in water levels, droughts, and floods adversely affect nesting (McNease and Joanen 1978). Surface water conditions probably affect nesting potential more than any other environmental factor, and thereby may cause considerable bias in annual population estimates based on nest transects.

Joaanen et al. (1981) conservatively reported the minimum after-hatching alligator estimate as 168,000 for non-marsh habitat. Highest non-marsh alligator densities were found in the 35,275 ha (87,100 acres) of cypress-tupelo lakes contained in the State, 1 alligator: 1.7 ha (4.1 acres). Cypress tupelo swamps, 329,00 ha (813,000 acres) contained an estimated 127,000 alligators for a density of 1 alligator: 2.6 ha (6.4 acres). The estimated population of the Atchafalaya Basin, containing 144,200 ha (356,000 acres) of alligator habitat, was 19,500 for a density of 1 alligator: 7.4 ha (18 acres).

**ALLIGATOR HARVEST:** During the period of 1972-1983, 107,878 alligator tags were issued to 5,337 hunters. Average tag allotment per hunter was 20.2 (Table 3). Ninety percent of the privately-owned wetlands open for harvest were actually hunted. A total of 100,712 alligators was taken (93% hunter success). Not all skins were sold; 3,860 skins were tanned at the expense of the hunter or landowner for trophy skins or manufactured into boots, saddles, gun cases, belts, and other items. Prices varied from \$17.50/linear 0.3 m (foot) in 1981 to \$7.88 in 1975. Prices varied according to the demand for skins, restrictions placed on the sale of products within certain states, international prohibition on foreign commerce, and inflation or devaluation of Japanese, French, and United States currency.



The largest alligator population occurs in the lower 1/3 of the State. This area comprises approximately 85% of the total statewide alligator habitat. As a result, 77% of the hunters are in the coastal zone and they accounted for 91% of the kill. The central 1/3 of the State had 16% of the hunters and 7% of the kill. The northern 1/3 of the State had 7% of the hunters and 1% of the kill. Non-resident hunters purchased 4.8% of the alligator licenses in 1983.

**SEX AND SIZE COMPOSITION OF HARVEST:** Telemetry studies (Joanen and McNease 1970, 1972) suggest a September hunt restricted to daytime hunting and open water areas would result in a kill composed primarily of larger males immature animals of both sexes. By restricting the pole hunting method in interior marshes, the take of breeding females was minimized. During the 1972 harvest season, 303 alligator carcasses were examined. Adult males (over 1.8 m (6 feet)) made up 83.1% of the mature alligators inspected. Adult females constituted 16.9% of the adult alligators examined. During the 1973 harvest, 843 alligator carcasses were examined. Adult males made up 67.9% of the mature alligators harvested. The total percentage of males in the kill was 66.3%. Adult females constituted 32.1% of the mature alligators examined (Table 4). The high kill on females in 1973 as compared to the 1972 season was attributed to flooded conditions resulting from tropical storm Della. Excessive rainfall combined with high tides provided hunters easy access into interior marshes which were usually not accessible at that time of year (Joanen et al. 1974).

In 1975, 85.5% of 684 mature alligators examined were males. Mature males also comprised the majority of the kill the following 2 years: 78.3% of 398 in 1976 and 70.3% of 212 in 1977 (Table 4). The average size class of the animals taken during the 10 years of harvest remained fairly constant from year to year. The average skin length was 2.11 m (6 feet 11 inches) with a range of 1.2-4.2 m (4-14 feet). Of the skins taken, 79% were between 1.5-2.4 m (5-8 feet) (Fig. 1).

The largest female harvested was taken in the Mermentau Basin of southwest Louisiana (2.73 m (9 feet 1 inch) and 94 kg (208 pounds)). Internal examination of the ovaries indicated she was barren. The largest male was taken in the Pearl River complex of southeastern Louisiana and measured 4.3 m (14 feet); no weight was obtained.

Mature animals, 2.1 m (7 foot) size class and above, appeared to be taken at the rate at which they existed in the hunt area. However, other factors such as limited hunter accessibility to animals during low rainfall years, easy accessibility during high rainfall years, and skin prices may affect the harvest to some degree. When high prices were paid for skins, hunter interest was stimulated the following year. The reverse was true when prices were lower.

Most of the large animals were taken by the fishing method. Those shot free swimming were generally of the smaller size classes. Smaller alligators usually remain in shallow interior marsh ponds

and feed on crustaceans or small fish (Chabreck 1971, Valentine et al. 1972, McNease and Joanen 1977). Immature females and adult females preferred natural marsh during the autumn period (Joanen and McNease 1970, McNease and Joanen 1974). Only 40% of the immature female segment of a population would be available if hunting were restricted to deep water bayous, lakes, and canals. Data collected during Louisiana's 1972 experimental alligator season (Palmisano et al. 1973) indicated immature females constituted 29.6% of the immature size classes of alligators harvested. In 1973, 1975, 1976, and 1977, immature females made up 37.5%, 36.7%, 29.1%, and 36.2%, respectively, of the immature alligators harvested (Table 4). Immature males showed a marked preference for deep water areas during summer and autumn. When availability of natural marsh was considered, usage by males was less than expected during all seasons (McNease and Joanen 1974).

**VALIDATION AND SALE OF SKINS:** From 1972-1977, when a maximum of 3 parishes were opened for hunting, hunters were required to bring their hides to a central check-in station. Department personnel measured and validated each skin. After validation, skins were sold at public auction. As the harvest program expanded statewide, buyers were required to submit detailed reports concerning their commercial transactions (Joanen and McNease 1981).

As the hunt area and kill was expanded, so did the amount of paperwork involved in monitoring the kill and commercial aspects of the harvest. Consequently, in 1979 a computer program was developed and upgraded through 1983 to follow hides from the hunters level through commerce until tanned into leather. Taxidermy or trophy hides, which did not enter commercial channels, and alligator meat and parts were monitored through a system of report forms.

Early in the program, 1972-1977, American tanners showed a strong interest in alligator leather and as a result purchased the majority of the skins taken during those years. However, since the delisting, when foreign buyers were allowed to export skins abroad, the French, Italians and Japanese have purchased the majority of the skins taken in the Louisiana harvest.

A total of 11 tanneries and 1 trading company purchased skins in Louisiana during a 10 year period. Of these, 4 were located in France, 3 in Japan, 2 in Italy, and 3 in the United States. Of the 95,963 skins sold from 1972 through 1983, French tanners purchased 48.4% of the skins. United States tanneries purchased 27.7% of the skins, Italians 12.4% and Japanese 11.5%.

**NUISANCE ALLIGATOR CONTROL:** During the 1979 nuisance harvest program, 11 hunters killed 51 alligators in 6 coastal parishes. In 1980, 34 hunters in the same 6 parishes took 225. The number of tags issued were based on the number of complaints received (Linscombe 1975). Complaints were randomly investigated on the site by Departmental personnel. Alligators taken under this program were taken in accordance with State and local regulations/ordinances.

During 1979-1980, Departmental personnel relocated alligators in the delisted areas. The magnitude of these requests were only slightly lessened with the nuisance complaint program. A statewide nuisance complaint program was initiated in September 1981. Nineteen nuisance control hunters took 197 alligators in 1981, 131 by 19 hunters in 1982, and 167 by 15 hunters in 1983. Skinning instructions issued by the Department were for 1 year and any skin not prepared according to the instructions was considered illegal. Disposition of skins, meat, and parts taken in the nuisance complaint program was the responsibility of the local governing body and/or the hunter. Over the 5-year period, 1979-1983, 771 alligators were harvested through the nuisance removal program by 98 licensed hunters.

**ALLIGATOR MEAT AND PARTS:** Since the 1979 season, approximately 45,000 kg (100,000 pounds) of alligator meat have been sold annually. Prices varied across the coast; however, average prices paid to hunters in southeastern Louisiana were about \$0.75 per 0.5 kg (pound) whereas in southwest Louisiana prices averaged \$1.50 per 0.5 kg. Over half of the meat sold was purchased by individuals for home consumption. The remainder was sold to restaurants and fish markets, New markets have been developed in California and along the east coast.

Fifteen licensed alligator parts dealers reported that teeth and skulls were sold to the jewelry trade and biological supply houses. Most jewelry items were sold within Louisiana, primarily in the New Orleans area.

**LAW ENFORCEMENT:** The number and severity of alligator law violations were compared to enforcement effort to determine unknown detrimental effects that the harvest program might cause to the resource. Federal and State Enforcement Agents were annually assigned to alligator law enforcement. No major hide poaching cases have been made in Louisiana since 1976. During the 1983 season, only 8 alligator-related cases were filed by State agents during the September harvest program, and all were of a relatively minor nature. Two hundred and twelve Louisiana field agents devoted part of their working hours to alligator enforcement activity. It is clearly evident that Louisiana's alligator harvest program did not stimulate alligator poaching.

#### Literature Cited

- Chabreck, R.H. 1966. Methods of determining the size and composition of alligator populations in Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 20:105-112.
- Chabreck, R.H. 1971. The foods and feeding habits of alligators from fresh and saline environments in Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:117-124.
- Chabreck, R.H. and G. Linscombe. 1978. Vegetative type map of the Louisiana coastal marshes. La. Dep. of Wildl. and Fish., Baton Rouge.

- Joanen, T., and L. McNease. 1970. A telemetric study of nesting female alligators on Rockefeller Refuge, Louisiana, Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 24:175-193.
- Joanen, T. and McNease. 1972. A telemetric study of adult male alligators on Rockefeller Refuge, Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 26:252-275.
- Joanen, T. and McNease. 1979. Time of egg deposition for the American alligator. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 33:15-19.
- Joanen, T., and L. McNease. 1981. Management of the alligator as a renewable resource in Louisiana. Ga. Dep. of Nat. Res. Tech. Bull. WL 5:62-72.
- Joanen, T. and G. Linscombe. 1974. An analysis of Louisiana's 1973 experimental alligator harvest program. La. Wildl. and Fish. Comm., New Orleans. 2opp. Mimeo.
- Joanen, T., G. Linscombe, and D. Taylor. 1981. Alligator management plan State of Louisiana. La. Dep. of Wildl. and Fish., New Orleans, 22pp. Mimeo.
- Linscombe, G. 1975. Alligator complaints summary 1975. La. Dep. of Wildl. and Fish., New Orleans. 8pp. Mimeo.
- McNease, L., and T. Joanen. 1974. A telemetric study of immature alligators on Rockefeller Refuge, Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 28:482-500.
- McNease, L. and T. Joanen. 1977. Alligator diets in relation to marsh salinity. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 31:36-40.
- McNease, L. and T. Joanen. 1978. Distribution and relative abundance of the alligator in Louisiana coastal marshes. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 32:182-186.
- Palmisano, A.W., T. Joanen, and L. McNease. 1973. An analysis of Louisiana's 1972 experimental alligator harvest program. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 27:184-206.
- Taylor, D. 1980. An alligator population model and associated minimum population estimate for non-marsh alligator habitat in Louisiana. La. Dep. of Wildl. and Fish. 15 pp. Mimeo.
- Taylor, D., and W. Neal. 1984. Management implications of size-class frequency distributions in Louisiana alligator populations. Wildl. Soc. Bull. 12(3):312-319.
- Valentine, J.M., J.R. Walther, K.M. McCarthy, and L.M. Ivy. 1972. Alligator diets on the Sabine National Wildlife Refuge Louisiana. J. Wildl. Manage. 36(3):809-815.

Table 1. Season dates and areas opened to alligator harvest in Louisiana 1972-1983

Year	No. of hunting		Parishes
	Season dates	days	
1972	5-17 Sept.	13	Cameron
1973	10-28 Sept.	19	Added Vermilion
1975	20 Sept.-19 Oct.	30	Added Calcasieu
1976	9 Sept.-8 Oct.	30	No change
1977	1-30 Sept.	30	No change
1979	7 Sept.-7 Oct.	31	Added Iberia, St. Mary, Terrebonne, Lafourche, St. Charles, Jefferson, Plaquemines, St. Bernard, St. Tammany
1980	4 Sept.-4 Oct.	31	No change
1981	31 Aug.-30 Sept.	31	Statewide (63 parishes)
1982	4 Sept.-3 Oct.	30	Statewide
1983	10 Sept.-9 Oct.	30	Statewide

Table 2. Louisiana coastal marsh alligator population based on nest surveys, 1970-1983.

Year	Population estimate	Total population	% change from 1970
1970	172,000		
1971	134,000		-22
1972	182,000		+ 6
1973	153,000		-11
1974	213,000		+24
1975	272,000		+58
1976	282,000		+64
1977	274,000		+59
1978	285,000		+66
1979	520,000		+202
1980	400,000		+132
1981	289,000		+68
1982	368,000		+114
1983	379,000		+120

Table 3. Alligator harvest in Louisiana, 1972-1983.

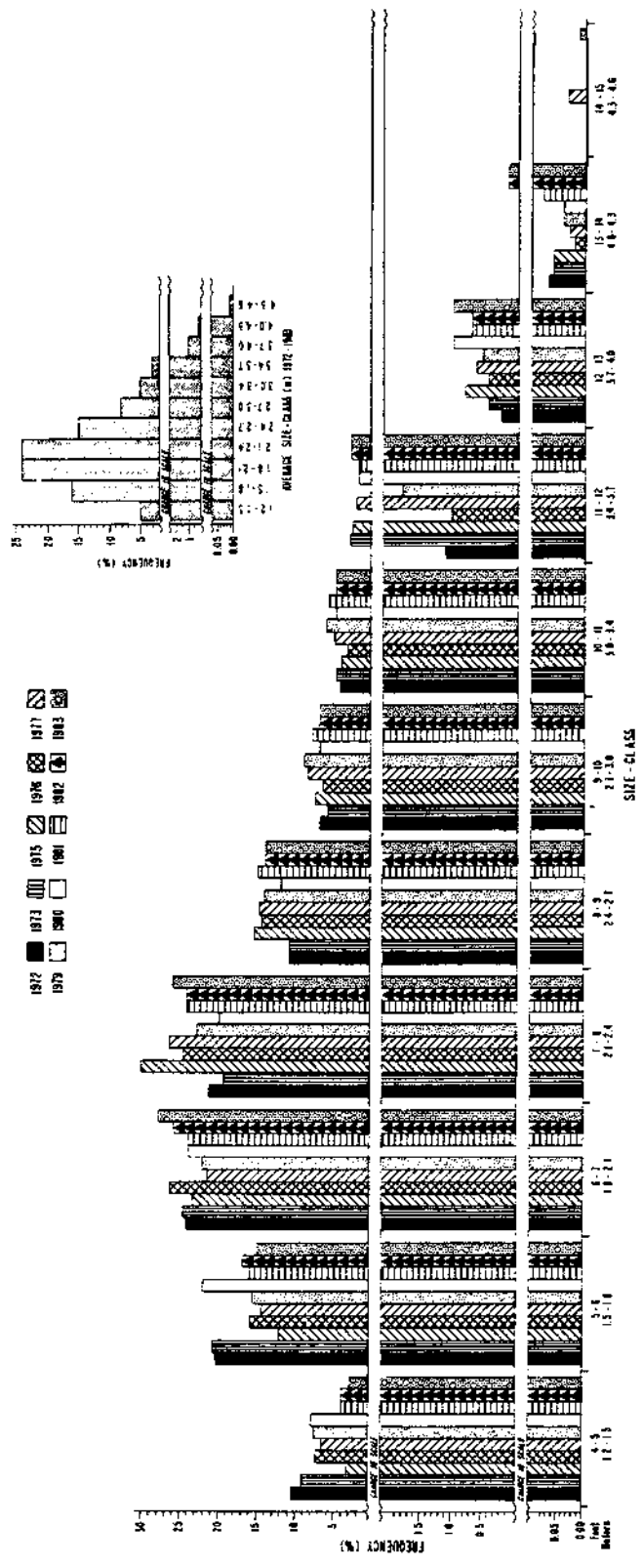
Year	Hunters	Tags issued	No. taken	Success (%)	Avg. t.l. (cm)	Value of skins	Avg./0.3 m	Ha hunted
1972	59	1,961	1,350	68.8	210.8	\$ 75,505	\$ 8.10	111,267
1973	107	3,243	2,921	90.1	213.4	\$ 268,994	\$13.13	216,544
1975	191	4,645	4,420	95.2	226.1	\$ 258,791	\$ 7.88	329,147
1976	198	4,767	4,389	92.1	215.9	\$ 512,240	\$16.55	327,036
1977	236	5,760	5,474	95.0	223.5	\$ 488,499	\$12.23	395,665
1979	708	17,516	16,300	93.0	213.4	\$1,711,500	\$15.00	1,047,230
1980	796	19,134	17,692	92.5	203.2	\$1,609,972	\$13.00	1,313,538
1981	913	15,534	14,870	95.7	210.8	\$1,821,575	\$17.50	1,415,488
1982	1,184	18,188	17,142	94.2	208.3	\$1,621,633	\$13.50	1,617,504
1983	945	17,130	16,154	94.3	210.8	\$1,452,568	\$13.00	1,417,038
Total	5,337	107,878	100,712	93.4	213.4	\$9,821,277	\$12.99	

Table 4. Size and sex composition of alligators sampled in Louisiana, 1972-1977.

Year	Total sample		Adults in sample	
	Number	% Males	Number	% Males
1972	303	78.5	195	83.1
1973	843	66.3	595	67.9
1975	782	82.7	684	85.5
1976	591	76.3	433	78.3
1977	281	68.7	212	70.3



Figure 1: Percentage composition by 0.3 m (1.0 ft) increments of alligator hides taken during the Louisiana harvest, 1972-1983 (N=95,963).



POPULATION BIOLOGY AND STATUS OF THE AMERICAN CROCODILE  
IN SOUTH FLORIDA

James A. Kushlan and Frank J. Mazzotti  
Department of Biology, East Texas State University Commerce  
Texas 75428  
and  
Department of Biology, Pennsylvania State University,  
University Park Pennsylvania 16802, USA

Introduction

The Florida population of the American crocodile occupies the northernmost point of the species range and is the only population in the United States. The status of this population has been a matter of concern because it has been believed to be relatively rare, to be subject to encroachment by human development, and to have suffered reductions in population size since the mid 1800's. Its status was initially evaluated by Moore (1953) and by Ogden (1978). From 1977 to 1982, we have studied the population biology and status of crocodiles occurring near Florida Bay, on the southern tip of the Florida peninsula. In this study we have particularly attempted to test various hypotheses of population limitation suggested by the work of Ogden in the early 1970's.

Ours was a collaborative effort involving several colleagues including Drs. William Dunson, Peter Lutz, Robert Menzies, and John Behler and assistants including Robert Austin, Amanda Muller, and Terri Jacobsen. At the same time other segments of the south Florida crocodile population were being studied by Paul Moler and by Ronald Gaby.

In this paper we briefly abstract some of the findings of our study with particular attention to providing new information on the various hypotheses previously suggested to account for presumed population decreases. The full reports on these studies will be published elsewhere (Kushlan and Mazzotti in prep., Mazzotti and Dunson in press, Mazzotti and Kushlan in prep, Mazzotti, et al. in prep.).

Historic Population Status: The historic presence of the American crocodile in south Florida is well documented after 1869, when a specimen was collected in the Miami River (Wyman 1870). Although observed occasionally as far north as Lake Worth and West Palm Beach on the east coast, crocodile sightings historically were concentrated from Biscayne Bay through northeastern Florida Bay. Dimock (1918) provided the most definitive statement of its early range as, "definitely limited to the region at the extreme southern end of the peninsula of Florida, a strip of ten miles long by three miles wide". Only infrequent records occurred outside this area. There is no reason to suspect that the core of the crocodile population ever extended much north of Biscayne Bay. Similarly there is no substantive evidence to indicate a permanent presence in the lower Florida Keys (Jacobsen 1983) or on the Florida west coast.

Published reports provide little information on numbers of crocodiles historically present. They were said to be "common", seen in certain places, but no contemporary statement as to numbers is available. Ogden (1978) in reviewing such accounts suggested that "the number of crocodiles in south Florida at the end of the 19th century was not more than five times the present population, probably between 1,000 and 2,000 animals". We however, believe that available reports provide insufficient information on which to base any such guess and that it is therefore impossible to estimate the number of crocodiles present historically in southern Florida.

#### Population distribution

We have evaluated the present distribution of the American crocodile in Florida from reports and from our extensive aerial surveys conducted over all potential crocodile habitat. The range of the crocodile can best be understood as consisting of three components. The overall range is the area in which crocodiles are occasionally reported. This is from Sanibel Island on the west coast of Florida, along the south and east coast to Fort Lauderdale, and southward to the lower Florida Keys. The core range is the area in which crocodiles occur continuously. This is from the lakes on Cape Sable along the north shore of Florida Bay to lower Biscayne Bay and Key Largo. The nesting range is the area in which nesting occurs regularly. This is along northeastern Florida Bay to Turkey Point and northern Key Largo. Within this range, our aerial surveys have shown that crocodiles are most abundant inland of northeastern Florida Bay and on Key Largo (Fig. 1).

Presently nesting occurs in three areas, northeastern Florida Bay, Turkey Point, and northern Key Largo. We have been able to locate records for 187 clutches of eggs deposited in southern Florida since the 1930's. Eighty clutches are known to have been deposited during the study period, 1978-82. Of these 54 were along northeastern Florida Bay, which must be considered the center of the nesting distribution.

Ogden (1978) concluded that a major reduction in breeding range has occurred in Florida Bay with the "gradual disappearance of nesting on islands in Florida Bay". His depiction of range reduction showed isolines that implied a concentric reduction of range into northern Florida Bay. We however do not interpret the loss of nesting sites to be a gradual retreat of animals into the northeastern bay. We agree with Ogden (1978) that most logical explanation for the loss of crocodile nest sites in eastern Florida Bay is the development of the islands of the upper Florida Keys. The bay islands where nesting had been recorded do not appear to provide year-round habitat for either adult or hatchling crocodiles, and we believe that females on these islands moved there from the Florida Keys only during the nesting season. Thus we suspect that it is the loss of the year-round habitat on the keys that adversely affected these females. Such island nests were probably always peripheral to

the population core and not highly productive owing to their exposed locations. Nesting on islands in the northeastern bay, used by females from the coastal mainland swamps has continued, and the known nest sites used has increased over the study period.

#### Population size and structure

We have found all size classes represented in the population, with a slight relative under-representation of juvenile animals. We interpret this result to be caused by high hatchling mortality, rapid growth rates, and a bias of survey data against juvenile animals. It is important that existence of juveniles indicates that survival is occurring, although perhaps not at the level found in the protected habitats on northern Key Largo (Moler pers. comm.).

The sex structure of crocodiles captured is biased in favor of females. Our best estimate of the sex ratio is 2:1 (n=24). It is not possible to determine whether the bias is real or the result of differential catchability. The lower proportion of males does not limit breeding, as we found a very limited occurrence of infertility (see beyond).

To estimate the size of the Florida population of the American crocodile we followed the method devised by Chabreck (1966), using population parameters derived from capture, survey, and nesting data. In our primary study area in northeastern Florida Bay, we estimate the nonhatchling population to consist of 90 individuals. We can extrapolate this figure to the remainder of the range using survey and nesting data. Our estimate for the south Florida population as a whole then is 220 nonhatchlings. Because of the seasonal addition of hatchling animals, we estimate the population seasonally can increase to about 570 animals, averaging over the course of the year about 400 animals of all age classes.

#### Nesting Biology

The average nesting date is May 5 (s=12.1 days) and the average hatching date is July 29 (s=6.7 days, n=27). The average incubation period is 85 days, rather than the 90 usually reported. The nesting cycle of Florida crocodiles avoids the low temperatures of winter and the high temperatures of late summer. It also avoids in most years, the potentially desiccating conditions of the dry season and the potentially flooding conditions of the peak of the rainy season. The average clutch size, based on 46 clutches, is 38.0 (s=9.45). This is less than the 44 previously reported by Ogden (1978), who inadvertently included double clutches in his calculations.

The fertility rate was high, only 10% of 314 eggs being unbanded (infertile or very early embryo death). The fertility of eggs in individual nests ranged from 46 to 100%; in all but one nest the fertility exceeded 84%.

Raccoons (Procyon lotor) were the only nest predators. We found that raccoon predation was relatively infrequent and unpredictable. From 1971 to 1982, 14% of 99 clutches were depredated. We found that individual clutches could be protected, if desired, by placing raccoon traps at specific nest sites where sign is observed. There do not appear to be individual predators that have learned to seek out and depredate crocodile nests.

Ogden (1978) concluded that an important factor regulating the number of American crocodiles was "mediocre nesting success, caused primarily by failure of eggs to hatch". He suggested that embryonic mortality was the result of low temperatures in marl nests. We closely examined nest temperatures to test this hypothesis and found that they were not low enough to inhibit development. Clutch temperatures averaged 31.6°C (28.4-35°C) in nests in marl substrate and 30.0°C (26.7-33.6°C) in nests in sand substrate.

Lutz and Dunbar-Cooper (1984), as part of our overall study, examined the gaseous environment of the egg chamber. They found that concentrations of O<sub>2</sub> and CO<sub>2</sub> and humidity were all within expected ranges under usual circumstances.

In investigating the egg chamber environment, we discovered that the cause of embryonic mortality was subterranean flooding, that is a rise of ground water into the egg cavity causing asphyxiation of the embryos. Such flooding is not recognizable above ground. Subterranean flooding occurs in low-lying nests, particularly along creeks, during very high water conditions. We also found that some embryonic mortality can result from desiccation. This occurs only during very dry periods in relatively high sand nests. Overall, embryonic mortality occurred in 14% of all known clutches.

#### Habitat and activity areas

Habitat use and activity areas were determined by aerial and boat surveys and by radio telemetry. Ten nonhatchling animals were telemetered and followed for periods ranging to over one year. The mean activity range was 107.5 ha (s=71.3 ha). The largest activity area was 262 ha. The activity areas of different animals overlapped substantially.

Use of available habitat was statistically non-random and crocodiles remained for most of the year in coastal mangrove swamps. Crocodiles primarily used protected ponds and small streams rather than open water or the bay. Females moved from the mangrove swamps into Florida Bay only during the nesting season when some nested on bay islands. Because of this inland pattern of habitat use, we found crocodiles in salinities averaging 14ppt.

### Mortality

Documented cases of mortality of crocodiles larger than hatchlings appear to be primarily man-caused. Of 25 known mortalities from 1971 to 1984, all but six were related to human activities. Most deaths were caused by automobiles along highways, on U.S. 1, the main road in Everglades National Park, and the road over Card Sound to northern Key Largo. Ten adult animals were known to have died in 12 years, a rate slightly less than one per year.

### Management needs

Our studies have failed to demonstrate that the crocodile population in Florida is decreasing. We have, in fact, evidence to suggest that recruitment to the breeding population occurs periodically. Although the population remains small and isolated, it is not in immediate danger of extinction. Most potential constraints on population growth are relatively minor and natural. As a whole, however, these natural constraints inhibit any rapid population increase, as would be expected at the northern limits of the range of an otherwise tropical species.

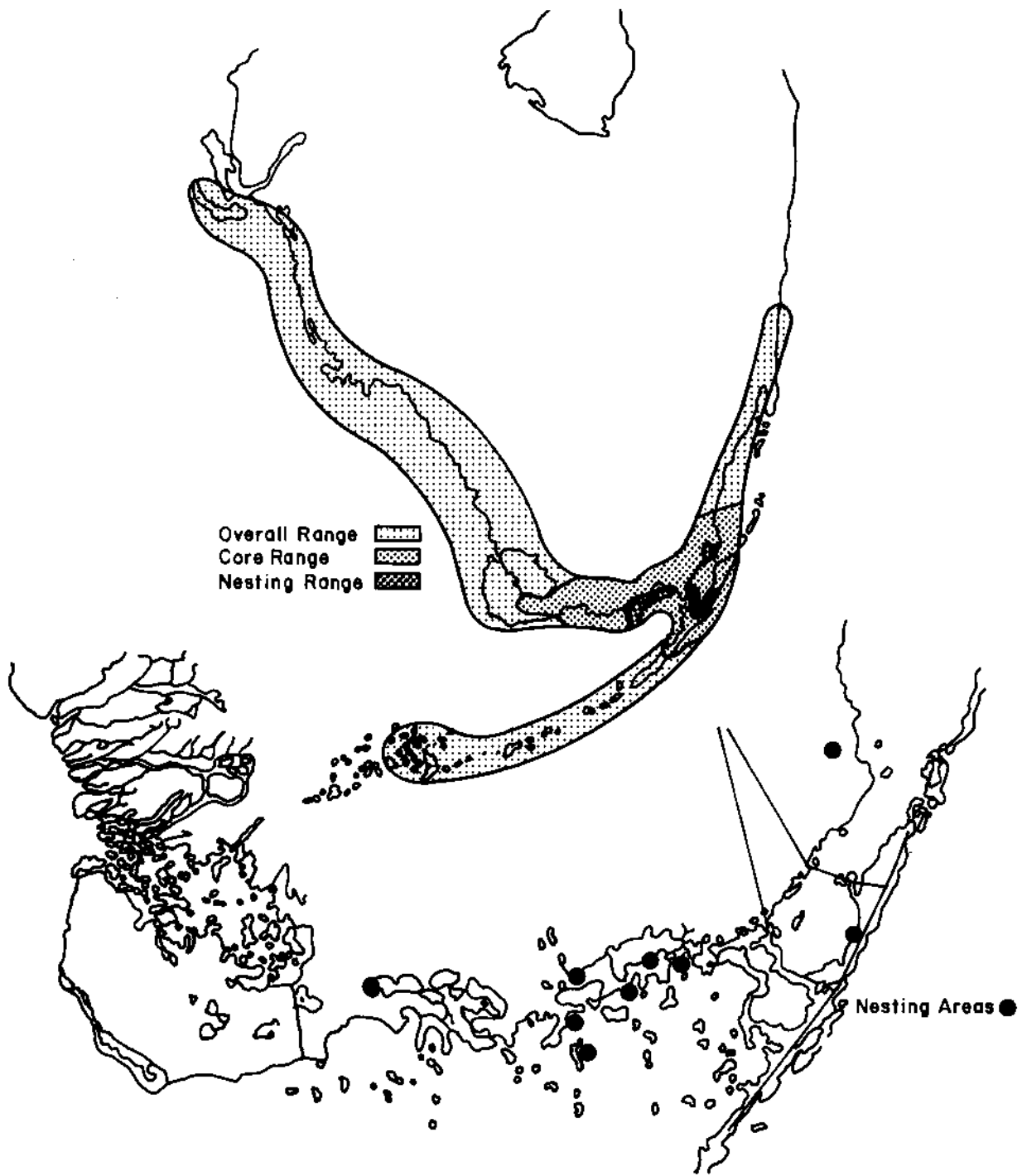
The population's range in Florida has decreased somewhat from historic times due to the loss of habitat in northern Biscayne Bay and Miami Beach. It is possible that this loss has been compensated by the artificial habitats on northern Key Largo and Turkey Point. This habitat modification has been of benefit to crocodiles in producing nesting sites where such previously were scarce or nonexistent.

As a result of our findings, we see no need for any drastic manipulative management of the southern Florida crocodile population. Several conservation concerns remain however. The first and most important is the protection of habitat on northern Key Largo. The acquisition of this land as part of the Crocodile Lake Wildlife Refuge by the US Fish and Wildlife Service is continuing. A second concern is the continuing mortality of crocodiles, especially adults, along highways. The future revamping of US Highway 1 from Miami to Key Largo provides an opportunity to halt such mortality by placing the roadbed on trestles as it passes through mangrove swamps. This is much preferred to simply installing culverts, as has been done as an intermediate measure, in that crocodile mortalities have occurred as individuals crossed the highway not far from such culverts. The third concern involves plans to increase the flow of water to the eastern reaches of Everglades National Park. Such flows may raise water levels in creeks in northern Florida Bay, thereby threatening the crocodile nests along these creeks. The threat of further increasing subterranean flooding of such crocodile nests needs to be alleviated.

Literature Cited

- Chabreck, R.H. 1966. Methods of determining the size and composition of Alligator populations in Louisiana. Proc. S.E. Assoc. Game Fish Comm. 20: 105-112.
- Dimock, A.W. 1918. The Florida crocodile. Am. Mus. J. 18: 447-452.
- Jacobsen, M.T. 1983. Crocodilians and islands: state of the American alligator and the American crocodile in the lower Florida Keys. Fla. Field Nat. 11: 1-24.
- Lutz, P. and A. Dunbar-Cooper. 1984. The nest environment of the American crocodile (Crocodylus acutus). Copeia 1984: 153-161.
- Mazzotti, F.J. and W.A. Dunson. In press. Adaptations of Crocodylus acutus and alligator for life in saline water. Comp. Biochem. Physiol.
- Morre, J. C. 1953. The crocodile in Everglades National Park. Copeia 1953: 54-59.
- Ogden, J.C. 1978. Status and nesting biology of the American crocodile, Crocodylus acutus (Reptilia, Crocodylidae) in Florida. J. Herp. 12: 183-186.
- Wyman, J. 1870. On the existence of a crocodile in Florida. Am. J. Sci. Arts. 49: 105.

Figure 1.: Range of the American crocodile (*Crocodylus acutus*) in southern Florida, USA.





THE PRESENT STATUS AND DISTRIBUTION OF CROCODYLUS  
ACUTUS ON THE CARIBBEAN ISLAND OF HISPANIOLA

John Thorbjarnarson  
Florida State Museum

and

School of Forest Resources and Conservation  
University of Florida - Gainesville, FL, 32611 - USA

Introduction

The American crocodile, Crocodylus acutus, is the most widely distributed of the four New World crocodiles. Primarily found in coastal regions, C. acutus ranges along both the Atlantic and Pacific coasts of southern Mexico, Central America and northern South America, as well as the southern tip of Florida and the Greater Antillean islands of Cuba, Jamaica and Hispaniola. As with the great majority of crocodylians, populations of C. acutus have been decimated by a combination of hide hunting, habitat destruction and wanton killing.

Although the species as a whole is seriously depleted (Groombridge 1982) a recent review of the overall status of C. acutus revealed our lack of detailed information from many parts of the species' range (King et al. 1982). Similarly relatively few studies have been done on the ecology of C. acutus. Today, our best data on ecology come from the population in southern Florida where studies have been on-going since the early 1970's (Ogden 1978, Kushlan and Mazzoti 1985). More recently ecological investigations have been initiated in the Dominican Republic (Ottenwalder and Inchaustegui, pers. comm.), Jamaica (Garrick, pers. comm.), Venezuela (Seijas 1985) and Haiti (Thorbjarnarson, in prep.).

With funding from the New York Zoological Society, my work on Hispaniola began in 1981, initially in the Dominican Republic and later in Haiti, Hispaniola, shared by these two nations, is the second largest and most ecologically diverse of the Greater Antilles (76,192 km<sup>2</sup>). Visited by Columbus in 1492, the island was settled by the Spanish in the early 16th century, displacing the indigenous Taino-Carib indian cultures. Following the more lucrative conquests of Peru and Mexico, the Spanish influence in Hispaniola wavered and other nations, most notably France, made inroads. In 1697 the western third of the island was ceded to France, setting the stage for the later revolution and establishment of Haiti, the world's first black republic, in 1804. Today, both Haiti and the Dominican Republic face major ecological problems stemming from high population densities and centuries of misuse. This is especially true of Haiti, the poorest country in the New World, where soil erosion has reached crisis proportions. The native wildlife has similarly suffered from overhunting, habitat loss and the introduction of exotic species. Today the crocodile remains one of the few large native species still found on the island.

Despite its ecological problems, Hispaniola still retains a wide variety of habitat types within its diverse topography (which includes the Caribbean's highest point, Pico Duarte 3175 m). Crocodiles, while still found in typical coastal habitats, remain in larger numbers in two land-locked lakes surrounded by arid semi-desert. This account will briefly outline the status of crocodile populations in both coastal and lake habitats, and describe some of the human-related factors which impinge on them.

#### Inland Lake Crocodile Populations

##### A. DOMINICAN REPUBLIC

The Cul-de-Sac/Valle de Neiba depression is a low-lying valley that stretches east from Haiti's capital Port-au-Prince to Barahona in the Dominican Republic. Contained in this valley are the island's two largest lakes; Lago Enriquillo and Etang Saumatre. Bordered to the north and south by a series of mountain ranges, this valley was until recently a submerged marine strait. Uplifted in the Pleistocene, water was trapped in a series of depressions creating four lakes which now support a mixed marine-coastal and freshwater biota. The largest of these depressions became the two lakes that now support crocodile populations.

Lago Enriquillo, in the Dominican Republic, is the largest of the lakes and is surrounded by a dry cactus-thorn scrub habitat receiving approximately 700 mm rain annually. Situated approximately 35 m below sea level, evaporation has concentrated the lake water and the salinity is presently 45 parts per thousand (ppt). Old coral reefs, some virtually intact, are scattered around the lake fringe, evidence of the region's recent uplifting.

Owing to fluctuations in rainfall, the lake level has varied considerably in the past. Since 1979, following a series of hurricanes, Lago Enriquillo has risen approximately 5 meters, inundating land previously used for agriculture. Prior to 1979 the lake salinity was much higher (70-80 ppt) causing severe ion-balance problems for the lake's fauna. During this time juvenile crocodile recruitment was apparently restricted to a few freshwater marsh habitats where springs or irrigation runoff entered the lake. As the major nesting areas are located on islands, some several kilometers from shore over frequently rough water, the great majority of hatchling crocodiles perished from dehydration within several weeks of hatching.

Furthermore, during this period of low water, Isla Cabritos, the lake's largest island and the site of much of the nesting activity, became connected to the mainland. This provided access to the island by poachers and feral animals (J.A.Ottenwalder, per. comm.).

The recent rise in lake level has diluted the water in Lago Enriquillo, again isolated Isla Cabritos, and flooded fringing woodland in several areas, creating a better quality habitat for juvenile and adult crocodiles. Additionally, in 1982 several yearling crocodiles were found living in small pools on Isla Cabritos, suggesting that at least some of hatchlings now able to tolerate the more diluted lake water.

Despite the marginal habitat conditions, Lago Enriquillo remains the largest and most locally dense C. acutus population known. Since 1977 scientists from the Museo Nacional de Historia Natural in Santo Domingo have been studying the ecology of the crocodiles in Lago Enriquillo. At least 6 nesting beaches are known, and the annual number of nests has been estimated as 100-150 (J.A. Ottenwalder and S. Inchaustegui, pers. comm.). Assuming a similar population structure and nesting frequency as in neighboring Etang Saumatre (Thorbjarnarson, in prep.), this suggests an adult population of 385-525 adult crocodiles, or a total population of 2,452-3,344. With 130 km of shoreline, the crocodile density in Lago Enriquillo is 18.9-25.7 crocodiles/km, or an estimated biomass of 188.4-256.1 kg/km. These figures represent only general estimates as we lack more precise demographic data. However, the density values are close to those reported by Cott and Pooley (1972) for nearly undisturbed populations of Crocodylus niloticus. This suggests that the population in Lago Enriquillo may be in a nearly pristine state. Nevertheless, poaching still takes place, despite protective legislation and occasional patrolling by park guards and National Museum personnel. In the Dominican Republic most of the crocodiles killed are adult males whose penis is used for making aphrodisiacs.

Isla Cabritos has been designated a national park by the government in order to protect the crocodiles and the endemic ground iguana Cyclura ricordi. Due to recent budgetary constraints in the national parks department, however, adequate patrolling of the lake has not been taking place. Furthermore, the boundaries of the park do not include the critical freshwater marsh habitats that fringe the lake in several areas (see Conservation Status and Recommendations).

#### B. HAITI

Etang Saumatre, located only 10 km west of Lago Enriquillo, is Haiti's largest lake. Approximately two-thirds the size of Lago Enriquillo, Etang Saumatre (113 km<sup>2</sup>) is similar in geological origin, but very different in ecology from its sister lake. Located 15 meters above sea level, Etang Saumatre, instead of being hypersaline, is brackish (8-10 ppt), and so contains a much more diverse biota. Similarly surrounded by a cactusthorn scrub habitat, the valley region containing both lakes is sparsely inhabited, a factor which has significantly reduced the potential for human impact on the crocodile populations.

Etang Saumatre was the site of a 13 month investigation into the ecology of C. acutus (Thorbjarnarson, in prep.). The adult crocodile population in Etang Saumatre is much smaller than in adjacent Lago Enriquillo, numbering approximately 70. Most of the crocodile population is concentrated along the uninhabited eastern lakeshore, which is also the shore most protected from the predominantly easterly winds. Overall, the crude density of crocodiles of all size classes is 6.3/km shore. Omitting shorelines avoided by the crocodiles (steep rocky or high wave exposure) the ecological density is 9.6/km (biomass 92.3kg/km).

Owing to a somewhat fortunate juxtaposition of the border between the two countries, the eastern lakeshore of Etang Saumatre is located in a restricted zone adjacent to the border. Together with a recent ban on boats from the lake and a lack of freshwater along the eastern lakeshore this has kept the eastern part of the lake free from human habitation for 7-8 years. Prior to this boats would travel across the lake, and fishermen and charcoal makers regularly visited the eastern lakeshore. As this part of the lake contains a large part of the crocodile population and virtually all the nesting areas, these factors have been of major importance in providing a de facto protection for the crocodile in Etang Saumatre.

Because the lake water is brackish, hatchling crocodiles do not face the osmoregulatory problems that they do in Lago Enriquillo. Nevertheless the impact of human populations on the crocodiles has been more severe in Etang Saumatre, and this fact is born out by the much lower density of crocodiles in that lake. Gill netting is commonly seen in the lake and every year crocodiles drown in these nets. Similarly, crocodiles that take domestic stock are baited in and killed. Although crocodiles and their eggs are generally not eaten in Haiti because of religious taboos (crocodiles play an important role in the highly animistic voodoo religion), some of the poorer people near the border with the Dominican Republic will resort to eating crocodile on occasion. Likewise, some of the more educated people, further divorced from these religious beliefs, will eat crocodiles or kill them for sport.

Another major source of mortality of adult crocodiles in Etang Saumatre is shooting by border guards at two posts on the lake (Malpaso and Las Lajas). This illegal shooting is often done out of boredom, or by the Dominicans to obtain the meat and the penis of the males.

#### Coastal Crocodile Populations

Historical accounts suggest that crocodiles were once both abundant and widespread along the coast of Hispaniola (Moreau de St. Mery 1797-8, Descourtilz 1809). In fact Haiti, then referred to as St. Domingue, is the type locality of the specimens described by Cuvier in 1807 (probably originating from the l'Ester-Artibonite region).

Presently in Haiti, crocodiles have been exterminated from 70% of their former coastal range, and those populations that do exist have been drastically reduced in size. The situation in the Dominican Republic is even worse as only one coastal population remains, and that one borders along Haiti on the northern coast of the island.

Four coastal populations can be defined, more or less restricted to the western one-third of the island (Fig. 1); 1) on the southern coast of the Tiburon Peninsula, 2) the western end of Ile de la Gonave (the largest of Hispaniola's satellite islands), 3) the l'Ester mangrove swamp, and 4) in the estuarine section of the Riviere Massacre and adjacent coastal lagoons.

All the coastal populations are quite small and are restricted to a few relatively isolated areas that still contain suitable habitat. As these populations are very diffuse and the remaining individuals are quite wary, no quantitative estimates of population size are available. The common problems shared by the crocodiles in all these areas are habitat loss, and human-related mortality, the latter primarily from drowning in fishing nets or being killed as vermin. As mentioned previously, in Haiti crocodile are not killed for food because of religious beliefs. However, in the Dominican Republic crocodiles are used for food, the body fat is taken for medicinal purposes, and the penis for an aphrodisiac. In border regions cross-cultural influences have resulted in Haitians adopting the Dominican attitudes towards crocodiles. This is evident to some extent in Etang Saumatre, but most obviously along the northern border on the Riviere Massacre.

Nevertheless in Haiti most of the crocodiles that are killed are only those which accidentally come into contact with man. Coastal regions where crocodiles have been extirpated have higher human population densities (247.9/km<sup>2</sup>) than areas where they still remain (134.6/km<sup>2</sup>). Similarly, crocodiles tend to remain in areas with more mangrove per kilometer of coast (0.39km<sup>2</sup>/km coast) than areas where they have been extirpated (0.05km<sup>2</sup>/km). The combination of these two factors is significantly correlated with the presence or absence of crocodiles in coastal provinces (Wilcoxon Rank test, p 0.05).

#### Conservation Status and Recommendations

Although crocodiles are legally protected in the Dominican Republic little enforcement of this legislation is currently taking place. Poaching continues to be a problem for both population (Lago Enriquillo, Rio Massacre). In Haiti, crocodiles are afforded no legal protection, and even if such laws were passed they would be almost impossible to enforce.

Due to the burgeoning human population along the coast and the concomitant need for space, and acceleration in the rats of habitat destruction, the future of coastal crocodile populations is not very bright. The Dominican Republic needs to take immediate steps towards including the estuarine section of the Rio Massacre in the existing national parks system. As this area is one of

the country's few remaining areas of riverine mangrove swamp it has a very important biotic role in the coastal ecosystem and should be seriously considered for protection.

In Haiti, crocodiles have managed to survive in some coastal areas despite frequently intense human population pressures. Although strict protection of areas would be virtually impossible to accomplish, a little planning could do much to reduce the impact on the crocodile populations. By restricting access as much as possible to certain critical areas (such as nesting beaches and nursery habitat), and designing gill-netting procedures to reduce crocodile mortality, these small coastal populations would have a much greater chance of survival. As several international aid agencies are now interested in helping the Haitian government develop a coastal zone management plan, specific recommendations could be made part of an overall program to conserve coastal wildlife (e.g. manatees, flamingos, sea turtles and crocodiles) many of which share the same habitats.

The crocodile populations in Lago Enriquillo and Etang Saumatre have a brighter, but far from secure, future. Because of the sparse human populations surrounding them, and the limited human usage of these saline lake, human-related mortality has been less severe than in the coastal areas, and the chances for habitat protection are better. In Etang Saumatra the ban on boats should be continued indefinitely. Furthermore, the uninhabited eastern lakeshore needs to be declared a wildlife sanctuary, as part of Haiti's newly developing national park system (which to date includes only montane areas). As the Haitian government owns virtually all the land in question, this could be done at little cost to the government. Providing the area is properly maintained and patrolled, this would also provide benefits by helping to reduce the smuggling that occurs across the border.

The protection of the crocodiles in Lago Enriquillo should be more rigidly enforced and the park boundaries urgently need to be expanded to include the vital freshwater marshes around the lake. As the lake's limited freshwater input is being increasingly diverted for agriculture, an integrated management plan needs to be undertaken to address the problem of freshwater is the lifeblood of the great majority of the lake's fauna, every effort should be made to ensure a constant supply into the lake ecosystem.

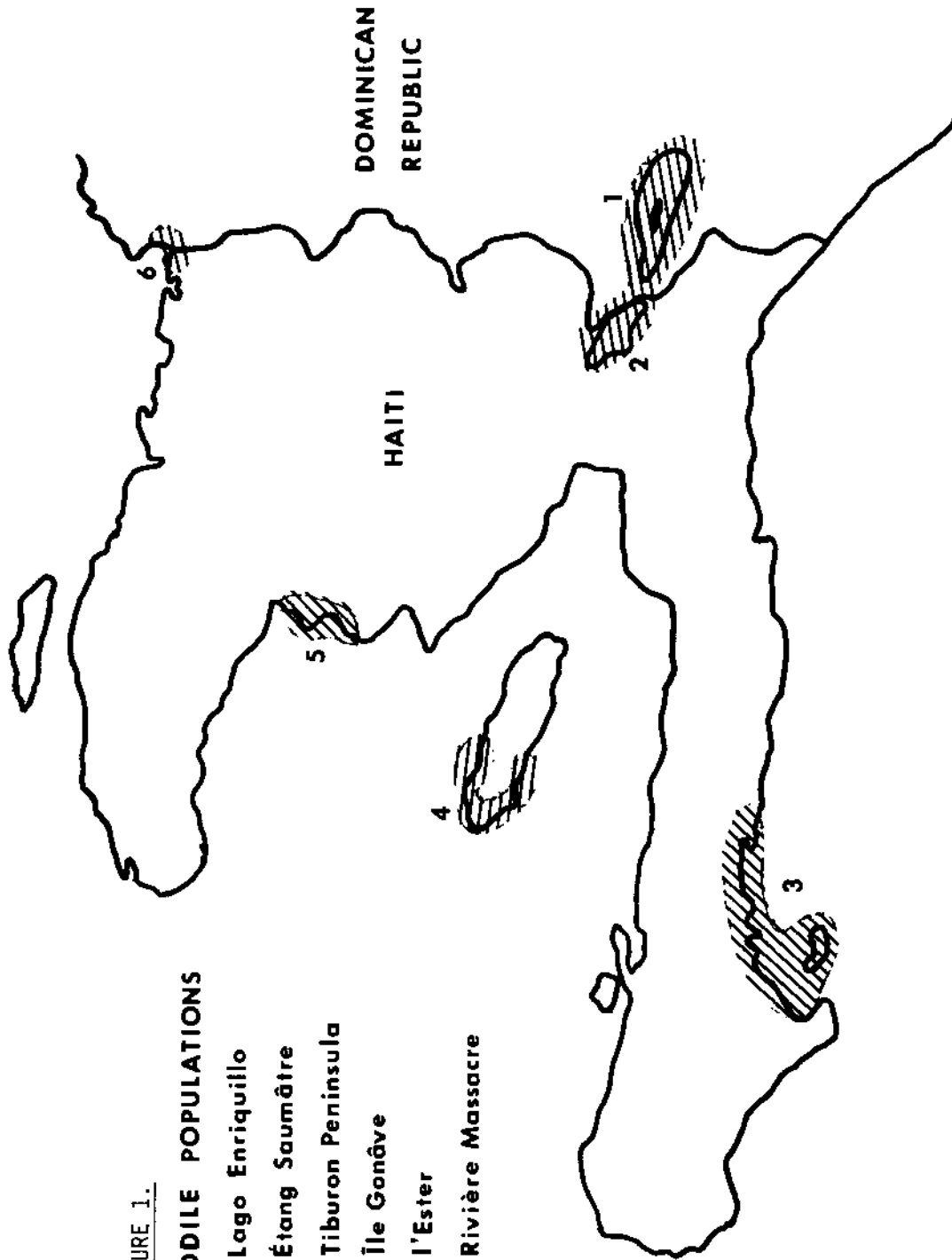
Literature Cited

- Cott, H.B. and A.C. Pooley. 1972. The status of crocodiles in Africa. IUCN Publ. (N.S.) Suppl. Paper 33: 1-98.
- Descourtilz, M.E. 1809. Voyages d'un naturaliste, et ses observations. Histoire naturelle du crocodile de Saint Domingue, etc.,.....  
Dufort pere Lib., Paris 3: 11-108.
- Groombridge, B. 1982. The IUCN Amphibia-Reptilia red data book. Part 1. Testudines, Crocodylia, Rhynchocephalia. Unwin Brothers Ltd., Surrey U.K. 426 pp.
- King, F.W., H.W. Campbell and P. Moler. 1982. Review of the status of the American crocodile. IUCN Publ. (N.S.) ISBN 2-8032-209-x. p. 84-98.
- Kushlan, J. and F. Mazzoti. 1985. Population biology and status of the American crocodile in south Florida. IUCN Publ. (N.S.) (this volume).
- Moreau de St. Mery, M.L.E. 1797-8. Description topographique, physique, civile, politique et historique de la partie Francaise de l'isle de Saint Domingue. 2 vols. Societe de l'Histoire des Colonies Francaises et Libraire Larose, Paris. 788 and 856 pp.
- Ogden, J.C. 1978. Status and nesting biology of the American crocodile, Crocodylus acutus, (Reptilia, Crocodylidae) in Florida. J. Herpetol. 12 (2): 183-196.
- Seijas, A.E. 1985. Situación actual del caimán de la costa, (Crocodylus acutus) en Venezuela. IUCN Publ. (N.S.) (this volume).

FIGURE 1.

**CROCODILE POPULATIONS**

- 1-Lago Enriquillo
- 2-Étang Saumâtre
- 3-Tiburon Peninsula
- 4-Île Gonâve
- 5-l'Ester
- 6-Rivière Massacre





## SOCIAL BEHAVIOR OF THE AMERICAN ALLIGATOR

Kent A. Vliet  
University of Florida  
Department of Zoology  
Gainesville, Florida 32611, USA

### Introduction

The study of alligator behavior is a rather young field with almost all of the significant contributions occurring in the last two decades. Early accounts, such as those of Reese (1907, 1915), Kellogg (1929), and McIlhenny (1935) were anecdotal observations but provided some useful information. Even these scanty early references indicated a complexity of behavior far more advanced than that of other reptiles.

The excellent work of Leslie Garrick and Jeffrey Lang (Garrick and Lang, 1977; Garrick et al. 1978) provided the first detailed analyses of alligator social behavior. These studies noted complex patterns of social communication involving visual, auditory and tactile signals and provided further evidence of the highly advanced nature of the behavior of these animals.

The social behavior of the American alligator is a complex array of acts lacking much of the behavioral stereotypy common to the behavior of other reptiles. Their highly vocal nature, well developed parental care, and the variability of behavioral responses in social interactions, all make the behavior of alligators far more similar to that of birds and mammals than to that of the other reptile groups.

The present paper describes certain aspects of the social behavior of the American alligator in captivity. This is not a review of all that is known of the behavior of these crocodylians but is, rather, a general depiction of some of the observations of alligator social behavior, specifically of alligator courtship and of two assertion displays, the bellow and the jaw-clap. A detailed analysis of the information described below will be published elsewhere.

### Methods

**Study site:** This study was conducted at the St. Augustine Alligator Farm, a privately-owned commercial tourist attraction in St. Johns county, Florida. The study site is a small, man-made lake of approximately 1/4 hectare surface area surrounded by another 4/10 hectare enclosed land surface containing a large number of captive adult American alligators. The lake is bordered with native coastal dune vegetation dominated by Southern Live oak, Saw palmetto, and Yaupon holly. Deep ground wells provide a constant flow of water into the lake throughout the year. The lake is traversed by a wooden boardwalk raised several feet above the water surface from which observations of behavior are made. The alligators within the lake are habituated to the daily presence of tourists on the boardwalk and apparently behave naturally while being observed.

Study methods: Observations were made from early April through mid-June from 1981 to 1983. These periods encompassed the whole of the courtship season and extended up to the period of egg laying. Observations were made primarily during daylight hours from first light intermittently to dusk. Some observations were made at night using image-intensifying equipment. Most observations were made from the boardwalk, recorded on taperecorders and later transcribed. Behavioral observations were usually made from 4 to 15 meters from the alligators. Visual records of behavior were made with 35 mm slides, 8 mm movie film, and 1/2" video. Recordings of vocalizations and other audible behaviors were made with a Nagra IV recorder and shotgun microphone. Some observations were made in the water to study visual communication of alligators.

Study animals: The size and composition of the study population varied between the three study seasons. The population contained between 145 and 165 adult American alligators ranging in length from 2.0 m to 3.2 m. The sex ratio within the group changed between study season as Farm personnel or I removed and added new individuals. During the 1981 season, there were approximately 1.3 males per female, in 1982 only 0.8 males for each female, and in 1983 about 1.1 males per female.

Prior to each study season, all animals in the population were captured, sexed, measured, and marked. Large, highly visible, numbered tags were attached to an anterior single caudal whorl of the tail for individual identification. These tags were easily readable up to 40 meters. The tags were changed before each new study season to reduce bias in the observations due to knowledge of an animal's past behavioral history.

### Courtship

Courtship in alligators is a slow, extended process involving visual, tactile, auditory, and probably olfactory sensory cues. In St. Augustine, the courtship season extends from the second week of April to the end of May, with a peak in courting intensity about the third week of May. Although courtship is seen throughout this two month period, the majority of copulations occur during the last two weeks of May. Adult alligators are large, powerful and very capable of injuring one another. This extended period of courtship is thought to be necessary to reduce the levels of aggression or anxiety between two individuals, or within a population, so that close approach, mounting and mating can occur. Levels of aggression do seem to be reduced during the courtship season in these captive alligators. There are significantly fewer serious injuries within the study population during the two months of the courtship season than during the two month period preceding courtship.

Behavioral acts involved in alligator courtship can be grouped into four functional categories. These are:

Behaviors related to the Introduction of partners;  
the Tactile interactions of the courting pair;  
Physical contests of strength; and  
Mounting and associated behaviors.

These functional groups are not necessarily sequential in alligator courtship as acts from different categories are often intermixed.

1. Introduction: Alligator courtship is instigated by one animal swimming to another and either initiating tactile interactions or remaining still until the second animal begins interactions. Introductory behavior may include the initiating animal blocking the progress of a swimming alligator. Visual communication between the potential partners is important in this phase of courtship. The approaching animal swims slowly and remains low in the water, often with only the eyes, nostrils, and cranial table exposed. Upon approach, the second animal often raises its position in the water thus exposing more of its body surface. This appears to serve as a warning to the approaching animal. The very low body profile above the water surface assumed by an approaching animal seems to be perceived as a non-aggressive signal by the second alligator. Obviously, the non-aggressive attitude of each animal must be communicated to the partner during this introductory phase if courtship is to continue.

Courtship may also be initiated by an alligator swimming parallel to another, eventually overtaking the second. As the latter attempts to turn out of this parallel swim, the former persists in maintaining its position. This persistence eventually stimulates the latter to slow or stop and begin courtship.

A characteristic vocalization, a low, soft flutter, is often made by one or both of the alligators during the initial phases of courtship. This flutter may be produced by an animal as it approaches another or as it is approached. This fluttering vocalization is made in short bursts and produces ripples in the water surrounding the head of the alligator. It is obviously perceived tactilly by the second animal when they are in contact. The function of this audible signal is unknown although it probably serves as a warning of a close approach or a caution to an approaching animal.

2. Tactile interactions: Following introduction, the approaching animal may make physical contact with the second or remain still. If the second alligator is responsive, it will move forward and begin tactile interactions with the former. Initial contacts are most usually made either at the premaxillary or the retro-articular process of the lower jaw, depending on the direction of approach of the alligator initiating the interaction. Throughout the tactile and physical contest phases of courtship, the interacting alligators orient themselves to each other in a position which I term a "face-off", one in which the heads of both animals are parallel but facing in opposite directions. Touches to the head and neck of the partner are made from this face-off orientation and the courting animals return to it repeatedly during the tactile interactions. Often, only one of the animals actively positions himself so as to assume the face-off, but many times both animals move simultaneously into the position, indicating a cooperative aspect to alligator courtship.

Touches to the head and neck are usually soft bumps but occasionally an animal will forcefully ram or push its courting partner. Once it has made contact, the alligator backs slightly and then moves forward again to make another contact. Contacts are usually made with the anterior-most part of the premaxillary but if the touching animal rides up onto the snout or cranial table of the other, contact is made with the under side of the jaw. In addition to discreet touches, courting alligators will rub back and forth along the side of the head of the partner.

3. Physical contests: After the initial tactile interactions, and also intermixed with subsequent tactile behaviors, the alligators engage in physical contests of strength and resistance involving attempts by one animal to press the other under water. From a face-off position, one animal circles the other, raises its head up onto the snout, cranial table, or nuchal scales of the second, and presses down. The second animal may resist vigorously or submit to the presses. If the second is pressed under, the first tries to keep the second from resurfacing. The submerged animal usually backs or turns out from under the pressing animal and rises to the water surface. Animals are often held under water for periods of up to five minutes although most presses do not last more than 20 seconds. Being pressed under seems to stimulate the alligator rather than diminish its interest in further courtship and both animals usually move directly back into a face-off to continue courting.

4. Mounting: Mounting may follow directly from pressing interactions. Once an animal is being pressed, the superior alligator can rotate his body parallel to the other, lift fore- and hind-limbs onto the dorsum of the other and draw itself up into a mounted position. Pressing behaviors usually continue from the mounted position. These behaviors are especially obvious during this phase of courtship. Every time the subordinant animal rises to the surface, the mounted animal quickly moves to press it under the surface again.

When an alligator has been mounted and pressed under, it usually begins swimming forward, or alternates moving forward and backing apparently trying to move out from under the mounted animal. If it is allowed to bring its head to the surface, the lower alligator will usually remain still. When pressed under again, it begins swimming once more. If the upper animal is persistent in maintaining its mounted position and in pressing the lower alligator under water, the latter will eventually slow or stop. It seems that this persistence by one animal in courting activity is important in stimulating the other alligator to allow mating to take place.

Once the lower animal is still, the upper alligator rolls over onto the side of the lower, while still maintaining his hold with both fore- and hind-limbs, and begins sweeping or "searching" motions with its tail. When its tail contact that of the lower animal, it is passed underneath and then drawn forward to bring the vents in contact for copulation to occur. Copulation was never seen to last more than 35 seconds in the course of this study.

All of the behaviors described above occur at the water surface. This is an indication that visual signals must be very important in initiating and propagating a courtship interaction. Once one animal has mounted the other, they may drop below the surface. Deep water is not necessary for copulation to take place. Many instances of copulation in less than two feet of water have been observed.

**Participants in Courtship:** I have made no mention to this point as to the sex of the participating animals. All of the behaviors described above are performed by both males and females. At the beginning of the courting season, usually in the second week of April in St. Augustine, many of the males begin to exhibit courting behaviors. As the season progresses, more and more males become active in courtship or courtship-like encounters, so that by the end of the first month of the courting season, almost all of the males which will court that year are already engaging in courtship. Females behave quite differently. Very few females are active in courtship encounters at the start of the season. It is only during the peak of the season, during the last two or three weeks of May, that the majority of the females which will court that season become active. Females actually appear to avoid contact with other alligators in the population and spend much more time of land in the basking areas than do the males. A consequence of these differences is that the average male has a very long courtship period, often encompassing the entire season, while an effective courtship season for an average female is much shorter, usually less than two weeks. However, when females are active, they tend to initiate most of the courtships and vigorously court the males, often mounting and pressing males much larger than themselves under water.

Perhaps as a result of the relative scarcity of active courting females, many of the "courtship" interactions observed in this study involved only male participants. In fact, during the first part of the courtship season, interactions occur almost exclusively between males. These interactions are, in almost every way, exactly like the courtship interactions between males and females. Any differences between these interactions and actual courtships are most probably due to the relatively large size of both participants. For instance, physical contest behaviors are very prevalent in these interactions. It is not known if these male-male interactions occur among alligators in nature but they are known to occur among alligators in other captive situations. Females very rarely interact with other females.

**Periods of Courtship Activity:** As stated previously, courtship is a highly seasonal activity and is generally observed in St. Augustine from the second week of April through the last week of May or first week of June. Some variation in time of onset and in intensity of courting activity does occur. This appears to be due primarily to meteorological features such as low night time air temperatures or low water temperatures. In a geographic sense, courtship activities are initiated earlier in the spring in southern localities than in more northerly areas.

Courting intensity varies dramatically throughout the day. In the early part of the season, courtship is obvious at first light and proceeds until the sun reaches the western basking areas in the lake. Courting activity is most intense during these early morning hours. At this point, most of the alligators halt interactions and leave the water for these basking sites. Only large, dominant males and a few infirm animals (blind, ill, or missing limbs) remain in the water. Basking continues throughout the day with animals sporadically re-entering the water to move to the eastern basking areas as the sun moves to the west. The alligators again enter the water and resume courting only after the sun is off of the eastern basking areas at dusk.

This pattern is modified later in the season as daytime high, night time low, and water temperatures increase. During the latter part of the season, alligators spend less time basking and, thus, a midday period of courtship develops as the animals have entered the water following the morning bask and before they again bask in the evening. Courtship activity is never as intense at midday as it is in the morning or evening hours.

Courtship also occurs throughout the night. However, as nocturnal courtship is never intense, does not appear to be different from diurnal activity, and is much more difficult to observe, few observations of courtship were made at night. Courting activity does seem to drop off quickly at last light in the evening, remains fairly low throughout the night and then increases noticeably about one hour before first light.

During the peak of the courtship season, courting occurs anytime the animals are in the water. The daily pattern of courting and basking described above is disrupted on days of inclement weather. On heavily overcast or rainy days, the alligators spend the entire day in the water and courtship is observed throughout the day. Even so activity is significantly more intense in the early morning and late evening hours.

A great deal of variation in courting intensity has also been noted between study seasons. During the 1981 study season, courtship activity was much more vigorous, in terms of total number of courtships observed, length of courtships, number of courtships leading to mounting, and number of copulations, than in the following two study seasons. Late winter and early spring meteorological conditions, especially night time low temperatures and their effects on water temperature, might be responsible for the reduced activity noted in the latter two study seasons. Alligator movements and basking behaviors suggest they are keenly sensitive to ambient temperatures. Unseasonally cold weather may cause, either hormonally or through some other physiological means, a decrease in the intensity of alligator courting behavior.

### Bellowing

Alligators are highly vocal reptiles and audible signals are used in many social contexts. The grunts or distress calls of juveniles are well known to anyone who has handled small alligators. Adult

alligators make vocalizations or other non-vocal sounds during courtship, when threatened, during aggressive encounters, and in many other social interactions. Adult alligators produce a loud, low frequency roar, or bellow. This vocalization is most commonly heard during the courtship season, although it may occur anytime in the year when the animals are active. The bellowing of one animal stimulates others in the population to bellow producing a "chorus". Choruses are typically heard in the early morning hours although choruses of much shorter duration may be heard anytime during the day or night.

The bellowing display involves a regular and highly stereotyped series of repeated inhalations and exhalations performed in a characteristic body posture with both the head and tail arched out of the water. The audible bellow is produced with the forced exhalation. A series of bellows are performed in a bellowing "bout". An individual alligator may perform more than one bout during a morning chorus.

The bellows of male and female alligators differ in a number of characteristics. The cadence of the display of the males is much slower than that of the females. Males also tend to perform fewer bellows per bout than do females. Most importantly, males produce an infrasonic signal, projected through the water, just prior to the audible bellow. Females never produce this infrasonic signal. This signal is so powerful that it makes the water surrounding the alligator's torso "dance" up off of the water surface. The "water dance" of a large male can cause vibrations in the ground and other nearby objects. Preliminary analysis of this subaudible signal suggests a frequency of approximately 10 hz. The length and intensity of the infrasonic signal decreases through a bellowing bout. The mechanism by which the signal is produced is unknown.

Bellowing choruses occur almost daily throughout the courtship season. In the first part of the season, choruses are somewhat irregular, vary greatly in length, and on some days do not occur at all. As the season progresses, choruses become more predictable. Through the courting season, as sunrise becomes earlier, choruses also are initiated earlier. In the last half of May, when courtship is at its peak, bellowing also is most intense. At this time, there are characteristically two choruses each morning; one very early, usually before sunrise, and another later in the morning. After courtship has ceased, morning bellowing choruses appear to be much less regular and less intense, although they occur sporadically throughout the remainder of the summer and fall. Bellowing is only rarely heard in the winter months.

The length and intensity of bellowing choruses seem to be a case of social facilitation. The few records of average bellowing chorus length which have been published seem to indicate that morning bellowing choruses continue for longer periods of time in large populations than in smaller ones. Herzog's (1974) study described a captive population of approximately 26 adult alligators and noted an average chorus length of 11.3 minutes. Garrick, et al (1978) stated that the average length of bellowing choruses of a group of about 35 alligators peaked at 21.5 minutes. In the

present study, the average chorus length for the entire courtship season in 1983 was 35.4 minutes for the total population of approximately 350 adult alligators maintained at the Farm. Obviously, the greater the number of animals in the population, the greater the number of animals available to initiate and propagate a bellowing chorus.

Bellowing sites are typically in shallow water with the animals facing the bank. If a bellowing chorus is initiated after animals have moved onto land in the morning, many of these animals will return to water to participate in the chorus. A lesser number of displaying animals will remain on their basking sites and bellow on land.

The function of the bellow is still poorly understood. The intensity of bellowing associated with the courting season of alligators suggests an important sexual component to the display. Alligators of opposite sex are obviously attracted to one another during choruses, especially during the peak of the courtship season. The fact that bellowing choruses are heard at other times of the year suggests that bellowing may serve other functions as well, perhaps as an agonistic or assertion, display between members of the same sex.

#### Head-Slapping

Alligator perform an assertion display referred to as a head-slap or a jaw-clap. The display is performed from a head-up, tail-up posture similar to that used during bellowing. About fifteen to 17 seconds after assuming this posture, the lower jaw is rapidly dropped to the surface of the water and the upper jaw is forcefully clapped against it, usually accompanied by the entire being slapped against the water surface and a deep, guttural growling vocalization. This act is often followed by the displaying animal rising up out of the water in a "high stance" accompanied by a vigorous thrashing of the water with the tail. The tail swish produces strong waves which alert alligators under water that a display has been made. The slapping of the head against the water surface is most probably heard by submerged alligators. The tail swish obviously emphasizes or strengthens the display. The head-slap display thus includes visual auditory and tactile components and easily draws the attention of all other alligators in the area.

Head-slap displays are highly variable in form and intensity. Any component of the display, such as the growling vocalization, high stance, or tail swish, may be omitted. Males may produce an infrasonic signal immediately prior to the display. In contrast with bellowing displays, a series of up to eight of these infrasonic bursts may be performed before the head-slap, although only one is normally produced. The tail swish may also begin before the clap is actually made and proceed through the display or may not be made at all.



Most head-slaps are produced by males although females account for a small percentage of all displays seen. The displays performed by females tend to be much less intense than those of males. Often a female performs only a jaw-clap with no accompanying body posturing, tail swish or vocalization.

Alligators select specific areas from which to jaw clap. This site selection often occurs as much as fifteen minutes before the display is actually performed. Display sites are usually very near the shore or other physical objects (such as emergent logs in the water), often in secluded portions of the lake, and are often under overhanging vegetation.

A head-slap display apparently causes other animals to head-slap. Often a display is followed by two or three other head-slap displays within the next fifteen to twenty minutes and then no displays are heard for thirty to forty-five minutes. The frequency of head-slaps varies throughout the day. Head-slaps are frequent (ca. 4.5/hr) in early morning, less frequent during the morning basking period, most intense during the afternoon hours (6/hr) and then drop off through the evening basking periods and dusk.

I have only briefly described the most conspicuous acts in the repertoire of alligator social behavior. Alligator social communication is far more complex than can be indicated in this paper. Subtle cues, such as shifts in movement patterns in relation to other alligators, or slight changes in body posture, have not been discussed. The intricate processes of social communication of the alligator are still poorly known and require further study.

#### Literature Cited

- Garrick, L.D., and Lang, J.W. 1977. Social signals and behavior of adult alligators and crocodiles. *Am. Zool.* 17: 225-239.
- Garrick, L.D., Lang, J.W., and Herzog, H.A., Jr. 1978. Social signals of adult American alligators. *Bull. Am. Mus. Nat. Hist.* 160(3): 153-192.
- Herzog, H.A., Jr. 1974. The vocal communication system and related behaviors of the American alligator (Alligator mississippiensis) and other crocodylians. MS thesis, Univ. Tennessee. Knoxville, 83 pp.
- Kellogg, R. 1929. The habits and economic importance of alligators. *Tech. Bull. U.S.D.A.*, N<sup>o</sup> 147.
- McIlhenny, E.A. 1935. *The Alligator's Life History*. Christopher Publ. House, Boston, 117 pp.
- Reese, A.M. 1907. The breeding habits of the Florida alligator. *Smithsonian Misc. Coll. Quart. Issue 3*: 381-387.
- Reese, A.M. 1915. *The Alligator and its Allies*. Putnam's, New York, 358pp.

STATUS, CONSERVATION AND UTILIZATION OF THE NILE CROCODILE  
IN ZIMBABWE

D.K. BLAKE  
Natal Parks Board  
Pietermaritzburg, South Africa

Status

**CURRENT:** There is only one species of crocodile in Zimbabwe. That is the Nile crocodile (Crocodylus niloticus laurenti). While the fortunes of the Nile crocodile population in Zimbabwe have fluctuated over the last century they can currently be classified in terms of the IUCN definitions as being "out of danger". This is a result of sound crocodile conservation and utilization policies implemented over the last twenty years by the Department of National Parks and Wildlife Management.

**HISTORICAL:** Prior to the advent of the European into the country, crocodiles were seldom killed because they had no commercial or food value to the local people. The early European hunters with their more sophisticated weapons shot the odd crocodile more to placate the local chiefs than for the trophy. With the opening up of more remote areas and a growing human population, the conflict between crocodiles and humans increased. This resulted in a reduction of crocodile populations except in the more remote areas of the country mainly limited to stretches of the major rivers, which lay outside suitable agricultural areas. The construction of large dams even within these areas has allowed reestablishment of odd populations.

Today crocodiles are distributed throughout the country, but mainly below 1.500 metres in altitude. They have established themselves in most dams constructed below this altitude and even in some above that; the Ngesi and Sebakwe being classic examples in which marginal populations exist. Being migratory animals, during the rainy season they quickly re-settle the upper stretches of the rivers and move down-stream once the rains abate.

**POPULATION:** The wide distribution of crocodiles through the country make an accurate estimate of the population impracticable. The major populations occur along the Zambezi river and Lake Kariba as well as in the Sabi/Dundi river systems of the south-east Lowveld.

In a submission to IUCN in 1982 the population of crocodiles in Zimbabwe was estimated as being in the region of 40/50.000 crocodiles. Of these 34.000 were estimated to occur in the Zambezi systems. This was based on aerial surveys and night counts conducted along the shoreline of Lake Kariba, Taylor et al (1982). Counts during 1983 over longer stretches of the shoreline indicated lower densities than previously obtained.

For the Lake itself the population has been estimated at 7,6 crocodiles per kilometer of shore-line resulting in a revised figure of 13.000 crocodiles. Counts along the Zambezi river between the Rukometjie and Chewore rivers have given estimates of between 20-40 crocodiles per kilometer of river. Taking the lower figure of 20 crocodiles per kilometer and the length of the river from Kariba dam to Kanyemba as 195 km., this give an estimated population of 3.900 crocodiles. Using the figure of 7,6 crocodiles per kilometre for the river upstream from Kariba gives a population of 1.200. This gives a population for the Zambezi river (including Kariba) of minimum of 18.000 crocodiles. The rest of the country can be divided into the rivers north of the watershed and those south of the watershed.

In the northern watershed there are 10 main rivers flowing into the Zambezi system. These each have a minimum of 200 kilometers of suitable habitat. Taking a nominal population of 2 crocodiles per kilometer, we have  $10 \times 200 \times 2 = 4.000$  crocodiles.

In the lowveld there are 7 main rivers. Working on the same formula we arrive at 2.800 crocodiles.

Thus we have population minimum of 25.000 for the country. This figure is probably much higher as no allowance has been made for population in many dams such as Kyle, McIlwaine, Darwendale, Ngezi, etc. The known population population for Ngezi dam alone is some 70 crocodiles.

It can safely be assumed therefore that the revised crocodile population for Zimbabwe is in the region of 35.000 crocodiles.

Crocodile populations in Zimbabwe have shown an upward trend since the early 1960's, especially in those areas in which the crocodile is protected. Recent intensive surveys on Lake Kariba have shown a marked increase over the last four years. The same situation exists in the lower Zambezi and is supported by counts made in 1971 and 1981/82 (unpublished Departmental records).

Observations by Departmental staff have indicated increased populations in the upper Zambezi as well as the Sambli/Lundi river system of the south eastern lowveld.

#### Conservation

Until 1961 crocodiles could be hunted without licence and there was no restriction on skin sales. The world demand in the 1950's for crocodile skin led to even the more remote population of crocodiles being decimated.

The Wildlife Conservation Act (1961) classified the crocodile as a game animal with the result that it could only be hunted under licence.

Skins could no longer be sold unless they were taken under a cropping permit. Probably as a result of these measures and aided by the remoteness and inaccessibility of some stretches of the major rivers the Nile crocodile was not exterminated.

In the mid-1960's the Department of Wildlife Conservation allowed the utilization of the growing crocodile populations along the Zambezi River including Lake Kariba.

In 1975 the promulgation of the Parks and Wild Life Act (1975) passed responsibility for all animals to the land holder. In order to safeguard the crocodile populations along the Zambezi river system, all crocodiles along the river (including Lake Kariba) were by Government Notice 969 of 1975, placed under the protection of the Director of National Parks and Wild Life Management for five years. This notice was replaced by Statutory Instrument 719 in 1980 thus affording protection for a further five years. At a meeting in June 1984 between the Department of National Parks and Wild Life Management and the Crocodile Farmers Association of Zimbabwe it was agreed that crocodiles throughout Zimbabwe should be placed under the protection of the Director of National Parks and Wild Life Management.

Since the inception of Crocodile Farming the Department has formulated a strong policy on the Conservation and Management of Crocodiles in Zimbabwe since 1982.

#### Utilization

Utilization can be divided into three main categories:

**SPORT HUNTING:** Under sport hunting a total of 12 crocodiles per annum are allocated to five Safari Operators along the shores of Lake Kariba. These crocodiles are only taken by bona fide Safari Hunters and the quota is not always taken up.

A quota for local hunters of 3 crocodiles per annum on a section of the Zambezi River below Kariba was allowed up to 1983. This was stopped in 1984 as it was apparent that the crocodiles were not being hunted as trophies but merely as "Part of the Bag".

On private land a number of Safari Operators allow the hunting of crocodiles. While exact numbers are not known, a total of five trophies were exported in 1983. The proposal to place all crocodiles in the country under the protection of the Director would mean that these crocodiles would have to be hunted under permit.

**CROCODILE FARMING/RANCHING:** Crocodile ranching(rearing) stations were originally started in Zimbabwe in 1967 (Blake, 1982). Ranching was seen as a means of utilising a growing crocodile population on Lake Kariba as well as a desire to provide a sufficient source of legal big quality skins so as to inhibit poaching. This was fulfilled and, in addition, the emerging value of the industry catalysed funds for research and the monitoring of wild stocks

which resulted in a widening public appreciation and tolerance of the species. Authorities to ranch were only issued once the following criteria had been met:

- a) The Department was reasonably satisfied that wild stocks could support the annual harvest of eggs and young.
- b) It was satisfied with the bona fides of the applicant, including his capital resources and ability to maintain the venture until a financial return could be expected after an anticipated three to five years; and
- c) The operators undertook to provide the Department with grown crocodiles amounting to 10% of the number of eggs or young originally collected.

By 1971 three of five stations started were still in operation, and making satisfactory progress and it was decided to hold the industry at this level until these stations could demonstrate their economic viability as well as the Department being reassured that the wild populations could sustain the necessary egg harvest. At the outset there was little knowledge of the general biology of crocodiles or even on how they should be raised in captivity. It soon became apparent that catching young crocodiles was uneconomic and biologically wasteful, and that rearing stations would have to depend on collection of eggs, preferably those with well developed embryos as they travel best. In 1977 it was decided to allow additional stations to open up and there are today 6 stations operating in the country.

	<u>NAME</u>	<u>POSITION</u>	<u>ESTABLISHED</u>
1.	Kariba Crocodile Farm (Pvt.) Ltd.	Kariba, Lake Kariba	1965
2.	Binga Crocodile Ranch	Binga, Lake Kariba	1967
3.	Spencer's Creek Crocodile Ranch (Pvt.) Ltd.	Victoria Falls Upper Zambezi	1971
4.	Sengwa Mouth Crocodile Ranch	Sengwa Mouth Lake Kariba	1977
5.	Rokari Crocodile Ranch	Ume estrary Lake Kariba	1981
6.	Lion and Cheetah Park	Harare District	1983

Egg quotas to the stations have been allocated to the stations on the following points:

- 1) The number of eggs believed to be available in the areas in which eggs are allowed to be collected.
- 2) The capability of the station to house and rear the hatchlings.

The allocation of eggs to the stations for the 1984/1985 season is 14.000 eggs, of which 11.000 will be collected along the shores of Lake Kariba.

This quota is based on known nesting sites and the estimates of eggs available are as follows:

I) Estimated Population of Lake Kariba	13.000
II) Estimated Proportion of Mature Adults (25%)	3.250
III) Estimated Number of Mature Females (50%)	1.625
IV) Estimated Number of Nests (75%)	1.218
V) Number of Nests likely to hatch (60%)	853
VI) Number of eggs available 853 x 40 per clutch	34.120

During collection 10% of the eggs found in nests are rejected as non-viable and therefore the allocation of 11.000 is in fact a 90% figure. The eggs which will be disturbed by collection will be therefore 12.222 or 305 nests, which is approximately 36% of the nests available.

**FARMING:** In order to increase the viability of the crocodile industry all stations have been encouraged to start farming operations.

Problem crocodiles captured by the Department have been sold at nominal rates to the stations over the years. In 1983 authority was granted to Sengwa Mouth to carry out their own capture operations on a section of the Lake where there was a conflict between fisherman and crocodiles. Over a period of 8 months only 14 crocodiles were caught. In March and May/June 1983 a method of "mass capture" was tried out by the Department. In these two operations a total of 15 and 14 crocodiles were captured. Of these, twelve breeding females were retained. It was agreed at the 1984 Crocodile Meeting, that mass capture would be carried out as a combined operation between the Department and the various stations in order to build up their breeding stock. These crocodiles will only be captured in those areas where there is conflict with human activities.

A. STOCKS HELD BY STATIONS AS AT JUNE 1984

STATION	HATCHLING	REARING Stock	BREEDING Stock	
			Male	Female
Binga	2.230	3.243	5	42
Kariba	2.200	4.650	22	23
Lion and Cheetah	295	--	5	23
Rokari	1.650	2.297	3	8
Sengua Mouth	1.979	3.843	5	16
Victoria Falls	3.112	2.214	11	74
	<u>11.466</u>	<u>16.247</u>	<u>52</u>	<u>186</u>
	=====	=====	==	===

B. PROJECTED SKIN PRODUCTION FROM 1984/85 SEASON

I. Eggs from Wild

5 Stations at 2.500 =	12.500
1 Station at 1.500 =	1.500
	<u>14.000</u>
96% Hatch =	13.440

II. Eggs from Farms

Ringa	1.680
Kariba	920
Lion and Cheetah	920
Rokari	320
Sengua	640
Victoria Falls	2.960
	<u>7.440</u>
85% Hatch =	6.324
	<u>19.764</u>

70% to slaughter stage = 13.835 skins in 1986/87

CONCLUSION

The combined policy of Conservation and utilization adopted by the Department of National Parks and Wildlife Management in the early 1960's has paid off.

Starting off with a crocodile population that had been severely depleted by skin hunters, the crocodile population has recovered to a point where they are in some areas quite common. More importantly a value has been placed on them which is accepted by the public.

For the future, danger lies in loss of value due to a moving away from crocodile rearing to farming which will lessen the dependence on the wild population. It is extremely unlikely however that such a swing would be one hundred per cent. Another danger lies in the "commercial value" of the wild populations. Zimbabwe as an "Emerging State", is short of foreign currency and the suggestion has already been made to Ministers to crop the crocodile population.

Fortunately to date the Department has been consulted and such proposals rejected.

Provided the Department keeps and implements its Crocodile Policy and has the Zimbabwe Farms Crocodile Association as an "Advisory Body" the future of the Crocodile in Zimbabwe is assured.

#### References

- Taylor R., Blake D.K. and Loverridge, J. P. 1982. Population Numbers of Crocodiles (*C. niloticus*) on Lake Kariba and Factors Influencing Them.
- Department of National Parks and Wildlife Management - National Parks Policy - Conservation and Management of Crocodiles in Zimbabwe.
- Blake, D.K. 1982. Crocodile Ranching in Zimbabwe. The Zimbabwe Science News, Vo. 16 N<sup>o</sup> 9.



A PRELIMINARY EXAMINATION OF CROCODILE POPULATION TRENDS  
IN PAPUA NEW GINEA FROM 1981-1984

Martin Hollands  
Senior Ecologist  
Crocodile Management Project  
Dept. of Primary Industry  
PO Box 2141 Boroko NCD  
Papua New Guinea

SUMMARY

A preliminary analysis is presented on 3 years data on trends in the PNG populations of Crocodylus porosus and C.novaeguineae. Aerial nest surveys were conducted at 23 sites along a 200 Km. section of the Sepik river and associated nesting habitat. Surveys were conducted in March and October each year, to incorporate the peak of each species' nesting.

Indices are calculated to show changes within different habitats for each species, and these are combined, with appropriate weighting, to give a nesting index for each species. There has been an increase of 38% in the index for C. novaeguineae. C. porosus remained unchanged from 1982 to 1983, but increased in 1984 to 23% above the 1982 level.

It is suggested that temporary nesting habitat destruction prior to the 1983 survey resulted in a reduced proportion of females breeding, and that both species are likely to be increasing at a steady rate. Possible reasons for the increase are considered, as are remaining problems.

An analysis of crocodile trade statistics, together with very limited survey data from other areas, is used to argue that the situation in the Sepik, which produces about 38% of the countries skin crop, is unlikely to be in major conflict with the national situation. It is concluded that the management programme is not only providing a good economic return to the country, but is allowing an expansion of the crocodile population.

## Introduction

Since the mid 1960's Papua New Guinea's populations of Crocodylus porosus and C. novaeguineae have been actively managed to improve the biological efficiency of harvesting. The government was keen to halt a severe decline in numbers, and steer the harvest towards the long term goal of "maximum sustainable yield cropping". The rationale behind the programme, based on a gradual shift from wild killing to the ranching of wild caught hatchlings, has already been extensively described (Bolton and Laufa 1982, Behler 1976, Downes 1978, New York Academy of Science 1983).

An integral part of such a programme has clearly to be a research and monitoring component, to assess the effects of harvesting on the wild population, and to give the understanding needed to make correct management decisions. Regrettably this aspect of the PNG programme was underemphasised in the early stages, only being implemented in 1980. As the project ecologists have always made clear, the initial research will be geared to monitoring population trends, not trying to quantify the resource (Grahame 1980, 1981, Hollands 1982(a)), however this is sufficient for management needs at present, and is a more realistic option with limited resources. Three years surveys, as have so far been conducted, are not sufficient to safely identify population trends -let alone understand them- and pose as many questions as they answer.

In Papua New Guinea a large number of people are heavily dependent on crocodiles as the only, and only foreseeable source of income. In view of this, and the fact that crocodiles have never been "on verge of extinction" there, it has been the government's policy that the restructuring of the industry has to occur without closing it down until all the answers are available. It has therefore been necessary to adopt a highly flexible attitude, and to continually review management options in the light of the best information currently available. For this reason a preliminary analysis of the monitoring data has been conducted, and will be presented here, despite, whatever qualms the author might have about discussing 'trends' at this stage.

The predominance of heavily vegetated swamps as the primary habitat occupied by crocodiles in most of the country has led to the utilization of aerial surveys of nest numbers as the principal field monitoring technique (Grahame 1981(b), Hollands 1982, Cox 1984). This has proved highly suitable for such areas as the Sepik flood plain (Fig. 1), which produces approximately one third of the crop of both species; nest survey results from this area constitute the main data for this analysis. Trade statistics analysis is also an essential part of the programme, with both the crop size, and more particularly its structure, providing valuable information on the wild population. In some parts of the country, particularly the more discreet rivers in the west south, night counts are also run. However, as these have been conducted over a shorter period than the nest counts, they can tell us little at present about changes in numbers.

## Methods

Although there is a large amount of excellent crocodile nesting habitat within the study area, it is in many relatively small sites, separated by unsuitable habitat (Figs. 1 and 2). When one takes into account the further requirement of good visibility from the air, the potential survey areas become even more fragmented. It was therefore decided that until information was available on percentage visibility of nests in different habitats, and accurate mapping of the area with regards to habitat had been conducted, it would be considerably more cost effective to preselect survey sites and routes, and survey these each season as an index of nesting, instead of trying to quantify nest numbers. Sites were selected to include all major nesting habitats appropriate to aerial surveying, areas with different harvesting regimes, and areas with different nest densities. As more information becomes available new sites will be incorporated, and probably some dropped, to give the optimal balance between variables.

The nest counts are made by one experienced observer in a Hiller 12E helicopter, which also carries a pilot, and a navigator/recorder. Survey routes are predrawn on aerial photographs (scale approximately 1:50,000), which allows accurate navigation and plotting, despite extremely complicated swamp formations. A 100 metre wide band is searched from a height of 150 feet above ground level, at a ground speed of 25 knots. Due to the frequent directional changes caused when following a lake fringe, or an overgrown barat (small river) and a lack of equipment for accurately correcting air/ground speeds, the ground speed is somewhat variable.

All nest sightings are inspected from a height of 25-50 ft., depending on vegetation, for an assessment of age of the nest, activity status, vegetation, /For details of the team's classification and visual assessment of nest age and activity status see Cox (1984)/. Surveys are only conducted during good light conditions, without rain or high winds. More than 50% of nests seen from the air are visited for full data collection, either during the survey or by surface transport soon after.

The timing of the surveys has been set to give the highest possible count of active nests. The freshwater crocodile (*C. novaeguineae*) surveys are carried out from the end of October into early November, and are immediately after the laying period, but before many nests have hatched. As sites are clearly visible for sometime after hatching, and species determination is possible from shells alone (Cox 1984), it is safer to be late rather than early in the surveys. Although the saltwater crocodile (*C. porosus*) nests virtually all year round in the Sepik, there is a significant peak in January/February (Cox 1984) and the surveys are set for just after this time. There is as yet insufficient information to predict the effects of rainfall patterns, or water level,

on the precise timing of nesting; it may well prove necessary to use these to set the optimal survey dates for each season, rather than using the same dates each year.

### Results

Tables 1-4 show the numbers of crocodile nests of each species that have been seen on the six aerial surveys conducted between Oct. 1981 and March 1984. Results are presented both for survey sites (Tables 1 & 3) and within different habitats (Tables 2 & 4).

There has been a highly significant increase in the number of freshwater crocodile nests seen during this period ( $p < 0.05$ , Wilcoxon matched pair sign rank test). There has also been an increase in the number of saltwater nests over this period.

As there is insufficient information available on the percentage visibility of nests in different habitats, it is not possible to extrapolate data to give an estimate of total nest numbers. Instead an attempt to identify trends has been made by calculating indices of nest numbers within each habitat for each year. The first year's results were arbitrarily set  $I=100$ , and subsequent years calculated by a proportional change from this - i.e.:-

$$I \text{ year } n = I \text{ year } n-1 \times \frac{\text{number of nests in year } n}{\text{number of nests in year } n-1}$$

Comparisons are only made between nest numbers on identical routes. This means that where new routes were introduced the results in tables 2 & 4 are tabulated twice for that year, once with the count on the same route as the previous year, (for computation of that year's index), and then on the full route surveyed in that and subsequent years, (for the computation of the following year's index).

The inability to equate the numbers seen in different habitats with the number present, and the absence of accurate habitat maps of the area, also cause problems in how to combine the results within habitats to give an overall index. We need to combine the individual habitat nesting indices with a weighting proportional to the importance of that habitat in nesting to the crocodiles in the area; i.e. proportional to the total percentage of nests which occur within that habitat. Unfortunately we do not know this. The habitat distribution of nests seen during aerial surveys is likely to be unrepresentative; habitats have not been surveyed proportionally to their overall distribution, and visibility from the air differs considerably between habitats. A better approximation to the true distribution of nests can probably be made from the habitats distribution in the (larger) sample visited by project staff after their discovery by local hunters. During the course of other activities most habitats are crossed frequently by village people, who always have an eye

open for crocodile nests. Although there are undoubtedly numerous biases in their discovery of nests it is likely to give us the best approximate to the true distribution that is available to us at present.

The habitat distribution of hunter reported crocodile nests in the Sepik (Cox 1984) is as follows:-

Crocodylus novaeguineae novaeguineae

1 Lake fringe	The floating vegetation fringing open bodies of water	19%
2 Scroll swales & levies	The serial pattern of high and low bands formed by river bend erosion/deposition	57%
3 Channels & barats	Either the bank of small channels or on floating mats which have grown over them	14%
4 Overgrown oxbows	Oxbow lakes across which a vegetative mat has developed	10%

Crocodylus porosus

1 Lake fringes	31%
2 Scroll swales and levies	33%
3 Overgrown oxbows and channels	36%

These percentages have been used as the weighting when combining the individual habitat indices, to give an index for each species which is likely to reflect changes in the total breeding population of the middle Sepik.

<u>Crocodile Nesting Index</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>
C. <u>novaeguineae</u>	100	131	138	-
C. <u>porosus</u>	-	100	101	123

It should be noted that the habitat in which nest numbers of both species have fared least well, the floating mat fringes of lakes, is considerably over-represented in the surveys. This is due to its ease of location, known distribution and location, and good aerial visibility, all combining to it being extensively covered in initial surveys. Now that we have a better knowledge of the distribution of nesting habitat in the area, new survey sites will be incorporated to rectify the imbalance. Until such time the raw survey data alone gives a slightly less optimistic impression.

### Discussion on nesting trends in the Sepik

In this paper it is only intended to consider the results of the surveys in terms of population trends and their relevance to management decisions. Obviously the results are of wider interest, but other aspects are covered in a fuller description of the nesting ecology of crocodiles in PNG (Cox 1984).

Unless these data are purely an artifact of the surveying method, such as a result of improved nest spotting abilities, there has been a significant increase in the breeding population of freshwater crocodiles in the Sepik. This increase appears to be of at least similar magnitude to that seen in nest numbers of Louisiana alligators from 1970-1979 (Joanen and McNease 1980), a population generally considered to have a low level of exploitation. The situation with regards to saltwater crocodiles is not so clear, with a significant drop in the number seen in 1983, though not in the more appropriate index, followed by a large rise in 1984. However, analysis of interhabitat differences, and due consideration of other factors, gives us a reasonable understanding of what happened in 1983.

Prior to the 1983 saltwater nesting season the Sepik area had been exceptionally dry, which had two significant effects on crocodiles. The increased accessibility to hunters combined with the concentration of crocodiles into lakes and small barats made hunting much easier. As skin prices had been extremely low for some time this did not result in an increased commercial harvest, however, in many areas it encouraged hunters to kill large crocodiles for their meat. The more accessible habitat, and less timid behaviour of the salties made them more vulnerable than freshies. In a few areas the effects on the saltwater crocodiles were devastating, for instance Lake Kwasenam (map.ref. 21), dropped from 15 saltwater nests in 1982 to only 2 in 1983 and 1984. Under the laws of PNG it is only the commercial killing of breeding stock that is prohibited.

The second effect of the dry was far more apparent to those on the survey, but more of a short term problem for the crocodiles. It is normal practice throughout PNG for hunters to burn off vegetation almost as soon as it is dry enough. This is used directly in hunting some game, such as wallabies, and also facilitates movement for other hunting. The damage to crocodile nesting habitat is usually relatively minor, as key habitats are normally too wet, however in extremely dry years the effect can be substantial. Vast areas of prime nesting habitat were burnt off in late 1982 and early 1983, and the regrowth of vegetation was not far enough advanced to support the floating nests normally used by crocodiles in this area, and there was insufficient material present for nest construction.

It seems that the saltwater crocodiles responded in two ways to the loss of nest sites; some apparently did not breed at all (or may have bred considerably later in the year, but we have

had no indication of this), and some moved to less disturbed, remoter, areas away from the open water. This movement is indicated by the fact that the changes that were observed in nest numbers between 1982 and 1983 were not uniform across habitats. In the most accessible habitat, the floating mats fringing open water, there was a drop of 50%, the numbers in overgrown oxbows and channels remained constant, and there was actually a rise in the number of nests in the remote scroll swales. By the following season the floating mats had recovered and there was a move back to the lake fringes, with scroll nests dropping in number despite the large overall increase in nesting, indicating such areas are only sub-optimal reserve nesting sites.

When the appropriate habitat weighting is given to the saltwater crocodile results they indicate there was a 23% rise in nest numbers between 1982 and 1984, showing that the drop that occurred in some habitats during 1983 was mainly attributable to the temporary loss of nesting habitat, not to the killing of breeding stock. It is therefore considered reasonable to assume that both species are increasing in number, and probably for the same reasons.

There are a number of factors that could be contributing to this:-

The main legislative protection given to crocodiles in PNG is a ban on the trade of skins above 20" bellywidth, a measure intended to at least protect the breeding stock from commercial, if not traditional exploitation. However political pressure caused the repeal of this law in the Sepik, soon after its introduction in 1975. It soon became apparent from skin exports that where the law was in effect there was a recovery in numbers, in comparison to a continued decline of the industry in the Sepik, resulting in its reintroduction there. Although this law does not give full protection it has probably been a major factor in allowing the breeding population to increase.

This analysis has concentrated on data from the Sepik, as this is the area in which the monitoring team has conducted most work. One consequence of this has been a greater awareness of conservation and management issues in the area, particularly pressure to stop setting hooks at nests. In many villages there arguments have been well received, and hooking breeding females has either stopped or been much reduced; some local councils have even passed laws protecting nests. Any reduction in the deliberate removal of nesting females must be beneficial.

One of the principal concepts of the programme is that by shifting cropping from larger animals to the more readily replaced hatchlings/yearlings, for farm rearing, the value of the industry can be raised. Furthermore, it was predicted that as crocodiles are harder to catch alive, there would also

be a reduction in the total number harvested (Kwapena/Bolton, 1980, Bolton/Laufa, 1982). It now appears that this is being achieved, and over the last 5 years PNG has been increasing skin production, despite a drop in the number removed from the wild (Hollands/Goudie, 1984). As the crop also includes more young stock the biological impact on the population will have dropped even more.

The Sepik is one of the main supply areas for stock for the farms, supplying approximately 63% of both species, and the shift in harvesting is more advanced there than in most areas. In a number of villages hunters now concentrate on live collection not skins. It has been extremely encouraging to note that in areas such as Kamiemu (Fig. 2, map. ref. 12), where hunting is heavy, but is now primarily directed at live collection, there has been such a large increase in nest numbers. Such a situation obviously bodes well for the future of crocodile management in Papua New Guinea.

Although there appears to be an upwards trend in nesting numbers, the results do show that there are still problems to be tackled. For both species the segment of the population that nests in the most accessible habitat -the floating fringes of open lakes- are doing least well, almost certainly as a direct result of human exploitation. Due to the relatively small distances, and normally easy communication, between the different nesting habitats, there is probably good distribution of stock. Movements of up to 10 kms were regularly found in hatchling C. porosus in Australia, and large movements made by older animals, particularly when approaching breeding size (Webb, 1977). It is therefore considered unlikely that the problems in these areas are from the overall level of commercial exploitation, but from the specific exploitation of the breeding females.

In most lowland areas of PNG crocodile nests have long been exploited as a food source. A saltwater crocodile nest can yield up to 8 kg. of eggs, and the nest site offers an easy opportunity for killing a large crocodile for meat. In the Sepik as many as 35% of saltwater nests, and 25% of freshwater nests may be raided for eggs, and up to 15% may have baited shark nooks or nets set for the females. One problem encountered is that the 20" maximum size limit does not fully cover breeding stock, particularly the freshwater crocodile which starts breeding in the wild as small as 15" (Hollands 1982), so a nesting female might yield a saleable skin. However as a major reason for setting a hook is to obtain meat, it seems unlikely that an indirect method of tackling the problem, such as reducing the maximum size, would be effective. The Crocodile Advisory Board has therefore recommended that a law should be introduced banning the setting of hooks or nets within a prescribed distance of a crocodile nest. It is likely to be a much longer task to stop the present egg harvest, though



frequent discussions on this point are held in villages, with increased protein becoming available from other sources, and increased economic value of the hatchlings, there should be a gradual reduction in the rate of nest harvesting. The government is also considering a trial egg harvest programme for farm rearing, in areas where high proportions would be removed for food anyway.

### The National Situation

An indirect indication of the status of the wild population on a national level can be taken from trade statistics; it was in fact these that initially drew attention to problems of over-exploitation in the 1960's. It has long been known that water levels throughout the year have a strong influence on the number of crocodiles harvested and we now know there is a marked correlation ( $r = 0.55$ ) between the price of skins and the number exported. Due to these factors and the gradual shift towards ranching, the annual harvest totals (fig. 3) are of little use in assessing trends in the wild population. However, the size structure of the harvest can give a useful indication.

For reasons of simple economics, hunters prefer to kill large crocodiles for their skins. During the 1960's, when the population was over-exploited, the average size of crocodile that the hunter managed to catch slowly dropped. By 1965 the average size skin exported from PNG was only 7 inches. Due to the changes brought about by the introduction of live purchase schemes, the introduction of maximum and minimum tradable skin sizes, and farm production of skins, a direct comparison of the current average export size (12.29 inches for FW and 10.8 inches for SW) are only of commercial and economic interest. However, if only wild skins between 9-20 inches are considered, to remove the effects of farm skins, it can be seen (fig. 4) that there has a steady increase in the size of skins available to hunters -which supports the idea of an expanding wild population.

Due to their preference for open water, less timid behaviour and greater skin value, the saltwater crocodile is in a more vulnerable position for over-exploitation. Concern was therefore felt as to whether the previous decline in saltwater crocodiles would continue, until they were no longer available in economic numbers when hunters' attention would then turn to the freshwater crocodile -by no means an unusual scenario in the history of crocodile exploitation. Figure 5 shows that the previous decline in the proportion of saltwater crocodiles in the country's harvest has now been halted, and they constitute a stable 20%. This gives support to the argument (above) that, despite a bad nesting year in the Sepik in 1983, the saltwater crocodile population increase is of a similar order of magnitude to that of the freshwater crocodile.

A night spotting survey programme has now been incorporated into the monitoring programme for rivers in Western, Gulf and Central Provinces, however these have not been conducted over a long

enough period to be of any assistance yet in identifying trends. Only one river has had directly comparable counts made over a sufficient period; this is a 120 km stretch of the Bensbach river in the extreme southwest of the country. Counts here show that there has been a substantial increase in the non-hatchling population since 1979. Many of the rivers in the delta system of Gulf Province which are now covered in the surveys were frequently "counted" for interest whilst being traversed on patrol. Those same officers say that the numbers they now see on systematic surveys have increased dramatically - particularly in the numbers of hatchlings.

Aerial surveys of nests have also been made for four years in Waigani swamp, a 2 km. long lake near the PNG capital, whose floating fringe supports both saltwater and freshwater crocodile nests. Annual nest counts on this fringe have been:

1980 - 4, 1981 - 5, 1982 - 8, 1983 - 11

This is a surprisingly healthy population in view of the large number of people who regularly fish and hunt the swamp. The timidity of this population is seen by the fact that although on the serial counts both nests and adults are seen, two hatchlings and one 3-4 ft. crocodile are the best our team has ever recorded there in a night. It should also be noted that there has been an increase in the number of problem crocodiles reported to the authorities.

#### Conclusions

Although the monitoring programme is still at an early stage, the indication to date is that both species of crocodile in Papua New Guinea are increasing in number, and the current management programme should therefore be continued as it gives considerable benefit to the country, particularly to remote groups with no other source of income, and the cropping appears to be within the sustainable limits of the wild population.

#### Acknowledgments

This report would not have been possible without the continued hard work of our field team in the Sepik, particularly Jack Cox, Benny Gowep, Tom Fitzgerald, Kayama Sinba and Thomas Willie. Also special thanks go to the pilots of the Summer Institute of Linguistics who have put up with a lot over the last three years.

Jack Cox and Dr. Mike Nunn kindly reviewed an early draft, and Sue Hollands and Veronica Rau helped in its preparation. The author would also like to thank Papua New Guinea's Department of Primary Industry for its support of the crocodile monitoring programme.

## References

- Behler, J.L. 1976. The Crocodile Industry in Papua New Guinea. A report to the United Nations. Wildlife in Papua New Guinea, 77/25, Wildlife Division, P.O. Wards Strip, Waigani, P.N.G.
- Bolton, M., Laufa, M. 1982. The Crocodile Project in Papua New Guinea. Biol. Cons. 22, 169-179.
- Cox, J. 1984. Nesting Ecology of Crocodiles in Papua New Guinea. FAO/UNDP PNG/74/029 Field Document N° 5.
- Downes, M. 1978. An explanation of the National Policy for the Crocodile Programme. Wildlife Division Publication 79/10 P.O. Wards Strip, Waigani, Papua New Guinea.
- Grahame, A. 1980. Monitoring Workplan. FAO/UNDP PNG/74/029. Assistance to the Crocodile Skin Industry.
- Grahame, A. 1981. Monitoring Final Report. FAO/UNDP PNG/74/029. Assistance to the Crocodile Skin Industry.
- Hollands, M. 1982(a). The Status of Crocodile Populations in Papua New Guinea. Proceedings of the 6th working meeting of the IUCN Crocodile Specialist Group, Held at St. Lucia, South Africa, September 1982.
- Hollands, M. 1982(b). Protecting the breeding Crocodiles in the wild. Crocodile Management Bulletin N° 1 pp. 11-15. Dept. of Primary Industry, P.O. Box 2141 Boroko NCD, Papua New Guinea.
- Hollands, M., Gbudie, G. 1984. Management of the Crocodile Industry in Papua New Guinea. Proceedings of the 7th. working meeting of the IUCN Crocodile Specialist Group. Caracas, Venezuela, October 1984.
- Joanen, T., McNease, L. 1980. Management of the Alligator as a renewable resource in Louisiana. Proceedings of the 5th working meeting of the IUCN Crocodile Specialist Group, University of Florida, USA, August 1980.
- Kwapena, N., Bolton, M. 1980. The National Crocodile Project in Papua New Guinea- a summary of policy and progress. Proceedings of the 5th working meeting of the IUCN Crocodile Specialist Group, University of Florida, USA, August 1980.
- New York Academy of Science. 1983. Crocodiles as a Resource for the Tropics. Report of the Ad Hoc Committee of the National Research Council in the series "Managing Tropical Animal Resources".
- Webb, G. 1977. The Natural History of Crocodylus porosus. pp. 240-310. Fromo "A study of Crocodylus porosus in Northern Australia. Shakespeare Mead Press, Sydney 1977.

Table 1  
LOW-WATER AERIAL SURVEYS OF C.NOVAEGUINEAE NESTS IN THE SEPIK

LOCATION	MAP. REF.	1981	1982	1983	COMMENTS
Korasameri o.g. bar	28	-	0	3	Old Hauguana barratt
Kapaimeri	27	-	0	1	On Salvinia Island
Japandai Oxbow scroll	26	-	0	0	
Suapmeri	25	1	1	1	
Walmau lagoon	24	1	1	3	Not hunted for 3 yrs.due to Salvinia
Yambi Yauwe	23	0	7	2	Extensively burnt 1983
Lapangai scroll	22	1*	3	2	Extensive canoe trails
Lake Kwasenam	21	1	5	6	Heavy hunting + Hooks
Biimba lagoon	20	3	3	1	Mod hunting + Hooks
Nyari, Kanai lagoons	19	5	5	10	Nyari Not hunted, Kanai Heavy hunting & Hooks
Kwandimbe lagoon	18	7	5	7	Mod hunting.Little nest exploitation
Wagu/Wasui fringes	17	2	2	3	Mod.Huntings. Good sw. pop.
Khapar og barat	16	0	0	1	Not hunted. Also has salties
Paiyagat head oxbow	15	2	3	1	Hunted + Hooks
Pwimakiyapa	14	13	20	20	No hunting
Yessan scroll	13	5*	5	10	Heavy hunting
Kamiemu main scroll	12	10	14	22	Mod Hunt. No eggs taken or Hooks
Kamiemu (S) Baratt	11	3	5	10	Females - Hooked 80/81
Kamiemu (W) scroll	10	-	4	4	No Hooks
(N) Swagup	9	7	9	8	No Hooks. Eggs eaten
Kwaisi	8	-	6	6	Females left. Eggs taken
Biaga scroll	7	3	4	4	
Kubkain og oxbow	6	3	2	5	Hunted
Kubkain open oxbow scr.	5	0	0	3	Heavy hunt. Females left.
Houna levels	4	11	13	9	Highwater hunting
Kubkain lagoons	3	4	7	4	Heavily hunted. Take eggs
Keipi swamps	2	3	3	2	Heavy hunting
Browami mountain lakes	1	4	2	0	

\* Denotes imperfect route compatability with following year's survey.

INTRAHABITAT ANALYSIS OF AERIAL SURVEY RESULTS OF C. NOVAEQUINEAE NESTS IN THE SEPIK

Table 2:

HABITAT	1981			1982*			1983			NESTS PER Km <sup>2</sup>
	COUNT	AREA Km <sup>2</sup>	NESTS P/Km <sup>2</sup>	COUNT	AREA Km <sup>2</sup>	NESTS P/Km <sup>2</sup>	COUNT	AREA Km <sup>2</sup>	NESTS P/Km <sup>2</sup>	
LAKE MARGIN	37	21.6	1.71	41	21.6	1.90	41	22.3	1.84	2.02
SCROLL	15	8.6	1.74	18	8.6	2.09	26	10.5	2.48	2.19
BARRATTS	13	6.2	2.10	26	6.2	4.19	32	8.7	3.68	5.06
OVERGROWN OXBOWS	23	5.9	3.90	31	5.9	5.25	31	5.9	5.23	6.10
TOTAL	88	42.3	2.08	116	42.3	2.74	130	47.4	2.74	3.12

\*Due to the inclusion of new sites the data for 1982 (FW) and 1983 (SW) are tabulated to show the results for the same route as the previous year as well as the result on the full route used then and in subsequent years.

HABITAT NESTING INDICES

HABITAT	1981	1982	1983	WEIGHTING
LAKE MARGIN	100	111	122	0.19
SCROLL	100	120	106	0.57
BARRATTS	100	200	275	0.14
OVERGROWN OXBOWS	100	135	157	0.10

C. POROSUS AERIAL NESTING SURVEY RESULTS

Table 3

HIGHWATER (MARCH) NEST COUNTS ON IDENTICAL ROUTES

	Map. Ref.	1982	1983	1984	COMMENTS
Kwasenam	21	15	2	2	Heavy burning + Killinf of breeders in dry '82
Kwandimbe	18	2	3	3	Deep fringe. Little burning
Nyali/Kanai	19	0	0	3	Kanai, shallow, no hooks
Wagu lagoons	17	10	10	14	No hooks. Moderate Burning
Kamiemu	12	4	6	6	
Paiyangat	15	0	2	2	Hooks + nests used in past
Kubkain og.oxbow	6	0	0	2	No hooks - eggs taken
Kubkain oxbow scroll	5	7	5	8	No hooks - eggs taken
Swagup	9	6	1	3	Eggs harvested
Houna	4	1	1	0	
Total		45	30	43	
=====					
Walmau	24	-	5	5	Salvinia cover stopped Hunting. Eggs still taken
Japandai	26	-	3	1	Heavily burnt
Korasmeri	28	-	0	4	S.D.A. area, hooks set for skin
Total			38	53	
=====					
Blackwater	29	-	-	6	
Mindimbit	30	-	-	3	

LOW-WATER (OCTOBER/NOVEMBER) NEST COUNTS

	Map. Ref.	1981	1982	1983	COMMENTS
Kwandimbe	18	1	0	0	
Khapar barratt	16	3	4	3	Nesting area not exploited
Kwasenam	21	0	1	1	
Wisui lagoon	17	1	0	0	

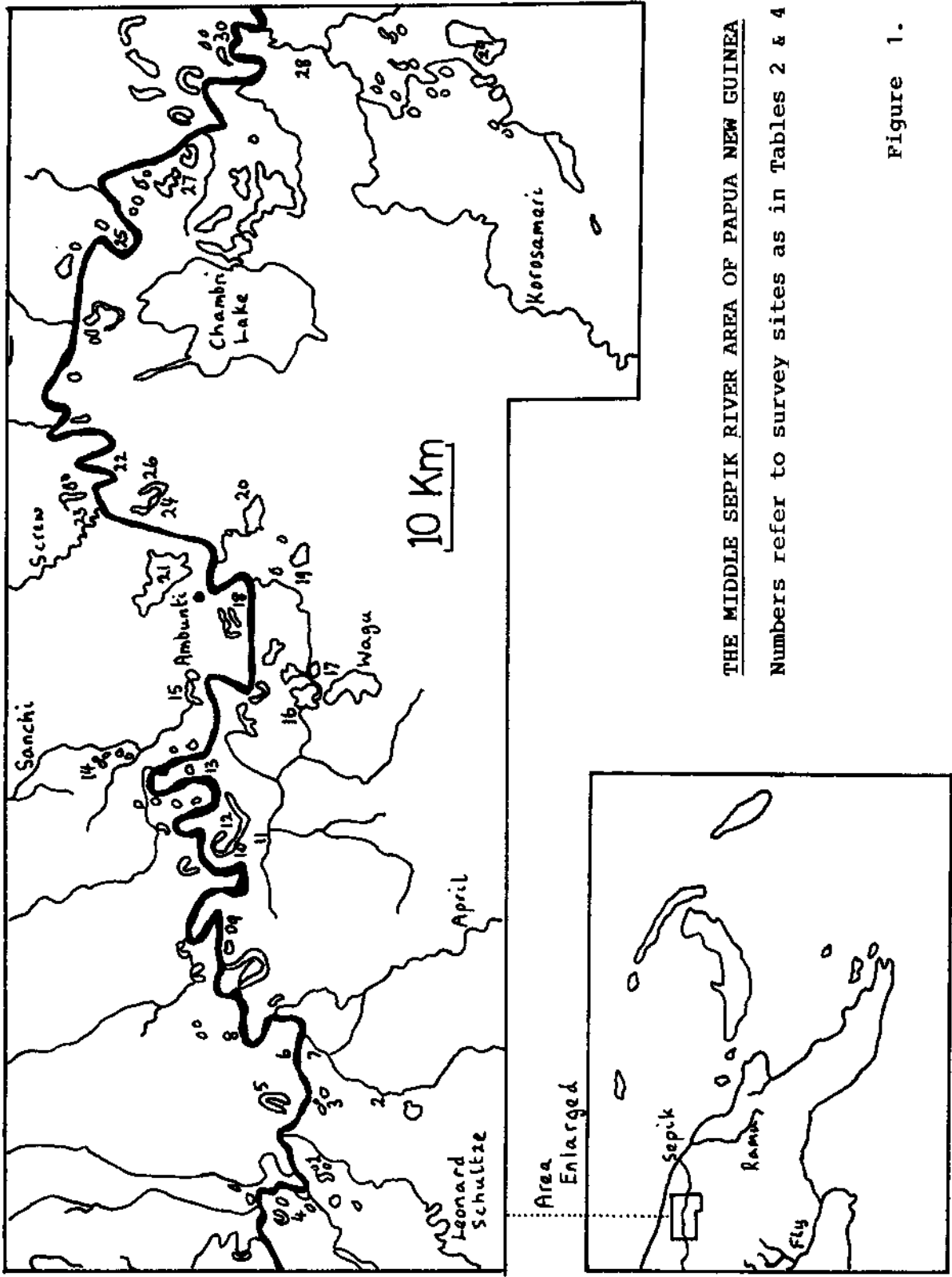
INTERHABITAT ANALYSIS OF AERIAL SURVEY RESULTS OF C. POROSUS NESTS IN THE SEPIK Table 4

HABITAT	1982			1983*			1983*			1984		
	COUNT	AREA Km2	NESTS Per Km2	+ COUNT	AREA Km2	NESTS Per Km2	COUNT	AREA Km2	NESTS Per Km2	COUNT	AREA Km2	NESTS P/Km
LAKE FRINGE	36	20.4	1.76	18	20.4	0.88	23	21.1	1.09	34	21.1	1.61
OVERGROWN OXBOWS + CHANNELS	8	11.7	0.68	8	11.7	0.68	8	14.2	0.56	13	14.2	0.91
SCROLL	6	8.6	0.69	9	8.6	1.04	12	10.5	1.14	10	10.5	0.95
TOTAL	50	40.7	1.22	35	40.7	0.85	43	45.8	0.93	57	45.8	1.24

\*Due to the inclusion of new sites the data for 1982 (FW) and 1983 (SW) are tabulated to show the results for the same route as the previous year as well as the result on the full route used then and in subsequent.

HABITAT NESTING INDICES

HABITAT	1982	1983	1984	WEIGHTING
LAKE FRINGE	100	50	74	0.31
OV. OXBOW/ CHANNELS	100	100	163	0.36
SCROLL	100	150	125	0.33



THE MIDDLE SEPIK RIVER AREA OF PAPUA NEW GUINEA

Numbers refer to survey sites as in Tables 2 & 4

Figure 1.



Figure 2  
 FRESHWATER CROCODILE NESTS ON KAMIEUJ OVERGROWN OXBOW HEAD SEPIK

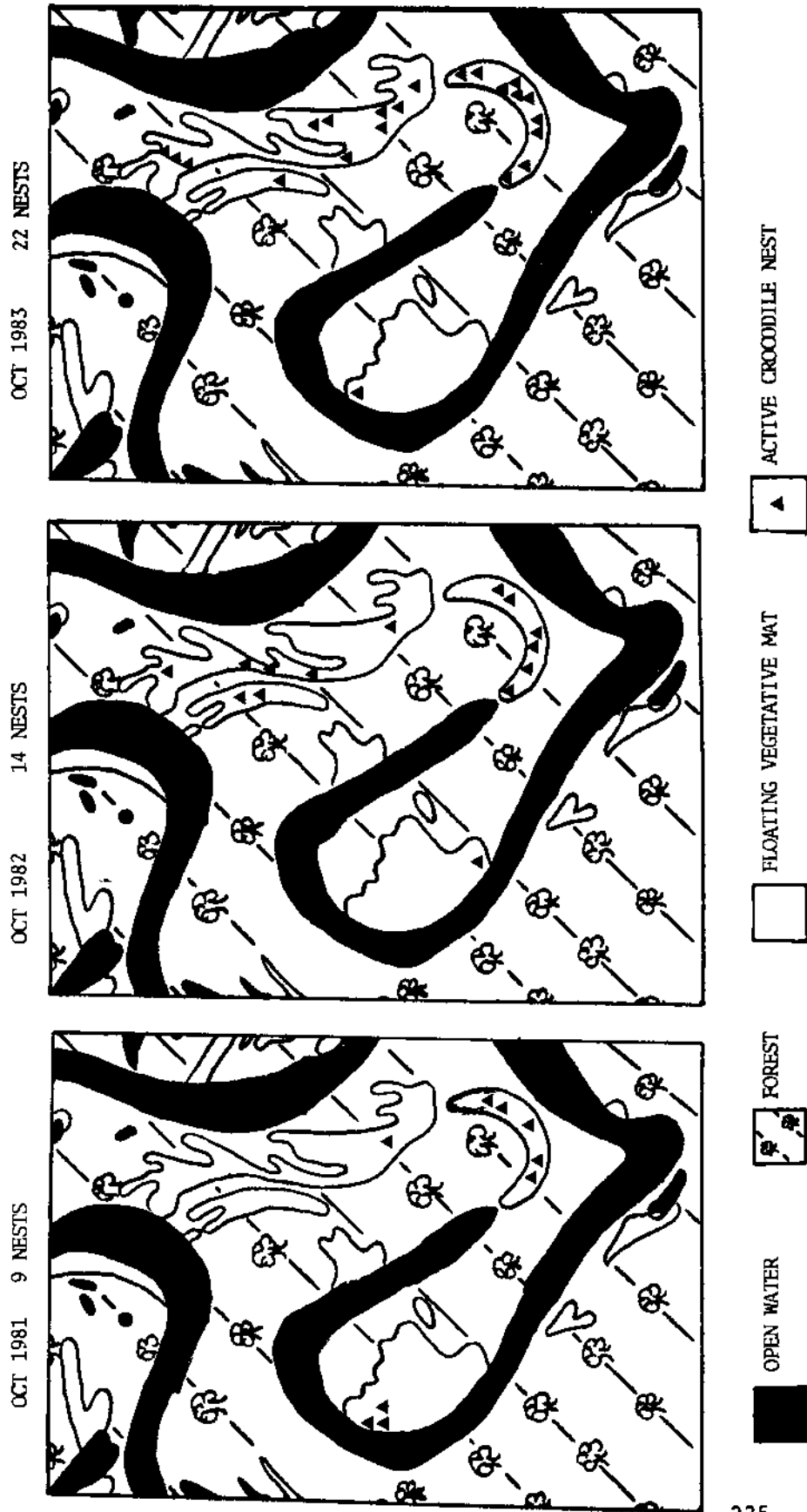


Figure 3

TOTAL CROP OF FRESHWATER (x—x) AND  
SALTWATER (o----o) CROCODILES TAKEN IN  
PAPUA NEW GUINEA DURING 1976 - 83.

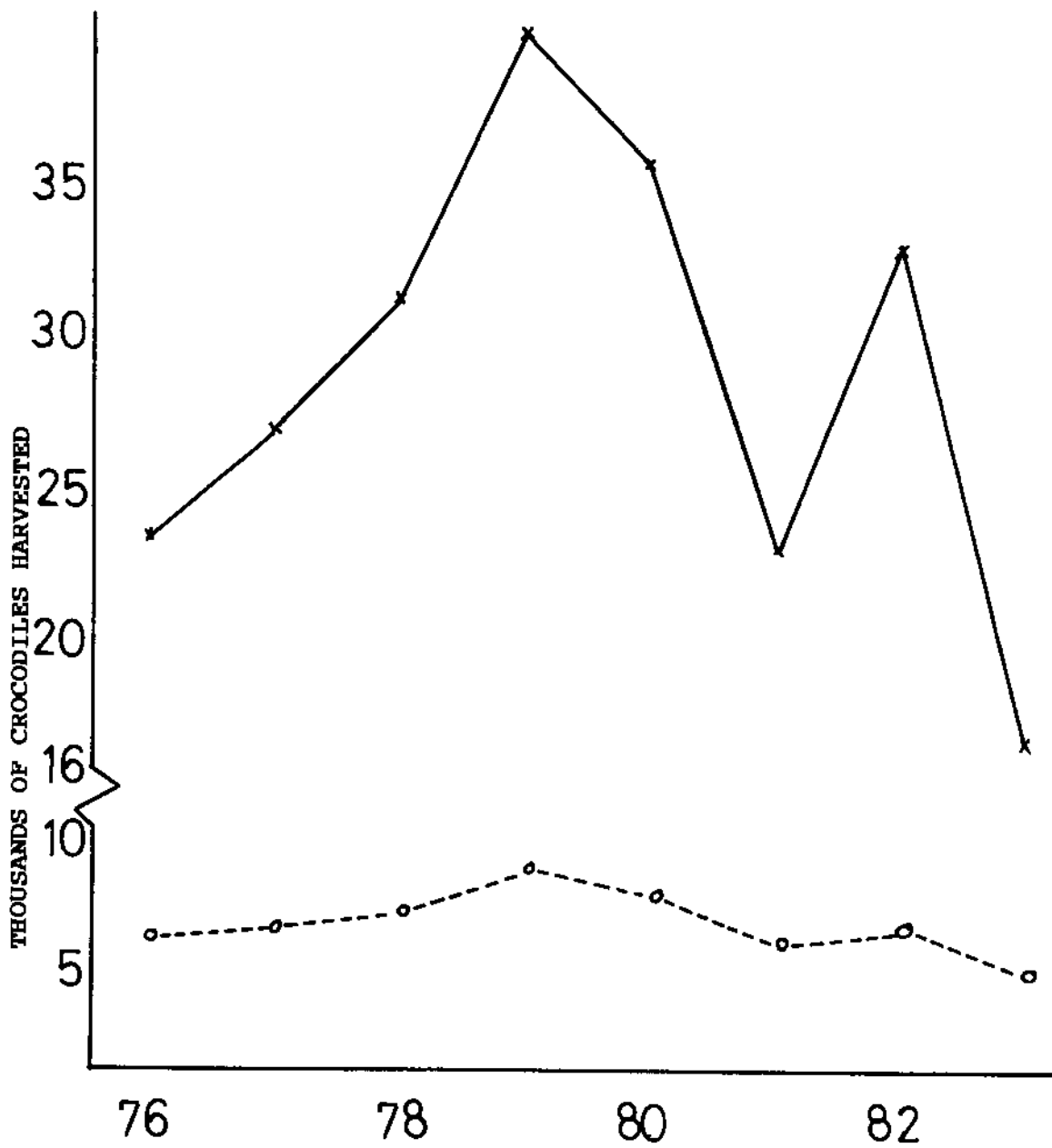


Figure 4

AVERAGE SIZE ( INCHES BELLY WIDTH ) FOR WILD  
SKINS BETWEEN 9 - 20 INCHES DURING 1976 - 1983

FRESHWATER (O----O)

SALTWATER (X—X)

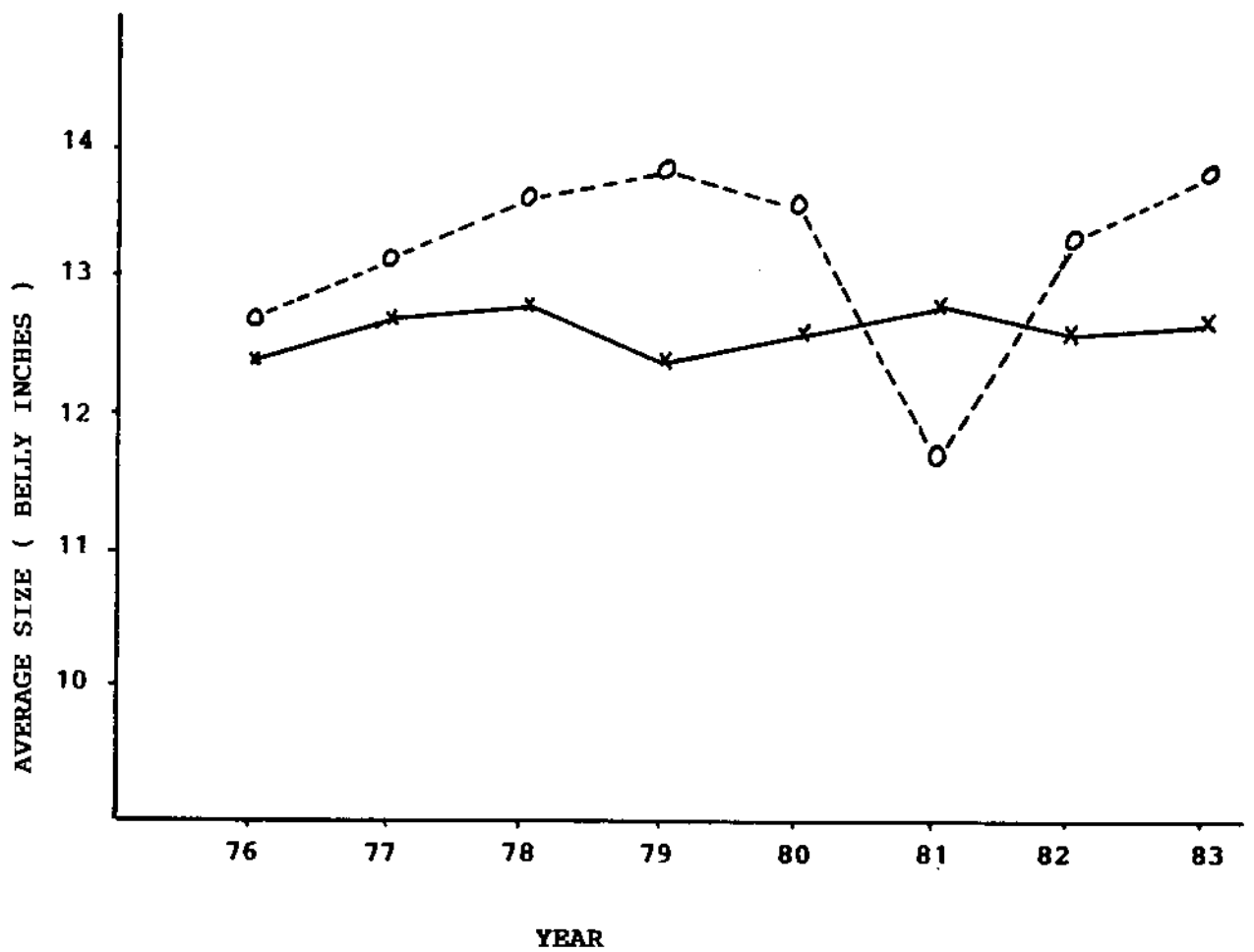
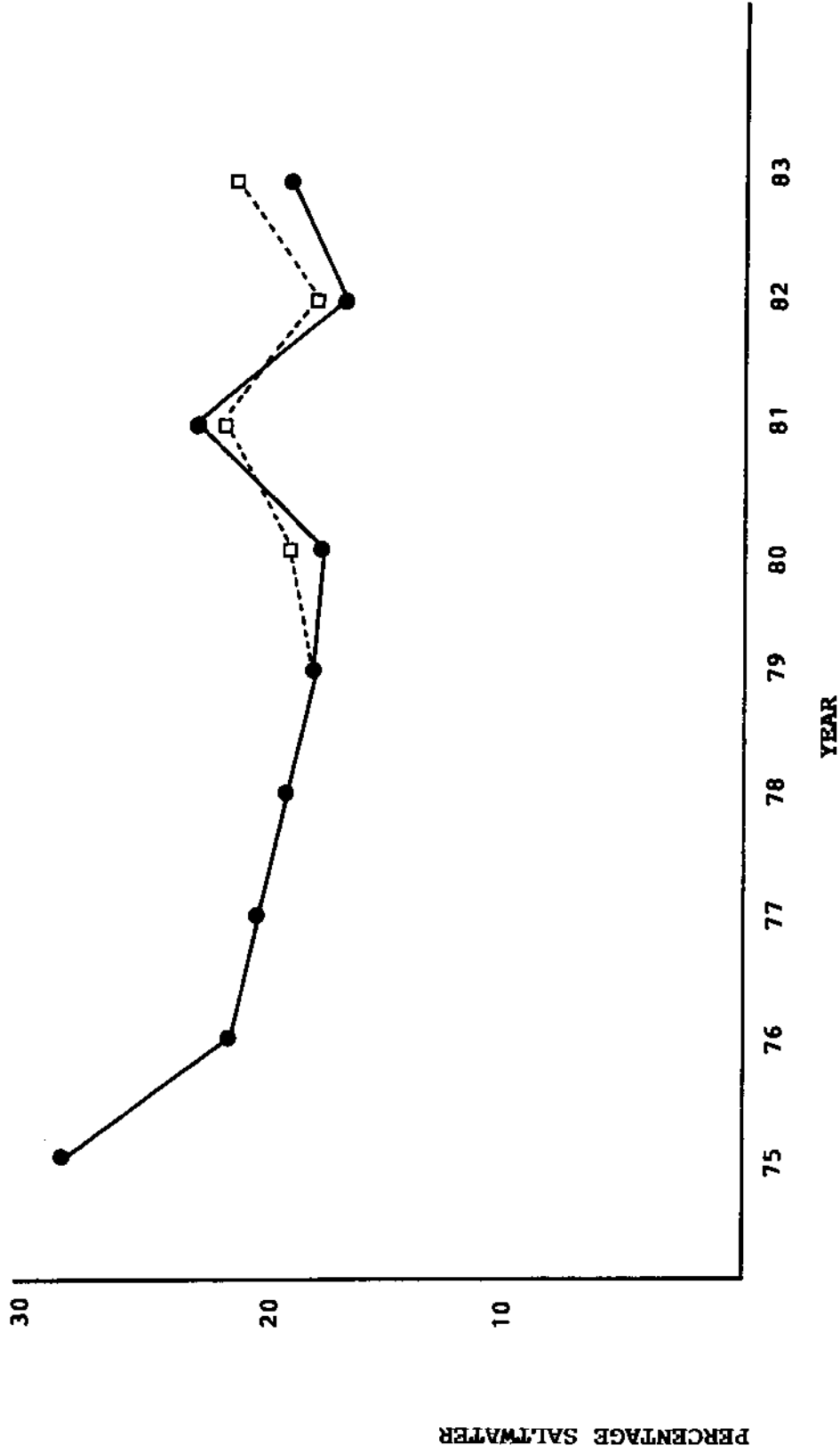


FIGURE 5

SALTWATER CROCODILES AS A PERCENTAGE OF THE EXPORTS (●—●—●)  
AND THE CROP (□-·-·-□).



CROCODYLUS POROSUS - A TEN YEAR OVERVIEW: THE POPULATION  
MODEL AND IMPORTANCE OF 'DRY WET' SEASON AND STATUS,  
MANAGEMENT AND RECOVERY

H. Messel, G.C.Vorlicek, W.J. Green and I.C. Onley  
Department of Environmental Physics,  
School of Physics,  
University of Sidney  
Australia, 2006

(Note: This paper is to from part of monograph 18  
To be published during 1984)

## CONTENTS

1. ABSTRACT
2. INTRODUCTION AND THE POPULATION MODEL
3. LIVERPOOL-TOMKINSON RIVERS SYSTEM, JULY 1-6 and OCTOBER 13-18 1983 SURVEYS
  - 3.1 July 1983 survey
  - 3.2 October 1983 survey
  - 3.3 An eight year overview
4. BLYTH-CADELL RIVERS SYSTEM, JULY 15-18 and OCTOBER 26-29 1983 SUVEYS
  - 4.1 General
  - 4.2 July 1983 survey
  - 4.3 October 1983 survey
  - 4.4 A ten year overview
5. THE TIDAL WATERWAYS OF ROLLING AND JUNCTION BAYS, JUNE 18-21 and OCTOBER 1-4, 1983 SURVEYS
6. ALTERNATIVE HABITAT
  - 6.1 Anamayirra and Beach Creeks, June 27-28 and October 10-11 1983 surveys
  - 6.2 Toms Creek, July 1 and October 13, 1983 surveys
  - 6.3 Crab Creek, June 25 and October 20, 1983, surveys
  - 6.4 Cadell Big and Cadell Gardens Billabongs, June-July and October 1983 surveys
  - 6.5 Extreme upstream section of Blyth River km.49.8-59 and billabong km.60.6-64.6, July 11-12 and October 23-24,1983 surveys
  - 6.6 Upstream Liverpool River, km 60-66.4, June 29 and October 8, 1983 surveys
  - 6.7 General
7. NGANDADAUDA CREEK, JUNE 26 and OCTOBER 12, 1983 SURVEYS
8. GLYDE RIVER - ARAFURA SWAMP
  - 8.1 July 7-8, 1983 survey
  - 8.2 October 6-8, 1983 survey
9. DISCUSSION
  - 9.1 'Dry wet' seasons
  - 9.2 An overview for the monitored waterways in the Maningrida area
  - 9.3 Recovery of the C. porosus population
  - 9.4 Management of the C. porosus population
10. ACKNOWLEDGEMENTS
11. REFERENCES
12. TABLES
13. FIGURES

Message to the Reader" Before reading this paper please turn to Tables 4 to 7 and in each case spend several minutes carefully looking down the numbers in each column. Then read on

## 1. ABSTRACT

This paper provides the overall results for 10 years of spotlight surveys carried out in the tidal waterways in the Maningrida area of northern Arnhem Land.

In previous publications we have developed a model of the dynamics of C. porosus populations on the tidal waterways of northern Australia, based on the results of repeated censuses. In this paper, by utilizing the results of additional surveys carried out in our monitoring area in June-July and October 1983, further confirmation and refinement of the basic features of the model is obtained and more is added to our already detailed understanding of population changes in the monitoring area. This paper focuses particular attention on a question raised in our previous paper: what role do 'dry wet' seasons play in determining observed influxes of (3-6') and especially large C. porosus onto the main sections of the tidal waterways and where do the animals come from? The wet season of 1982-83 was a 'dry' one, as was that of 1981-82, and this has enabled a detailed analysis, based on our model, of the population dynamics during such periods.

We found it essential to carry out surveys, in both June-July and October, of two additional systems last surveyed in 1979, Ngandadauda Creek and the Glyde River. Extensive aerial surveys of the large Arafura Swamp, draining the Glyde, were also carried out. With these additional surveys, we believe we have essentially unravelled the importance of 'dry wet' seasons in the dynamics of C. porosus populations in our monitoring area. There is very considerable interaction between our monitoring area and the Arafura Swamp, some 150 km away by water. Animals forced out due to the drying back of the swamp habitat have moved into our monitoring area and a proportion have remained, giving rise to an increase in the number of large animals in the systems. Some of these animals may well have been originally recruited in our monitoring area.

We also review the results of some ten years' work on the 330 km of tidal waterways in the monitoring area. The results and analysis of this work clearly indicate that further work in this area would yield little new knowledge in the short-term and we will now shift our attention to another section of northern Australia, to check whether our model is applicable there and if it is not, then to develop it further. Different estimates are given for the very high losses (but it is at least 70%) that we have found as C. porosus grows to sexual maturity, and these mostly account for the essentially unchanged number of (3-6') animals and for the only small increase in large animals that we have found over ten years. It is almost as if there were a set number of territories or slots in a river system, and the crocodiles themselves are primarily responsible for the very high losses that occur in the process of trying to secure these slots or to increase them in number. After reviewing prospect for recovery and management of Australia's C. porosus population, we feel we can realistically and unfortunately conclude only this about the saltwater crocodile's future:

IT HAS NONE

## 2. INTRODUCTION AND THE POPULATION MODEL

It is twelve years since the University of Sydney Crocodile Research Group commenced its study of Crocodylus porosus in northern Australia. The results of this lengthy and extensive study have appeared in numerous publications covering the physiology, nesting, growth, movement, mortality and population structure and status of C. porosus over much of the northern Australian coastline. Our basic work on the status and population dynamics of C. porosus in tidal waterways up to and including 1979 has been presented in a series of 17 monographs and 2 reports by Messel and his co-workers (Messel et al. 1979-1982).

Intensive population surveys and studies were continued during 1980, 1981, 1982 and 1983 on some 330 km of tidal waterways (Figs. 1 to 3) centred on our northern Arnhem Land headquarters at Maningrida on the Liverpool-Tomkinson Rivers System (Monograph 7, also see pages 14, 15 and 440-446 Monograph 1 where the results of the 1980 and 1981 surveys appear as addenda). The results of the 1979-1982 surveys were analysed and discussed in a paper entitled "The continuing and mysterious disappearance of a major fraction of sub-adult C. porosus from tidal waterways in northern Australia" presented to the 6th Working Meeting of the IUCN/SSC Crocodile Specialist Group at St. Lucia, South Africa, September 28-30, 1982. The results of our October 1982 surveys appear as an Appendix to the above paper. For brevity, we shall refer to the paper and appendix as the "St. Lucia 1982" paper.

The model which we have built up (see especially Chapter 6, Monograph 1 and Monographs 5, 7, 9, 10, 11, 16 and 17) and have been refining as more data is obtained, enables us to account in a consistent fashion for the vast store of field observations and results we have accumulated for some 100 tidal waterways in northern Australia. It also enables us to predict successfully, results to be expected on future surveys -as we did in July 1982 when we made predictions about the decrease in the number of small and/or large C. porosus which would be sighted in October 1982, on the 330 km of tidal waterways monitored in the Maningrida area. The model runs as follows:

The tidal waterways of northern Australia have been classified according to their salinity signatures into TYPE 1, TYPE 2 and TYPE 3 systems as delineated in Chapter 3, Fig. 3.4.11A of Monograph 1 (pages 100 and 101). TYPE 1 systems are the main breeding ones and non-TYPE 1 systems are usually poor or non-breeding systems. It is the TYPE 1 systems and the freshwater billabongs and semipermanent and permanent freshwater swamps associated with them which account for the major recruitment of C. porosus; the other systems contribute to a lesser degree and they must depend largely upon TYPE 1 systems and their associated freshwater complexes for the provision of their crocodiles. Non-TYPE 1 systems also sometimes have freshwater complexes associated with them but these are normally quite minor.

In Table 9.2.1 (page 419) of Monograph 1, our results show that in TYPE 1 systems some 27% of the crocodiles sighted are hatchlings (of which some 50% are normally lost between June of one year and June of the next, page 394 Monograph 1), whereas in TYPE 2-3 systems this figure falls to 14% and in TYPE 3 systems down to 4%, showing a much decreased hatchling recruitment in non-TYPE 1 systems. In TYPE 3 systems the percentage of



crocodiles in the hatchling, (2-3') and (3-4') size classes combined is some 11% whereas in TYPE 1 systems it is at least 52%. On the other hand the percentage of crocodiles in the (4-5') size classes is some 39% in TYPE 1 systems and 73% on TYPE 3 systems. Some 79% of the non-hatchling crocodiles are sighted on TYPE 1 waterways and 21% on non-TYPE 1 waterways (page 419 Monograph 1).

The relatively few large, and more frequent small freshwater billabongs and semipermanent and permanent freshwater swamps associated with tidal waterways are known to contain C. porosus but have not been inventoried systematically, except in a few cases. The accurate extent of their non-hatchling C. porosus populations is unknown. Based upon the fact that the number of large freshwater swamp areas, with substantial water (normally bordering old river channels), in northern Australia is very limited -perhaps 400 km<sup>2</sup> maximum- and upon limited observations, we estimated that in 1979 the non-hatchling C. porosus population was less than 20% of the non-hatchling population sighted in tidal systems (page 433 Monograph 1, note error on page 433 when the statement "less than 20% of the population sighted in TYPE 1 tidal river systems" is made, and again in the Table below it; the words 'TYPE 1' should have been omitted. The figure of 836 is based on 20% of the number of non-hatchling sighted in tidal systems). We now believe that that the 20% figure was an overestimate for 1979 -an unusual year associated with one of the 'driest wet' seasons on record.

It appears that the populating of non-TYPE 1 systems (hypersaline or partially hypersaline coastal and non-coastal waterways) results mostly from the exclusion of a large fraction of the sub-adult crocodiles from TYPE 1 systems and any freshwater complexes associated with them. Adult crocodiles appear generally to tolerate hatchling, (2-3') and sometimes even (3-4') sized crocodiles in their vicinity (but not always -they sometimes eat them, page 43 Monograph 14- or kill them, page 334 Monograph 1), but not larger crocodiles. Thus once a crocodile reaches the (3-4') and (4-5') size classes, it is likely to be challenged increasingly not only by crocodiles near or in its own size class (pages 454-458 Monograph 1) but by crocodiles in the large size classes and to be excluded from the area it was able to occupy when it was smaller. A very dynamic situation prevails with both adults and sub-adults being forced to move between various components of a system and between systems. Crocodile interactions or aggressiveness between crocodiles in all size classes increases around October -during the breeding season (page 445 Monograph 1 and St. Lucia 1982) and exclusions, if any, normally occur around this period. A substantial fraction (80%) of the sub-adults, mostly in the (3-6') size classes but also including immature larger crocodiles, are eventually excluded from the river proper or are predated upon by larger crocodiles. Of those crocodiles that have been excluded, some may take refuge in freshwater swamp areas and billabongs associated with the waterway from which they were excluded or in the waterways' non-TYPE 1 creeks if it has any. Others may travel along the coast until by chance they find a non-TYPE 1 or another TYPE 1 waterway, however in this latter case they may again be excluded from it; others may go out to sea and possibly perish (perhaps because of lack of food, as they are largely shallow water on edge feeders, or they may be taken by sharks). Those finding non TYPE 1 systems, or associated freshwater complexes, frequent these areas, which act as rearing stockyards, for varying periods, until they reach sexual maturity, at which time they endeavour to return to a

TYPE 1 breeding system. Both sub-adults and just mature adults might attempt to return and be forced out of the system many times before finally being successful in establishing a territory in a TYPE 1 system or in its associated freshwater complex. Crocodiles may have a homing instinct (this important point requires further study) and even though a fraction of crocodiles may finally return to and remain in a TYPE 1 system or in its associated freshwater complex, the overall sub-adult numbers missing -presumed dead- remain high and appear to be at least 60-70%. Since a large fraction of the crocodiles sighted in non-TYPE 1 systems must be derived from TYPE 1 systems and their associated freshwater complexes, they are predominantly sub-adults or just mature adults (page 431 Monograph 1).

Normally, the freshwater complexes (swamps and/or billabongs) associated with tidal systems, are found at the terminal sections of small and large creeks running into the main waterway, or at the terminal sections of the mainstream(s). Though this alternative habitat is usually very limited in extent, sporadic (and sometimes yearly) nesting does take place on it. There are, however, several fairly extensive freshwater complexes associated with TYPE 1 tidal systems and these are important as they may act both as rearing stockyards and as breeding systems, just as the TYPE 1 waterway does itself. Examples of these are the Glyde River with the Arafura Swamp (Monograph 9), the Alligator Region Rivers with their wetlands (Monographs 4 and 14), and the Daly, Finnis, Reynolds and Moyle Rivers with their wetlands (Monograph 2). Not only can the loss factor, which appears to occur during the exclusion stage, be expected to be lower for movements into and out of swamp areas associated with a TYPE 1 waterway, than for movement into and out of coastal non-TYPE 1 systems, but the loss of nests due to flooding can also be expected to be less. We have observed nests made on floating grass cane mats in the Daly Aboriginal Reserve area. Thus recovery of the C. porosus population on TYPE 1 tidal waterways, with substantial associated freshwater complexes, can be expected to be faster than on other systems (page 445 Monograph 1, page 98 Monograph 14).

Though we are confident about the correctness of the basic structure of the above model, this is not to imply that amendments will not be necessary in the future as more data become available. Every good model should be capable of refinement and improvement, based upon further systematic and accurate observations.

The following additional important results, some of which have been only partly incorporated into the model itself, are understandable on the basis of it (pages 14, 15, 440-446 and Chapters 6 and 9 Monograph 1, St. Lucia 1982):

1. Because of the 80% exclusion and at least 60-70% losses of sub-adult crocodiles as they proceed toward sexual maturity, there has been no significant sustained increase in the non-hatchling C. porosus population on the tidal waterways of our monitored area in northern Australia since the commencement of our systematic surveys, a period of ten years.

2. Assuming the results from our monitored area apply elsewhere, any significant sustained increase in the non-hatchling C. porosus populations on the tidal waterways of northern Australia must be measured in decades.
3. Though there has been no sustained significant increase in the number of non-hatchling crocodiles sighted on the tidal waterways since our surveys started in 1974, the size structure of the animals sighted appears to be changing slowly. Notwithstanding substantial fluctuations, the ratios of small (2-6') to large (>6'), and (3-6') to large animals is decreasing on the Blyth-Cadell, may be decreasing on the Liverpool-Tomkinson and is decreasing overall on the tidal waterways of the Maningrida monitoring area. Thus there is some indication of the commencement of a slow recovery phase. However even this could be open to dispute.
4. Though there are wide fluctuations, especially after 'dry wet' seasons when the animals are concentrated into the tidal waterways, it appears that as the number of large crocodiles in a tidal waterway, increases, there is a tendency for the number of sub-adults in the (3-6') size classes to decrease or increase marginally only. Thus the total number of (3-6') and large animals sighted appears generally to be holding steady or increasing slowly only. It is almost as if there were a set number of territories or slots in a river system, and the crocodiles themselves are primarily responsible for the very heavy losses of 70% that occur in the process of trying to secure these slots or to increase them in number.
5. When a steady state is reached in a 'recovered' population, the ratio of (3-6') to large animals might be considerably less than one.
6. If one considers a group of 100 of the sub-adult crocodiles in a TYPE 1 tidal system, one can expect some 80 to be excluded from it, at least 60-70 to end up missing -presumed dead, less than 15-20 to successfully establish territories on the system without having to leave it and the remainder might eventually also return and establish a territory when becoming sexually mature. The very nature of this matter is such as to preclude precise figures and they must be looked upon as broad estimates only, however study of Tables 4, 5, 6 and 7 now indicates that the missing-presumed dead figure is likely to be in excess of 70.
7. When there is an exclusion of sub-adult animals, mostly (3-6') in size but also including larger immature animals, this takes place mainly in the breeding season, normally commencing around September-October and apparently lasting throughout the wet season. Any influx of animals, in the (3-6') and/or large size classes, appears to occur in the early dry season and to be completed in the Hune-early September period, but may in some years be earlier.
8. After a single 'dry wet' season there is a substantial influx of large and sometimes (3-6') animals, forced out of freshwater complexes, into the tidal waterways and these are sighted during June-July surveys. Surveys made in October-November of the same year, usually reveal a substantial decrease in the number of (3-6') and/or large animals sighted, however the number of large animals sometimes remains higher and hence a number of the new large animals do not return, to from whence they came.

These animals appear successful in establishing a territory on the waterway, and it could be the waterway from which they had originally been excluded. The 'dry wet' variation in the number of animals sighted appears to be superimposed upon the variations normally found during surveys following usual wet season -which generally result in extensive flooding on the upstream sections of the tidal waterways. Hatchling recruitment on the tidal waterways is generally greatly enhanced during 'dry wet' seasons but appears to be greatly reduced in major swamp habitat. The reverse appears to be true during normal or heavy wet seasons.

Observation 8 indicates the important role which 'dry wet' seasons play in the dynamics of C. porosus populations and this is the main subject of the present paper, which also reports the results of our June-July and October 1983 surveys and gives an overview of the surveys carried out over the past ten years in our monitoring area.

It is fortunate that we continued to monitor the tidal waterways after 1970. If our survey programme had been discontinued at the end of 1979, it would have been natural to interpret the significant increase, between the 1975 surveys and the 1979 resurveys, in the non-hatchling C. porosus population sighted on a number of major tidal waterways, as indicating the commencement of a sustained recovery in the population (Chapters 6 and 9 Monograph 1, then also see pages 440-446). The results of the October 1980 resurvey of some 330 km of tidal systems in our Maningrida monitoring area, and of the resurveys made in June-July and October - November in each succeeding year indicates that such an interpretation would have been premature. One is viewing an exceedingly complex and dynamic situation in relation to C. porosus populations, which apparently does not lend itself to facile interpretations and answers.

Not only were we fortunate in continuing our survey programme after 1979, but we were also lucky in that the 'driest wet' on record, that of 1978-1979, was followed by two usual wet seasons, those of 1979-1980 and 1980-1981. These in turn were followed by two consecutive 'dry wets', those of 1981-1982 and 1982-1983. Though the latter 'dry wets' were not as dry as that of 1978-1979, we again observed in 1982 a repetition of the events given in (8) above, in relation to the influx and departure of (3-6') and/or large crocodiles. Two major questions quickly come to mind; where did the influx in 1979 and again in 1982 of (3-6') and large crocodiles come from and where did they go to when they left? What happened to these temporarily missing (3-6') and large animals?

By the end of the 1980 surveys, it was already becoming evident that in order to eliminate some of the many possible answers, we would have to survey all possible C. porosus habitat to which we could gain access in our monitoring area. This was a daunting task and a helicopter would be required to ferry survey boat and staff to many of the areas. Pragmatic cost considerations, as well as the logistics and time and effort involved -especially after already having spent some 10 years working on C. porosus on the tidal waterways of one of the world's most remote areas -made us wonder whether further understanding of the dynamics of C. porosus populations really warranted the money and enormous effort required. Each of the two annual resurveys made of the waterways in our monitoring area requires over 1,000 km of survey boat travel at night and 20 hours of helicopter flying time. The 'dry wet' of 1981-1982

settled the issue, again bringing about an influx of (3-6') and large animals into the tidal waterways of our monitoring area. The decision to continue for two further years was probably correct, for we believe we have essentially unravelled another important component of the dynamics of C. porosus populations.

The success of our model in being able to account in a consistent fashion for the data resulting from the repeated night surveys of the tidal waterways and their associated freshwater complexes in the Maningrida area on the northern Arnhem Land coast, and to successfully predict results of surveys, indicates that it would now be more rewarding scientifically to shift our centre of studies. It is unlikely that a further 4 years' study on the waterways in the Maningrida area would add much to the picture gained over the past 10 years. Furthermore, the senior author (HM) retires from the University of Sydney in 4 years' time and it is most important that before that happens we determine whether one is justified in extrapolating the conclusions, gained from the study of C. porosus on some 460 km of waterways in the Maningrida area (Tables 1 and 8, Figs. 1 to 5), to tidal systems elsewhere on the coast of northern Australia. We believe that one can do so, but this point must be tested and it will take the 4 years to do so.

The University of Sydney Crocodile Research Facility at Maningrida was closed in November 1983, after functioning in this remote and costly area for some 11 years. From 1984 onwards our studies will concentrate on the waterways of the southwestern Gulf of Carpentaria (Monographs 12 and 13) using our excellent research facility at Urapunga on the Roper River (page 440 Monograph 1). We may also resurvey a number of other important tidal systems which we have not resurveyed since 1979.

### 3. LIVERPOOL-TOMKINSON RIVERS SYSTEM, JULY 1-6 and OCTOBER 13-18, 1983 SURVEYS

The 1983 surveys of the Liverpool-Tomkinson System (Figs. 1 and 2) were particularly important because this was the first occasion, since our research programme commenced 12 years ago, that there have been two consecutive 'dry wet' seasons, those of 1981-1982 and 1982-1983. These coincided with the now famous El Niño weather pattern which drastically changed weather conditions in many areas of the world. The results of the surveys are shown in Tables 1, 2, 3, 5, 7 and 8.

#### 3.1 July 1983 survey

We sighted a total of 54 large animals during our July 1983 survey (the same number as in July and October 1981), compared to 69 on the October 1982 one. On the Liverpool mainstream we sighted 7 large animals less, on the sidecreeks 7 less, and 1 less on the Tomkinson River (Table 5). This decrease was not unexpected. In the Appendix to the St. Lucia 1982 paper, we pointed out that the number of large animals sighted on the System, during the October 1982 survey, had not yet decreased and that this was largely due to the large animals entering the sidecreeks of the Liverpool-Tomkinson System, probably on their way out. Apparently, as predicted, the exclusion from the System eventually did occur. Where did the excluded animals go?

No overall increase in the number of large animals frequenting the tidal waterways of Rolling and Junction Bays (Fig. 1) was sighted during the June 1983 survey -in fact 3 less were seen (Tables 6 and 7). Examination of Table 8 also reveals that additionally there may have been 3 large animals missing from the alternative habitat associated with the Liverpool-Tomkinson System. Thus, what happened to the missing 15-21 large animals? On the basis of our model we must assume some are probably missing -presumed dead- some may have entered the Blyth River and some may be temporarily frequenting the tidal waterways of the Milingimbi Complex (Monograph 9, also see DISCUSSION later). One thing is certain; if the excluded large animals were in the process of returning to swamp habitat after October 1982 -such as the Arafura and/or smaller swamps- they could not have returned for long, because the second 'dry wet' ensured that the water levels were eventually just as low as that which forced them out in the first instance. Thus some of the excluded animals were probably temporarily frequenting the Blyth-Cadell System and/or the Milingimbi Complex until freshwater levels rose sufficiently for them to return to swamps- though this return could be temporary also.

Tables 1, 2, 3 and 5 show the number of small animals sighted during the July 1983 survey. At first sight, the jump from 171 small animals (2-6') sighted during the October 1982 survey to 257 on the July 1983 one, looks spectacular. However, matters are not as good as they seem. Of the increase of 86 small animals, Table 1 shows that some  $(83-16) = 67$  are in the (2-3') size class. In June 1982, 193 hatchlings were sighted and from Table 8.4.1, Monograph 1, one could expect some 45% or 87 of these to be in the (2-3') size class in July 1983 (note that the Blyth-Cadell survivorship figure was also obtained for a 'dry wet', that of 1978-1979). This was approximately so with 83 being sighted. However from our previous results one can expect a large fraction of the increase to disappear once the animals enter the (3-4') size classes. It is to be noted that for reasons unknown to us, but perhaps related to losses being greater during usual wet seasons than during 'dry wet' ones, the 289 hatchlings of July 1979 gave rise to only 51 sightings in the (2-3') size class in October 1980. Unfortunately, we are unable to say how many (2-3') animals there were in June-July of that year as no surveys were made during that period.

Though we include the (2-3') size class in the small animals in order to decrease errors in size estimation, the more meaningful size classes to consider are those in the (3-6') range. This is so because it appears that it is crocodiles in these size classes which are most susceptible to exclusion and loss from the tidal waterways; interactions between crocodiles generally increase with size. Note however that caution is required when interpreting data for an individual size class or small group of size classes because of inevitable error in size class determination. On June surveys one can sometimes classify animals just in the (3-4') size class as (2-3') animals thus yielding too large a number of (2-3') animals and too few (3-4') ones (page 335 but also pages 80 and 389 Monograph 1).

Examination of Table 5 shows that for the Liverpool-Tomkinson System, the number of (3-6') animals sighted during the July 1983 survey was 174, compared to 178 in June 1982 and 155 in October 1982. The number of (3-6') crocodiles sighted on the July 1983 survey thus appears to have returned almost to the June 1982 survey figure. The number of

(3-6') animals sighted on the Liverpool mainstream, km 3-60, was 59 in June 1982, 78 in October 1982 and 67 in July 1983; on the sidecreeks the number were 34, 28 and 35; and on the Tomkinson River, km 17-73.7, the numbers were 85, 48 and 71 respectively.

Our field data enables us to analyse every section of the river system surveyed, even down to fractions of a km and we are able to follow changes on various sections of the waterway. For instance, one could easily see from the October 1982 survey results that the increase, since the June 1982 survey, of the 19 (3-6') crocodiles sighted on the Liverpool mainstream sections (mainly in the vicinity of the mouth of the Tomkinson River, see Appendix, St. Lucía 1982), probably mostly came from the mouth sections of the Tomkinson River and from Mungardobolo Creek, where decreased numbers were sighted (Fig. 2). Likewise, essentially the same phenomenon appears to have occurred in reverse when one compares the October 1982 data with that of the July 1983 survey.

One point which stands out strongly from our data (Table 5) is that the Tomkinson River, the present main breeding area of the Liverpool-Tomkinson Rivers System, is where many of the major changes in the population of hatchlings, (2-3') and (3-6') crocodiles occur. The number of large animals sighted on the Tomkinson has remained fairly constant since 1976, first hovering around the 20 figure and then around 24 since 1979 with fluctuations up and down on these. Changes in the number of large animals sighted occur also on the Liverpool mainstream and its sidecreeks and there is little doubt that some large animals are excluded from the System and later re-enter it. Since hatchling recruitment on the Liverpool is very low, the fact that one sights over 60 (3-6') animals on it each year shows that these must come largely from the Tomkinson. Some of the small, and especially animals in the (3-6') size classes, may also leave the Liverpool-Tomkinson System (for instance see the results for Toms Creek, Table 8), but the Liverpool-Tomkinson has a number of alternative unsurveyed habitats (St. Lucía 1982), such as the extreme upstream section of the Tomkinson beyond km 81.3 and numerous tiny creeks, for the animals to hide and take haven in. Thus a substantial fraction of the (3-6') animals missing on the October 1982 survey may have never left the waterway, and these could easily constitute some of the additional 19 (3-6') animals sighted in July 1983 (Table 2). This picture differs considerably from what is observed on the Blyth-Cadell Rivers System, where both the small and large animals have only very limited alternative habitat within the System and thus a large fraction of the sub-adults excluded from the mainstream have little choice but to leave the System.

Hatchling recruitment on the Liverpool-Tomkinson over the 'dry wet' of 1978-1979 appears to have been excellent, with 24, 5 and 260 hatchlings being sighted on the Liverpool mainstream, sidecreeks and Tomkinson River, respectively, on the July 1979 survey. Following the 'dry wet' of 1981-1982 there was again a major input of hatchling with 178 being sighted on the Tomkinson during the June 1982 survey (Table 5). Then came the second consecutive 'dry wet', that of 1982-1983, and one would again have expected heavy hatchling recruitment. However this was not to be. Why this was so, we do not know. Only 91 hatchlings were

sighted on the Tomkinson, but hatchling recruitment was up slightly on the Liverpool mainstream where we sighted 27 on the July 1983 survey. Could be that some of the females do not nest each year, or could it be that some nest more than once in a wet season? Could it be that food supply is the proximal factor involved? Perhaps the second consecutive 'dry wet' resulted in a substantial decrease of available food and hence some of the females did not nest since their condition factor might already be low at the onset of the second 'dry wet' season? This would not necessarily be so at the beginning of a first 'dry wet'.

We now return to a further perplexing matter which we discussed at some length in the St. Lucia 1982 paper. This is the matter of nesting on the Liverpool mainstream and the Tomkinson River. From our capture programme of 1973, 1974 and 1975 we know definitely that there were at least 62, 34 and 60 hatchlings on the Liverpool mainstream during those respective years (Tables 7.2 to 7.4, page 59 Monograph 7) and that on the Tomkinson River there were respectively 55, 53 and 10 hatchlings. In 1972 one of the authors (HM) sighted over 100 hatchlings on the Liverpool mainstream and 44 (2-3') animals were caught on it in 1973. After one of the largest floods ever recorded, over the 1975-1976 wet season, very few hatchling were sighted -only 19 on the overall Liverpool-Tomkinson System, during the July 1976 survey (Table 5). Thereafter low hatchling recruitment persisted until 1979 when 260 hatchlings and 24 large animals were sighted on the Tomkinson during the July survey. On the Liverpool mainstream only 24 hatchling were seen; however 29 large animals were sighted. Thereafter, hatchling recruitment remained low on both the Liverpool and Tomkinson, until the 'dry wet' of 1981-1982 when, during the June 1982 survey, 7 hatchlings only and 30 large crocodiles were sighted on the Liverpool mainstream and 178 hatchlings and 27 large animals on the Tomkinson. Essentially, we had a repeat of the above along the same lines, over the second consecutive 'dry wet' of 1982-1983.

The Liverpool mainstream has some excellent nesting habitat (Monograph 7); this habitat was utilized during the early 1970s and hatchling recruitment on it was equal to or greater than on the Tomkinson. The Liverpool mainstream and the Tomkinson appear to contain roughly equal numbers of large animals. Why is the major habchling recruitment now taking place on the Tomkinson rather than on the Liverpool mainstream? Why did it change? Again, has food supply something to do with this matter; could the food supply on the Liverpool have decreased, and increased on the Tomkinson? If so, why haven't the breeding animals moved from the Liverpool mainstream to the Tomkinson? We simply do not have the answers to these questions and obviously considerable further research into breeding and nesting is indicated. The purely descriptive field naturalist study stage of breeding and nesting is over. Now the hard questions should be researched.

### 3.2 October 1983 survey

Table 5 summarizes the results obtained form the October 1983 survey series for the Liverpool-Tomkinson System and the first seven entries of Table 8 show the relevant data for surveys of various associated alternative habitats.



On the Liverpool River mainstream and its sidecreeks, the number of animals sighted on the October survey was down on the number sighted during the June 1983 one; 7 hatchlings, 13 (3-6') and 3 large animals were missing; 10 of the missing 13 (3-6') animals were from the sidecreeks.

As in June, again the most important changes occurred on the Tomkinson River. The number of hatchlings sighted dropped from 91 to 40, a fall of 57%. This is to be compared with falls of 45% and 24%, over the same time periods, for the 1979 and 1982 survey series respectively. However, it should be noted that during 1982 there were a number of late nests on the Tomkinson River which hatched after the June survey (Appendix, St. Lucia 1982).

Though the number of hatchlings sighted fell steeply, it is interesting to note that the number of (2-3') animals sighted during the October survey was only one less on the Liverpool mainstream, one more on its sidecreeks and 6 less on the Tomkinson River, than on the June survey. The matter of high hatchling and very low (2-3') losses is considered again in our discussion of the Blyth-Cadell results where the same thing happened.

The number of (3-6') C. porosus spotted was 18 less than on the June survey and in addition 10 (3-6') crocodiles were missing on the extreme upstream km 73.7-81.3 section of the river (Table 8). The number of large animals sighted decreased also, from 24 to 17. This is the largest variation between two consecutive surveys, in the number of large animals sighted on the Tomkinson River, since 1978.

On the overall Liverpool-Tomkinson System there was a decrease from 121 to 63 hatchlings, from 83 to 77 (2-3'), 174 to 142 (3-6'), and 54 to 45 large animals. In addition, on the alternative habitat (Table 8) there was a decrease from 45 to 19 small animals; all of the 26 missing animals were in the (3-6') size class. Thus  $(32 + 26) = 58$  (3-6') and 9 large animals are to be accounted for between the June and October 1983 surveys. Undoubtedly some of the 58 (3-6') animals joined the ranks of the missing -presumed dead and most of the remainder probably took refuge- as appeared to be the case on previous occasions- in the inaccessible sections of the Tomkinson River (upstream of km 18.3) and in the numerous unsurveyable tiny creeks. Of the missing 9 large crocodiles, 7 were missing from the Tomkinson and the decrease was spread fairly uniformly over it. A number of these 7 missing animals are likely to be upstream of km 81.3. Two additional large animals were sighted on Tom's and Maragulidban (km 37.8-42.5) Creeks and 3 additional ones on the extreme upstream Liverpool River section, km 60.0-66.4 (Table 8). Thus, there is no problem in accounting for the 9 large animals missing; they appear to be still in the System but excluded to the alternative habitat. This matter also highlights the importance of comparing results for equivalent survey seasons, that is, breeding and non-breeding versus non-breeding periods whenever possible. For example, October-November surveys should, if possible, be compared with other October-November surveys and not June-July ones.

It is interesting that the influx of both (3-6') and large animals into the Liverpool-Tomkinson System following the 'dry wet' of 1981-1982 was almost totally dissipated by the time of the October 1983 survey

when the number of (3-6') animals sighted was only 9 more than in October 1981 and the number of large animals was in fact 9 less. So far, the outcome of the 1981-1982 and 1982-1983 'dry wets' contrast with that of the 1978-1979 'dry wet', when the number of large animals sighted on the System established itself at a level of around 54 large animals rather than 40 which appeared to be the level before 1979 (Table 5).

### 3.3 An eight year overview

In Figure 6 we have plotted, using Tables 3 and 5, the number of (3-6'), large and their sum (3-6') plus large, or (>3') animals sighted on the 13 surveys of the Liverpool-Tomkinson Rivers System over the past 8 years. As is evident from our population dynamics model and as mentioned previously, the more important size classes are the (3-6'), large and (>3'). A plot of small and non-hatchling crocodiles can be distorted because of temporary variations arising from the input of (2-3') animals after a heavy hatchling recruitment year as after the 'dry wets' of 1978-1979, 1981-1982 and 1982-1983. This variation appears to soon disappear once the animals reach the (>3-4') size classes.

Figure 6 demonstrates vividly the process of dynamic change which we have come to associate with C. porosus populations. Any influx of large and/or (3-6') animals usually occurs in the May-early September period and any exclusion of such animals occurs largely during the breeding season around October. It is in this latter period that many large and (3-6') animals appear to join the ranks of the missing -presumed dead. Aggressiveness between animals of all size classes, whether mating or otherwise, appears to reach a peak during the breeding season.

What can one say about the trend in the number of (3-6') animals sighted on the Liverpool-Tomkinson Rivers System during the surveys of the past 8 years? One does not require any esoteric trend analysis to be carried out to see that there has been but little overall change. We started with some 130 (3-6') animals in July 1976 and ended up with 174 in July, and 142 in October, 1983 with substantial variations in between. There were 140 (3-6') animals sighted during the October 1977 survey. The three substantial increases, one in May 1977 and the two in June 1982 and July 1983, following the 'dry wets' of 1981-1982 and 1982-1983 when the animals were concentrated onto the tidal waterways, had disappeared by October 1983. We are unable to say whether the 'dry wet' instigated increases consist purely of animals originally recruited on the Liverpool-Tomkinson System or whether animals recruited originally in such places as the Arafura Swamp are included. We believe the former to largely be the case.

Following the 'dry wet' of 1978-1979 the number of large animals sighted increased spectacularly, from the 40 sighted on the July 1976 and September 1978 surveys to 74 on the July 1979 one. However by the October survey of that year the number had dropped to 58 and then remained closely the same for the 1980 and 1981 surveys; the October 1981 survey revealed 54 large animals. Following the 'dry wet' of 1981-1982 there was an influx of large animals again but not quite to the same degree as in 1979; the June 1982 survey revealed 67 large animals and the October one, 69. Unsurprisingly and as discussed previously, there was a decrease from 54, instead of an increase in the number of large animals sighted on the Liverpool-Tomkinson System on the July 1983 survey. This

was followed by a further decrease of 9 large animals; 45 were on the October 1983 survey.

Comparing equivalent survey seasons, July 1976 with July 1983 yields an increase of 44 (3-6') and 14 large animals and comparing October 1977 with October 1983 surveys yields an increase of 2 (3-6') animals only, and 20 large ones. OBVIOUSLY THE EXCLUSIONS AND/OR LOSSES OF ANIMALS IN ALL SIZE CLASSES HAVE TO DATE NEARLY EQUALLED THE INPUT. It should be stressed that the large size classes are included; that they also suffer substantial exclusion and/or losses for we know from our recapture work that some (3-6') animals do enter the large size class and yet the overall number of large animals sighted increases marginally only. However the evidence does indicate that some 14 to 20 additional large animals are in the process of successfully establishing a territory in the Liverpool-Tomkinson System.

We have calculated rough estimates for the exclusion and losses of animals previously (for instance Chapter 6 Monograph 1, St. Lucia 1982). These estimates can now be recalculated for the Liverpool-Tomkinson System using data from surveys made over the past 8 years. One can obtain an estimate for the maximum average percentage of hatchlings which survive to the (2-3') stage by taking for each year the maximum number of hatchlings sighted during the surveys of that and doing the same for the (2-3') animals for each succeeding year and dividing the two figures. The maximum average percentage of hatchlings over the past 8 years which reach the (2-3') class is thus found to be (256/699) or 37% on the Liverpool-Tomkinson System.

A broad estimate for the minimum percentage of (3-6') crocodiles which are excluded and/or lost from the System may be obtained by noting (Table 5) that 130 (3-6') and 40 large animals were sighted during the July 1976 survey and that the October 1983 survey revealed 45 large crocodiles only. Each of the (3-6') animals of 1976 would, if they survived, be in the large size class by 1983 and hence the minimum percentage which have been excluded and/or lost (minimum because we have assumed that all the increase originated from the 130) by October 1983 is  $(130-5)/130$  or 96%. It is more useful however to compare surveys made in equivalent periods. The Table below gives the minimum exclusion and/or loss percentage for various important cases.

However one views the matter, the exclusions and/or losses are very high. If one assumes that the 'dry wet' of 1981-1982 and concentrated back into the Liverpool-Tomkinson, practically all of the surviving large animals originally recruited there -and none originating from elsewhere- then 69 to 79% becomes the estimate for the missing -presumed dead 3-6') animals.

Survey Used	(3-6')	Large ( >6')	Minimum % of (3-6') animals excluded and/or lost
July 1976 October 1983	130	40 45	(130-5)/130 or 96%
July 1976 July 1983	130	40 54	(130-14)/130 or 89%
July 1976 June 1982	130	40 67	(130-27)/130 or 79%
October 1977 October 1977	140	25 45	(140-20)/140 or 86%
October 1977 October 1982	140	25 69	(140-44)/140 or 69%

#### 4. BLYTH-CADELL RIVERS SYSTEM, JULY 15-18 and OCTOBER 26-29, 1983 SURVEYS

##### 4.1 General

The eighteenth and nineteenth general surveys of the Blyth-Cadell System (Figs. 1 and 3) were made in July and October 1983. These surveys have been carried out over a span of 10 years and are in addition to the 204 calibration surveys which we made of two 10 km sections of the waterway (Monograph 1). It is no exaggeration to state that we are rather well acquainted with this remote and excellent tidal waterway which is quite different from the Liverpool-Tomkinson System to the west of it. We were fortunate to have been able to concentrate our study, of the dynamics of C. porosus populations, on these two different major tidal waterways. However, the cost of the study in human terms, in such a remote area of Australia has been beyond imagination -aside from the grisly financial aspect. It is unlikely to be repeated.

Our July 1983 survey of the Blyth-Cadell System was in some regards more important than usual. It was following on two consecutive 'dry wets', discussed elsewhere in this paper and our October 1982 survey had indicated that some 28 large animals had been excluded from the System between the June and October surveys of last year. Would we find an increase in the number of large animals sighted? Had some of the excluded animals returned? And if they had returned, where had they returned from? If they hadn't returned, then what happened to them; where were they, if still alive? What about the (3-6') sub-adults, would the number sighted be up or down

and how would they be distributed throughout the System? And how would the number sighted relate to the two consecutive 'dry wets' and tie in with the number of (3-6') and large animals sighted in the other waterways surveyed in June-July 1983? What about hatchling recruitment and survivorship on the Blyth-Cadell after two consecutive 'dry wets', would it be up, down or remain essentially steady? Our July survey would provide answers and/or leads to most of these questions.

#### 4.2 July 1983 survey (Tables 1,2,3,4,7 and 8)

On the matter of the 28 missing large animals from the Blyth-Cadell in October 1982; note that there had been an influx of 28 large animals between the October 1981 and the June 1982 survey (Table 2). It is now apparent that the influx was triggered by the intervening 'dry wet' of 1981-1982, when falling water levels in swamps, both large and small, simply forced the crocodiles back into the tidal waterways -perhaps back to the same tidal waterway from which they were originally recruited. The same events had transpired in 1979 after the 'dry wet' of 1978-1979; we were thus witnessing a replay of the 1979 events after the 'dry wet' of 1981-1982. The results of the many surveys carried out, especially those of 1979 and 1982, left no doubt that both large and (3-6') animals were entering and leaving the Blyth-Cadell System via the mouth of the Blyth River. We now believe that the influx of 35 (3-6') and 32 large animals -and especially those animals in size classes >(5-6'), note especially the 7' animals, Table 1 -sighted in June 1979 and the influx of 28 large and 36 (3-6') animals -especially those animals in size classes >(4-5') -sighted on the Blyth-Cadell during the June 1982 survey were mostly crocodiles forced out of the Arafura Swamp (Figs. 1 and 4) some 130 km by sea and river to the east, which had been acting as a rearing stockyard for them, and that these animals may have originally been excluded from the Blyth-Cadell System on which had been recruited. By the October 1982 survey, 28 large animals were missing from the System, practically all of them from the downstream sections and they must have travelled eastward for we did not sight an increased number of large crocodiles in the waterways surveyed to the west of the Blyth-Cadell or in the alternative habitat surveyed (Table 8).

These animals were probably on their way back to the Arafura Swamp and other minor freshwater complexes via the Milingimbi Complex of tidal waterways. However, a second 'dry wet' intervened and it is likely that the crocodiles remained in the Milingimbi Complex and Glyde River waiting for the usual wet season to raise the water levels in the Arafura Swamp and other small swamps. If this is so, there would be nothing to trigger an influx in 1983 of sub-adults, both small and large, into the Blyth-Cadell System from the hypersaline Milingimbi Complex; 'dry wets' could be expected to have little direct effect upon animals frequenting the hypersaline tidal waterways. On this basis, one would not expect to find a major increase in the number of (3-6') and large animals sighted on the Blyth-Cadell System during the July 1983 survey. On the other hand, if the crocodiles did return to the Arafura Swamp over the 'dry wet' of 1982-1983, then one might expect an influx of the animals again excluded from it. However, the results of our June-July 1983 surveys of the Liverpool-Tomkinson (Table 2) and of the waterways of Junction and Rolling Bays (Table 5) showed no major influx of crocodiles into these

systems. Furthermore the large animals sighted on the Liverpool mainstream and side creeks near its mouth, during the October 1982 survey, appeared, because of their distribution near the mouth, to be on their way out of the waterway. This was confirmed by the results of our July 1983 survey, when a decrease of 15 large animals was found the Liverpool-Tomkinson System. Hence if there was substantial increase in the number of large animals sighted on the Blyth-Cadell on the July 1983 survey then the most likely source of these animals would have to be from those 15 large animals excluded from the Liverpool-Tomkinson System. These animals would normally encounter the Blyth River mouth on their way back to the Arafura Swamp and hence might attempt to enter it. As can be seen from the results in Table 4 this appears to have been the case for 11 additional large animals were sighted. One could thus expect that the October 1983 survey would reveal that most of this increase had disappeared as it is unlikely that any of these additional animals would be allowed to remain in the Blyth-Cadell System, especially if they had originally been recruited on the Liverpool-Tomkinson.

Following the 'driest wet' on record of 1978-1979, we fully expected to find increased hatchling recruitment on the Blyth-Cadell in 1979. However, we were surprised to find that the number of hatchlings sighted on the System during the June 1979 survey was only 123 (86 on the Blyth, 37 on the Cadell), compared to 173 (137 on the Blyth, 36 on the Cadell) sighted during the June 1978 survey (Table 4), which followed a normal wet season with its substantial flooding of the upstream nesting sections of the waterway. This was in contrast to what happened on the Tomkinson River (Table 5) where 260 hatchling were sighted during the July 1979 survey, compared to only 17 sighted on the September 1978 one.

Thus already in 1979 it was evident that even though heavy flooding of nesting habitat almost invariably led to the catastrophic loss of riverside nests laid down during the January-March period, non flooding did not necessarily indicate that increased hatchling recruitment would follow (page 333 Monograph 1). It was obvious that flooding or non-flooding of nests was only one of a number of important factors involved in hatchling recruitment.

This matter has been brought more sharply into focus by the results of our June-July 1983 surveys. In the Section on the Liverpool-Tomkinson System, we discuss the surprising result of sighting only 91 hatchlings on the Tomkinson during the July 1983 survey as compared to 178 hatchlings during the June 1982 one (Table 5) and possible reasons for this result. The wet season of 1982-1983 had been a 'dry wet' as had been the one of 1981-1982 and there had been only minor flooding on the upstream nesting sections of the waterway during both of the wet season. Study of Table 4 for the Blyth-Cadell System makes matters appear even more complex. On the Blyth River mainstream a record 146 hatchlings were sighted and yet on the Cadell River only 9 were seen. What happened? Why the sudden drop on the Cadell River and the sudden increase on the Blyth mainstream? We are unable to answer these questions satisfactorily at present but believe that the level of available food and the condition factors of the animals may well be involved in determining whether they nest early or late in the wet season and whether they nest once or twice or even at all during it.

As shown in Table 2, the number of small crocodiles sighted, increased from 197 in November 1982 to 258 in July 1983. However this increase, significant at the 95% level, consisted of 55 (2-3') and only 6 (3-6') animals. One notes in Table 1 that the 111 hatchlings sighted in November 1982 appear to have yielded 98 (2-3') animals by July 1983. On the basis of hatchling survivorship studies made on the Blyth-Cadell System (Table 8.4.1 Monograph 1) one would have expected about 70% of the hatchlings to have survived and hence to have only sighted some 78 rather than 98 (2-3') animals. On the basis of our model, one might expect to soon find a substantial decrease in the number of small animals sighted. However in view of the record hatchling recruitment on the Blyth mainstream during 1983, following high hatchling recruitment in 1982, the number of small and (3-6') animals could be temporarily exaggerated even further by the resultant (2-3') animals. However, the important size classes to watch are the large and (3-6') ones.

A study of the distributional pattern of the (3-6') animals on the Blyth-Cadell System (Table 4) is of interest and again highlights further the dynamics of the situation. Though the number of (3-6') animals sighted on the June and November 1982 and July 1983 surveys remained essentially constant, 163, 154 and 160 respectively, their distribution on the waterway varied greatly from survey to survey. This is further delineated in the Table below, where we have also included the distribution of large animals. The km 0-20 section is called the mouth section of the Blyth and contains all of the major sidecreeks. The Cadell River joins the Blyth at km 19.1. On June and July surveys one normally sights a higher density of (3-6') and large animals on the mouth section of the Blyth River than on October or November surveys when the animals have been either forced out of the waterway or further upstream. On the km 20-49.8 section, we found during the July 1983 survey some 23 (3-6') animals missing since the November 1982 survey. However, on surveying the mouth section of the Blyth River 14 additional (3-6') animals were sighted and on the Cadell River 14 additional ones. This matter simply highlights again the danger of drawing conclusions about C. porosus populations for a whole waterway from results gained on only a part of it.

Size Classes	(3-6')				Large (>6')			
	June 82	Nov 82	July 83	Oct 83	June 82	Nov 82	July 83	Oct 83
Blyth River	52	36	50	41	29	12	24	14
km 0-20	52	36	50	41	29	12	24	14
km 20-49.8	42	57	34	43	12	13	11	9
Sidecreeks	13	9	10	10	6	3	2	2
Cadell River	56	52	66	57	20	11	13	10
Totals	163	154	160	151	67	39	50	35

### 4.3 October 1983 survey

This survey provided additional evidence for very considerable movement of animals between the various components of the river system. Examination of the Table above shows that on the Cadell River, the October survey revealed 9 (3-6') animals less than on the July 1983 one. From Table 4 one can show that 16 (2-3') animals were missing also. On the Blyth km 20-49.8 section precisely 16 (2-3') and 9 (3-6') additional animals were sighted. The above Table highlights again the redistribution and/or exclusion of animals in the (3-6') and large size classes which takes between the June-July and October-November surveys. It also shows that the influx and exclusion of animals occurs largely via the mouth section of the Blyth River. However, as discussed in the Section on Alternative Habitat, a small number of (3-6') and large animals appear to be forced to take haven in alternative habitat during the breeding season. For instance, an additional 3 large and 2 (3-6') animals were sighted on the extreme upstream section of the Blyth River during the October survey and probably includes the missing 2 large animals from the km 20-49.8 section. The same phenomenon was noted in the October 1982 surveys.

Tables 1, 2, 3, 4, 7 and 8 contain the results of our final survey of the Blyth-Cadell Rivers System. The results contained no surprises in relation to the (3-6') and large size classes and followed the apparent pattern for October-November surveys. The consistency of this pattern in 1982 and 1983 is indeed striking. Overall there was a decrease of 9 (3-6') and 15 large animals since the July 1983 survey. The 9 (3-6') crocodiles and 10 large animals were missing from the mouth section of the Blyth River. Recall that 12 additional large animals had been sighted on the mouth section of the Blyth during the July 1983 survey. Furthermore, it had been postulated that this increase may have included some of the 15 large animals which had been excluded from the Liverpool-Tomkinson System -that these animals were probably on their way back to the Arafura Swamp, not having been successful in establishing a territory for themselves on this occasion. We predicted that if this was so, then it was highly likely that the animals would also be excluded from the Blyth River by October. Our survey results support this contention and the missing 9 (3-6') and 10 large animals are either missing -presumed dead or on their way back to the Arafura Swamp via the Milingimbi Complex. Our October 1983 surveys, however, did not reveal any additional large animals in Crab, Anamayirra or Beach Creeks (in fact there was a decrease) to the west of the Blyth River mouth (Fig. 3 and Table 8) and no additional (3-6') or large animals, since the June survey, in Ngandadauda Creek and the Glyde River to the east of the Blyth River (Fig. 4 and Table 1).

In the discussion of the Liverpool-Tomkinson results we referred to the surprisingly heavy hatchling losses (121 to 63) and very low (2-3') losses (83 to 77), between the July and October 1983 surveys. Precisely the same thing occurred on the Blyth-Cadell System. The number of hatchling sighted decreased from 157 to 73 (a fall of 54% compared to the fall of 30% for 1978 given on page 391 Monograph 1) and the number of (2-3') animals decreased from 98 to 95 only. Even allowing for errors in size class estimation, these are startling results. Why were there especially heavy hatchling losses during the June-October 1983 period following the second consecutive 'dry wet'? Why were there exceedingly



low losses of (2-3') animals occurring at the same time? Are they somehow related? Why were there very low hatchling losses between November 1982 and July 1983? We are unable to answer these questions.

#### 4.4 A ten year overview

In Fig. 7 we plotted, using Tables 3 and 4, the number of (3-6'), large their sum (3-6') plus large, or (>3') animals sighted on the 19 general surveys of the Blyth-Cadell Rivers System over the past 10 years. The plot reveals in a dramatic fashion the picture of dynamic change to which we have referred to so often, especially when discussing the (3-6') and large animals. Especially note the dramatic drop between the September and October 1977 surveys. One has the picture of a couple of hundred (3-6') animals which are being added to year after year from the recruitment of hatchlings several years earlier and yet the number of (3-6') animals sighted remaining constant or decreasing. The number of (3-6') animals sighted on the tidal waterway during the surveys of a given year is at a maximum during the May -early September period, the non-breeding season when aggressiveness between animals of all size classes is at a minimum, and is usually at a minimum during the breeding season around the October period, when aggressiveness between the animals is at a maximum. The constant battle which goes on for the establishment of a territory leads to the exclusion, influx and heavy losses of the (3-6') animals. But matters do not rest here for one sees essentially the same thing happening with the large animals, many of which are still not sexually mature. However, as seen in Fig. 7, some of these animals are successful in establishing a territory and holding it, for the number of large animals sighted is increasing, the major jump coming after the 'dry wet' of 1978-1979 when some 32 large animals were forced out of the drying freshwater complexes and into the tidal waterway. These animals then had little choice but to fight for territory. Apparently some succeeded. All of this appears to be superimposed upon a base, made up of some 15 to 20% of the (>3') animals sighted which appear to be successful in establishing a territory in the waterway without being excluded in the first instance. For example, we have just recaptured (on the Liverpool-Tomkinson) 2 large animals which were captured and marked as hatchlings in 1973 and 1975 and one of these animals was recaptured at the original capture site and the other only 1.8 km away from its original capture site.

Two other animals captured originally in 1974 were recaptured in 1980 and 1981 only 0.8 km and 1.5 km respectively from their original capture site. Of course we cannot say where these animals had been in the intervening years. It appears that on the Blyth-Cadell, there has been a decrease, between 1975 and 1983, in the number of (3-6') animals which could hold a territory on the System (we do not use the 1974 figures except in special cases because the figures of that year include both captures and sighting of animals missed). Whereas in November 1975 the figure was 183 (3-6') animals, in October 1983 it was down to 151. This is opposite to what appears to be happening with the large animals. In November 1975 the number of large animals sighted was 14, in October 1983 it was 35 or an increase of 21 over the 9 years, or if one compares the September 1976 and July 1983 numbers, the increase is 24. It appears as if there were a set number of territories or slots in the river system and the increasing of this number results in the loss of a very high fraction of the animals trying to secure these territories.

In the Section on the Liverpool-Tomkinson, we calculated the maximum average percentage of hatchlings which survive to the (2-3') stage and found the figure to be 37%. Doing the same for the Blyth-Cadell, for the years between 1974 and 1983, yields a figure of 709/960 or 74%. Why is there a difference by factor of 2? Could it be related to the fact that the number of large animals in the Liverpool-Tomkinson was generally greater than in the Blyth-Cadell over the period? But then why do the number of (3-6') animals sighted in the Blyth-Cadell appear to have gone down between 1975 and 1983 and yet the Liverpool-Tomkinson they appear to be about steady? Again we are unable to answer these difficult 'why' questions and leave to future generations.

As for the Liverpool-Tomkinson we can give a Table showing various broad estimates for the minimum exclusion and/or loss percentages for the (3-6') animals.

Survey	(3-6')	Large ( $\geq 6'$ )	Minimum % of (3-6') animals excluded and/or lost
November 1975	183	14	(183-21)/183 or 89%
October 1983		35	
September 1976	177	26	(177-41)/177 or 77%
June 1982		67	
June 1977	196	25	(196-42)/196 or 79%
June 1982		67	
November 1975	183	14	(183-25)/183 or 86%
November 1982		39	
October 1977	158	22	(158-13)/158 or 92%
October 1983		35	

From the above Table one sees that for the Blyth-Cadell the minimum exclusion and/or lost percentage is very high also, generally in excess of 80%. Again, if one assumes that the 'dry wet' of 1981-1982 had concentrated back into the Blyth-Cadell, nearly all of the surviving large animals originally recruited there -and none originating from elsewhere- then 77 to 79% becomes the estimate for the missing -presumed dead (3-6') animals.

5. THE TIDAL WATERWAYS OF ROLLING AND JUNCTION BAYS, JUNE 18-21 and OCTOBER 1-4, 1983 SURVEYS

The summary results from the reduced June and October 1983 survey data for tidal waterways of Rolling and Junction Bays (Fig. 1) are shown in updated Tables 1 and 6.

The fact that the 1982-1983 wet season was again a 'dry wet' with negligible flooding (following on that of the 1981-1982 'dry wet') is perhaps reflected in increased hatchling recruitment, especially on Nungbulgarri Creek where 34 hatchling were sighted during the June survey; the maximum number sighted on previous surveys was 10. These hatchling were concentrated mostly between km 5 and 13; no obvious creches were sighted and it is likely that these hatchlings resulted from only one or two relatively successful nests. Only 15 hatchlings were sighted on the October survey.

Hatchling recruitment on the Goomadeer River in June was 24, much the same as that found on June-July surveys after previous 'dry wet' seasons, 1979 (29H), 1982 (18H) and occurred on the same sections of the waterway. On the October survey, 33 hatchlings were sighted indicating that there may have been an additional input from one or more late nests.

Four hatchling were sighted in TYPE 3 Majarie Creek in June, where sporadic nesting is believed to occur (page 61 Monograph 5). No hatchling were sighted on the October survey. No hatchlings were sighted on TYPE 3 Wurugoi Creek on either the June or October surveys. Thus overall, 62 hatchlings were sighted on the 4 waterways of Junction and Rolling Bays during our June survey and 48 on the October one. These numbers are to be compared with the previous maximum number of 39 hatchling sighted during the July 1979 survey following the 'dry wet' of 1978-1979.

The 57 (3-6') animals sighted on the overall systems both during the June and October 1983 surveys are to be compared with the 51 and sighted during the June and October 1982 and 56 and 60 on the June and October 1981 surveys, respectively. Thus there has been little overall change in the number of (3-6') animals sighted during the last 6 surveys. As may be seen in Table 6 there has been only little change since the August 1975 survey when 46 (3-6') animals were sighted. The low figure of 33 for 1976 is probably accounted for by the historic floods of the 1975-1976 wet season when the sea penetrated several kilometres inland. Many of the smaller animals would have been swept away and dispersed at the time. The number of (3-6') animals sighted during 1977 increased to 40 and on the July 1979 survey 66 were sighted. There is now little doubt that this relatively high number is accounted for by the 'driest wet' on record (1978-1979) when animals in associated freshwater complexes were forced, by falling water levels, to re-enter the tidal systems. As pointed out in the DISCUSSION, we now believe that some of the increase may have been derived from the Arafura Swamp (however a substantial number could also have been forced out of swamps near the Goomadeer River) and that a few of these animals may have returned to there by the time of the June 1981 survey. Study of Table 1 shows that nearly all of the animals concerned were in size classes  $>(4-5')$  and that as would be expected from our model not many animals in the (3-4') size class were involved.

The situation in relation to the large animals is somewhat different. There was a major influx of large animals after the record 'dry wets' of 1978-1979 and the most likely sources are the minor swamps of the Goomadeer and the Arafura Swamp. As expected, the number of large animals sighted dropped between the July 1979 and June 1981 surveys, from 33 to 22 in June 1981 and then to 12 only on the October 1981 survey. Again we believe that some of these animals may have returned to the Arafura Swamp and the large fraction to the other associated freshwater complexes from which they came.

Following the 'dry wet' of 1981-1982, there was an influx of large animals into the tidal waterways of Rolling and Junction Bays again; the number sighted increasing from 12 to 29 between the October 1981 and June 1982 surveys. The number sighted then dropped marginally to 24 for the October 1982 survey and to 21 for the June 1983 one. The October 1983 survey revealed 26 large animals; the 5 additional large animals could include the missing 5 large animals from Anamayirra, Crab and Beach Creeks (Table 8) or animals from the Liverpool-Tomkinson System. Thus it appears that few if any of the 17 additional large animals sighted on the June 1982 survey had returned by October 1983 to the area from which they came. This is in keeping with the fact that the wet season of 1982-1983 was again a 'dry wet' and hence the animals would not have been able to return to the area from which they were forced to leave originally because of falling water levels.

Our results show that there can be considerable adjustment between the 4 waterways, in the number of animals sighted on them. Note the decrease from 8 large animals sighted on Nungbulgarri Creek during the October 1982 survey to only 2 large animals sighted during the June 1983 survey and the increase from 12 non-hatchlings sighted in Majarie Creek in October 1982 to 20 sighted during the June survey.

The survey result for the 4 waterways of Junction and Rolling Bays over the past 9 years (Table 6) appear to be in keeping with those for the overall waterways of our Maningrida monitoring area (Table 7), that is a steady, or marginally increasing, number of (3-6') animals accompanied by an apparent increase in the number of large animals sighted. Comparing the August 1975 survey results with those of June 1983 (see Section on the Liverpool-Tomkinson as to why not October 1983), one finds that the increase in the number of (3-6') animals was 11 only and the increase in large animals was 9 -a relatively large increase- however note that on the October 1981 survey only 12 large animals were sighted as in 1975, (but the 1975 survey was made in August). The ratio of (3-6') to large animals appears to be decreasing but there are substantial fluctuations, aggravated because of the relatively small numbers involved and the inclusion of Majarie and Wurugoij Creeks, both TYPE 3 systems.

## 6. ALTERNATIVE HABITAT

### 6.1 Anamayirra and Beach Creeks, June 27-28 and October 10-11, 1983 surveys

A helicopter was used for ferrying the survey boat and staff to these two hypersaline coastal creeks (Fig. 2). When Beach Creek (0.2.2. km) was surveyed during 1982, 6 crocodiles, 3 (3-6') and 3 large were sighted on the July survey and 3 (5-6') animals on the October one (Table 8). The survey of June 27, 1983 revealed 7 crocodiles, 6 (3-6') and one large animal, thus the number sighted on the June 1983 survey was back to almost the same number sighted on the July 1983 one. Note however that the size structure of the animals sighted was different, indicating that some animals may have left the creek and others had entered it. Further evidence for considerable movement of animals (albeit, the numbers involved are small) into and out of the waterway was gained from the October 10, 1983 survey when the number sighted had dropped back to 2 (3-6') animals, almost the same again as the number sighted on the October 1982 survey. That the animals are moving in and out is also indicated by the fact that nearly all sightings are in the first 800 metres.

The survey of Anamayirra Creek (7.3 km) on June 28, 1983 resulted in the sighting of 16 crocodiles - exactly the same number that was sighted during the previous two surveys of 1982 - quite a remarkable coincidence. The size structure of the animals was 9 (3-6') and 7 large in July, 11 (3-6') and 5 large in October 1982, and 10 (3-6') and 6 large in June 1983. Our survey of October 11, 1983 revealed 8 crocodiles only, 5 (3-6') and large animals.

Thus 13 animals are missing from the two creeks, 9 (3-6') and 4 large, since our June survey. What happened to them?

#### 6.2 Toms Creek, July 1 and October 13, 1983 surveys

We made our first systematic survey of Toms Creek (Fig. 2), a hypersaline coastal waterway with a surveyable length of 8.9 km, in 1976 and then annually thereafter until 1979 (St. Lucia 1982). Of the five previous surveys, no survey revealed more than 2 non-hatchlings, until our resurvey in July 1983 when 6 animals, 5 (3-6') and one large one were sighted (Table 8). On the October 1983 survey 4 crocodiles were sighted, a (2-3'), (4-5') and 2 (6-7') animals. Thus Toms Creek is evidently frequented by a small number of itinerant animals, moving in and out of the Liverpool-Tomkinson System.

#### 6.3 Crab Creek, June 25 and October 20, 1983 surveys

This 3 km hypersaline coastal creek (Fig. 3) was surveyed in November 1981 and again in October 1982. Two large crocodiles (EO >6', >7') were sighted on the first survey and one crocodile (EO >6'), during the second one (Table 8). The survey of June 1983 again revealed 2 crocodiles (EO >6', 6-7') and on the October one we sighted 2 animals (5-6', EO >6'). Thus as far as C. porosus are concerned, Crab Creek appears unimportant; it provides a temporary haven for several (3-6') and large animals only. Whether these are animals which were excluded from the Blyth or the Liverpool Systems we are unable to say, however the latter is the more likely.

#### 6.4 Cadell Big and Cadell gardens Billabongs, June-July and October 1983 surveys

A helicopter is used to gain access to the 4 km long Cadell Big Billabong, ferrying survey boat and staff. The billabong (Fig. 3) was first systematically surveyed on July 9, 1982 when 5 C. porosus were sighted, 3 EO, one >7' and a (3-4) animal (Table 8). On the June 30, 1983 survey only 3 crocodiles were sighted, one EO >6', one (8-9') and one (9-10'). The October 9, 1983 survey revealed 3 animals again, a (6-7'), (7-8) and (EO >6').

Survey of Cadell Gardens Billabong on the night of July 10, 1983 yielded 3 crocodiles as it did on the October 1982 survey. We sighted 2 (4-5') and one (EO >6') animals. On the survey of October 22, 1983 we sighted 3 animals again, a (4-5'), a (5-6') and a (EO >6').

It is evident that the Cadell billabong normally only contain small numbers of (3-6') and large animals excluded from the Cadell River. These numbers are in keeping with the observation that the available food supply in these billabongs is quite limited. Sporadic nesting does occur, for in 1973 a number of hatchlings were caught in Cadell Gardens Billabong by aboriginals.

6.5 Extreme upstream section of Blyth River km 49.8 and billabong km 60.6-64.6, July 11-12 and October 23-24, 1983 surveys

The extreme upstream sections of the Blyth River (Fig. 3) were resurveyed on the nights of July 11 and 12. The results of the surveys are shown in Table 8. Note how the number of (3-6') and large animals sighted (12) in October 1982 had increased from the number sighted during the previous June 1982 survey (4) and how again on the present July 1983 survey the number of (3-6') and large crocodiles sighted dropped from 12 to 3. Whereas during the October 1982 survey 3 large crocodiles were sighted in the billabong between km 60.6-64.6, during the present survey none were sighted.

As pointed out in the St. Lucia 1982 paper such variation is predicted by our model and provides further support for our contention that sub-adults are being excluded by the larger animals -especially during the breeding season. If the animals are not excluded completely from the waterway, then as in the present instance they are forced into less desirable habitat such as the extreme upstream section of the waterway. From km 55 to km 59 the river is very rocky. With the breeding season over, the animals appear to again return to the main sections of the breeding system. Further support for this view was provided by the results of the October 1983 survey when the number of (3-6') and large animals sighted had increased by 2 and 3 respectively. Again no crocodiles were sighted on the billabong between km 60.6-64.6.

6.6 Upstream Liverpool River, km 60-66.4, June 29 and October 8, 1983

The sandy and snag-ridden terminal section, km 60-66.4, of the Liverpool River mainstream, which was not normally surveyed during previous surveys, was surveyed on three occasions during 1982 and 1983 and the results for these surveys are shown in Table 8. A small number of (3-6') and large animals frequent this section of the mainstream and it is to be noted that the number of large animals sighted was larger for both of the October surveys than for the July one.

6.7 General

Some 75% of our survey effort during 1982 and 1983 was spent gaining the information shown in Table 8, for those years. However we believed it was important to survey every bit of habitat we could gain entry to, using boats, vehicles and a helicopter, in order to eliminate the various possibilities as to where the large number of apparently missing crocodiles could be. As may be seen in Table 8, the alternative habitat does provide some important rearing stockyards for both large and small animals, but the number of animals involved is small compared to the hundreds missing. The October 1983 survey yielded 24 (3-6') and 28 large animals compared to 48 (3-6') and 25 large animals sighted during the July 1983 one. Reference to Table 7, shows that of all the (3-6') and large animals sighted during the October 1983 survey, some 5% of the (3-6') and 25% of the large animals were sighted in the alternative habitat.

7. NGANDADAUDA CREEK, JUNE 26 and OCTOBER 12, 1983 SURVEYS

This important hypersaline creek (Figs. 1 and 4) was first surveyed on September 8, 1975 and again on June 24, 1979 when the University of Sydney's research vessel was used to gain entrance to the Milingimbi

Complex of tidal waterways (Monograph 9). For logistic reasons, we were unable to resurvey Ngandadauda Creek until June of 1983 at which time a helicopter was used to ferry our survey boat and crew to this TYPE 3 coastal creek which has a navigable length of 20.9 km, and a sidecreek at km 9.7 with a navigable length of some 3 km.

It was most important that we resurveyed the creek this year both in June and October. Following two consecutive 'dry wets', our model would suggest that the creek should be acting as a haven for a substantial number of both (3-6') and large animals excluded from the Blyth River and excluded or forced out from the Glyde River-Arafura Swamp. Thus, it could be acting as a haven for some of the 28 large animals which had left the Blyth River by the time of our November 1982 survey (Table 2) - probably on their way back to the Arafura Swamp from which they had been excluded or forced out during the previous 'dry wet' of 1981-1982. However another 'dry wet' intervened and the animals would essentially be 'caught' in the Milingimbi Complex and the Glyde River until the wet season of 1983-1984. It is likely that some of the animals on their way back to the Arafura Swamp had been recruited on the Blyth-Cadell System originally.

The survey on the night of June 26, 1983 fulfilled our expectations; 30 crocodiles were sighted, 20 (3-6') and 10 large animals. However note from Table 1 that of the 30 animals sighted 13 were EO, suggesting that these animals were exceedingly wary and hence that a high fraction of them had probably entered the creek only recently. These results are to be compared with those of September 1975 when 3 hatchlings, 2 (2-3'), 9 (3-6') and 5 large animals were sighted and with those of the June 1979 survey, following the record 'dry wet' of 1978-1979, when 10 (3-6') and 11 large animals were observed (Tables 9.22 and 9.23 Monograph 9 and present Table 1).

Ngandadauda Creek was resurveyed for the second time during 1983 on the night of October 12. On this occasion 21 crocodiles were sighted, 14 (4-6') and 7 large; the number of EO crocodiles sighted dropped from 13 on the June survey to 2 only on this one, suggesting strongly that most of these animals which had entered the waterway by June 1983 had either been excluded again or joined the class 'missing - presumed dead'. The fact that no additional crocodiles in the (3-6') and large size classes were sighted during the October survey of the Glyde and Blyth-Cadell and Liverpool-Tomkinson Systems provides support for the latter. The crocodiles missing were from the mouth and the upstream sections of the waterway only.

The results of the two latest surveys support further our contention that Ngandadauda Creek, which is a TYPE 3 waterway, is largely frequented by animals coming from other waterways, such as the Blyth-Cadell System and the Glyde River-Arafura Swamp, which act both as breeding and rearing systems. The creek acts as a temporary haven and/or rearing stockyard for sub-adults excluded or forced out from other systems, like those above, until the animals are able to return (pages 39, 40, 122 - 124 and 125 Monograph 9).

We record here two important observations made during our last survey. The measured salinity some 4 hours after low water of Ngandadauda Creek at km 20.9, the terminal survey point, was 830/00. This is to be compared with the measurement made at high tide on Creek C of the Adelaide River in September 1979 (pages 375-377 Monograph 1) of 850/00. Furthermore a (4-5') C. porosus was sighted at km 20.5 on Ngandadauda Creek where the

measured salinity was 78<sup>o</sup>/00. We have never before sighted a crocodile in waters as hypersaline as this. The previous record was for a (7-8') animal sighted on Creek C of the Adelaide River; the measured high tide salinity was 61<sup>o</sup>/00 and the extrapolated low tide value was 75.5<sup>o</sup>/00 (same referencie as above).

In the early monographs (Monographs 3, 5, 6 and 7 ) of the serie of 17, we stated repeatedly that our results indicated that C. porosus appears to tolerate hypersaline conditions poorly and that crocodiles tended to leave highly hypersaline waterways. We were perplexed by this matter for a number of years. However by 1979 numerous additional observations showed that C. porosus in all size classes are able to tolerate very high salinities, but probably for short periods of time only that the time period may be size dependent (page 380 Monograph 1). Since that date Taplin and Grigg discovered lingual salt glands in both C. porosus and C. johnstoni thus providing a method of getting rid of excess salt. In addition we now have a much clearer understanding of the dynamics of C. porosus populations and of the itinerant crocodiles, mostly sub-adults, populating the hypersaline TYPE 3 waterways. Exclusion of some 80% of the sub-adult crocodiles from TYPE 1 tidal waterway and their associated freshwater complexes appears to be the dominant factor involved in the populating of TYPE 3 waterways. Itinerant animals are more likely to be excluded from TYPE 1 and/or TYPE 3 waterways during the September-November period, the breeding season, when crocodile interactions between all size classes appear to reach a maximum (page 457 Monograph 1). This also happens to be the period when salinities increase rapidly in the hypersaline TYPE 3 waterways. A (4-5') crocodile staying in water of 83<sup>o</sup>/00 salinity must be paying some metabolic penalty; a penalty he is forced to pay to stay in the creek.

#### 8. GLYDE RIVER-ARAFURA SWAMP

The results from the survey of Ngandadauda Creek on the night of June 26 dictated that we resurvey the Glyde River and also make an aerial helicopter survey of the Arafura Swamp (Figs. 1, 4 and 5). It appeared crucial that we do so and resurvey in October, if we were to obtain a more comprehensive picture of what was happening to the (3-6') and large animals on the northern Arnhem Land coast, following two 'dry wet' seasons. This meant re-arranging our 1983 survey schedule and complicating further the already complicated logistics of our survey programme. The Glyde River and the Arafura Swamp are some 150 km, by very rough bush track, east of Maningrida. Flying in survey gear by helicopter would simply be prohibitively expensive and vehicular access had to be made.

##### 8.1 July 7-8, 1983 survey

Following the 'driest wet' on record of 1978-1979, when many crocodiles had been forced out of the Arafura Swamp, we sighted during the July 1979 survey of the Glyde River 36 (3-6') and 19 large animals compared to 17 (3-6') and 11 large during the September 1975 survey. Following the two 'dry wets' of 1981-1982 and 1982-1983, again we expected to sight a substantial number of (3-6') and large crocodiles in the Glyde River, especially on both the mouth and extreme upstream sections. And so it turned out.



As may be deduced from Table 1, 73 (3-6'), of which at least 35 were in the (3-4') size class, and 31 large animals were sighted. Furthermore there were 19 animals sighted on the km 0-5 mouth section and the majority of these were large; 15 of the animals were sighted between km 0 and 2, strongly indicating that they were either entering or leaving the river (in fact the October survey indicates they were entering the system). Three pairs of these large crocodiles were sighted interacting; that is, one was in the water directly facing one up on the bank. On the terminal km 40-45.9 section of the river, 3 hatchlings, one (2-3'), 11 (3-6') -most of which were in the (3-4') size class- and 5 large animals were sighted. However on our helicopter aerial survey of the same section of the river, during the day of July 2, we sighted 7 large (some very large, > 13', which one rarely ever sees at night because of their wariness, probably going back to the days of shooting) crocodiles on the last 2 km of the surveyable section of the river, that is from km 43.9 to 45.9. It is highly probable that most of these animals had been forced out of the Arafura Swamp, because of the low water levels following on two consecutive 'dry wets'. During the July 1979 survey of the Glyde we also observed a high density of crocodiles on the mouth and upstream terminal sections (Fig. 9.59 Monograph 9), however the overall number of animals concerned was less than that sighted during the present survey.

The fact that the number of large animals sighted during the July 1983 survey of the Glyde River was considerably higher than the number sighted in July 1979 (31 versus 19) is not surprising. The July 1979 survey followed on immediately after the record 'dry wet' of 1978-1979 and the crocodiles which had been forced out of the Arafura Swamp were spread throughout the tidal waterways from Arnhem Bay in the east to the King River in the west (Fig. 1, also see DISCUSSION). On the other hand, the July 1983 survey followed on two consecutive 'dry wets'. Examination of Table 7 shows that after the 1981-1982 'dry wet' there had been by July 1982 a major influx of 58 large animals into the monitored waterways of the Maningrida area, from 105 to 163. Since most of these additional large animals had been forced out of the Arafura Swamp via the Glyde River, one could expect, as in 1979, the number of large animals to have increased in the Glyde River also, over that in the previous normal year. By the time of the October 1982 survey, 31 of the additional 58 large animals had been excluded or were missing from the waterways of the Maningrida area. Some of the 31 animals were probably in the class of missing -presumed dead, while the remainder were on their way back to the Arafura Swamp via the Milingimbi Complex of waterways. But the second 'dry wet' of 1982-1983 intervened and it is likely these animals remained in the Glyde River and in the other waterways of the Milingimbi Complex over the wet season. Thus the Glyde River in July 1983 could be expected to contain not only its share of the large animals originally excluded but also a share of the returning animals. On this basis too, one would not necessarily expect an increase in the number of large animals sighted on the Glyde River during the October 1983 survey, for the animals had already returned. An explanation along similar lines can be given also for the increased number of (3-6') animals seen in July 1983. The possibility of many further animals being excluded into the river from the swamp after July is considered very small, because of the drying up by July of the channel connecting the river to the swamp.

Two interesting points arise from a study of the size structure of the animals sighted. The Glyde River has good breeding habitat (so does the Arafura Swamp when the water levels are up) and yet after a 'dry wet' season, when there could be little or no loss of nests due to flooding, only 5 hatchlings were sighted during the survey. Surely there must have been more? Could they have been cannibalized by the increased number of large crocodiles? And where did the 35 (3-4') animals, shown in Table 1, come from? Did they arise from normal recruitment on the Glyde? If they did, then there must have been an excellent nesting year over the wet season of 1980-1981, which we know had heavy flooding. Hence it is likely that most of these (3-4') crocodiles come from elsewhere -perhaps from the Arafura Swamp and/or the Blyth-Cadell System? The Arafura Swamp must be the more likely source for a majority of these (3-4') animals.

We wish to emphasise again what we have been saying about the increase in the number of crocodiles sighted on the Glyde River, during the July 1983 survey. The increase has not arisen from a major population increase since 1975, but again, as in 1979, predominantly consists of animals which were already present in the freshwater ad which, because of the 'dry wet', were concentrated into the tidal waterways.

We report here an observation made on July on the Glyde River at km 35.9. A (8-9') dead crocodile was sighted midstream floating with belly up and the front half of the body missing. Suddenly the corpse appeared to dive at which time we sighted another (9-10') crocodile pulling on it, apparently in an endeavour to tear a piece off. Considering the concentration of large crocodiles on the Glyde, at this time, it is likely that crocodile was killed by another one and that we were witnessing another case of cannibalism.

We carried out a daytime aerial helicopter survey of the Arafura Swamp (Fig. 5) on July 2, 1983. Water levels in the swamp were low and with the exception of areas near old river courses, much of the swamp area at present could not provide habitat suitable for crocodiles. Practically all of the old river courses were completely covered by a heavy of water hyacinths. However, a number of deep billabongs along the old river courses still had areas of open water. These areas could be expected to hold concentrations of C. porosus which had not been forced out of the swamp and into the Glyde River. We sighted a dead (9-10') crocodile with a rear foot missing floating on its back in an old Goyder River bed and one (8-9') animal in a large deep waterhole, also part of an old river bed.

Surprisingly, only one probable old nest was sighted. It appears that little nesting took place during the 'dry wet' and one may ask why. Bird life was very scarce and consisted mainly of magpie geese.

## 8.2 October 6-8, 1983 survey

The resurvey of the Glyde River on the night of October 6 revealed 91 C. porosus (Table 1), 3 (2-3'), 58 (3-6') and 30 large animals. The 5 hatchling sighted on the July survey were missing as were 6 (2-3'), 13 (3-4') and 4 (4-5') animals. The number of large animals sighted remained essentially constant, 31 having been sighted in July. The ratio of (3-6)

to large animals decreased from 2.4 in July to 1.9 for the October survey. These numbers are consistent with the predictions which could be made on the basis of the population dynamic model outlined in the INTRODUCTION. It is to be noted that, as predicted previously, there was no influx, since the July 1983 survey, of animals returning from the Milingimbi Complex to the Arafura Swamp.

The distribution along the river of the 91 animals sighted differed considerably from the July survey when 11 large animals were sighted on the km 0-5 mouth section of the river. On the present survey only 6 large animals were sighted on this section, however the number of large animals on the upstream sections above km 35 increased from 7 in July to 13 on the October survey. This further supports our view that some of the animals which had been on the km 0-5 section in July were moving back to the swamp. By October they were waiting on the upstream sections to re-enter the Arafura Swamp during the forthcoming wet season.

It seems reasonable that the animals which had been forced to leave the Arafura Swamp first were those which had been excluded originally from systems such as the Blyth-Cadell. One could expect animals hatched and reared in the Arafura Swamp to be the ones concentrated into the few remaining large billabongs there. The excluded animals could be expected to try to establish territories in the system from which they had been excluded originally, however in trying to do so, some undoubtedly join the ranks of the missing -presumed dead. Others could still be on their way back, but the matter is very complex to unravel indeed.

Some 5 hours of helicopter flying time were used on October 6 and 7 for carrying out an intensive aerial survey of the Arafura Swamp. The swamp water level had dropped further since the July survey and there was a mere trickle of freshwater out of the swamp into the Glyde River. Downstream of the Glyde River Crossing at km 45.9, the river was almost totally drained of water for several km at low tide. Only a few inches of water were seen to trickle between the high exposed mud banks. Whereas the salinity in July was 240/00 at km 0 and 10/00 at km 20, during the October survey it was measured to be 340/00 at km 0 and 200/00 at km 20. In fact the salinity at km 40 was still 50/00.

As during the July aerial survey, no definite old nest were sighted, indicating that very little nesting occurred in the swamp during the 'dry wets' of 1981-1982-1983. Old nests would have been easily spotted had there been any. The failure to nest during the 'dry wet' is puzzling. As will be seen shortly, there were some 32 large animals concentrated into the large billabong at Old Arafura and it is surrounded by some excellent nesting habitat. Why was there essentially no nesting?

Twelve large crocodiles were sighted from the helicopter during the day-time survey (including one very large animal, 14', in Old Arafura Billabong), 10 in the open water billabongs and 2 trapped in old river courses, heavily matted with water hyacinths.

The large and strategically situated billabong at Old Arafura (Fig. 5) was surveyed on the night of October 7. This billabong, which has a length of some 4.5 km, had some 2 km of open water; the remainder was matted very heavily with water hyacinths. Even the open area of the billabong was fringed by a heavy matting of hyacinths. This billabong

joins the Goyder and Glyde Rivers and could be expected to contain animals concentrated into it from elsewhere in the Arafura Swamp and which had not left via the Glyde River. Animals entering or leaving the swamp would normally have to pass through it. Thus we expected to sight a high concentration of animals. We were not disappointed, sighting 70 animals, the highest concentration sighted by us during our 12 years of research on the waterways of northern Australia. We sighted 22 (2-3'), 16 (3-6') and 32 (>6') animals - a spectacular sight. No hatchlings were sighted. All the animals were in or near the edge of the water hyacinths; some of the large animals scrambled frantically through the matting into the open water when the survey boat approached the edge of the matting. Interestingly, all except 4 of the 22 (2-3') animals were concentrated in the northern half of the billabong and this portion of the billabong contained only a few larger animals. We sighted 4 pairs of large animals in the southern half of the billabong, all of which were within a radius of 5 metres. At least 3 other pairs were sighted. These might have been mating pairs. Only one crocodile was sighted out in the matting extending over the remainder of the billabong at the southern and northern ends. Our spotlight would have picked up any eye shine to a distance of some 300 metres.

Old Arafura Billabong was first surveyed by one of the authors (HM) in July 1972, at which time the daytime survey revealed one very large C. porosus >14' and another animal (10-11'). The nighttime boat spotlight survey revealed 4 animals, the >14' animal sighted during the day, 2 other large and one (5-6'). Water hyacinths covered much of the billabong, and especially at the northern and southern ends, in 1972 also. However the mats were not as thick then as at present and they floated freely over the surface of it, pushed by the wind. Our records show that progress could be made through the matting using a 12' fibreglass dinghy and small outboard motor. This would not be possible in October 1983. It should be noted that the wet season of 1971-1972 was not a 'dry wet' and so there would not have been the concentrating process that we have discussed.

How many non-hatchling C. porosus did the Arafura Swamp still contain in October 1983? We can perhaps give an informed estimate based upon the results of our spotlight survey of the strategically situated major billabong in the swamp- the Old Arafura Billabong. Taking into consideration the remaining few open water billabongs and their situation, the almost total heavy cover of the old river beds with a matting of hyacinths and the low water level of the swamp, the number probably falls somewhere around 200 with 400 being a very generous upper limit.

The almost total absence of old nests makes one wonder just how much breeding does take place in the Arafura Swamp and what fraction of the animals are sub-adult itinerant from elsewhere. There is little doubt that some nesting does take place as evidenced by the 22 (2-3') animals sighted in the Old Arafura Billabong. Apparently the adult C. porosus of the Arafura Swamp nest mainly during normal or heavy wet seasons and only rarely during 'dry wet' ones.

## 9. DISCUSSION

### 9.1 'Dry wet' seasons

When Monographs 9 to 11 were written in 1979, we had not yet completed resurveying the tidal waterways of the Northern Territory coast west of Maningrida and were not aware that the substantial increase in the number of non-hatchling C. porosus sighted during the 1979 surveys, as compared to the number sighted on the 1975 ones, was in fact a general phenomenon on the tidal waterways of the Northern Territory coast and appeared to be connected with a special event -the 'driest wet' on record. Furthermore, when the 1979 surveys were completed, we interpreted the statistically significant (at the 95% level) increase in the number of non-hatchling C. porosus sighted, as indicating a slow but important recovery on certain major sections of the northern Australian coast. When one analyses the substantial amount of additional survey data we have gathered in the intervening 4 years, it appears that interpretation may have been overly optimistic at that time (Tables 1 to 7) and that the additional animals sighted were already present in 1978 and perhaps earlier, but were scattered throughout various associated freshwater complexes. All that the 'driest wet' did was to concentrate these animals onto the tidal waterways. As soon as another usual wet came, many of the animals apparently returned from there.

In "Addendum August, 1981" pages 440-445 of Monograph 1, we discussed in some detail the influx of large C. porosus into the tidal waterways in 1979, which in some cases was accompanied by an increase (Blyth-Cadell) and in some cases by a decrease (East and South Alligator) in the number of (3-6') animals sighted. Comparison of data obtained on surveys during 1978 and again during 1979, for a number of major tidal systems (Adelaide, Blyth-Cadell, Liverpool-Tomkinson, East Alligator, South Alligator, West Alligator, Wildman) established that the major influx of animals took place between the 1978 and 1979 surveys. Furthermore, consideration of the data following the completion of the 1981 surveys, indicated that the 1979 influx may have been due to the 'driest wet' on record and that the number of (3-6') crocodiles sighted on subsequent surveys had returned to almost pre 1979 levels, whereas the number of large animals sighted remained at a higher level than previously, Update Table 6.2.31, page 14 Monograph 1. This Table (present Table 2), which was further updated after our June and October 1982 surveys (Appendix, St. Lucia 1982), also provided some evidence that the ratio of small, and (3-6'), to large animals was decreasing on the Blyth-Cadell and Liverpool-Tomkinson Rivers Systems, though there were substantial fluctuations in the ratio. There was evidence that an increase in the number of large C. porosus sighted on a tidal waterway (often accompanied by an increase in (3-6') animals was usually followed by an eventual decrease in the number of small and/or (3-6') animals counted. Furthermore our data indicated that the exclusion of sub-adults, both in the (3-6') and large size classes coincides with the breeding season which commences around the September-October period. All of these observations and conclusions were in keeping with our model and might well be incorporated into it. However, there were a number of troublesome points which remained to be resolved. We quote from the St. Lucia 1982 paper: "we suggested that the common factor, which may have been connected with this general influx of animals, was the exceedingly dry wet season of 1978-1979 and the severe drought conditions which prevailed until the wet season of 1979-1980. Such

conditions might be expected to force any itinerant animals in swamp areas and semipermanent waterholes back into the tidal waterways. However we pointed out that there are a number of worrisome points about this, firstly there are very few swamp areas in the vicinity of the Blyth-Cadell System (certainly not enough to hold the number of animals involved) and secondly if the sub-adults were returning from non-TYPE 1 tidal waterways elsewhere (for instance the Milingimbi Complex, see Monograph 9) then why would a very dry wet season and severe drought conditions trigger the return of sub-adults to TYPE 1 systems? In addition there were indications of an increase, rather than a decrease, in the number of non-hatchlings sighted in TYPE 3 systems in August 1979 (see the results for Majarie and Wurugoiij Creeks, Table 1). Finally, how does one account for the decrease in the number of large crocodiles (from 74 to 58) spotted on the Liverpool-Tomkinson System during the October 1979 survey (Table 2); where did they disappear to? The missing crocodiles could not have returned to the freshwater swamps and/or billabongs from which it was postulated they had come, for these were even drier in October than in June and July. One is thus tempted to dismiss the 'drying up swamp and billabong' explanation for 1979. However, the 1981-1982 wet season along the northern Arnhem Land coastline was again a dry one and again there has been an influx of large animals into the Goomadeer (from 3 to 14), Blyth-Cadell (from 39 to 67) and Liverpool-Tomkinson (from 54 to 67) Systems (see the results for the June 1982 surveys in Tables 1 and 2). The increase in the number of large animals sighted on the Liverpool-Tomkinson System was accompanied by a major increase of small (from 166 to 207, significant at the 95% level) and (3-6') (from 133 to 178) animals, whereas on the Blyth-Cadell it was accompanied by an increase of (3-6') animals (from 127 to 163) only. The number of small animals remained constant.

In June 1979 the increase in the number of large animals sighted (from 23 to 55) on the Blyth-Cadell System was accompanied by a significant increase at the 95% level (from 221 to 287) in the number of small, and an increase (from 161 to 196) in the number of (3-6') animals sighted. However, on the Liverpool-Tomkinson System this was not so -both the number of small and (3-6') animals remained essentially constant.

Thus we ask what role, if any, do the dry wet seasons play in determining the influx of small and especially large C. porosus onto the main section of the tidal waterways?

It is to be noted from Table 2 that on the second survey of the Liverpool-Tomkinson System in 1979, namely the October survey the number of large animals spotted had decreased (from 74 to 58), but still was at a considerably higher level than for the September 1978 survey when only 40 large animals were spotted. The number of small animals sighted had also decreased, but not significantly -from 152 to 136. For the Blyth-Cadell System there was a similar occurrence, however the next survey, after the June 1979 one, could not be made until October 1980; the drop in the number of small animals was from 287 to 249, just missing being significant at the 95% level".

The results of the 1980 surveys (Tables 1 to 7) indicated that the number of animals on the tidal waterways in the Maningrida monitoring area remained fairly static except for the further exclusion, between the July and October 1981 surveys, of 40 animals in the (3-6') size classes from the Blyth-Cadell System (Table 2). Then came the 'dry wet' of 1981-

1982 and again the influx, referred to above of (3-6') and large animals into the Liverpool Tomkinson and Blyth-Cadell Rivers Systems. The distribution of the animals sighted left little doubt that for the Blyth-Cadell System, the animals were entering and leaving the system largely through the mouth of the Blyth River. You could see the animals on the mouth sections of the waterway in both June 1979 and June 1982. In our St. Lucia 1982 paper we wrote: "As is evident from our discussion, consideration of the survey results for the Blyth-Cadell System can be indicative only as to where the fluctuating number of small and large crocodiles disappear to and return from. Most of these large C. porosus are in the (6-8') size class and thus are sexually immature or just sexually mature animals for it is known that females are often sexually mature when reach the (6-7') size class (page 339 Monograph 1, also personal communication from Dr. Gordon Grigg). The evidence suggests strongly that most of these large crocodiles and a substantial fraction of the excluded small crocodiles leave and re-enter the Blyth-Cadell System through the mouth of the Blyth River. Those that leave, go out to sea and are probably lost or they travel along the coastline until they reach another tidal waterway to which they gain entrance.

To the east of the Blyth River mouth, the closest tidal waterways are those discussed in Monograph 9, Ngandadauda, Bennett, Darbitla, Djigagila and Djabura Creeks, all TYPE 3 or 2-3 waterways, and which provide excellent rearing stockyards for sub-adult and just mature C. porosus referred to in our model. However to reach the first of these waterways, Ngandadauda Creek, necessitates a sea journey of some 36 km and the rounding of Cape Stewart. This creek is also joined to Creek B on the Blyth River by an open paperbark swamp and crocodiles could move from one to the other during the height of the wet season (page 39 Monograph 9). There is a very small but distinct channel joining the two creeks.

When last surveyed in June 1979, 39 large and 44 (3-6') animals were sighted in the creeks above and since they are all TYPE 3 or 2-3 waterways, nearly all the animals sighted must have been derived from elsewhere. The Blyth-Cadell System is probably one of the sources for crocodiles".

On pages 39, 40, 106, 124 and 125 of Monograph 9 we also discussed the probable source (s) of the major portion of those crocodiles frequenting Ngandadauda Creek and the remainder of the Milingimbi Complex, which consists of TYPE 2 - TYPE 3 waterways. Excluding the small number of animals which are derived from within the Complex itself and from scattered semipermanent freshwater billabongs and small swamps bordering it, the two major and nearest sources are the Blyth-Cadell River System and the Glyde River System which drains the Arafura Swamp. Our 1979 survey results strongly suggested that the Glyde River was acting as a channel for C. porosus entering and leaving the Arafura Swamp. On page 106 of Monograph 9 we stated:

"Examination of Tables 9.43 and 9.44 indicates that at least one half of the crocodiles in size classes >(5-6') may have been derived from crocodiles moving into the river mainstream from elsewhere. Since the nearest TYPE 1 river systems are the Blyth River in Boucaut Bay to the west and the Kalarwoi River in Buckingham Bay to the east (Fig. 9.1), it is highly unlikely that crocodiles from those rivers would enter the TYPE 1 Glyde River. In fact as we shall see in the Discussion of the

overall Castlereagh Bay and Hutchinson Strait results, it is highly likely that some of the crocodiles in the >(4-5') size classes spotted in the other river and creek systems in the Bay and Strait were derived from and through the Glyde River. This reasoning leads one to conclude that substantial numbers of crocodiles in size classes >(4-5') are moving out of the Arafura Swamp into (and some out of) the Glyde River. Furthermore a fraction of the crocodiles in these size classes recruited from within the river itself are probably also excluded from the river proper. This would be in full accord with the picture we have developed of the dynamics of the populations of C. porosus (Monographs 1, 10 and 11).

That substantial number of C. porosus in size classes between (4-6') are probably leaving the river, and some in larger size classes entering it, is supported by our sighting of 12 animals in these size classes between km 0 and 1.2 (Fig. 9.59). We have surveyed most navigable tidal rivers and creeks in the Northern Territory and this first occasion on which we have sighted such a concentration of C. porosus at a river mouth.

It is to be noted that the density of non-hatchlings sighted during the 1975 survey was 0.61/km, whereas during the 1979 survey it was 1.39/km. The increase in the number of non-hatchling crocodiles is highly significant (Table 9.45). Not only is the Glyde River with its excellent nesting habitat helping to repopulate itself but the Arafura Swamp is helping as well. The Woolen River, Hutchinson Strait and the Milingimbi Creek complex are undoubtedly recipients of some of these crocodiles. The Arafura Swamp is probably functioning both as rearing stockyard and as a breeding system".

And on page 124 of Monograph 9, where we discussed the increased number of non-hatchling crocodiles sighted during the 1979 surveys of the Milingimbi Complex, and again discussed possible source (s) of these crocodiles, we wrote: "As discussed previously, the increase observed on the Glyde River can be accounted for by recruitment on the river and by crocodiles entering the fast flowing upstream sections of the river from the Arafura Swamp, where certain parts may act as rearing stockyards and others as breeding areas. Some of these crocodiles probably dispersed from the Glyde River to the other river and creek systems surveyed. However, it is most improbable that crocodiles from the Arafura Swamp and the Glyde River could account for the total increase in the number of non-hatchling crocodiles sighted, specially those in size classes >(4-5'). Using Tables 9.24, 9.25, 9.40, 9.41A, 9.43, 9.44, 9.53 and 9.54 and making due allowance for the EO classes (and subtracting the 7 crocodiles spotted on the additional 35.4 km of Bennett Creek which was surveyed in 1979 and not in 1975), we find the following accounting for crocodiles in size classes >(4-5'), where we show the number of crocodiles in the 2-3' and 3-4' size classes in brackets:

	<u>1975</u>	<u>1979</u>
Milingimbi area	29 (14)	63 (15)
Glyde River	19 ( 9)	38 (26)
Woolen River	16 (10)	27 (10)
Hutchinson Strait	11 ( 8)	26 (12)
Total	75 (41)	154 (63)



Thus there was increase of at least 79 crocodiles sighted in size classes > (4-5'), this is more than a doubling in numbers.

Reference to Fig. 9.1 indicates that the Blyth-Cadell Rivers System form which some 80% crocodiles sighted in the (2-5') size classes during the 1974 survey were missing by 1979 (Monograph 1), and the Arnhem Bay Rivers (Monograph 11) from which some 88% were missing, are the likely candidates from which at least a portion of these crocodiles came".

Further analysis of our extensive survey data obtained since 1979, and especially that of the June and October surveys of 1982 and 1983, which included the survey and resurvey of all major and minor alternative habitat (St. Lucia 1982 and Table 8) we could gain entrance to, suggests strongly that a substantial fraction of the INCREASED NUMBER of crocodiles sighted, not only on the Milingimbi Complex in 1979 and on Ngandadauda Creek and the Glyde River in 1983, but also on the Blyth-Cadell and Liverpool-Tomkinson Rivers during the 1979, 1982 resurveys, were animals RETURNING from the Arafura Swamp. Examination of Table 8, showing the number of animals sighted in alternative habitat, available for animals leaving the TYPE 1 Blyth-Cadell System (Fig. 3), indicates that even though this habitat is frequented by some animals excluded from the System, a substantial fraction of the animals must move eastward, rather than westward, along the coast and move into the TYPE 2 - TYPE 3 waterways of the Milingimbi Complex and the Arafura Swamp prior to returning from there to the System. In 1976, a 12' male C. porosus which had been caught in 1975 at km 49.9 on the Tomkinson River and had a transmitter fitted was sighted at the mouth of Darbitla Creek in the Milingimbi Complex, roughly ten months later. In June of 1983, a (5-6') animal was sighted stationary in the water some 1 km from shore and some 5 km east of the Blyth River mouth. Yet we do know from our mark-capture-recapture studies of 1973-1975 that some of the sub-adults from the Blyth River move westward also, for we recaptured a (3-4') animal south of Bat Island in the Liverpool River (Fig. 2) which had been marked in the Blyth River. However the fraction of the animals excluded from the Blyth River which move westward and frequent alternative habitat such as Anamayirra, Beach and Crab Creeks (Fig. 3), rather than moving eastward is unknown. Perhaps this habitat is utilized more by animals excluded from the Liverpool-Tomkinson System, but we are really unable to say. The results given in Table 8 show that the number of crocodiles frequenting these small hypersaline coastal waterways is relatively small.

A further important result comes from our resurvey of Ngandadauda Creek in June 1983. This TYPE 3 creek was first surveyed in September 1975 when 9 (3-6') and 5 large animals were sighted in it; on the resurvey of June 1979, 10 (3-6') and 11 large animals were sighted, indicating an influx of (3-6') and probably some different large animals into this TYPE 3 waterway -most likely of animals moving between the Blyth River and Arafura Swamp. On the October 1983 survey 14 (4-6') and 7 large animals were sighted, indicating a loss of 9 animals. As discussed in the Section on Ngandadauda Creek, it is reasonable to assume that on this occasion many of these should be classified as missing- presumed dead.

The situation in relation to the Liverpool-Tomkinson System appears to be somewhat different from that of the Blyth-Cadell System. There is considerable alternative habitat available for sub-adults excluded from the Liverpool and Tomkinson Rivers proper (St. Lucia 1982). For instance, Morngarri-, Mungardobolo, Gudjerma and Toms Creeks, which are part of the Liverpool-Tomkinson System are each TYPE 2-3 creeks and provide excellent non-TYPE 1 habitat for animals excluded -without them having to leave the System. Our results for these creeks show that there is a flow of both small and large animals into and out of them. There is other alternative habitat in addition, such as the extreme upstream sections of the Liverpool and Tomkinson mainstreams (Table 8), which we discussed at some length in the St. Lucia 1982 paper and in which we presented evidence for the upstream terminal sections of the Tomkinson River acting as excellent rearing stockyards for large and specially small animals. Also there are numerous small permanent and semipermanent swamps and billabongs and tiny creeks associated with the System in which sub-adult crocodiles could hide. In addition there are the waterways of Rolling and Junction Bays (Fig. 1) which appear to be frequented by animals from the Liverpool-Tomkinson System (page 75 Monograph 7) as well as Crab, Anamayirra and Beach Creek (Fig. 3) which act as rearing stockyards also. Thus there appears to be little difficulty in accounting for a substantial fraction of the variation in the number of (3-6') animals sighted on the Liverpool-Tomkinson System.

It is not possible to do so as easily for the substantial variations in the number of large animals sighted during the 1979, 1982 and 1983 surveys (Table 2). A study of the distribution and variation in the number of large animals sighted on each individual survey section, for all surveys, suggests (but certainly does not prove) that perhaps one half of the increase of 34 large animals sighted in June 1979 may be attributed to animals returning from the extreme terminal sections of the Tomkinson River and the unsurveyable terminal swamp and billabong sections of Maragulidban Creek and perhaps of the other small creeks as well. However, the distribution of the remainder of the animals on the down-stream sections of the Liverpool River and the downstream creeks suggests that the remainder of the increase may have been derived from outside the Liverpool-Tomkinson System. This is especially so for the apparent increase of 13 large animals sighted during the June 1982 survey; an increase of 11 large animals was sighted on the mouth section of the Liverpool River. Rolling and Junction Bay waterways were not responsible for the increase sighted in June 1979 and 1982, for there were increases in the number of large animals sighted on those surveys as well (Tables 6 and 7). Similar remarks apply to the decreases. Furthermore the same applies to the Blyth-Cadell System and hence one is forced to assume that some of the animals returned from or to a substantial rearing stockyard and breeding system - the Arafura Swamp.

The perplexing question of what happened to the apparent 16 missing large crocodiles from the Liverpool-Tomkinson System in October 1979 must be considered again. If these animals were excluded by the time of the October 1979 survey, they certainly could not have returned to

swamp habitat -including the Arafura- for such habitat was even more dried up in October than in June. Thus we are forced to surmise that large crocodiles excluded from the Liverpool-Tomkinson System probably entered the Milingimbi Complex of tidal waterways and returned to the Arafura Swamp when the wet season of 1979-1980 arrived. The same probably occurred with the 23 large animals excluded from the Blyth-Cadell System by the time of the October 1980 survey. It is to be stressed that we have no direct proof of this -we cannot survey such large complexes continuously.

We thus now believe that our original contention (Monograph 9) was correct. The only reasonable explanation we are able to give, which is in accord with the observations made during the 1979, 1982 and 1983 surveys following 'dry wet' seasons, is that the Arafura Swamp is acting both as a breeding system (during normal wet season periods) and as a rearing stockyard of varying extent, for sub-adult crocodiles from Arnhem Bay in the east to the King River in the west (Fig. 1). The Blyth-Cadell System is a very important component of this. During a severe 'dry wet' season as in 1978-1979, the water levels in small and large swamps fall drastically and crocodiles inhabiting these have no choice but to leave. They can only return to the tidal waterways, both TYPE 1 and non-TYPE 1, and this they do- as they did in 1979 and 1982. Many animals frequenting the alternative freshwater habitat must have come from TYPE 1 tidal breeding systems and hence, as the swamps dry, some of the sub-adult animals probably return to the tidal system from whence they originally came, the others apparently have to frequent non-TYPE 1 tidal systems -even though temporarily- until they can go back to the swamp rearing stockyard or a TYPE 1 system. Some of the returning large animals appear successful in establishing a territory for themselves (and perhaps a few of the (3-6') animals also); the others appear to be excluded yet again -and especially the (3-6') and sub-adult large animals- on the commencement of the breeding season. When the next 'dry wet' arrives (if there has been the usual wet season (s) in between so that the animals could have returned to the swamps (s)) large and sometimes (3-6') animals again are excluded from the swamps and the degree of the process must depend upon just how 'dry' the wet season is -upon much the swamp water levels fall. The whole process is superimposed upon the normal exclusion and re-entry of animals which takes place in usual years and which accounts for most of the sub-adults sighted in non-TYPE 1 systems. Thus, whether 'dry wet' seasons are the proximal factor involved or not, they are certainly associated with the major influxes of large and sometimes (3-6') animals sighted on the tidal waterways during surveys made in June-July, after a 'dry wet'. Thus 'dry wets' appear to play a very important role in the dynamics of C. porosus populations.

An interesting possibility which follows from the above picture or model is that C. porosus may be able to 'sense' how drastic the drop in freshwater levels will be, for the influx of sub-adults has already occurred before the June surveys -perhaps before the water level, which forces the animal to leave, is reached.

A matter which becomes somewhat clearer on the above picture is why the influx of large animals is sometimes accompanied by an influx of (3-6') animals and sometimes not (see Table A.1 on page 422, Monograph 1 and Table 2). Though there probably is an interplay of a complex set of factors, it is reasonable to assume that large animals require higher water levels than small animals and hence in some years and from some swamps only the large animals are forced to leave. In addition, the number of large and/or adult animals in the tidal waterway may also be a factor involved (St.Lucía 1982) -and perhaps tending to prevent the (3-6') animals from remaining in the waterway over the dry season (see Table 2, July 1979 survey of the Liverpool-Tomkinson System).

## 9.2 An overview for the monitored waterways in the Maningrida area

In Fig. 8 we have plotted using Table 7, the number of (3-6'), large and their sum, (3-6') plus large, or (>3') animals sighted on surveys over the past 8 years of the Liverpool-Tomkinson, Blyth-Cadell and the 4 waterways of Rolling and Junction Bays. The waterways of Rolling and Junction Bays could not be surveyed every time the Blyth-Cadell and Liverpool-Tomkinson were, thus resulting in a number of incomplete totals. These cases are referred to in the caption of Table 7 and certain corrections are suggested.

Unsurprisingly the graph shown in Fig. 8, largely mirrors those shown in Figs. 6 and 7 for the Liverpool-Tomkinson and Blyth-Cadell respectively. We refer the reader to the Overview Sections for each of those Systems, for essentially the same broad general remarks can be made here as were made there. The number of large crocodiles sighted on the overall Systems during the surveys of 1976 was 83 and the number of (3-6') animals was 340. The number of both (3-6') and large crocodiles sighted then essentially held steady or even declined slightly until June-July 1979 when there was a dramatic jump following the 'driest wet' on record of 1978-1979. By the time of the June-July 1981 surveys the number of (3-6') animals sighted was back to almost the same figure as in 1976 (347 versus 340) whereas the number of large crocodiles remained at a higher level, 113 versus 83. Obviously a number of the returning large animals were being successful in establishing a territory for themselves, probably in the very waterways from which they had been excluded, but many of their less successful rivals were joining the ranks of the missing -presumed dead in the process. Then came the two 'dry wets' of 1981-1982 and 1982-1983. Again there was an influx, this time of 72 (3-6') and 58 large animals; 392 (3-6') and 163 large animals (amazingly the number for 1979 had been 162) were sighted. Again substantial fraction of the increase, especially for large animals could only have been derived from animals excluded from the Arafura Swamp. By the time of the June-July 1983 surveys the number of large animals sighted had dropped to 125 whereas the number of (3-6') animals remained almost constant (392 versus 391). Then came the expected drop in numbers for the October 1983 survey when 350 (3-6') and 106 large animals were spotted.

Obviously only a relatively small number of additional (3-6') animals may have been successful in establishing a territory for themselves during the 8 year period; it is as if there were a fairly definite number of slots or territories on the waterways for the (3-6') animals

and the number and size of those slots can vary depending upon a complex set of factors of which food supply is one. Of course the (3-6') animals utilizing these in 1983 were not the same animals which filled those slots in 1976. Superimposed upon this is the increasingly aggressive behaviour of the animals as the October-November period approaches and the more aggressive behaviour of the large animals towards the (3-6') ones during the breeding season.

The picture for the large animals is along the same lines. Comparing the surveys of July-September 1976 with those of June-July 1983 indicates that an additional (125-83) = 42 large animals had or were well on the way to establishing a territory for themselves. Study of Tables 4, 5 and 6 reveals that, as expected, those territories were in the TYPE 1 waterways. On the other hand, since only 106 large animals were sighted during the October 1983 survey, it is apparent that a number of large animals which held a territory in the July 1983 period could not do so once the breeding season commenced. Again one must realize that one is viewing a highly dynamic situation; a large animal may be successful in holding a territory for only a limited period. Even the largest animals may eventually be deposed by younger and more aggressive ones. This continual battle for the eventual right to breed is documented for many species. The losses involved during this process in the case of C. porosus are startlingly high.

What determines the carrying capacity of tidal waterway in relation to C. porosus? This is a complex matter. Obviously the availability of food, nesting habitat, basking habitat and many other factors are involved. The results presented in Tables 1 to 8 and the above discussion of them make one wonder whether the tidal waterways which we have been monitoring in the Maningrida area have already almost reached their maximum carrying capacity under present day conditions. Or is it that the dynamics of the population in such that a major sustained increase in the number of (3-6') and large crocodiles, and the change in population structure from a dominance in the number of (3-6') to a major dominance in the number of large animals (ratio of (3-6')/L  $\ll$  1) present, is inherently a slow and very long term process. During this period, there is an exceedingly severe sorting out process resulting in only a small fraction of highly successful animals surviving. Our results and population dynamics model based on them, provide strong evidence to support this latter view. The fact that C. porosus has been on earth for some millions of years and is superbly adapted to its environment provides further support for it.

The above views imply that we do not believe that the tidal waterways in the Maningrida area have reached their maximum carrying capacity and furthermore that we believe that population numbers of 40 to 200 years ago were far greater than they are today. Of course we are in a 'no win' situation in trying to prove this for no systematic survey work, that we have heard about, was ever carried out or recorded for C. porosus in northern Australia. However the reports of early explorers such as Phillip Parker King, Lort Slokes, Cadell (see Monographs 4, 12 and 17) and many others, of perhaps less repute,

leave no doubt whatever in our minds that C. porosus numbers were vastly greater in the past than they are at present. No reliable statistics are available, but it is evident that tens of thousands of animals were taken for their skins during the 1950's and 1960's and there was a small but viable industry during this period, based on crocodiles. That could not be true today. We must also give strong credence to reports to us by individuals such as Hugh Roberts (former manager of our Maningrida Research Facility and pilot of the University's research airplane) who was a pilot during the 1939-1945 war and flew numerous patrols along the northern Arnhem Land coastline. He and his co-pilot saw hundreds of large crocodiles lying on the beaches along the coastline and used them for machine gun target practice. This was recorded in letters to his now wife, Maidie. Today you can fly for days and see no crocodile on a coastal beach. The fact that mostly large crocodiles were sighted is easily understandable. On the basis of our model, one can well imagine that as the ratio of large to (3-6') animals increases along with a major increase in the number of large animals, the increasing competition for good habitat would lead to the exclusion of big numbers of large animals. Life would also be very tough and relatively short -even more so than today- for most of the (3-6') animals.

As we did for the Liverpool-Tomkinson and Blyth-Cadell Systems, we calculated for the overall waterways monitored in the Maningrida area, the maximum average percentage over the past 8 years, of hatchling which survive to the (2-3') stage and find it to be 824/1594 or 52%. The broad estimates for the minimum exclusion and/or loss percentages for the (3-6') animals are shown below and are obtained using Table 7. Thus for the overall waterways we have been monitoring the minimum exclusion and/or loss percentage is a very high 88%. Again if we assume that the 'dry wet' of 1981-1982 had concentrated back into our monitored waterways nearly all of the surviving large animals originally recruited there -and none originating from elsewhere -then 76% becomes the estimate for the missing- presumed dead (3-6') animals.

	(3-6')	Large (>6')	Min.% of (3-6') animals excluded and/or lost
July/Sept 1976	340	83	(340-42)/340 or 88%
July 1983		125	
July/Sept 1976	340	83	(340-80)/340 or 76%
June/July 1982		163	

### 9.3 Recovery of the C. porosus population

On the basis of the results above, it is small wonder that the population of C. porosus appears to be recovering at a very slow rate and that it may take many decades to recover -if ever. In fact, one may ask legitimately whether the population is already below a critical level, from which it cannot recover. We do not believe this is so, but it is one possibility suggested by the results. One thing that continually impresses us is the smallness of the numbers we are dealing with. The variations we are talking about are measured in tens, not hundreds or thousands.

The results of the ten years of systematic and carefully recorded surveys speak for themselves. It is no exaggeration to state that no one is more surprised by them than we are but we have finally reconciled ourselves to them. In 1972 when the ban on the export of crocodile skins and products was imposed by the Australian Government at the request of one of us (HM) and commercial hunting ground to a halt -more because of the paucity of crocodiles than because of the ban -we felt very confident that given a decade or so of protection, Australia could again look forward to a substantial crocodile skin industry. We were further encouraged during the 1970's by the apparent very rapid recovery in alligator populations in the southern States of USA. During that period it was claimed by the relevant wildlife authority that the alligator number had increased from some 450,000 to 750,000. An alligator skin industry started up again in the USA. We, along with many other individuals, hoped and in fact believed, that the same would happen with C. porosus. But alligators are not saltwater crocodiles; they may appear to be superficially the same but in fact they are very different. C. porosus appears to be its own worst enemy.

Perhaps a further reason for the apparent differing recovery rates of alligators and saltwater crocodiles relates to the nature and amount of the habitat available to be utilized. In the southern States of the USA there are evidently still substantial areas of swamp habitat available for alligators and the alligators appear to be thriving in it. We have stressed the importance of swamps habitat for C. porosus in the present paper and elsewhere (Monographs 1,2,4 9 and 14) and pointed out the very high loss factors for (3-6') and large crocodiles on the tidal waterways could be expected to be considerably lower for animals inhabiting swamps (see especially Monograph 14). The fact remains however, that even though in recent history there was little swamp habitat available in northern Australia, much of what there was has been destroyed by feral water buffaloes. Examples of serious destruction may be seen in areas around the Adelaide, Mary, and Alligator Rivers Region, areas which contain some of the best and most important TYPE 1 river systems in northern Australia. The remaining areas in the Daly, Finnis, Reynolds and Moyle Rivers region (Monograph 3) and the Arafura Swamp thus take on added importance.

The laudable steps being taken by the Australian Government to include most of the waterways in the Alligator Rivers Region in a large national park (Kakadu) is leading to closer management of the feral water buffalo population there and hopefully may lead to the eventual recovery of the swamp habitat. This matter may be of major importance for the recovery of the C. porosus population in the park and surrounding areas. In Table A.1 page 442 of Monograph 1 we show the number of (3-6') and large animals sighted during surveys made of the Adelaide River and rivers of the Alligator Region during 1978 and 1979 and one notes that the ratio of (3-6') to large animals was already less than one on Murgarella Creek and on the South Alligator and Wildman Rivers. Of course it must be recalled that the 1979 survey was carried out after the record 'dry wet' season of 1978-1979 and hence many of the animals had been forced out of the swamps and into the tidal waterways. However, this evidence along with that presented in this paper indicates that as the C. porosus population recovers and increases, there will be many more large than (3-6') animals.

How many non-hatchling -but more importantly (3-6') and large-saltwater crocodiles are there remaining in Australia? Our estimate for 1979 was a maximum of 15,000, but as discussed elsewhere in this estimate was based on numbers obtained in a year when most of the crocodiles were concentrated into the tidal waterways and could well be too high. Our present results indicate that there is no reason to increase this estimate for 1983, although we must check to see whether the results gained for the waterways monitored in the Maningrida area are generally applicable to waterways in northern Australia.

It should be apparent that the present wild C. porosus population could not support a commercial skin industry based on indiscriminate shooting. If every saltwater crocodile in northern Australia was shot today, and the skins brought an average of \$100 per skin, the total value would only be around \$1.5 million. This is considerably less than the money spent over the past 12 years to gain the scientific information presented in our 17 Monographs and numerous papers.

#### 9.4 Management of the C. porosus population

What are the management implications of our results? We are not management authorities, but are aware that a multitude of factors -some of them political- must be taken into consideration. For example, for reason based on public safety, Australian society could decide that all waterways utilized for business and/or pleasure or which had settlements near them, should be cleared of C. porosus and that C. porosus should be allowed to exist and perhaps recover, only in a number of designated parks and/or reserves used for scientific and/or reserves used for scientific and/or tourism purposes. Such a decision would result in the removal of C. porosus from many of the waterways in northern Australia and could have far reaching ecological consequences, many



of which probably could not be foreseen beforehand. Based on examples from elsewhere in the world, the removal of a predator from the top of a complex food chain cannot occur without some major consequences. The Australian people would have to decide whether the unhindered enjoyment of the waterways of northern Australia is worth the risk of possibly disastrous consequences to the whole ecology of the waterways. The fishing industry is one group that readily springs to mind as a possible sufferer.

Or it might be decided to encourage the establishment of a commercial C. porosus skin industry based upon the wild population. Since at least 70% of the (3-6') animals are lost -and these are the most valuable ones commercially- one is tempted to believe that their removal beforehand would yield a valuable resource without harming it. But one must proceed with extreme caution before embarking upon such an enterprise. Undoubtedly the exclusion and/or loss of some 80% of the (3-6') animals is an integral part of the vital process of sorting out the successful from the less successful, of sorting out the stronger and more dominant component of the population. Removing a given fraction of the population might very well remove the stronger component and thus over the long term set the population on a declining course. We simply do not know. On page 15 of Monograph 1, we proposed in 1981 a critical experiment to test effect of removing a given fraction of the (3-6') C. porosus population and proposed that some 25 to 40% of the (3-6') animals be removed annually for a period of 4 to 5 years from the downstream sections of the Adelaide River to see what effect if any this had upon the population in that river. For the experiment to be meaningful, one had to monitor the population changes on another set of control tidal waterways in which the C. porosus population remained. The University of Sydney financed the costly monitoring of a control group of waterways for 4 years and this work has now been completed successfully. Though the proposed experiment had very important ramifications for the management and ranching of the C. porosus resource, no financial support had been forthcoming, from relevant authorities, for the other half of it. The opportunity has now been lost, thus ensuring that decisions made in relation to ranching will perforce be made on a much weaker scientific base.

We have already discussed in Monograph 1 (pages 437 and 445 to 446) various other management implications arising from our results. These relate to control of feral water buffaloes, prohibition of net fishing in rivers, establishment of marine or other parks and the release of hatchlings. We do not repeat these here but perhaps it is worthwhile to emphasize one apparent important issue again, an issue which is of great and fundamental importance. This relates to allowing net fishing upstream of and near the mouths of rivers. Our results show that over 80% of the (3-6') animals are excluded from TYPE 1 waterways and that this exclusion also involves large animals; that there is great and continuing movement of these animals into and out of the river systems. Allowance of net fishing in or at the mouths of rivers, specially the TYPE 1 waterways is certain to remove an important component of the large animals and could well ensure that the population in those waterways never recovers or even declines further. Undoubtedly economic and political

considerations are involved in arriving at a reasonable compromise in relation to this very important matter. We have no desire whatever to become involved in argumentation about it. However we would suggest that at the very minimum, all net fishing be definitely phased out over a period of 2 years in rivers included in national parks.

Most people are not aware that net fishing is still being permitted in the East Alligator River up to Coopers Creek and that relatively large numbers of large crocodiles are still being drowned in that river annually. This river forms the backbone of Kakadu National Park, one of Australia's most important national parks. More importantly, Stage Two of Kakadu National Park has just been announced by the Australian Government and most of the important tidal waterways in the Alligator Rivers Region will now be included in the park. These waterways constitute the largest and probably the most important group of TYPE 1 breeding systems in Australia and they are associated with large freshwater swamps which, as discussed elsewhere in this paper, are of great importance. These tidal waterways must all now be monitored annually, systematically, carefully and completely as we did in 1977, 1978 and 1979 - and net fishing in them totally prohibited.

We now end this paper with our own view on the long term future of C. porosus outside of national parks in Australia: Considering the present greedy nature of society,

IT HASN'T ANY.....!

And even in the rivers of the national parks, unless net fishing is prohibited in them, the future for C. porosus is grim.

#### 10. ACKNOWLEDGEMENTS

The authors thank the University of Sydney and its Science Foundation for Physics for their great financial support over so many years. Kayama Sinba from the Papua New Guinea Crocodile Project spent one month participating in our final programme of surveys from Maningrida in order to learn our techniques. It was a pleasure to have him with us. Our thanks also go to Doung Martyn and Colin Wiles, the pilots of the helicopters used for the July and October 1983 surveys respectively, of alternative habitat.

Our thanks also to Kim Mawhinnew, HM's secretary, for typing (and retyping;) the manuscript and Tables.

# Surveys of Tidal River Systems in the Northern Territory of Australia and their Crocodile Populations

A series of monographs covering the navigable portions of the tidal rivers and creeks of the Northern Territory. Published by Pergamon Press, Sydney Australia 1979-1984.

## MONOGRAPH

- 1 The Blyth-Cadell Rivers System Study and the Status of *Crocodylus porosus* in Tidal Waterways of Northern Australia.  
Methods for analysis, and dynamics of a population of *C. porosus*  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J.
- 2 The Victoria and Fitzmaurice River Systems.  
Messel, H, Gans, C, Wells, A G, Green, W J, Vorlicek, G C and Brennan, K G
- 3 The Adelaide, Daly and Moyle Rivers.  
Messel, H, Gans, C, Wells, A G and Green, W J
- 4 The Alligator Region River Systems.  
Murgarella and Coopers Creeks: East, South and West Alligator Rivers and Wildman River  
Messel, H, Wells, A G and Green, W J
- 5 The Goomadeer and King River Systems and Majorie, Wurugoiy and All Night Creeks.  
Messel, H, Wells, A G and Green, W J
- 6 Some River and Creek Systems on Melville and Grant Islands.  
Johnson River, Andranangoo, Bath, Dongau and Tinganoo Creeks and Puloooloo and Brenton Bay Lagoons on Melville Island; North and South Creeks on Grant Island  
Messel, H, Wells, A G and Green, W J
- 7 The Liverpool-Tomkinson Rivers System and Nungbulgarri Creek.  
Messel, H, Wells, A G and Green, W J
- 8 Some Rivers and Creeks on the East Coast of Arnhem Land, in the Gulf of Carpentaria  
Rose River, Muntak Creek, Hart River, Walker River and Koolalong River  
Messel, H, Elliott, M, Wells, A G, Green, W J and Brennan, K G
- 9 Tidal Waterways of Castlereagh Bay and Hutchinson and Cadell Straits.  
Bennett, Darbitia, Djigagila, Djabura, Ngandadaufa Creeks and the Glyde and Woolen Rivers  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 10 Tidal Waterways of Buckingham and Ulundurwi Bays  
Buckingham, Kalarwoi, Warawurwoi and Kurala Rivers and Slippery Creek  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 11 Tidal Waterways of Arnhem Bay  
Darwarunga, Habgood, Baratminar, Gobalpa, Goromuru, Cato, Peter John and Burungbinung Rivers.  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 12 Tidal Waterways on the South-Western Coast of the Gulf of Carpentaria  
Limmen Bight, Towns, Roper, Phep and Wilton Rivers, Nayarnpi, Wunggulyanga Pannytalya, Mangkurdurrungku and Yiwapa Creeks  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J and Johnson, A
- 13 Tidal Systems on the Southern Coast of the Gulf of Carpentaria.  
Calvert, Robinson, Wearyan, McArthur Rivers and some intervening Creeks.  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J and Johnson, A.
- 14 Tidal Waterways of Van Diemen Gulf  
Ilamayi, Iwalg, Saltwater and Minimini Creeks and Coastal Arms on Cobourg Peninsula  
Resurveys of the Alligator Region Rivers.  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J.
- 15 Work Maps of Tidal Waterways in Northern Australia.  
Messel, H, Green, W J, Wells, A G and Vorlicek, G C.
- 16 Surveys of Tidal Waterways on Cape York Peninsula, Queensland, Australia, and their Crocodile Populations  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J, Curtis, H S, Rolf, C R R, Weaver, C M and Johnson, A
- 17 Darwin and Bynoe Harbours and their Tidal Waterways  
Messel, H, Vorlicek, G C, Elliott, M, Wells, A G and Green, W J
- \*18 Population Dynamics of *Crocodylus porosus* and Status, Management and Recovery, Update 1979-1983.  
Messel, H, Vorlicek, G C, Green, W J and Onley, I C.

Appearing in the same series and published by the Western Australian Government

1. The status of the salt-water crocodile in some river systems of the north-west Kimberley, Western Australia  
Dept. Fish Wildl. West Aust Rept. No 24 1-50 (1977).  
Messel, H, Burbidge, A A, Wells, A G and Green, W J
2. The status of the salt-water crocodile in the Glenelg, Prince Regent and Ord River Systems, Kimberley, Western Australia.  
Dept. Fish Wildl. West Aust Rept. No 34 1-38 (1979)  
Burbidge, A A and Messel, H

TABLE 1

Number of *C. porosus* sighted within each size class on tidal waterways of the 330 km of control systems in the Maningrida area of northern Arnhem Land (see pages 14, 15, 440-446 Monograph 1) and on Ngandadauda Creek and the Glyde River draining the Arafura Swamp, during night-time spotlight surveys. The midstream distance surveyed and density of non-hatchling crocodiles sighted on each waterway is shown, as are the 95% confidence limits for the estimate of the actual number of non-hatchlings present. The TYPE classification of each waterway is given also. Note that we corrected the 1976 results for the Liverpool-Tomkinson, given on pages 14 and 416 of Monograph 1 and in the Tables of the St. Lucia, 1982 paper, by subtracting 20 animals seen between the normal terminal point at km 73.7 and km 80.1 on the Tomkinson River. This makes the survey results more comparable. The 20 animals are now shown in Table 8.

Systems	Total	Size Class Numbers								km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	E0				
<u>MONOGRAPH 1</u>													
<u>BLYTH-CADELL</u>													
Oct 74	387	89	81	147	58	6	2		4	91.9	3.2	454-524	1
Nov 75	353	50	106	81	72	23	4	2	15	94.9	3.2	462-532	
Sept 76	348	82	63	104	46	14	7	6	26	92.0	2.9	403-469	
Nov 76	307	61	61	103	47	10	4	2	19	92.0	2.7	371-435	
Apr 77	327	72	70	108	48	10	2	4	13	92.0	2.8	386-450	
May 77	333	88	60	94	55	13	4	1	18	92.0	2.7	370-432	
June 77	365	108	36	102	69	13	10	3	24	90.5	2.8	389-453	
Sept 77	386	105	45	132	47	17	4	4	32	90.5	3.1	427-495	
Oct 77	360	112	68	83	47	18	8	3	21	90.5	2.7	375-439	
June 78	432	173	65	81	67	15	6	4	21	90.5	2.9	393-457	
Sept 78	399	155	60	79	56	18	8	6	17	90.5	2.7	369-431	
June 79	465	123	91	93	59	31	16	26	26	94.5	3.6	524-598	
Oct 80	400	119	89	71	48	22	9	4	38	92.9	3.0	427-495	
July 81	366	76	86	84	43	24	11	9	33	90.1	3.2	442-510	
Oct 81	315	72	77	60	32	20	16	7	31	89.9	2.7	367-430	
Jun 82	408	136	42	59	49	31	22	20	49	91.9	3.0	413-479	
Nov 82	347	111	43	66	46	28	15	10	28	92.5	2.6	356-418	
July 83	465	157	98	61	48	30	19	9	43	91.8	3.4	470-540	
Oct 83	354	73	95	69	45	24	11	10	27	92.8	3.0	427-495	

TABLE 1

Systems	Total	Size Class Numbers								kg Surveyed	Density	95% Levels	TYPE	
		H	2-3	3-4	4-5	5-6	6-7	>7	E0					
<u>MONOGRAPH 5</u>														
<u>GOOMADEER</u>														
Aug 75	46		27	7	5	4				3	45.3	1.0	61- 89	1
Sept 76	52	18	5	8	5	1	3	3	9	45.3	0.8	44- 68		
June 77	50	2	9	13	10	6	2	1	7	45.3	1.1	65- 83		
July 79	90	29	14	7	14	10	6	1	9	45.3	1.4	84-116		
June 81*	43	6	5(3)	11(3)	8(1)	4	3	1	5	45.0	0.8	49- 73		
Oct 81	45	17	3	13	6	1			5	45.0	0.6	35- 47		
June 82	61	18	5	12	5	2	4	4	11	45.3	0.9	58- 84		
Oct 82	54	9	7	9	11	5	4	3	6	45.3	1.0	61- 87		
June 83	63	24	5	6	8	3	3	4	10	45.3	0.9	51- 77		
Oct 83	73	33	8	5	8	5	4	3	7	45.3	0.9	53- 79		
<u>MAJARIE</u>														
Aug 75	12	1	1	2	2	1	1	2	2	20.1	0.5	11- 25	3	
Aug 76	7			3					4	20.1	0.4	7		
July 79	18			1	7	4	1	3	2	24.1	0.7	21- 39		
June 81	19			2	2	4	2	3	6	21.2	0.9	22- 40		
Oct 81	17			3	4	2	1		7	22.0	0.8	20- 36		
June 82	17	2	1	1	2	2	1	3	5	23.8	0.6	17- 33		
Oct 82	12				4	5	1	1	1	23.3	0.5	13- 27		
June 83	24	4		4	4	5	2		5	24.1	0.8	24- 42		
Oct 83	19		1	4	1	6	3	1	3	24.1	0.8	22- 40		
<u>WURUGOIJ</u>														
Aug 75	4				3	1				16.4	0.2	4	3	
Aug 76	1								1	16.4	0.1	1		
July 79	9					2	2	4	1	16.4	0.5	9		
June 81	6			1	1	1	1	1	1	16.4	0.5	6		
Oct 81	8		1	1	1	3			2	16.4	0.5	8		
June 82	7					2		2	3	16.2	0.4	7		
Oct 82	8	1			2	2	1	1	1	16.4	0.4	7		
June 83	6		1		1	2	1		1	16.4	0.4	6		
Oct 83	11			2	3	1	2		3	16.4	0.7	11- 25		

\* Numbers in brackets give numbers of crocodiles removed by Biology researchers before survey.

TABLE 1

<sup>1</sup> Results for Tom's Creek included in these surveys; July 1976 survey, 1 (4-5'); May 1977 survey, 1 (3-4') and 1 (6-7'); September 1978 survey, no crocodiles sighted; July 1979 survey, one hatchling and 2 (>7') sighted. No further surveys of Tom's Creek were made until October 1982; results for this and subsequent surveys are shown under alternative habitat, in Table 8 and are not included in the totals below.

\* Previously classified as TYPE 2.

Systems	Total	Size Class Numbers								km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	EO				
<b>MONOGRAPH 7</b>													
<b>LIVERPOOL-TOMKINSON</b>													
July 76 <sup>1</sup>	228	19	39	56	27	13	3	3	68	152.5	1.4	314-372	1
May 77 <sup>1</sup>	245	40	6	51	59	30	13	5	41	145.1	1.4	307-365	
Oct 77	228	56	7	39	62	24	9	1	30	123.4	1.4	256-308	
Sept 78 <sup>1</sup>	233	37	18	37	65	19	14	8	35	141.4	1.4	293-349	
July 79 <sup>1</sup>	515	289	11	39	43	34	29	20	50	150.0	1.5	341-401	
Oct 79	355	161	16	36	37	29	17	23	36	141.1	1.4	290-346	
Oct 80	295	71	51	37	32	29	12	14	49	140.6	1.6	337-397	
July 81	256	26	52	48	29	23	15	15	48	140.6	1.6	347-407	
Oct 81	254	34	33	50	34	23	14	14	52	141.1	1.6	331-391	
June 82	467	193	29	64	50	37	23	17	54	141.1	1.9	416-482	
Oct 82	384	144	16	48	51	25	21	17	62	141.1	1.7	363-425	
July 83	432	121	83	64	56	32	17	15	44	141.1	2.2	475-545	
Oct 83	327	63	77	47	39	34	8	14	45	141.1	1.9	400-466	
<b>NUNGBULGARRI</b>													
Aug 75	29		4	11	3		1		10	15.0	1.9	37- 59	1*
July 76	15	2		3	5	1	1		3	13.6	1.0	14- 28	
June 77	14	2	2		6	1	1		2	13.6	0.9	13- 27	
July 79	35	10		4	4	6	5	2	4	14.8	1.7	31- 51	
June 81	27	2	4	10	4		1		6	14.8	1.7	31- 51	
Oct 81	25		2	12	4	2			5	14.8	1.7	31- 51	
June 82	23		2	8	4	3	1	1	4	14.8	1.6	28- 48	
Oct 82	29		1	9	8	2	2	4	3	14.4	2.0	37- 59	
June 83	55	34	2	6	5	5			3	14.4	1.5	25- 43	
Oct 83	38	15	1	5	4	6	1	1	5	14.4	1.6	28- 48	

TABLE 1

Systems	Total	Size Class Numbers								km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	E0				
<u>MONOGRAPH 9</u>													
NGANDADAUDA													
Sept 75	19	3	2	5	1	1	2	1	4	22.6	0.7	18- 34	3
June 79	21			2	3	3	4	4	5	23.9	0.9	25- 43	
June 83	30			2	5	7	1	2	13	23.6	1.3	38- 60	
Oct 83	21				5	8	4	2	2	23.6	0.9	25- 43	
GLYDE													
Sept 75	28			3	6	2	1	4	12	45.9	0.6	35- 57	1
July 79	100	36	9	10	9	10	6	6	14	45.9	1.4	89-121	
July 83	118	5	9	35	16	8	6	10	29	45.9	2.5	164-206	
Oct 83	91		3	22	12	11	5	11	27	45.9	2.0	130-168	

TABLE 2

BLYTH-CADELL RIVERS SYSTEM

Update Table for the Blyth-Cadell Rivers System (Monograph 1) showing the (2-3'), (3-4') and (4-5') size classes grouped together (2-5') and the size classes above those in another group (>5'). We have also grouped the crocodiles sighted into small (2-6'), (3-6') and large (>6'). Also shown are the ratios small/large and (3-6')/large. This Table was obtained by using the data given in Table 1. See caption to Table 3 for division of the E0 crocodiles among the various size classes and the Section on the July 1983 survey of the Liverpool-Tomkinson System for the reason we sometimes use the small rather than the important (3-6') size class.

Survey	Totals	Hatchlings	2-5'	>5'	Small 2-6'	Large >6'	3-6'	Small/Large	3-6'/Large	
26 October 74	387	89	286	12	292	6	211	48.7	35.2	
1 November 75	353	50	263	40	289	14	183	20.6	13.1	
Major Flooding										
23 September 76	348	82	221	45	240	26	177	9.2	6.8	
4 November 76	307	61	217	29	230	16	169	14.4	10.6	
11 April 77	327	72	230	25	242	13	172	18.6	13.2	
3 May 77	333	88	215	30	231	14	171	16.5	12.2	
8 June 77	365	108	215	42	232	25	196	9.3	7.8	
16 September 77	386	105	234	47	257	24	212	10.7	8.8	
23 October 77	360	112	204	44	226	22	158	10.3	7.2	
10 June 78	432	173	219	40	238	21	173	11.3	8.2	
12 September 78	399	155	200	44	221	23	161	9.6	7.0	
No Flooding - Driest Wet on Record										
10 June 79	465	123	251	91	287	55	196	5.2	3.6	
4 October 80	400	119	220	61	249	32	160	7.8	5.0	
Heavy Flooding										
9 July 81	366	76	223	67	253	37	167	6.8	4.5	
19 October 81	315	72	179	64	204	39	127	5.2	3.3	
Dry Wet - Minor Flooding Only										
25 June 82	408	136	166	106	205	67	163	3.1	2.4	
6 November 82	347	111	164	72	197	39	154	5.1	3.9	
Dry Wet - Minor Flooding Only										
15 July 83	465	157	221	87	258	50	160	5.2	3.2	
26 October 83	354	73	217	64	246	35	151	7.0	4.3	



TABLE 2 (CONT'D)

LIVERPOOL-TOMKINSON RIVERS SYSTEM

Summary Table for the overall Liverpool-Tomkinson Rivers System (Monograph 7). See caption of Table 1 for changes made in relation to the 1976 survey results. Note also that the 1976 survey shows 68 (E0) crocodiles sighted and 34 of these were taken to be large. This is probably too high a figure for the large animals. An intensive recapture programme was carried out in 1975 thus making many more animals more wary than normal. Most of the animals involved in the recapture programme were small. It is thus likely that the true ratios for 1976 are somewhat higher than those shown.

Survey	Totals	Hatchlings	2-5'	>5'	Small 2-6'	Large >6'	3-6'	Small Large	3-6' Large	
18 July 76	228	Major Flooding					40	130	4.2	3.3
		19	144	65	169					
25 May 77	245	40	129	76	166	39	160	4.3	4.1	
27 October 77	228	56	118	54	147	25	140	5.9	5.6	
27 September 78	233	37	131	65	156	40	138	3.9	3.5	
16 July 79	515	No Flooding - Driest Wet on Record					74	141	2.1	1.9
19 October 79	355	289	109	117	152	58	120	2.3	2.1	
		161	101	93	136					
15 October 80	295	71	136	88	173	51	122	3.4	2.4	
2 July 81	256	Heavy Flooding					54	124	3.3	2.3
5 October 81	254	26	145	85	176	54	133	3.1	2.5	
		34	134	86	166					
12 June 82	467	Dry Wet - Minor Flooding Only					67	178	3.1	2.7
16 October 82	384	193	161	113	207	69	155	2.5	2.2	
		144	135	105	171					
1 July 83	432	Dry Wet - Minor Flooding Only					54	174	4.8	3.2
13 October 83	327	121	217	94	257	45	142	4.9	3.2	
		63	177	87	219					

TABLE 3

Summary Table showing for each survey of the overall Blyth-Cadell Rivers the number of crocodiles in the size classes indicated. The EO classes have been added together in each survey and 50% of these have been distributed equally among the (3-4'), (4-5') and (5-6') size classes; the remaining 50% have been distributed to the (>6') size classes with 1/3 being allocated to the (6-7') size class and 2/3 to size classes (>7'). This weights the distribution heavily in favour of larger crocodiles, which are known to normally be the most wary. When the EO is an odd number, the bias is also given to the larger size classes. For 1974, all EO crocodiles were put in the (>7') size class.

		Totals	H	>2'	>3'	>4'	>5'	>6'	>7'	km Surveyed	Density
26 October	74	387	89	298	217	70	12	6	4	91.9	3.24
1 November	75	353	50	303	197	114	40	14	7	94.9	3.19
23 September	76	348	82	Major Flooding						92.0	2.89
4 November	76	307	61	266	203	95	45	26	15	92.0	2.67
				246	185	79	29	16	6		
11 April	77	327	72	255	185	75	25	13	9	92.0	2.77
3 May	77	333	88	245	185	88	30	14	7	92.0	2.66
8 June	77	365	108	257	221	115	42	25	11	90.5	2.84
16 September	77	386	105	281	236	99	47	24	15	90.5	3.10
23 October	77	360	112	248	180	94	44	22	10	90.5	2.74
10 June	78	432	173	259	194	110	40	21	11	90.5	2.86
12 September	78	399	155	244	184	103	44	23	12	90.5	2.70
10 June	79	465	123	No Flooding - Driest Wet on Record						94.5	3.62
				342	251	154	91	55	35		
4 October	80	400	119	281	192	115	61	32	17	92.9	3.02
9 July	81	366	76	Heavy Flooding						90.1	3.22
19 October	81	315	72	290	204	115	67	37	20	89.2	2.70
				243	166	101	64	39	18		
25 June	82	408	136	Dry Wet - Minor Flooding Only						91.9	2.96
6 November	82	347	111	272	230	163	106	67	37	92.5	2.55
				236	193	123	72	39	19		
15 July	83	465	157	Dry Wet - Minor Flooding Only						91.8	3.36
26 October	83	354	73	308	210	142	87	50	24	92.8	3.03
				281	186	113	64	35	19		

TABLE 3 (CONT'D)

Equivalent Table for Liverpool-Tomkinson System. Also see captions to Tables 1, 2 and 5 for the 1976 survey.

		Totals	H	>2'	>3'	>4'	>5'	>6'	>7'	km Surveyed	Density	
18 July	76	228	19	Major Flooding					40	26	152.5	1.37
				209	170	103	65					
25 May	77	245	40	205	199	142	76	39	19	145.1	1.41	
27 October	77	228	56	172	165	121	54	25	11	123.4	1.39	
27 September	78	233	37	196	178	136	65	40	20	141.4	1.39	
16 July	79	515	289	No Flooding - Driest Wet on Record					74	37	150.0	1.51
19 October	79	355	161	194	178	136	93	58	35	141.1	1.38	
15 October	80	295	71	224	173	128	88	51	31	140.6	1.59	
2 July	81	256	26	Heavy Flooding					54	31	140.6	1.64
5 October	81	254	34	230	178	122	85	54	31	141.1	1.56	
				220	187	129	86	54	32			
12 June	82	467	193	Dry Wet - Minor Flooding Only					67	35	141.1	1.94
16 October	82	384	144	274	245	172	113	69	38	141.1	1.70	
				240	224	166	105	69	38			
1 July	83	432	121	Dry Wet - Minor Flooding Only					54	30	141.1	2.20
13 October	83	327	63	311	228	157	94	45	29	141.1	1.87	
				264	187	133	87	45	29			

TABLE 4

Number of *C. porosus* sighted within the hatchling, small (2-6'), (3-6') and large (>6') size classes on the three major components of the Blyth-Cadell Rivers System: Blyth mainstream, Blyth sidecreeks and Cadell River; 49.8, 12.5 and 29.7 km respectively. \* Bias to large.

	Blyth Mainstream			Blyth Sidecreeks			Cadell			Totals						
	H	S (3-6')	L	H	S (3-6')	L	H	S (3-6')	L	H	S (3-6')	L				
26 October 74	41	207	151	6	3	3	0	47	82	57	0	89	292	211	6	
1 November 75	41	177	120	11	3	11	7	6	101	56	1	50	289	183	14	
23 September 76	48	159	108	14	16	14	5	32	65	55	7	82	240	177	26	
4 November 76	40	142	108	10	3	16	1	18	72	48	5	61	230	169	16	
11 April 77	65	142	104	6	3	17	14	4	83	54	4	72	242	172	13	
3 May 77	74	144	111	10	0	15	3	14	72	45	1	88	231	171	14	
8 June 77	88	129	107	19	2	23	4	18	80	69	2	108	232	196	25	
16 September 77	75	164	139	19	2	18	2	28	75	58	3	105	257	212	24	
23 October 77	76	136	94	14	3	15	11	33	75	53	6	112	226	158	22	
10 June 78	136	148	99	14	1	21	18	4	69	56	3	173	238	173	21	
12 September 78	115	130	92	15	1	17	17	1	74	52	7	155	221	161	23	
10 June 79	85	171	106	40	1	15	14	9	37	101	76	6	123	287	196	55
4 October 80	86	139	101	22	0	16	12	4	33	94	47	6	119	249	160	32
9 July 81	48	144	97	27	2	25	22	3	26	84	48	7	76	253	167	37
19 October 81	37	127	75	28	3	13	12	2	32	64	40	9	72	204	127	39
25 June 82	84	118	94	41	1	14	13	6	51	73	56	20*	136	205	163	67*
6 November 82	55	116	93	26*	0	9	9	3	56	71	51	11*	111	197	154	39
15 July 83	146	127	84	35*	2	10	10	2	9	121	66	13	157	258	160	50*
26 October 83	70	140	84	23	0	10	10	2*	3	96	57	10	73	246	151	35*

TABLE 5

Number of *C. porosus* sighted within the hatchling, small (2-6'), (3-6') and large (>6') size classes on the three major components of the Liverpool-Tomkinson Rivers System: Liverpool mainstream, Liverpool sidecreeks and Tomkinson (normally 57.0, 27.4 and 56.7 km respectively, but distances can vary from year to year - see page 16, Monograph 7; also see captions to present Tables 1 and 2). Note specially that during the 1977 and 1978 Tomkinson surveys, the river was surveyed to km 70 only and that a number of small and large crocodiles were thus not counted. Probably not more than 3 or 4 of each were thus omitted. Normally the Tomkinson is surveyed to km 73.7. Also see Table 8.

\* Bias to large.

	Liverpool Mainstream						Sidecreeks			Tomkinson						Totals				
	H	S	(3-6')	L	H	S	(3-6')	L	H	S	(3-6')	L	H	S	(3-6')	L	H	S	(3-6')	L
18 July	76	11	64	51	14	4	27	22	7*	4	77	56	20*	19	169	130	40			
25 May	77	13	67	64	12	4	28	27	7*	23	71	69	20	40	166	160	39*			
27 October	77	23	77	73	13*	5	20	20	4*	28	49	46	9	56	147	140	25			
27 September	78	13	69	63	21	7	20	17	5	17	67	58	14*	37	156	138	40*			
16 July	79	24	63	59	29	5	24	20	21	260	65	62	24	289	152	141	74			
19 October	79	17	63	51	32	2	21	20	5	142	52	49	21	161	136	120	58			
15 October	80	28	61	51	25	17	25	23	7*	26	87	48	19	71	173	122	51*			
2 July	81	8	75	47	23	1	23	18	8*	17	77	58	24*	26	176	124	54			
5 October	81	2	74	54	19	2	26	22	9*	30	65	57	27*	34	166	133	54			
12 June	82	7	66	59	30	8	36	34	10	178	105	85	27	193	207	178	67			
16 October	82	6	82	78	27*	3	32	28	18	135	56	48	25*	144	171	155	69			
1 July	83	27	74	67	20	3	37	35	11*	91	145	71	24*	121	257	174	54			
13 October	83	21	70	64	19	2	28	25	9	40	121	53	17*	63	219	142	45*			

TABLE 6

Number of *C. porosus* sighted within the hatchling, small and large size classes on the tidal waterways of Junction and Rolling Bays, which are within the Maningrida monitoring area. Also shown is the number of (3-6') crocodiles and the ratios of small to large and (3-6') to large for the overall systems.

- 1 This relatively high number may have resulted from animals leaving the Liverpool System after our intensive catching effort on it during the period of 1973-1975. See page 75, Monograph 5.
  - 2 Wurugojj and Majarie Creeks were not surveyed resulting in the omission of a few small and large animals. Hence the value of S/L and (3-6')/L are probably slightly TOO HIGH.
- \* Numbers in brackets give numbers of crocodiles removed by Biology researchers before survey.

	Goomadeer						Wurugojj			Majarie			Nungbulgarri			Totals														
	H		S		L		H		S		L		H		S		L		H		S		L		S/L		(3-6')/L			
August 75	-	44	2	-	4	-	1	7	4	-	23 <sup>2</sup>	6	1	78 <sup>1</sup>	46	12	6.5	3.8												
July/August/September 76	18	23	11	-	-	1	-	5	2	Major Flooding			2	10	3	20	38	33	17	2.2	1.9									
June 77	2	41	7	No Survey			No Survey			2	10	2	4	51	40	9	5.7 <sup>2</sup>	4.4 <sup>2</sup>												
July 79	29	49	12	-	2	7	-	13	5	No Flooding - Driest Wet on Record			10	16	9	39	80	66	33	2.4	2.0									
June October 81	6	30(7)*	7	-	3	3	-	11	8	Heavy Flooding			2	21	4	8	65(7)*	56(4)*	22	3.0	2.5									
October 81	17	25	3	-	7	1	-	12	5				-	22	3	17	66	60	12	5.5	5.0									
June October 82	18	29	14	-	3	4	2	8	7	Dry Wet - Minor Flooding Only			-	19	4	20	59	51	29	2.0	1.8									
October 82	9	35	10	1	4	3	-	9	3				-	21	8	10	69	61	24	2.9	2.5									
June October 83	24	27	12	-	4	2	4	15	5	Dry Wet - Minor Flooding Only			34	19	2	62	65	57	21	3.1	2.7									
October 83	33	29	11	-	7	4	-	13	6				15	18	5	48	67	57	26	2.6	2.2									

TABLE 7

Number of *C. porosus* sighted within the hatchling, small (2-6'), (3-6') and large (>6') size classes on the major component tidal systems within the Maningrida monitoring area. Also shown is the ratio of small to large and (3-6') to large crocodiles and the total number of (3-6') plus large animals (that is animals >3'). \* Numbers in brackets give numbers of crocodiles removed by Biology researchers before survey. \*\* See captions to Tables 1, 2 and 5 for the Liverpool-Tomkinson.  
 1 See Table 6; Majarie and Wurugoi Creek were not surveyed thus resulting in the omission of a few small and large animals. Hence the values of S/L and (3-6')/L are probably slightly TOO HIGH.  
 2 Because the 4 waterways of Rolling and Junction Bays were not surveyed in October 1977, September 1978 and October 1980 the Totals for those surveys are TOO LOW. Inspection of the results for immediately preceding and succeeding surveys indicates that the Totals for the 3 missing cases are too low by a MAXIMUM of 40(H), 80(S), 66(3-6'), 33(L) and 99(>3'). The ratios shown for these surveys are thus probably TOO HIGH.

	Blyth-Cadell System				Liverpool-Tomkinson System				Rolling & Junction Bays				Totals			
	H	S	(3-6')	L	H	S	(3-6')	L	H	S	(3-6')	L	>3'	S/L	(3-6')/L	
	Data Unusable				Major Flooding				No Surveys							
Aug/Nov 75	50	289	183	14	19	169	130	40**	1	78	46	12				
July/Sept 76	82	240	177	26	20	38	33	17	121	447	340	83	423	5.4	4.1	
May/June 77	108	232	196	25	40	166	39	9 <sup>1</sup>	152	449 <sup>1</sup>	396 <sup>1</sup>	73 <sup>1</sup>	469 <sup>1</sup>	6.2 <sup>1</sup>	5.4 <sup>1</sup>	
October 77	112	226	158	22	56	147	25	No : Surveys	168	373	298	47	345	7.9	6.3 <sup>2</sup>	
September 78	155	221	161	23	37	156	40	No Surveys	192	377	299	63	362	6.0	4.7 <sup>2</sup>	
June/July 79	123	287	196	55	289	152	141	No Flooding - Orifest Wet on Record	451	519	403	162	565	3.2	2.5	
October 80	119	249	160	32	71	173	122	No Surveys	190	422	282	83	365	5.1	3.4 <sup>2</sup>	
June/July 81	76	253	167	37	26	176	124	Heavy Flooding	110	494(7) <sup>1</sup>	(4) <sup>*</sup>	113	460	4.4	3.1	
October 81	72	204	127	39	34	166	132	8   65(7)*56(4)* 17   66   60   12	123	436	320	105	425	4.2	3.0	
June/July 82	136	205	163	67	193	207	178	Dry Wet - Minor Flooding Only	349	471	392	163	555	2.9	2.4	
Oct/Nov 82	111	197	154	39	144	171	155	20   59   51   29 10   69   61   24	265	437	370	132	502	3.3	2.8	
June/July 83	157	258	160	50	121	257	174	Dry Wet - Minor Flooding Only	340	580	391	125	516	4.6	3.1	
October 83	73	246	151	35	63	219	142	62   65   57   21 48   67   57   26	184	532	350	106	456	5.0	3.3	

TABLE 8

Number of *C. porosus* sighted within the hatchling, small and large size classes on the main alternative habitats of the Blyth-Cadell and Liverpool-Tomkinson Rivers Systems, such as various fresh and saltwater complexes and the extreme upstream sections of the Systems (see Fig. 2 and 3). The results for these 59.3 km of waterways are not included in Tables 1 to 7. The first seven habitats listed appear to provide alternative habitat largely for animals from the Liverpool-Tomkinson and Rolling and Junction Bay Systems. Subscripts show the number of (2-3') animals included.

	Elevation	Oct-Nov 1981			June-July 1982			Oct-Nov 1982			June-July 1983			October 1983				
		H	S	L	H	S	L	H	S	L	H	S	L	H	S	L		
Liverpool River km 60.0 - 66.4	6.4	No Survey			No Survey			-	5	3	-	5	1	4	-	1	4	
Maragulidban Ck. km 37.8 - 42.5	4.7	No Survey			-	1		-	1	1		-	1		-	-	1	
Tomkinson River km 73.7 - 81.3	7.6	11 July 1976 to km 80.1			-	18	14	-	11	13	2	18 <sub>1</sub>	9	9	-	-	8	9
Tom's Creek	8.9	1	-	2	No Survey			1	2	-	-	5	1	2	-	-	2	
Crab Creek	3.0	-	-	2	No Survey			-	-	1	-	-	2	-	-	1	1	
Anamayirra Ck.	7.3	No Survey			-	9	7	-	11	5	-	10	6	3	-	5	3	
Beach Creek	2.2	No Survey			-	3	3	-	3	-	-	6	1	2	-	-	-	
Blyth R.+Billabong km 49.8 - 64.6	13.2	1	2 <sub>1</sub>	3	1	1	3	5	7 <sub>2</sub>	7	1	4 <sub>2</sub>	1	4	-	-	4	
Cadell Gardens Billabong	2.0	-	1	3	No Survey			-	2	1	-	2	1	1	-	-	1	
Cadell Big Billabong	4.0	No Survey			-	2	3	No Survey			-	-	3	-	-	-	3	



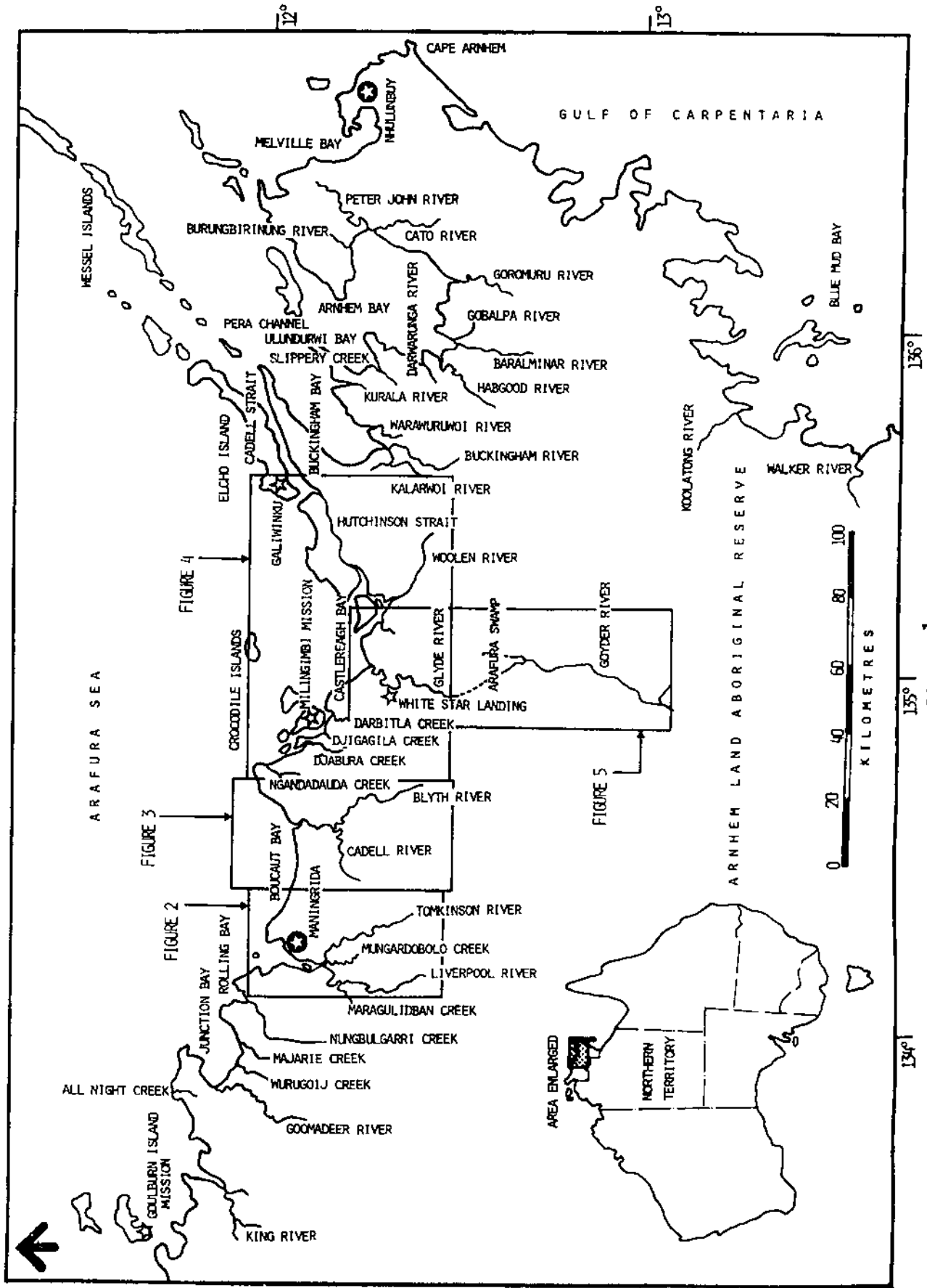


FIGURE 1  
GENERAL AREA MAP  
NORTH EASTERN ARNHEM LAND

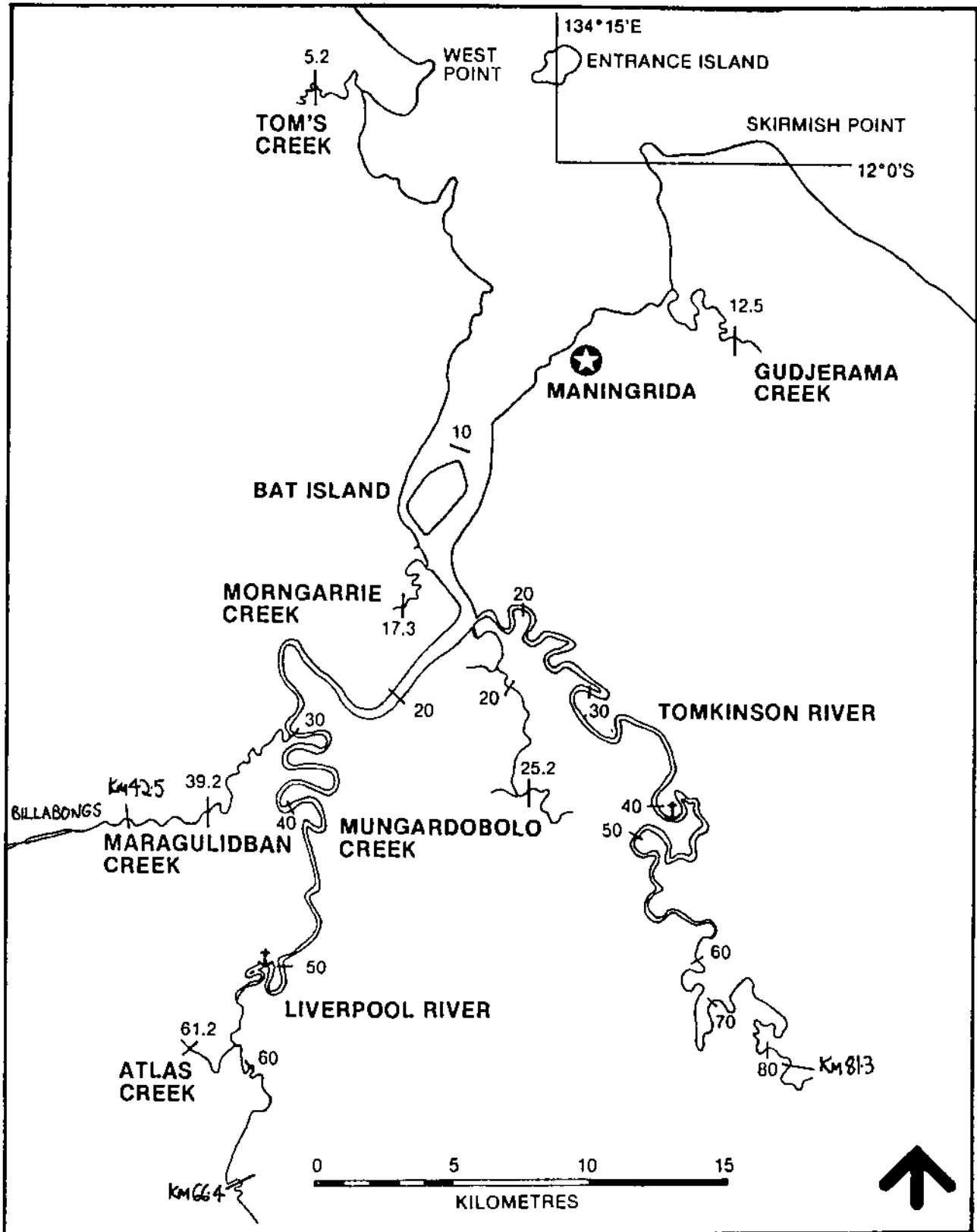


FIGURE 2  
THE LIVERPOOL - TOMKINSON RIVERS

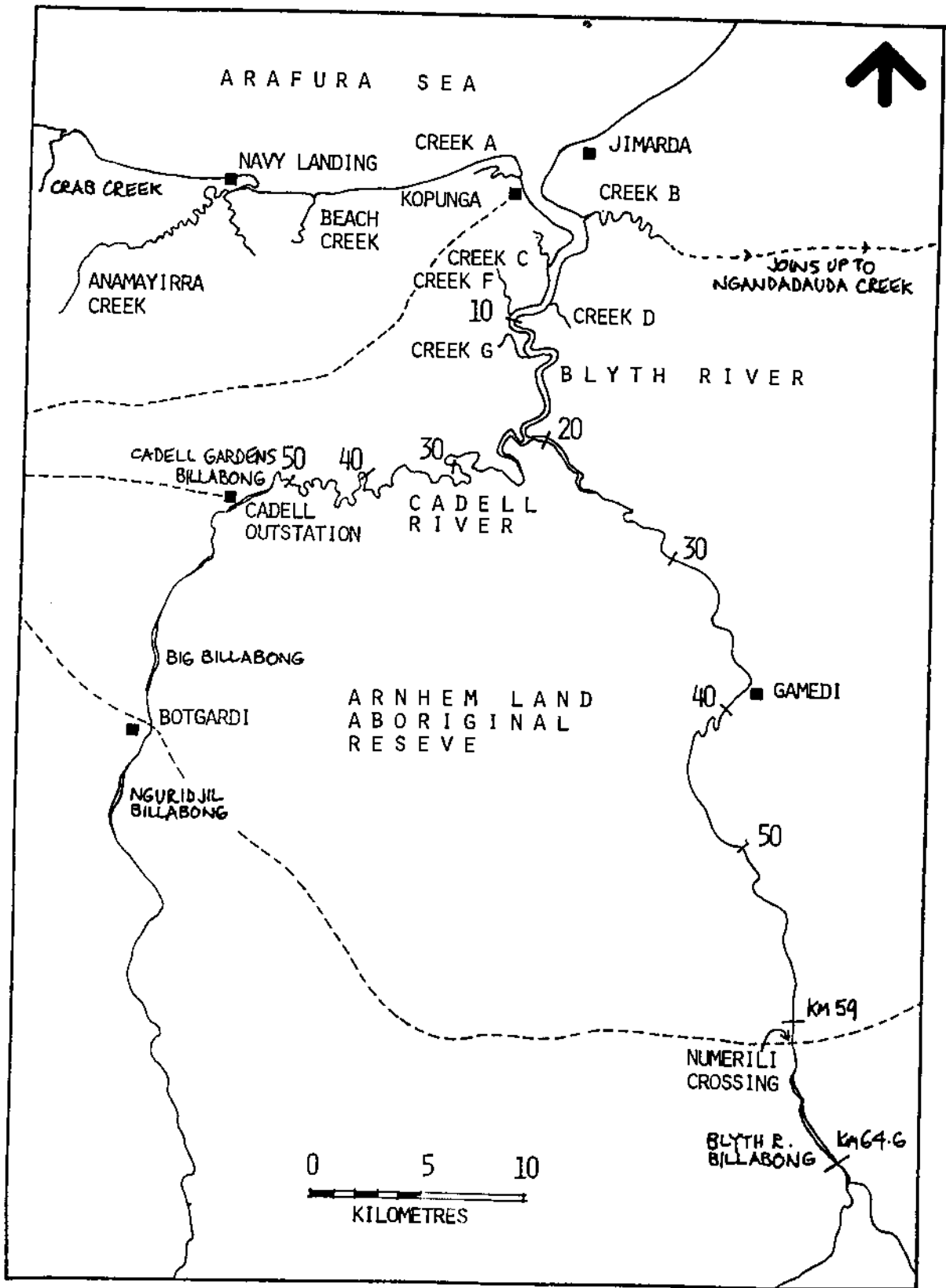


FIGURE 3  
THE BLYTH - CADELL RIVERS

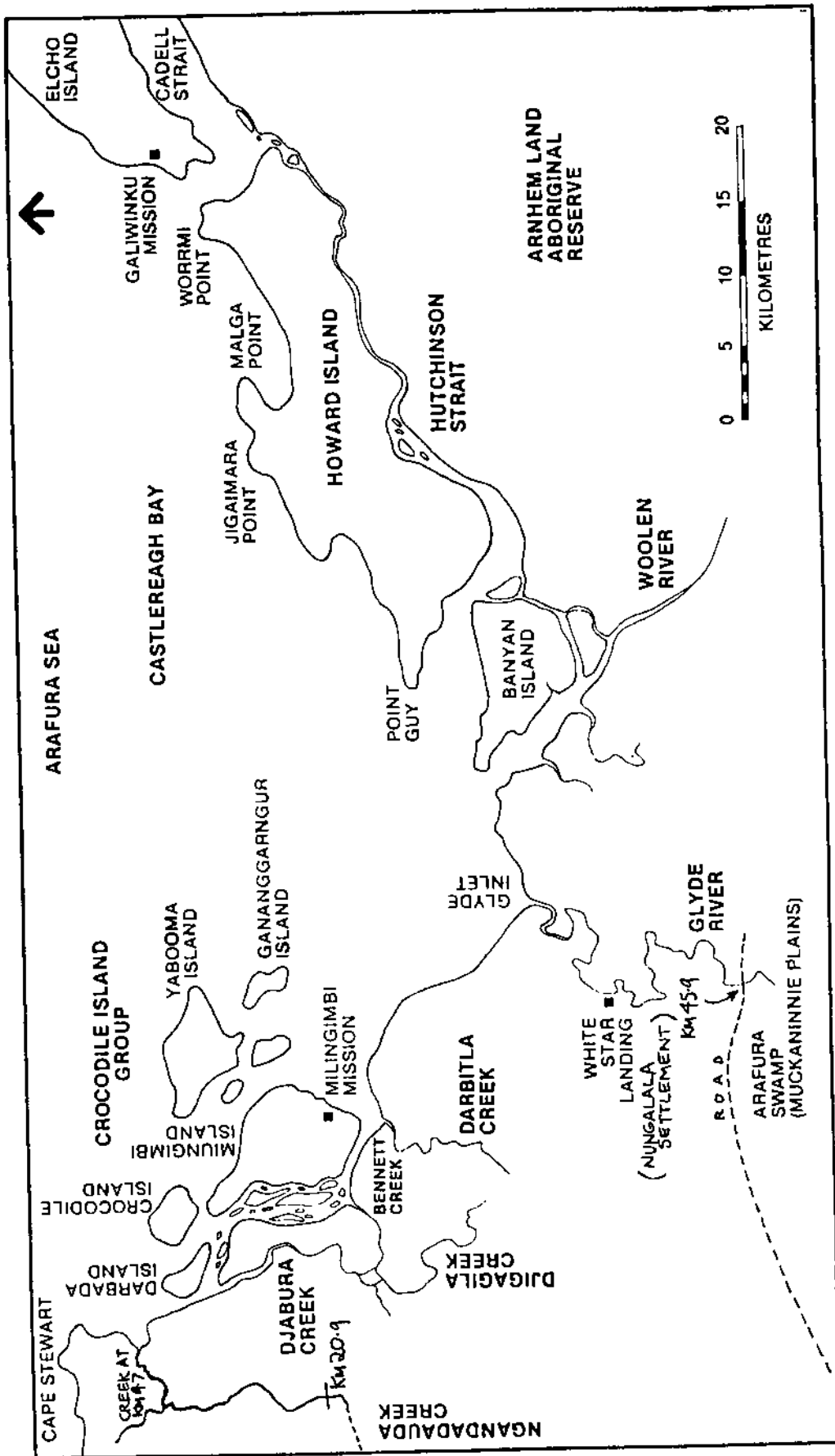


FIGURE 4  
 GENERAL AREA MAP SHOWING THE TIDAL WATERWAYS OF THE MILINGIMBI COMPLEX  
 AND OF CASTLEREAGH BAY.

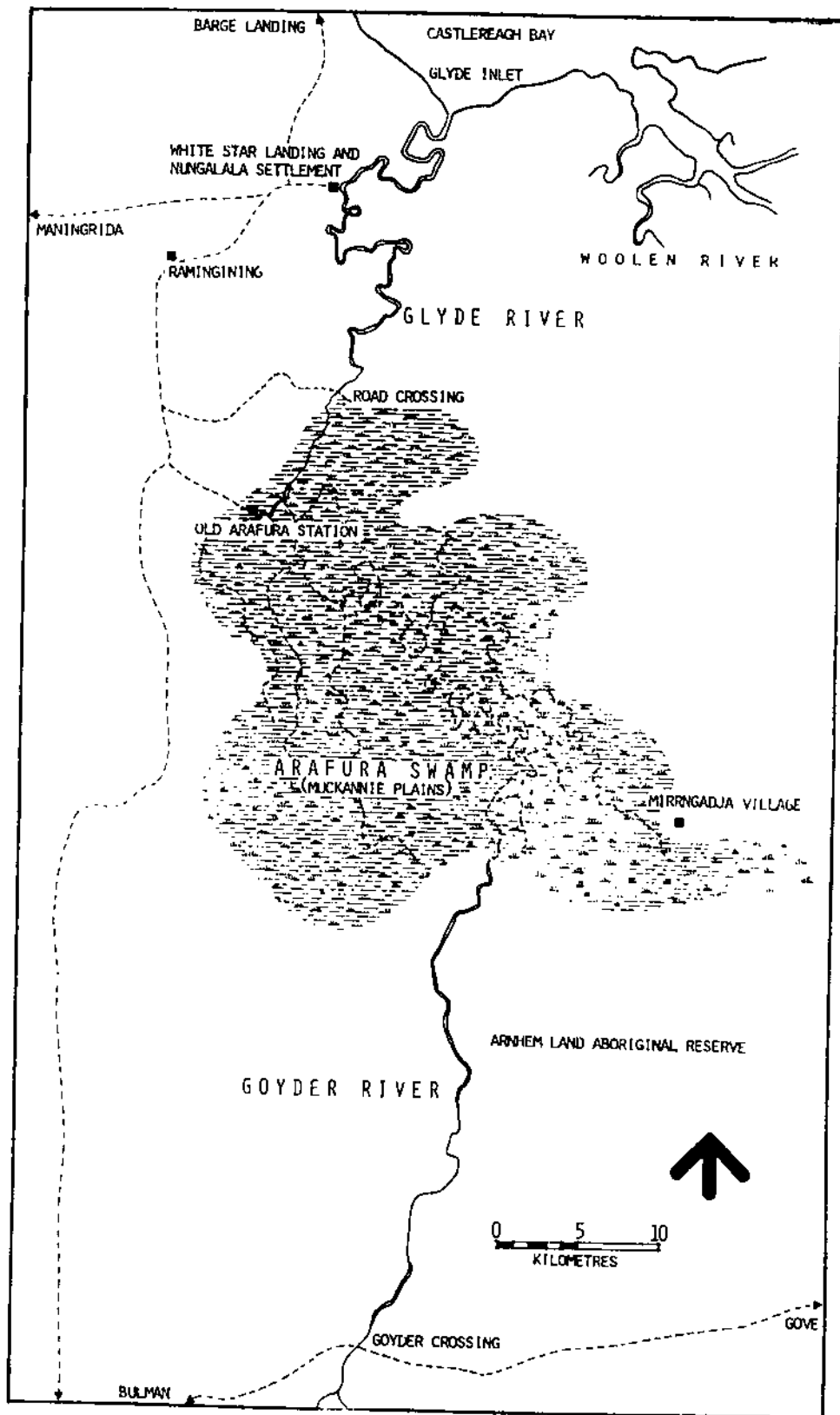


FIGURE 5  
THE GLYDE-ARAFURA AND GOYDER AREAS

LIVERPOOL - TOMKINSON SYSTEM 1976 - 1983

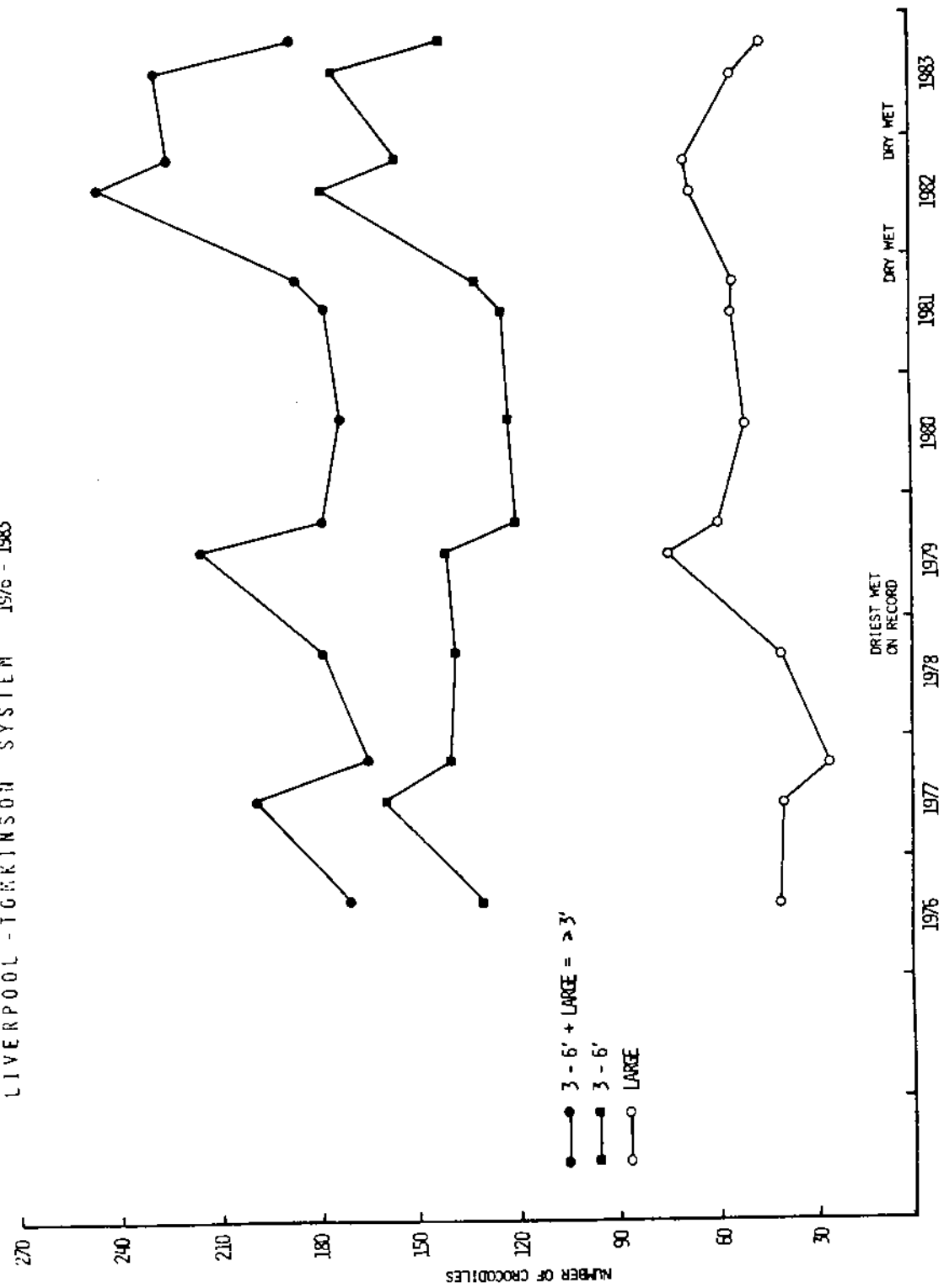


Fig. 6 A plot of the number of (3-6'), large (>6') and their sum, (3-6') plus large or (>3') animals for the 13 surveys carried out on the Liverpool-Tomkinson Rivers System during the eight years 1976 to 1983. Table 5 was used.

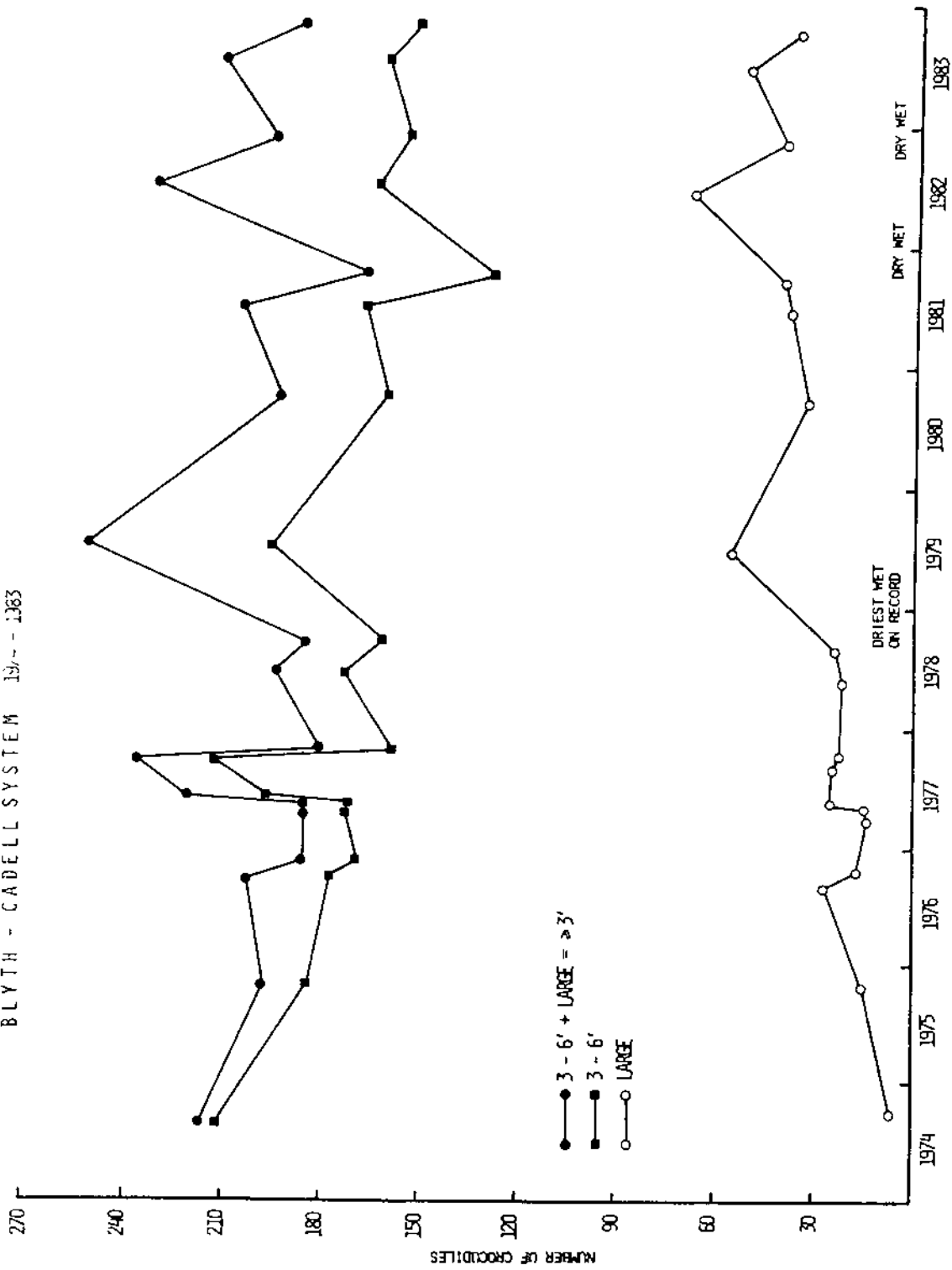


Fig. 7 A plot of the number of (3-6'), large (>6') and their sum, (3-6') plus large or (>3') animals for the 19 surveys carried out on the Blyth-Cadell Rivers System during the ten years 1974 to 1983. Table 4 was used.

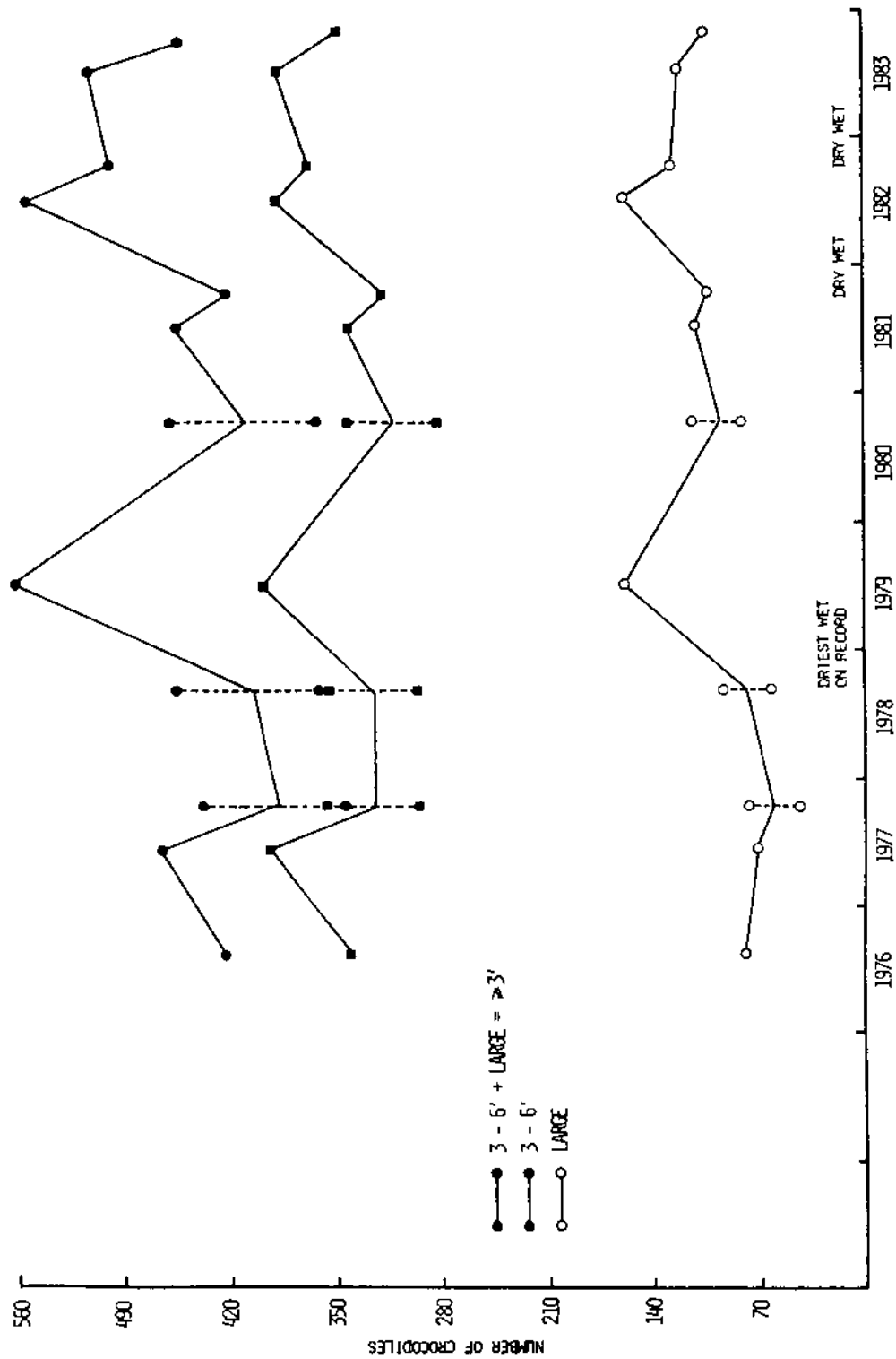


Fig. 8 A plot of the number of (3-6'), large (>6') and their sum, (3-6') plus large or (>3') animals for surveys carried out on the Liverpool-Tomkinson, Blyth-Cadell and Rolling and Junction Bays Rivers Systems during the eight years 1976 to 1983. For those years in which the waterways of Rolling and Junction Bays were not surveyed, we have plotted the numbers shown in Table 7 and the maximum figures also, but have drawn the line through the average value only.



STATUS OF CROCODYLUS POROSUS, JULY 1984, IN THE  
TIDAL WATERWAYS OF THE ALLIGATOR REGION AND IN  
THE ADELAIDE RIVER SYSTEM OF NORTHERN AUSTRALIA  
RECOVERY UNDER WAY

H. MESSEL, G.C. VORLICEK, A.G. WELLS, W.J. GREEN and I.C. ONELY  
Department of Environmental Physics,  
School of Physics  
University of Sydney  
Australia 2206

SUMMARY

This paper presents the results of resurveys in July, 1984 of the tidal waterways of the Alligator Region, of TYPE 3 Saltwater Creek and the Cobourg Complex of TYPE 3 waterways, which lie just to the north of the Alligator Region, and of the Adelaide River. Most of these waterways were surveyed three times previously, in 1977, 1978 and 1979.

The model of C. porosus population dynamics developed in previous publications predicts that the recovery of the population should be faster in TYPE 1 waterways with extensive associated freshwater complexes, such as in the Alligator Region, than in those without such habitat, because the losses of crocodiles should be lower. The recovery should thus be faster in the Alligator Region than found over the last 10 years in the monitored area centred on Maningrida, which has little such associated habitat. The results of the resurveys were in full conformity with the model: despite continued heavy losses due to drowning in fishermen's nets, in most of the tidal waterways of the Alligator Region there has been a major increase in the number of large (>6') crocodiles between 1978 and 1984. A substantial fraction of this increase appears to be derived from the freshwater complexes.

The Adelaide River was also expected to have a higher recovery rate than that of the monitored area, for two reasons: there are some remaining freshwater complexes not yet destroyed by feral buffalo and there is an extensive system of mostly TYPE 3 creeks on the downstream sections which could act as havens during the breeding season, thus decreasing the numbers leaving the river through the mouth. Again there was a most significant increase, between 1977 and 1984, in the number of large animals sighted.

There was no significant increase in the number of crocodiles sighted in the TYPE 3 waterways of the Cobourg Complex or in TYPE 3 Saltwater Creek between the 1979 survey and the 1984 resurvey.

The results of the surveys also confirm the existence of a bottleneck in the (3-6') size class. As in the result for the monitored area there is an amazing constancy in the number of animals in this size class, especially if only the (4-6') animals are considered. The increase in the number of large animals has shown however that a significant recovery is under way in the

Alligator Region and in the Adelaide River. The recovery in the Alligator Region would be even more marked if commercial net fishing were to be stopped.

### Introduction

The Adelaide, East Alligator, South Alligator, West Alligator and Wildman River Systems and Murganella Creek -all TYPE 1 systems - (Fig. 1) were first systematically surveyed in 1977 (the Wildman in 1978) and then resurveyed in 1978 and again in 1979. Just to the north of the Alligator Region, the largest of TYPE 3 waterways in northern Australia the Cobourg Complex consisting of the Ilamaryi and Minimini Complexes and Saltwater Creek -were surveyed for the first time in 1979 (Figs. 1 and 4). Our results for, and discussions of, the surveys were presented in Monographs 1, 3 and 18 for the Adelaide River System and Monographs 1, 4 and 14 for the Alligator Region River Systems and the Cobourg Complex. Detailed descriptions of the waterways were given in those Monographs also and full work maps in Monograph 15.

Our systematic surveys of some 100 tidal waterways in northern Australia between 1974 and 1983, reported in detail in a series of 18 Monographs and 2 Western Australian Reports, revealed that the tidal waterways in the Alligator Region, along with their associated freshwater complexes, constituted the largest concentration of TYPE 1 C. porosus breeding systems in northern Australia and could play a very important role in any potential recovery of the population. Importantly, the East Alligator River was included in Stage 1 of Australia's Kakadu National Park and the remainder of the Alligator Region's tidal waterways and their associated freshwater complexes were recently included in Stage 2 of the Park. We pointed out in Monograph 14 in 1980, and privately in the same year and in 1979, and again in 1983 (communication to Professor J. D. Ovington, Director of the Australian National Parks and Wildlife Service) the importance of systematically resurveying all the tidal waterways of the Alligator Region, twice annually, in July and again in October. It was further pointed out that resurveys of only one river system, or part of a river systems, in the Region, had very limited value and that such part resurveys would be difficult to interpret meaningfully. The results of our further repeated surveys, between 1980 and 1983, of the 330 km of control tidal waterways (see pages 14, 15 and 440-446 of Monograph 1, and Monograph 18) centred on the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems and the alternative C. porosus habitat (some 60 km) associated with them, reinforced this opinion. Surprisingly however, the resurveys of the overall tidal waterways of the Alligator Region have not been supported financially by the relevant Wildlife authorities and neither have they themselves carried out meaningful and adequate surveys of them.

Following on the surveys prior to 1980, we continued to monitor and resurvey the tidal waters in the Maningrida area and the results of these surveys enabled us to refine further our picture of the dynamics of C. porosus populations (see Monographs 1 and 18). The population model now runs as follows:

1. The tidal waterways of northern Australia have been classified according to their salinity signatures into TYPE 1, TYPE 2 and TYPE 3 systems as delineated in Chapter 3, Fig. 3.4. 11A of Monograph 1 (pages 100 and 101). TYPE 1 systems are the main breeding ones and non-TYPE 1 systems are usually poor or non-breeding systems. It is the TYPE 1 systems and the freshwater billabongs and semipermanent and permanent freshwater swamps associated with them which account for the major recruitment of C. porosus; the other systems contribute to a lesser degree and they must depend largely upon TYPE 1 systems and their associated freshwater complexes for the provision of their crocodiles. Non-TYPE 1 systems also sometimes have freshwater complexes associated with them but these are normally quite minor.
2. In Table 9.2.1 (page 419) of Monograph 1, our results show that in TYPE 1 systems some 27% of the crocodiles sighted are hatchlings (of which some 50% are normally lost between June of one year and June of the next, page 394 Monograph 1), whereas in TYPE 2-3 systems this figure falls to 14% and in TYPE 3 systems down to 4%, showing a much decreased hatchling recruitment in non-TYPE 1 systems. In TYPE 3 systems the percentage of crocodiles in the hatchling, (2-3') and (3-4') size classes combined is some 11% whereas in TYPE 1 systems, it is at least 52%. On the other hand the percentage of crocodiles in the (4-5') size classes is some 39% in TYPE 1 systems and 73% on TYPE 3 systems. Some 79% of the non-hatchling crocodiles are sighted on TYPE 1 waterways and 21% on non-TYPE 1 waterways (page 419 Monograph 1).
3. The relatively few large, and more frequent small freshwater billabongs and semipermanent and permanent freshwater swamps associated with tidal waterways are known to contain C. porosus but have not been inventoried systematically, except in a few cases. The accurate extent of their non-hatchling C. porosus populations is unknown. Based upon the fact that the number of large freshwater swamp areas, with substantial perennial water (normally bordering old river channels), in northern Australia is very limited -perhaps 400 km<sup>2</sup> maximum- and upon limited observations, we estimated that in 1979 the non-hatchling C. porosus population was less than 20% of the non-hatchling population sighted in tidal systems. We now believe that the 20% figure was an overestimate for 1979 -an unusual year associated with one of the 'driest wet' seasons on record.
4. It appears that the populating of non-TYPE 1 systems (hypersaline or partially hypersaline coastal and non-coastal waterways) results mostly from the exclusion of a large fraction of the sub-adult crocodiles from TYPE 1 systems and any freshwater complexes associated with them. Adult crocodiles appear generally to tolerate

hatchlings, (2-3') and sometimes even (3-4') sized crocodiles in their vicinity (but not always -they sometimes eat them, page 43 Monograph 14- or kill them, page 334 Monograph 1), but not larger crocodiles. Thus once a crocodile reaches the (3-4') and (4-5') size classes, it is likely to be challenged increasingly not only by crocodiles in the larger size classes and to be excluded from the area it was able to occupy when it was smaller. A very dynamic situation prevails with both adults and sub-adults being forced to move between various components of a systems and between systems. Crocodile interactions or aggressiveness between crocodiles in all size classes increases around October -during the breeding season (page 445 Monograph 1 and page 109 Monograph 18) and exclusions, if any, normally occur around this period. A substantial fraction ( 80%) of the sub-adults, mostly in the (3-6') size classes but also including immature larger crocodiles, are eventually excluded from the river proper or are predated upon by larger crocodiles.

5. Of those crocodiles that have been excluded, some may take refuge in freshwater swamp areas and billabongs associated with the waterways from which they were excluded or in the waterways' non-TYPE 1 creeks if it has any. Others may travel along the coast until by chance they find a non-TYPE 1 or another TYPE 1 waterways, however in this latter case they may again be excluded from it; others may go out to sea and possibly perish, perhaps because of lack of food, as they are largely shallow water on edge feeders, or they may be taken by sharks. Those finding non-TYPE 1 systems, or associated freshwater complexes, frequent these areas, which act as rearing stockyards, for varying periods, until they reach sexual maturity, at which time they endeavour to return to a TYPE 1 breeding system. Since a large fraction of the crocodiles sighted in non-TYPE 1 systems must be derived from TYPE 1 systems and their associated freshwater complexes, they are, as seen in (2) above, predominantly sub-adults or just mature adults (page 431 Monograph 1). Both sub-adults and just mature adults might attempt to return and be forced out of the system many times before finally being successful in establishing a territory in a TYPE 1 system or in its associated freshwater complex. Crocodiles may have a homing instinct (this important point requires further study) and even though a fraction of crocodiles may finally return to and remain in a TYPE 1 system or in its associated freshwater complex, the overall sub-adult numbers missing -presumed dead- remain high and appear to be at least 60-70%.

6. Normally, the freshwater complexes (swamps and/or billabongs) associated with tidal systems, are found at the terminal sections of small and large creeks running into the main waterway, or at the terminal sections of the mainstream(s). Though this alternative habitat is usually very limited in extent, sporadic (and sometimes extensive yearly) nesting does take place on it. There are, however, several fairly extensive freshwater complexes associated with TYPE 1 tidal systems these are important as they may act both as rearing stockyards and as breeding systems, just as the TYPE 1

waterway does itself. Examples of these are the Glyde River with the Arafura Swamp (Monograph 9), the Alligator Region Rivers with their wetlands (Monographs 4 and 14), and the Daly, Finnis, Reynolds and Moyle Rivers with their wetlands (Monograph 2). Not only can the loss factor, which appears to occur during the exclusion stage, be expected to be lower for movements into and out of swamp areas associated with a TYPE 1 waterway, than for movement into and out of coastal non-TYPE 1 systems, but the loss of nests due to flooding can also be expected to be less. We have observed nests made on floating grass cane mats in the Daly River Aboriginal Reserve area. Thus recovery of the C. porosus population on TYPE 1 tidal waterways, with substantial associated freshwater complexes, can be expected to be faster than on other systems (page 445 Monograph 1, page 98 Monograph 14).

7. Because of the 80% exclusion and at least 60-70 losses of sub-adult crocodiles as they proceed toward sexual maturity, there has been no significant sustained increase in the non-hatchling C. porosus population on the tidal waterways of our monitored area in northern Australia since the commencement of our systematic surveys, a period of ten years (Monograph 18).

8. Assuming the results from our monitored area apply elsewhere, any significant sustained increase in the non-hatchling C. porosus populations on the tidal waterways of northern Australia must be measured in decades. However, as discussed in (6) above, on tidal systems with associated freshwater complexes, the recovery could be expected to be more rapid.

9. Though there has been no sustained significant increase in the number of non-hatchling crocodiles sighted on the monitored control tidal waterways since our surveys started in 1974, the size structure of the animals sighted appears to be changing slowly. Notwithstanding substantial fluctuations, the ratios of small (2-6') to large (6'), and (3-6') to large animals is decreasing on the Blyth-Cadell, may be decreasing on the Liverpool-Tomkinson and is decreasing overall on the tidal waterways of the Maningrida monitoring area. Thus there is some indication of the commencement of a slow recovery phase. However even this could be open to dispute.

10. Though there are wide fluctuations, specially after 'dry wet' seasons when the animals are concentrated into the tidal waterways, it appears that as the number of large crocodiles in a tidal waterway increases, there is a tendency for the number of sub-adults in the (3-6') size classes to decrease or increase marginally only. Thus the total number of (3-6') and large animals sighted appears generally to be holding steady or increasing slowly only. It is almost as if there were a set number of territories or slots in a river system, and the crocodiles themselves are primarily responsible for the very heavy losses of 70% that occur in the process of trying to secure these slots or to increase them in number.

11. When a steady state is reached in a 'recovered' population, the ratio of (3-6') to large animals might be considerably less than one.

12. If one considers a group of 100 of the sub-adult crocodiles in a TYPE 1 tidal system without a substantial freshwater complex associated with it, one can expect some 80 to be excluded from it, at least 60-70 to end up missing -presumed dead, less than 15-20 to successfully establish territories on the system without having to leave it and the remainder might eventually also return and establish a territory, especially after becoming sexually mature. The very nature of this matter is such as to preclude precise figures and they must be looked upon as broad estimates only, however detailed study of our results (Monograph 18) now indicates that the missing -presumed dead figure is likely to be in excess of 70.

13. When there is an exclusion of sub-adult animals, mostly (3-6') in size but also including immature larger animals, this place mainly in the breeding season, normally commencing around September-October and apparently lasting throughout the season. Any influx of animals, in the (3-6') and/or large size classes, appears to occur mainly in the early dry season and to be completed in the June-early September period, but may in some years be earlier.

14. After a single 'dry wet' season there is a substantial influx of large and sometimes (3-6') animals, forced out of freshwater complexes, into the tidal waterways and these are sighted during June-July surveys. Surveys made in October-November of the same year, usually reveal a substantial decrease in the number of (3-6') and/or large animals sighted, however the number of large animals sometimes remains higher than previously and hence a number of the new large animals do not return from whence they came. These animals appear successful in establishing a territory on the waterway, and it could be the waterway from which they had originally been excluded. The 'dry wet' variation in the number of animals sighted appears to be superimposed upon the variations normally found during surveys following usual wet seasons -which generally result in extensive flooding on the upstream sections of the tidal waterways. Hatchling recruitment on the tidal waterways is generally greatly enhanced during 'dry wet' season but appears to be greatly reduced in major swamp habitat. The reverse appears to be true during normal or heavy wet seasons.

Thus on the basis of this model one would predict that the recovery, between 1979-1984, of C. porosus populations in the tidal waterways of the Alligator Region should be greater than that found on the tidal waterways in the Maningrida area, where the immediate freshwater complexes associated with the tidal systems are quite minor in comparison to those associated with the tidal systems in the Alligator Region. However (see Monograph 18) we have stressed the important role played by the Arafura Swamp for many of the animals in the Maningrida area. Furthermore, even though the destruction (by feral water buffalo) of the freshwater complexes associated with the Adelaide River Systems has been severe, recovery on this waterway during the intervening 5 to 7 year period, might be substantial since there are over 100 km of

saltwater creeks on the downstream sections of the waterway, many of which could act as rearing stockyards for the (3-6') and sexually immature large animals. This could be expected to cut the exclusion and/or loss factor substantially as we found on the Kalarwoi River in Bruckingham Bay (page 28 Monograph 10).

The transfer of the University of Sydney's C. porosus field headquarters, in November 1983, from Maningrida on the Liverpool-Tomkinson Rivers System to Urapunga on the gaint Roper River System in the southwestern corner of the Gulf of Carpentaria (Monograph 18), provided an opportunity for a fourth and final resurvey of the tidal waterways in the Alligator Region and of the Adelaide River Systems and also for a resurvey of the Cobourg Complex. Our survey boats and gear had to be moved by road just past these Systems. The opportunity to check the change in the status of C. porosus in these waterways during the last 5 years and to test our model further in a different area, and to amend it if necessary, was too good to be missed. Thus it was decided to charter a vessel -The Shiralee S (The Harry Messel, the University's research vessel, was already on charter to the Australian Institute of Marine Sciences, Townsville, Queensland) and to resurvey the waterways during June-July 1984. The results presented in this paper are a consequence of this decision.

### Results

Standard survey methods as laid down in detail in Chapter 2 of Monograph 1 were used for each of the spotlight surveys and the same two spotters (WJG and AGW) were used for the 1977, 1978, 1979 and 1984 surveys. Summary results for each of the tidal waterways resurveyed are shown in Tables 1 and 2. The detailed results, including the distributional diagrams, for each of the latest resurveys will appear, in due course, in Monograph 19.

In Table 1 we have updated the relevant portions of Table 9.2.1 of Monograph 1 by including the results of our July 1984 resurveys. Table 2 was prepared by using the data given in Table 1 and groups the size classes in such a way as to focus attention on important aspects of the dynamics of the C. porosus population in the area concerned. We found this method of viewing the data very helpful when considering the data for surveys carried out in the Maningrida area.

We draw attention to two important points when considering and comparing the results shown in Tables 1 and 2. The first relates to the matter of errors in size class estimation. We discussed this matter in some detail on pages 80, 335 and 389 of Monograph 1 and on page 117 of Monograph 18, and refer the reader to these. The matter concerns the importance of comparing results for equivalent survey season, that is, breeding versus breeding and non-breeding versus non-breeding periods whenever possible (pages 124, 125 Monograph 18). For example, October-November surveys should, if possible, be compared with other October-November surveys and not June-July ones. IN THE CASE OF THE PRESENT JUNE-JULY SURVEYS OF THE TIDAL WATERWAYS IN THE ALLIGATOR REGION, RESULTS CAN BE MOST MEANINGFULLY COMPARED WITH THOSE FOR

THE JUNE-JULY 1978 AND AUGUST 1979 SURVEYS RATHER THAN THE OCTOBER 1977 ONE. However even in the case of the 1979 results, considerable caution must be used, for the 1978-1979 wet season was the driest on record and many of the animals that would have normally been in the associated freshwater complexes at the time of the survey were forced back into the tidal waterways (see Monographs 1, 4, 14 and especially Monograph 18 where this matter is discussed in detail). In the case of Murgenella Creek, the concentration appears to have taken place in 1978 (page 18 Monograph 4 and page 76 Monograph 14).

#### MURGENELLA CREEK

This Creek System (Figs. 1, 2 and 4 ) is an important one as it is included in Murgenella Wildlife Sanctuary and has substantial freshwater swamps upstream which constitute both important breeding and rearing habitat. The Creek is closed to commercial net fishing. However during our 1977 and 1978 surveys, 13 poachers' nets were found and confiscated by a Wildlife Ranger working with us. No nets were sighted during the 1979 survey or the survey on the night of July 7, 1984. One could thus hope that the number of C. porosus sighted on Murgenella Creek during the 1984 survey would reflect an undisturbed, natural recovery over at least the past six years. The number and size class distributions of the animals sighted are shown in Tables 1 and 2 and reveal a major and statistically significant ( 99% level) increase from 125 in June 1978 to 229 in July 1984 in the number of non-hatchling sighted. The density of non-hatchlings has increased from 2.8/km to 5.0/km. Attention is drawn to a number of other important points in relation to the results:

1. Note that of the increase of 104 non-hatchlings, at least 57 are in the (3-4') size class and on the basis of our model one can expect a large fraction of these animals not to reach the (4-5') size class and hence for the number of animals remaining in the (3-6') size classes to fall back close to previous levels. The density figure of 5.0 is thus somewhat inflated by the figure of 117 (3-6') animals shown in Table 2, of which at least 61 are in the (3-4') size class. These latter animals would have arisen from the excellent hatchling recruitment during the 'dry wet' of 1981-1982.

2. Special attention should be focussed on the number of animals sighted in the (4-5') plus (5-6') size classes -46 in 1977, 41 in 1978, 46 in 1979 and 49 in 1984. The constancy of this total is truly an important and remarkable result and reflects precisely the same phenomena we have been observing on the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems for the past 10 years (Monographs 1 and 18). Regardless of how large the recruitment may be, the number of animals sighted in the (4-5') plus (5-6') size classes seems to remain closely constant or increase slowly only. It is as if there were a definite number of slots for these animals on a given river system and that the number of these increase slowly only.



3. The most important aspect of the number count is the increase in the number of large animals sighted, increasing from 59 in 1978 to 95 in 1984 or an increase of some 61% (Table 2). This result provides strong support for the contention that one is witnessing a sustained and important recovery of the C. porosus population in Murgarella Creek and its associated freshwater complexes.

4. One may obtain an estimate for the minimum percentage of (3-6') crocodiles which were excluded and/or lost from Murgarella Creek by noting (Table 2) that 50 (3-6') and 59 large animals were sighted during the June 1978 survey and that the July 1984 survey revealed 95 large animals. Each of the (3-6') animals of 1978 would, if they survived, be in the large size classes by 1984 and hence the minimum percentage which have been excluded and/or lost (minimum because we have assumed that all the increase originated from the 50 (3-6') animals of 1978) is  $(50-36)/50$  or 28%. Using the figures for the 1979 and 1984 surveys yields an exclusion and/or loss factor of  $32/66$  or 48%. These figures are to be compared with those found for tidal systems such as those in Arnhem Bay (88%, Monograph 11), the Blyth-Cadell Rivers System (80%, page 134 Monograph 18), Liverpool-Tomkinson Rivers System (80%, page 127 Monograph 18). Each of these latter waterways are excellent TYPE 1 breeding systems but the freshwater complexes associated with them are very limited. The model we outlined in the introduction (see point 6) predicts that the loss factor, which appears to occur during the exclusion stage, should be expected to be lower for movements into and out of swamp areas associated with TYPE 1 waterways, than for movement into and out of coastal non-TYPE 1 systems and that the recovery of the C. porosus population on such systems should be faster than for the latter ones. The present results for Murgarella Creek provide excellent support for this hypothesis.

5. Hatchling recruitment on the Creek appears to continue to be minimal in relation to the number of large animals sighted and hence one is led to believe that a large fraction of the (3-6') and large animals sighted on the Creek must come from the associated freshwater complexes associated with the terminal sections of it. This is further borne out by a study of the distributional pattern of the animals (see Monograph 4 and 14 for previous surveys; Monograph 19 will contain the distributional diagram for the 1984 survey) which shows that the number of animals sighted generally increases as one proceeds upstream, rather than decreasing once the freshwater sections are reached -as occurs on tidal systems with minimal swamp habitat at or bordering their upstream sections (Monographs 1, 12 and 18). The freshwater complexes associated with the upstream sections of Murgarella Creek are acting both as breeding systems and rearing stockyards, with substantial interchange with the mainstream and its subcreeks. In fact the relatively high loss factor of 48% given in (4) for the 1979-1984 period is undoubtedly partially due to a fraction of the animals returning to the freshwater complexes after having been concentrated back into the tidal system by the drying back of swamps. The freshwater complexes appear to be as, or even more, important than the tidal waterway itself, as far as recruitment is concerned.

## EAST ALLIGATOR RIVER SYSTEM (Figs. 1 and 2)

This tidal waterway, which formed the backbone of Australia's Kakadu National Park Stage 1, was resurveyed for the fourth time during the period July 4-6, 1984; having been surveyed three times previously, in 1977, 1978 and 1979. The 1979 survey was made after the 'driest wet' on record, that of 1978-1979, and the resurveys of that year indicated that many large animals had been forced out of the freshwater complexes associated with the System, and concentrated back into it (pages 440-445 Monograph 1, Monographs 14 and 18). Did these animals manage to establish territories for themselves and to remain on the tidal system or were they perhaps forced out of it -yet again? And how many of the large animals were drowned in barramundi fishermen's nets set between the mouth of the East Alligator and Coopers Creek at km 13- for the Australian National Parks and Wildlife Service have continued to allow commercial net fishing in the East Alligator River from km 0 to 13 and in Coopers Creek itself. Though we are unable to give exact figures for the number of animals drowned, we do know for certain that the figure is substantial and hence must be reflected in the exclusion and/or loss figure to be derived later and must also impact heavily upon the rate of recovery of C. porosus on the East Alligator River System. The results given in Tables 1 and 2 for the East Alligator reveal:

1. That the density of non-hatchling C. porosus has increased from 2.4/km in June 1978 and 2.9/km in August 1979 to 3.3/km in July 1984.
2. That there has been a statistically significant ( 99% level) increase, from 290 in June 1978 to 389 in July 1984, in the number of non-hatchling C. porosus sighted (Table 1). Even the increase from 340 non-hatchlings sighted in August 1979 is statistically significant at the 95% confidence level. However note the relatively high number of (2-3') animals giving rise to the increase between 1978 and 1984 and the fact that many of these were unlikely to ever enter the (4-5') size class.
3. The number of Eyes Only (EO) crocodiles sighted increased from 38 in each of 1977 and 1978, and 58 in 1979, to 100 in 1984. Since the EO crocodiles reflect wariness, the results of our present resurvey indicate increasing disturbance of the animals on the waterway, especially upstream. The relatively high EO count makes an unambiguous discussion of the results difficult and probably accounts for the fact that only 59 crocodiles were positively identified in the (4-5') plus (5-6') size classes, whereas during the 1977, 1978 and 1979, 98, 93 and 86, respectively, were sighted in these size classes. If one distributes the EO's as suggested in the caption to Table 2 and then distributes equally among the (3-4'), (4-5') and (5-6') size class (also see Table 6.2.30 Monograph 1), the respective numbers for the 1977, 1978, 1979, and 1984 surveys become 111, 106, 107 and 93 respectively, again indicating the relative constancy of the number of (4-5') plus (5-6') sized class animals sighted. As in the case of Murgarella Creek (point 2) this again appears to indicate a fairly constant number of slots for these animals on a given tidal waterway.

4. As for *Murgenella* one may obtain an estimate for the exclusion and/or loss factor for animals in the (3-6') size classes. Using the 1978-1984 and 1979-1984 results given in Table 2, one obtains the factors 119/175 and 153/159 or 68% and 96% respectively. This suggests that a substantial portion of the influx of some 50 large animals into the System following the 'driest wet' on record of 1978-1979 had been lost (certainly some through drowning in commercial fishermen's nets, but the exact number is unknown) or that some of these animals had returned to the freshwater complexes associated with the waterway, or that the exclusion and/or loss factor for animals in the (3-6') size classes was high. A combination of all three possibilities is probably close to the actual situation.

5. The number of (3-6') animals sighted on the waterway during the surveys of 1977, 1978, 1979 and 1984 has remained relatively constant, varying between 154 and 181, whereas the number of large animals sighted has increased from 101 in 1978 to 151 for 1979 and then only by 6 more in the intervening 5 year period, between 1979-1984. This again makes one suspect that some of the heavy losses in the (3-6') size classes and also heavy losses of large crocodiles are probably due in considerable measure to drowning in fishermen's nets. Compare the respective results for *Murgenella* Creek and the East Alligator River System for the (3-6') and large size classes (Table 2). In spite of the above, the East Alligator River appears to be on the road to recovery and if one did not have results for 1979 and just compared the results of the 1978 survey with those for 1984, one would feel pleased.

6. The relatively low hatchling recruitment on the East Alligator tidal waterway (for instance compare with the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems, pages 114 and 115 Monograph 18) suggests substantial additional recruitment of animals from the important freshwater complexes associated with it.

#### SOUTH ALLIGATOR RIVER SYSTEM (Figs. 1 and 3)

This tidal waterway must rank as one of the most important crocodile-wise and most ugly scenic-wise in the Alligator Region. Its inclusion into Kakadu National Park, Stage 2, makes it even more important. Much of the riverine and swamp habitat associated with its downstream sections has been destroyed by feral water buffaloes, but its inclusion into Kakadu National Park could ensure that buffalo numbers are closely controlled and hopefully the habitat will be restored. The upstream sections of the waterway are still associated with some excellent freshwater habitat and importantly Nourlangie Creek drains much of this and acts as a funnel for C. porosus between this freshwater complex and the tidal system.

Unfortunately commercial net fishing for barramundi is still permitted from km 0 to km 24.5 on the South Alligator and again there are heavy losses -mostly of large crocodiles- through drowning in barramundi nets.

One is able to view the greatest concentration of large crocodiles on a tidal system in Australia in Nourlangie Creek and on the upstream km 90-95 section of the mainstream. During the 1984 survey 28 large animals (some very large, 14ft or more) were sighted on the km 90-95 section of the waterway and 31 on Nourlangie Creek (km 84-90). With the inclusion of the South Alligator River System into Kakadu Park, this C. porosus resource could easily become a tourist attraction of considerable national and international renown.

Our previous surveys of the South Alligator System highlighted a number of perplexing problems (page 91 Monograph 14) in relation hatchling recruitment and the relatively high proportion of (3-6') and large animals sighted on the waterway. It is now clear that hatchling recruitment on the tidal system will remain minimal until the riverine habitat is restored and that in the meantime the System will continue to depend mostly upon the influx of animals from the freshwater complexes associated with it or from other systems in the Alligator River Region. One need only examine, for the South Alligator, the size class columns of Tables 1 and 2 to see that there is no way that the spectacular increase in the number of large animals sighted, from 75 in 1978 to 147 during the 1984 survey could be derived from within the tidal sections of the waterway itself. These animals have come from elsewhere and are using the waterway predominantly as a rearing stockyard rather than as a breeding system. Though the South Alligator is a very typical TYPE 1 system salinity-wise, because of the catastrophic destruction of much of its riverine habitat, nesting on it is minimal. In consequence, the normal exclusion and/or loss calculations carried out for the other TYPE 1 systems in the Region are of limited value, for even though there are losses due to interactions and certainly heavy and continued losses due to commercial net fishing, these losses are fortunately being offset by an influx of animals from elsewhere. Carrying out our normal loss calculation for the (3-6') size classes, for the years 1978-1984 and 1979-1984, yields minimum exclusion and/or loss factors of 1/73 and 12/58 or some 1% and 21% respectively. However, as pointed out previously, most of the (3-6') animals themselves come from elsewhere and not from within the tidal sections of the waterway itself. Other points which are evident from Tables 1 and 2 are:

1. The number of (3-6') animals sighted on the waterway has remained relatively constant, varying between 73 on both the 1977 and 1978 surveys down to 58 in 1979 and back to 78 on the 1984 survey. Probably the increasing number of large C. porosus on the waterway is keeping the number of (3-6') animals down. Note the decreasing ratio of (3-6') to large animals shown in Table 2; down from 1.06 in 1977 to 0.53 in 1984.

2. The density of non-hatchling C. porosus sighted during the surveys increased from 1.2/km in 1977 to 2.1/km in 1984, with the major increase taking place between the surveys of 1979 and 1984 and in the large size classes. The density was still only 1.4/km during the 1979 survey.

3. The increase from 151 non-hatchling sighted in July 1978 to 240 sighted during the July 1984 survey is statistically significant at 99% level. However one does not need statistical arguments to see that there has been a spectacular increase and that most of it occurred in the important large size classes.

#### WEST ALLIGATOR RIVER SYSTEM (Figs. 1 and 3)

This excellent little TYPE 1 waterway has also been included into Australia's National Kakadu Park -Stage 2, but is being slowly throttled crocodile-wise by the commercial barramundi fishermen who are able to net legally from km 0 to 17.2 on the 42.2 km of the surveyable length of the waterway. In the process, they drown large numbers of large C. porosus and only catch a few barramundi. In addition, feral water buffaloes have destroyed much of the former excellent riverine habitat and a substantial fraction of the freshwater complex habitat associated with the tidal waterway. The feral water buffalo problem is likely to be solved relatively quickly by Kakadu Park Authorities but not so for the commercial barramundi fishing; there are some hard major decisions to be made here if the valuable C. porosus resource is to be allowed to recover in the National Park.

The results shown in Tables 1 and 2 for the West Alligator System show that:

1. The density of non-hatchling C. porosus sighted, has increased from 1.5/km in 1978 to 2.4/km in 1984. Furthermore, this increase was due almost solely to the increase from 37 to 77 in the number of animals sighted in the (3-6') size classes and at least 21 of the increase were in the (3-4') size class. As Table 2 shows, there was an increase of 4 large animals only, from 20 to 24, between the 1978 and 1984 surveys.

2. The number of non-hatchlings sighted increased from 62 in 1978 to 103 in 1984 and this increase is statistically significant at the 99% confidence level.

3. It is probably of limited value to conjecture about the dynamics of the population when one knows that so many animals are lost through drowning in nets. During each of our four surveys, in 1977, 1978, 1979 and 1984, we found the West Alligator System a maze of barramundi nets (page 55 Monograph 4, pages 91-92 Monograph 14) and it appears a miracle that any C. porosus at all remain on the km 0-17.5 section of the waterway. Carrying out our normal exclusion and/or loss calculation for the (3-6') size classes for the surveys of 1978-1984 shows that the minimum loss factor was 33/37 or 89% and for the 1979-1984 surveys the loss was 100%. Not only did the 41 (3-6') animals sighted during the 1979 survey, NOT give rise to any additional large animals, but 10 of the 34 large animals sighted in 1979 were missing also. We have no doubt whatever, that one of the reasons for these heavy losses is the drowning, in fishermen's nets, of a substantial fraction of the animals on the tidal waterway. Of course some of the animals may have returned to the freshwater complexes associated with the System.

4. Examination of the number of (4-5') plus (5-6') animals sighted during each of the four surveys is of limited value, because of the totally artificial situation created on the waterway through exceedingly heavy net fishing. The figures for 1977, 1978, 1979 and 1984 were 29, 22, 21, and 39 respectively and the increase in the number for 1984 might be related to the relatively large decrease, from 34 to 24, in the number of large animals sighted, however it is difficult to be firm on this point.

5. The very small hatchling recruitment rate on the tidal waterway suggests that a large portion of the (3-6') and large animals sighted were derived from elsewhere -from other tidal systems in the Region and/or from the important freshwater complexes associated with the West Alligator System.

#### WILDMAN RIVER (Figs. 1 and 3)

This tidal waterway is very much like the West Alligator System except that unlike the West Alligator it has no surveyable creeks on its downstream sections and has a surveyable length of 33.5 km only. It too, has fortunately been included in the Kakadu National Park -Stage 2, but again commercial net fishing is still permitted from km 0 to 22. Rather than repeating here the introductory remarks we gave for the West Alligator System, one should reread those and substitute the word "Wildman" for the West Alligator.

Though superficially the two waterways appear much the same and both have freshwater complexes associated with them, our survey results show that crocodile-wise, the Wildman is a far better system. From Tables 1 and 2 one sees that:

1. There has been a spectacular increase, from 1.9/km in 1978 to 6.0/km in 1984, in the density of non-hatchling C. porosus sighted on the waterway. The density was 4.0/km in 1979 when many C. porosus were concentrated back into the tidal waterway from the drying out freshwater complexes associated with it. The non-hatchling numbers sighted increased from 65 in 1978 to 200 in 1984. This is the kind of increase we had been waiting for, even though at least 106 of the 200 non-hatchlings sighted were in the (2-3') and (3-4') size classes and most of these were unlikely to ever reach the (4-5') size class.

2. The exclusion and/or loss calculation for the (3-6') size classes shows for 1978-1984 a loss factor of 5/28 or 18% only, but using the 1979-1984 data shows that not only did the 44 (3-6') sized animals sighted in 1979 disappear, but in addition 12 of the 56 large animals sighted had disappeared by the time of the 1984 survey. Net fishing for barramundi must be responsible for the loss of a high fraction of these animals.

3. The number of large animals sighted increased from 21 in 1978 to 44 in 1984, however, it must be noted that the number sighted in 1979 was 56 and were it not for the crocodiles drowned in nets it is likely that the figures of 56 would have been surpassed in 1984. Note that this was the case for Murgarella Creek where commercial net fishing for barramundi is prohibited. Note too from Table 1, that the missing large animals were all in the (>7') size classes; decreasing from at least 31 in 1979 to 13 in 1984. However some of these animals may have returned to the freshwater complexes from which they came.

4. The same remarks may be made here for the Wildman as they were for the West Alligator in relation to the relative constancy until 1984 of the number of animals sighted in the (4-5') plus (5-6') size classes.

5. If commercial net fishing is prohibited on the Wildman, the Tables indicate that a relatively rapid and substantial increase in large animals could occur since there appears to be significant recruitment of hatchlings on the upstream sections of the waterway in addition to the animals being contributed by the freshwater complexes associated with it.

#### OVERALL TIDAL WATERWAYS OF THE ALLIGATOR REGION (Fig. 1)

In Tables 1 and 2 we show results summed for the 354.5 km of TYPE 1 waterways surveyed in the Alligator Region -that is for all the TYPE 1 tidal waterways in the Region including Murgarella Creek and the Wildman River. They show without doubt, that a recovery of C. porosus in the Alligator Region is underway in conformity with the predictions of our model, discussed in the introduction. We can also state that, were it not for the drowning of large numbers of large crocodiles (probably considerably more than 100 annually in the Region) in commercial fishermen's nets, the recovery would be even more spectacular. The following points are shown by the Tables for the Alligator Region with the Wildman:

1. That the number of non-hatchling C. porosus sighted increased from 693 on the 1978 survey to 869 on the 1979 one and to 1161 on the July 1984 survey. This 68% increase highly significant statistically (99% confidence level), however a number of qualifying points should be borne in mind. Note that the increase of (1161-693) = 468 animals includes the large increases in the number of (2-3') and (3-4') animals sighted -increases of 91 and 140 respectively- (especially note that these large increases reflect high recruitment during the two 'dry wets' of 1981-1982 and 1982-1983, see Monograph 18) and that a very high fraction of these are unlikely to enter the (3-5') size class. The number, 549, of animals sighted in the (3-6') size classes is thus a very temporary fluctuation. This can also readily be appreciated by noting the relative constancy of the number of (4-5') plus (5-6') animals sighted; 231, 210 and 233 were positively identified during the 1978, 1979 and 1984 surveys respectively

and if one corrects for the EO classes then numbers become 261, 258 and 291 respectively. As pointed out in the model, it is as if there were only a certain number of slots on the tidal waterways for the animals in these size classes and the number of these slots remains relatively constant or increases slowly only. Thus the big bottleneck seems to occur mostly in the (4-5') and (5-6') size classes.

2. The density of non-hatchling C. porosus increased from 2.0/km on the 1978 survey to 3.3/km on the 1984 one.

3. Though the number of animals positively identified in the (6-7') size class increased from 97 on the 1978 survey to 145 on the 1979 one -after the 'driest wet' on record, when most of these animals had been concentrated back into the tidal waterway from the swamps- only 146 (6-7') animals were positively identified during the 1984 survey. However, the number of (7') animals, which were positively identified, increased from 132 to 186 to 233 on the 1978, 1979, and 1984 surveys respectively. The increase of only 48, in the number of positively identified large animals after an interval of 5 years, does not look at all impressive, however one must bear in mind that 1979 was a very unusual year and many of the large animals which had been forced out of the swamps would have returned to them during the normal wet season of 1979-1980. Thereafter some could be expected to endeavour to gain territory on the tidal systems over a period of a number of years. Furthermore, as we pointed out previously, for the individual waterways, there is irrefutable evidence that exceedingly heavy losses were suffered by animals in the large size classes (6'), through drowning in commercial fishermen's nets, and hence the increase in the number of large animals sighted would have been much greater, but for these heavy losses. If one corrects for the EO crocodiles, then the number of large crocodiles sighted increased spectacularly from 274 in 1978 to 40% in 1979 (because of the drying out swamps) and then less spectacularly to 467 in 1984. The increase of 193 large animals over a period of 6 years -in spite of the losses referred to above- again highlights the excellence and importance of the tidal systems in the Alligator Region, and especially of their associated freshwater complexes.

4. The ratio of (3-6') to large animals sighted decreased from 1.33 for 1978 to 0.92 for 1979 and then increased to 1.18 for the 1984 survey. However this latter ratio is a somewhat artificial one, in the present instance, because the figure of 549 for the number of animals sighted in the (3-6') size classes is inflated by at least an additional 141 (3-4') animals, many of which will not reach the (4-5') size class and are likely to have disappeared within a year. Furthermore, the figure of 467 for the number of animals sighted in the large size classes is artificially low because of the heavy losses of large animals through drowning.



5. The minimum exclusion and/or loss factor calculation for the (3-6') size classes shows for 1978-1984, a loss factor of 172/365 or 47% and for 1979-1984, a factor of 304/369 or 82%. These percentages require careful interpretation for included in them are not only the exclusions and/or losses in the (3-6') size classes but also the losses due to drowning of many of the large animals. One must also continue to bear in mind that each of the tidal waterways in the Alligator Region has freshwater complexes associated with it and that there is substantial movement of animals between the waterways and its complexes.

6. The relatively low hatchling recruitment rate on the tidal waterways in the Alligator Region -only some 9% compared to an average of 27% for all TYPE 1 systems -supports our contention that substantial recruitment of animals in all size classes occurs in the freshwater complexes associated with the TYPE 1 tidal systems of the Alligator Region. Furthermore, a study of the distributional diagrams for the animals on each the systems in the Region (appearing in Monograph 19) shows an atypical distribution with most of the large animals distributed on the extreme upstream sections of the waterways rather than on the brackish midstream sections (Chapters 6 and 9 Monograph 1). This again supports our contention that a substantial fraction of the animals sighted on the tidal waterways of the Alligator Region are derived from the freshwater complexes associated with these systems.

The relatively high figures for the number of (2-3') and (3-4') animals sighted (145 and 229 respectively) during the 1984 probably reflects high recruitment during the 'dry wets' of 1981-1982 and 1982-1983 as it did on the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems (see Table 1, pages 114 and 115 Monograph 18).

#### COBOURG COMPLEX AND SALTWATER CREEK (Figs. 1 and 4 to 6)

Saltwater Creek (4 km from the mouth of important and excellent Murgarella Creek) and the Cobourg Complex, consisting of the Minimini and Ilamaryi Complexes were first surveyed in 1979 (Monograph 14). These waterways constitute the largest assemblage (275.1 km) of TYPE 3 waterways in northern Australia and provide rearing stockyards for C. porosus excluded from TYPE 1 breeding systems in the area -probably, largely for animals excluded through the mouths of the tidal waterways of the Alligator Region- though it means sea journeys of at least 40 km for such animals. For completeness sake and because these Complexes were unlikely to be resurveyed again in the foreseeable future, it was decided to resurvey them in July 1984, though the undertaking was one of considerable complexity. The results from these resurveys are shown in Tables 1 and 2 and the highlights are:

1. On Saltwater Creek (Figs. 1 and 4), the number of non-hatchling C. porosus sighted decreased from 29 on the 1979 survey to 19 for the 1984 one. Furthermore, whereas no hatchling were sighted during the 1979 survey of this hypersaline creek, on the present survey, 6 were sighted, again showing that sporadic nesting can and does occur on TYPE 3 waterways.

Because of the significant increase in both the number of (3-6') and large animals sighted on Murgarella Creek, one might have expected to sight on Saltwater Creek an increased number of (3-6') and large animals -animals excluded for Murgarella Creek- but as shown in Table 2, this was not the case. The number of (3-6') animals remained almost constant, 12 were sighted during the 1979 survey, when many animals had been concentrated back into the tidal waterways, and 11 during the 1984 survey. On the other hand the number of large animals decreased from 16 to 8 for the same surveys and this decrease might be related to the fact that breeding occurred on the creek during the 1983-1984 wet season. This sort of variation appears typical for TYPE 3 systems, which act largely as rearing stockyards, and there appears to be a continual flow of animals back and forth between them and TYPE 1 and/or other TYPE 3 systems (page 121, Table 6 Monograph 18 and Monographs 5 and 6).

2. The 1984 resurvey of the three hypersaline tidal waterways included in the Minimini Complex -Minimini Creek, Middle Arm and Iwalg Creek (Figs. 1, 4 and 5)- revealed an increase, from 27 to 44 in the number of (3-6') and large animals sighted with the major increase occurring in the large size classes. Whereas only 9 large animals were sighted on the 125.8 km Complex during the 1979 survey, the 1984 survey revealed 21 (Table 2). Perhaps because breeding did occur on Saltwater Creek during the last wet season, some of the immature large animals may have been excluded from it and these then entered the Minimini Complex just to the north of it.

3. On the Ilamaryi Complex (Figs. 1, 4 and 6) consisting of coastal Arms A, B, C, D and the Ilamaryi River, and encompassing 135.2 km of slightly hypersaline, clear tidal waterways, a decreased number of (3-6') animals -20 in 1979, 8 in 1984- were sighted. On the other hand the number of large animals sighted increased slightly, from 20 in 1979 to 24 for the 1984 resurvey.

4. Considering the two interlinked Complexes together -known as the Cobourg Complex- shows that the total number of C. porosus sighted on the 261.0 km of waterways increased from 67 for the 1979 survey to 76 for the 1984 one. This increase is not statistically significant and the density figure for the Complex increased from 0.26/km to 0.29/km only.

5. Careful note should be made of the size structure of the crocodiles sighted on both the Minimini and Ilamaryi Complexes. On the Minimini Complex not a single hatchling or (2-3') animal was sighted; all animals were in size classes (3-4'). This was

also the case for the 1979 survey. The same comment applies to the Ilamaryi Complex, however in this case no (3-4') sized animals were observed either; all were in size classes (4-5'). It is apparent that no breeding of C. porosus occurs in the Cobourg Complex and that all animals sighted have entered the Complex from elsewhere.

6. Interestingly, there has been a considerable change since the 1979 survey, in the size structure of the animals sighted. During the 1979 survey the ratio of (3-6')/large was 1.31; for the 1984 resurvey this ratio dropped to 0.69, reflecting the increased number of large animals sighted (45 compared to 29) and the decreased number of (3-6') animals observed (31 compared to 38).

7. If one adds the (>3') animals sighted on Saltwater Creek to those of the Cobourg Complex, then one finds that the number sighted during the 1979 survey was 50 (3-6') and large 45 or a total of 95 (>3'), whereas for the 1984 survey the number was 42 (3-6') and 53 large, for a total of 95 (>3') again. A coincidence of number -or is it possible that animals had been concentrated into the Complex in 1979 as they had elsewhere and after the normal wet season of 1979-1980 they had returned from where they came? This was then followed by a slow increase back to the numbers sighted on the 1979 survey. We are unable to answer this question, but considering the population increase, over the past 5 years, in the TYPE 1 systems of the Alligator Region, it is surprising that we did not find a proportionate increase on the 275.1 km of TYPE 3 waterways resurveyed.

#### ADELAIDE RIVER SYSTEM (Fig. 7)

Scenic-wise and crocodile-wise, this 231.6 km waterway with its few remaining freshwater complexes must rank as still the best, or be amongst the very best, in northern Australia. We have often wondered why so many people flock to the waterways of Kakadu National Park, when the Adelaide River is only 1 hour's drive from Darwin, is a far prettier waterway than any in the Park, and certainly has more large crocodiles on it. In 1977 and 1978 we fought strongly to have its waters closed to all commercial net fishing and to have the overall system included in a wildlife reserve. We almost succeeded, but self government came to the Northern Territory at about the same time and with it came a driving determination to discard -with glee- every idea, good or bad, which had been proposed previously.

Because of the importance of the Adelaide River System, the University of Sydney had established its main field station in northern Australia at Beatrice Hill, only a few away from the Adelaide River Bridge, with the view of carrying out intensive studies on the System. Such intellectual endeavour was an anathema to the new government and we were soon hounded out of Beatrice Hill. One of the major factors militating against the Adelaide River System today is its closeness to Darwin. Yet this very fact could act in its favour and provide the people of Darwin with a tourist attraction of world reknown.

Each of the four surveys of the Adelaide River System were made prior to the breeding season and should be comparable. However, again, it must be remembered that the 1979 survey was carried out after the 'driest wet' on record and most of the animals inhabiting the freshwater complexes associated with the upstream sections of various creeks of the System would have been concentrated back into it (Addendum, Monograph 1). Examination of Tables 1 and 2 reveals that:

1. The number of non-hatchling C. porosus sighted during the 1977, 1978, 1979 and 1984 surveys was 369, 319, 321 and 542, respectively. Thus the non-hatchling numbers have increased significantly and dramatically since the 1977-1979 surveys -especially when compared with the results for tidal systems in the Maningrida area of Arnhem Land (Monographs 1 and 18). Furthermore this major increase is not predominantly due to increases in the (2-3') and (3-4') size classes. Comparing the 1977 survey results with those for 1984 (Table 1) shows that the increase was only 12 for the (2-3') and some 17 for the (3-4') size classes. Importantly the major increases, during the 7 year interval, occurred in the large size classes, going from 81 to 228 (Table 2).
2. Thus the increase in the density of non-hatchling sighted from 1.6/km in 1977 to 2.3/km in 1984 is important and signifies that an excellent and sustainable recovery is underway on this waterway.
3. Note also (Table 2) that the number of crocodiles sighted in the (3-6') size classes during the surveys of 1977, 1978, 1979 and 1984 was 264, 217, 190 and 278 respectively and in the (4-5') plus (5-6') size classes (Table 1) it was 163, 133, 133 and 143 respectively. Note that the figure of 278 (3-6') animals contains at least 105 (3-4') crocodiles and as mentioned previously most of these could be expected to be lost. Again they were derived from the excellent breeding season during the 'dry wet' of 1981-1982. The constancy of the (4-5') plus (5-6') figures again highlights the bottleneck which occurs for these size classes.
4. The minimum exclusion and/or loss factor calculation for the (3-6') size classes shows for the 1977-1984, 1978-1984 and 1979-1984 surveys, exclusion and/or loss factors of 117/264, 67/217 and 85/190 or 44%, 31% and 45% respectively. The relative constancy and size of these factors makes us suspect that most of these losses are natural and that only a small fraction are due to causes related to netting and poaching. During our July 1984 survey not a single barramundi fishing boat was sighted on the Adelaide River -so different from former times. Apparently the river has been well and truly netted out and barramundi have become a relatively scarce commodity on it. However, it appears that C. porosus still manages to obtain sufficient food. During movement of "The Shiralee" upstream, we sighted a very large crocodile at km 41, dragging a dead bloated feral water buffalo across the river. The crocodile was midstream when we sighted

it, at which time it dived with the buffalo held in its mouth and swam underwater some 20 to 30 m. This awe inspiring feat of strength had to be seen to be believed. The crocodile was the largest ever seen by HM during his 14 years of research on the tidal waterways of northern Australia and was estimated to be in excess of 20 feet in length. We had excellent views of the animal's head and estimated it to be at least one metre in length. A few days later we observed a 14 ft C. porosus with a freshly captured 6 ft struggling eel in its mouth. The eel struggled fiercely and kept wrapping its body around the head of the crocodile -but to no avail. The crocodile kept a posture, similar to that which we described on page 454 Monograph 1, when we witnessed a large crocodile capture a shark.

We believe that the relatively low loss factors found for the Adelaide River are related not only to the few remaining freshwater complexes (most have been destroyed by feral water buffalo) associated with the System, but also importantly to the 101.8 km of mostly TYPE 3 saltwater creeks which drain into the downstream sections of the mainstream. These must act as havens of refuge for many of the (3-6') and large animals during the highly interactive breeding season and thus decrease the need for them to leave the tidal system and face the many dangers of sea travel. The situation here is much like that found on the Kalarwoi River System in Buckingham Bay (page 28 Monograph 10) and could be expected to cut the loss factor considerably. Apparently this is the case.

5. The ratio of (3-6') to large animals sighted, decreased from 3.26 for 1977, to 1.22 for the 1984 survey.

6. Examination of the hatchling and (2-3') numbers sighted for each of the four surveys indicates that recruitment of animals must also be occurring on the freshwater complexes associated with the Adelaide River System. Furthermore, the relatively high figures for the number of (2-3') and (3-4') animals sighted, probably reflects high recruitment during the 'dry wets' of 1981-1982 and 1982-1983 (as it did in the Alligator Region).

7. The distributional diagram for C. porosus on the Adelaide River System (see Monograph 3 for the 1977 and 1978 diagrams, Monograph 18 for the 1979 one; Monograph 19 will contain the diagram for the July 1984 survey) is quite different to those for the TYPE 1 tidal waterways of the Alligator Region which have extensive freshwater complexes associated with them. The peak of the distribution does not occur on the extreme upstream tidal sections of the waterway as in the case of the waterways in the Alligator Region, but occurs on the middle sections. Thus the distributional diagram for the Adelaide Systems is very much like those for the Blyth-Cadell (Monograph 1 and 18) and Liverpool-Tomkinson (Monographs 7 and 18) Rivers Systems. The few remaining freshwater complexes associated with the Adelaide River System, which haven't been totally destroyed by feral water buffaloes, mostly occur at the terminal sections of creeks draining into the mainstream (see Monographs 3, 15 and 18).

8. During the 1977 survey of the Adelaide System we recorded the sighting, for the first time, of a C. johnstoni in brackish water with a measured salinity of 70/00 (page 39 Monograph 3). Since that time we have sighted C. johnstoni on the tidal sections of many waterways in northern Australia (Monograph 2,3,8,12,13 and 16, see specially page 459 Monograph 1) and in Monograph 16 reported the sighting of a C. johnstoni near the mouth of Duck Creek, where the measured salinity was 26.50/00. We postulated at the time that the previous scarce observations of C. johnstoni in tidal rivers reflect exclusion by C. porosus rather than an intrinsic intolerance of saline conditions. Recent work by Webb et al. (reported in Aust. Wildl. Res. 1983, 10, 639-50) tends to support this view as does the discovery by Taplin and Grigg (Science 1981, 212:1045-1047) of lingual salt glands in both C. porosus and C. johnstoni. During the 1979 survey of the Adelaide System (Monograph 18) we identified positively, 16 C. johnstoni on the km 94.7-117.0 section of the waterway and during our 1984 survey 11 C. johnstoni were identified; 3 on the km 69.0-82.2 section and 8 on the km 94.7-117.0 section. It would be interesting to see whether the number of C. johnstoni sighted on the tidal sections of the Adelaide River continue to decrease as the number of C. porosus increases. Both Webb et al's data and ours tend to suggest this but neither data allows a firm conclusion on this point.

#### COMBINED WATERWAYS OF VAN DIEMEN GULF (Fig. 1)

Because of the very dynamic situation which prevails for C. porosus -the movement during certain seasons of a significant fraction of the animals within a system and between widely dispersed tidal systems- we have emphasized repeatedly (Chapter 9 Monograph 1, Chapter 4 Monograph 18) the importance, for C. porosus status and recovery studies, of not considering just a portion of a waterway or even a single waterway. Whenever possible ONE SHOULD ENDEAVOUR TO SURVEY AND RESURVEY ALL THE TIDAL SYSTEMS WITHIN A GIVEN BROAD GEOGRAPHIC AREA AND ROUGHLY NEAR THE SAME TIME OF THE YEAR, otherwise ambiguities could easily arise in the interpretation of the results. For instance the tidal waterways of the Alligator Region were first surveyed during October 1977 and then resurveyed in June 1978, August 1979 and July 1984. One must be very cautious when comparing the October 1977 results with those of the other 3 surveys for we know that the breeding season commences around October and that many (3-6') and immature large animals are excluded from the breeding sections of the tidal system at that time (see point 13 in the Introduction). Furthermore, study of the results in Table 2 shows that one might gain erroneous picture about the status of C. porosus if one looked purely at the results for the West Alligator System rather than for the other systems nearby as well. The same remarks apply with even greater force if one monitors only limited sections of a waterway (pages 130 and 131 Monograph 18).

In Tables 1 and 2 we have combined the results for the tidal waterways surveyed, from the Ilmarayi River on the Cobourg Peninsula to the Adelaide River in Adams Bay. The various

combinations shown allow one to view the results from a number of different angles and to assess the recovery of C. porosus in this broad geographical area of northern Australia.

1. One point which stands out strongly, for each of the combinations shown, is the inflated number of animals sighted during the July 1984 survey in the (3-4') size class (Table 1) and that this in turn has inflated the (3-6') size class number count and the (3-6')/large ratio (Table 2). These animals in the (3-4') size class are the result of the excellent breeding season during the 'dry wet' of 1981-1982 and as already pointed out several times previously, a large fraction of them are unlikely to enter the (4-5') and (5-6') size classes. Excluding such fluctuations, which appear to level out rather quickly, the number of (3-6') animals sighted normally remains fairly constant (see Tables 2 and 5, pages 116 and 120 Monograph 18). However as we have accumulated more and more data it has become clear that it is the (4-5') and (5-6') size classes which provide most of the bottleneck and that the neck size appears to remain surprisingly constant for a given tidal system.

2. Examining the results in Table 1 for the Alligator Region plus Cobourg Complex and Saltwater -629.6 km- shows that the number of (4-5') plus (5-6') animals sighted during the 1979 and 1984 surveys were 252 and 261 respectively. Interestingly the number of (6-7') animals positively identified was 164 on each survey.

For the 'Adelaide plus Alligator Region with Wildman' -586.1 km- the (4-5') plus (5-6') counts for 1978, 1979 and 1984 were 364, 343 and 376 respectively. Considering the errors -of up to one size class- which can easily arise in size class estimation, this is an amazing constancy.

If one then adds in the results for the Cobourg Complex and Saltwater, the (4-5') plus (5-6') counts for 1979 and 1984 become 385 and 404 respectively -again surprisingly constant for the 861.2 km of tidal waterways surveyed.

3. Though the number count for the (4-5') plus (5-6') size classes appears to remain closely constant from survey to equivalent survey, this is not the case for large animals. Once the animals have passed through the bottleneck, their numbers appear to continue to increase -in spite of various and continuing losses within their size classes as well (Table 2).

For the 'Alligator Region plus Cobourg Complex and Saltwater' -629.6 km- the numbers of large animals sighted on the 1979 survey was 447 while the 1984 survey yielded 519 large animals.

For the 'Adelaide plus Alligator Region with Wildman' -586.1 km- the number of large animals sighted during the 1978, 1979 and 1984 surveys was 352, 525 and 695 respectively. And if one adds in the Cobourg Complex and Saltwater Creek, then the number of large animals sighted on the 861.2 km of these tidal waterways during the 1979 and 1984 surveys is 569 and 747 respectively.

4. As already pointed out previously, the 'dry wet' season of 1981-1982 resulted in heavy hatchling recruitment and this in turn resulted in a high (3-4') animal count during the July 1984 survey. As has been shown during the course of our lengthy study on the Blyth-Cadell and Liverpool-Tomkinson Rivers Systems such fluctuations are soon smoothed out (Monograph 1 and 18). The heavy (3-4') animal count in turn inflated the (3-6') count which in turn halted the decreasing (3-6')/large ratio (Table 2). Furthermore, the very heavy losses of large animals through drowning in barramundi nets set in the tidal waterways of Kakadu National Park also leads to an artificially high ratio. If commercial net fishing was halted in the tidal waterways of National Park, one could be confident that the ratio would continue to fall over the long term. However only repeated, careful and systematic surveys of the overall waterways in the area can provide a long term check on this matter.

5. The density of non-hatchling crocodiles sighted during the 1984 resurvey increased in each of the systems and areas (Table 1). For the overall 861.2 km of tidal waterways resurveyed, the increase was from 1.5/km for 1979 to 2.1 for 1984. This is significant statistically at 99% level of confidence and importantly the increase is not made up increases in the (3-6') size classes (870 versus 610) only, but there was also a large increase in the number of large animals sighted (747 versus 569).

Thus the present results support the view that a sustainable recovery in the C. porosus population is in progress in the Adelaide River System and in the tidal waterways of the Alligator Region. Furthermore this recovery is very much in accord with the predictions of our model, discussed in the Introduction and lends further support for it.

#### Discussion

In the Introduction, we summarized the model which we have been deriving over the past 5 years for the dynamics of C. porosus populations in the tidal waterways of northern Australia, based upon repeated night-time spotlight surveys. The model is able not only to account in a consistent fashion for the vast store of field observations and results we have accumulated for some 100 tidal waterways in northern Australia but has also been successful in predicting results to be expected on future surveys of various types of tidal waterways (Monographs 1 and 18).

In points 7 and 8 of the model we stated:

" Because of the 80% exclusion and at least 60-70% losses of sub-adult crocodiles as they proceed toward sexual maturity, there has been no significant sustained increases in the non-hatchling C. porosus population on the tidal waterways of our monitored area in northern Australia since the commencement of our systematic surveys, a period of ten years (Monograph 18)."

and



" Assuming the results from our monitored area apply elsewhere, any significant sustained increase in the non-hatchling C. porosus populations on the tidal waterways of northern Australia must be measured in decades. However, as discussed . . . , on tidal systems with freshwater complexes, the recovery could be expected to be more rapid".

In Table 3, we have extracted data for 1979 and 1983 from Table 1, page 114 Monograph 18, for the 411.5 km of tidal waterways monitored in the Maningrida area, which encompass the Goomadeer, Liverpool-Tomkinson, Blyth-Cadell and Glyde Rivers Systems and various TYPE 3 creeks in the area, and presented these in the same form as the results shown in Tables 1 and 2. This then permits us to compare surveys results for the monitored tidal waterways in the Maningrida area with those for the 861.2 km of waterways bordering Van Diemen Gulf. Comparing Tables 2 and 3 highlights immediately and strongly the two important points quoted above.

The results derived from the present resurveys of 861.2 km of tidal systems bordering Van Diemen Gulf, last resurveyed in 1979, are very much in agreement with what we predicted for them. They provide strong evidence for an important and continuing recovery of C. porosus on the tidal waterways of the Alligator Region and on the excellent Adelaide River System. This recovery is much stronger than that found for the tidal waterways in the Maningrida area and the explanation for the difference is straightforward. Whereas the freshwater complexes associated with the TYPE 1 waterways in the Maningrida area are scant, and hence most of the animals excluded from the tidal systems in the area had little choice but to leave the systems (and later endeavour to return or to be killed if they remained). In this process the losses in the (3-6') and large size classes are very high. On the other hand, in the Alligator Region, there are substantial freshwater complexes associated with the TYPE 1 tidal waterways and many of the excluded animals take refuge in these and they are used both as rearing stockyards and as breeding systems. The losses in this case could be expected to be lower (see points 5 and 6 of the introduction) and the recovery rate faster than on systems without associated freshwater complexes. For the overall waterways in the Alligator Region we found that the exclusion and/or loss factor varied between 47 and 82%. This latter high figure can probably be attributed largely to the loss of crocodiles through drowning in nets. Were it not for this, the figure would undoubtedly have been much lower and the recovery more spectacular.

For the Adelaide River System, two important factors appear to come into play. Though many of the former freshwater complexes associated with the System have been destroyed by feral water buffalo, the waterway has in addition an extensive (101.8 km) systems of mostly TYPE 3 waterways on its downstream sections and hence when animals are excluded from the breeding section they can take refuge in these without leaving the System. As we have seen, the exclusion and/or loss factor for the Adelaide System

was only between 31 and 45%, compared to the 80 to 90% or more, for the waterways in the Maningrida area (pages 127, 134 and 155 Monograph 18). The increase from only 81 large animals sighted on the Adelaide during the July 1977 survey to 228 large animals sighted on the July 1984 one is the consequence of these smaller losses. Given another decade or two of protection, the Adelaide System may begin approaching its former self, crocodile-wise.

We believe our results for the waterways in the Alligator Region also indicate the potential for recovery, at a rate equal to or even better than that already found for the Adelaide System. However, this will only be so if commercial net fishing for barramundi is halted.

Other than on the extreme upstream sections of the tidal waterways there is so little to see on the tidal waterways, a few feral water buffaloes, some birds and, of course, the crocodiles. Properly protected, C. porosus in large numbers could easily and quickly become one of the most outstanding and spectacular tourist attractions in the Park - vying with the best C. niloticus attractions of Africa. This whole matter raises an important issue - what is a National Park? Is it an area where indigenous flora and fauna is to be preserved and fully protected for posterity, or is it an area which is closed and protected from the ordinary citizen and yet left open to exploitation and destruction by commercial fishing interests? Kakadu National Park is a very strange Park indeed. Does the Australian public know what is happening? In whose interests are the crocodiles in the National Park being drowned? How are scores of large crocodiles being balanced against a few barramundi? More importantly, when is it going to be halted? Not wishing to withstand a further campaign of persecution for asking difficult questions and exposing the truth, we shall abstain from any further comment. As far as we are concerned, this matter is now closed.

Our results have demonstrated that considerable care must be taken when discussing the recovery of C. porosus on the tidal waterways of northern Australia. For the tidal waterways on the northern coast of Arnhem Land - from the Goomadeer River in the west to the Glyde River in the east (Monograph 18), some 411.5 km of waterways - there are only scant signs that a recovery is underway. On the basis of some 10 years of surveys in the area, it appears that any significant sustained increase in the non-hatchling C. porosus populations, on those waterways, may take decades. For the waterways of the Alligator Region and the Adelaide River System, a significant recovery is already underway and must be encouraged further by maintaining full protection of the animal and halting commercial net fishing in the tidal waterways of the Region.

On the basis of our 1983 and 1984 results, when we resurveyed some 1272 km of tidal waterways, one would predict that a recovery is also underway on the mighty Roper River System, for in many ways it is like the Adelaide System. However, commercial net fishing is permitted well upstream on this waterways and we know that large numbers of crocodiles are drowned annually in the nets. The waterway was surveyed in 1979 and it would be of interest to

resurvey it carefully and systematically again, after a period of 6 years. Furthermore, one would predict any recovery on many of the tidal waterways in the Kimberly of Western Australia to be similar to that found in the Maningrida area. The tidal waterways there are mostly devoid of freshwater complexes of any consequence, however the Glenelg and the Prince Regent Systems have extensive TYPE 3 systems -similar to the Cobourg Complex- at their mouths and these might help keep the exclusion and/or loss factor down. We surveyed these tidal waterways in 1978 and 1979 (W.A. Reports 24 and 34) and a resurvey in the near future could throw further light on our model and allow further refinement of it.

#### ACKNOWLEDGEMENTS

We are pleased to acknowledge the continuing support of the University of Sydney and its Science Foundation for Physics, without whose help there could never have been a research of the magnitude, scope and completeness of the present one. The Foundation has, over the past 30 years, never erred from its motto "The Pursuit of Excellence" and our lengthy northern Australian research effort has provided ample opportunity for pursuing it. If ever there was a research programme where "close is not good enough", our "Surveys of Tidal Waterways in Northern Australia" provided the perfect example. It has required the support, encouragement, breadth of view, scientific expertise, dedication and tenacity which only a great academic institution could provide.

We wish to give special thanks to John and Marie Saltmarsh who own the "M.V. Shiralee S" and their son Peter. They provided marvellous service on a great little ship and did everything we could wish for to help make our surveys a success. Peter even became a navigator-recorder for one of our survey boats. Many thanks again.

Finally our sincere thanks go to Wally Gill, our long time helper, who over the years has acted in every capacity imaginable. "Wally, you are a great cook, but a better boat driver" Cheers;

# Surveys of Tidal River Systems in the Northern Territory of Australia and their Crocodile Populations

A series of monographs covering the navigable portions of the tidal rivers and creeks of the Northern Territory. Published by Pergamon Press, Sydney Australia 1979-1984.

## MONOGRAPH

- 1 The Blyth-Cadell Rivers System Study and the Status of *Crocodylus porosus* in Tidal Waterways of Northern Australia.  
Methods for analysis, and dynamics of a population of *C. porosus*  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J.
- 2 The Victoria and Fitzmaurice River Systems.  
Messel, H, Gans, C, Wells, A G, Green, W J, Vorlicek, G C and Brennan, K G
- 3 The Adelaide, Daly and Movie Rivers.  
Messel, H, Gans, C, Wells, A G and Green, W J
- 4 The Alligator Region River Systems,  
Murgarella and Coppers Creeks, East, South and West Alligator Rivers and Widman River  
Messel, H, Wells, A G and Green, W J
- 5 The Goomadeer and King River Systems and Majarie, Wuruguij and All Night Creeks  
Messel, H, Wells, A G and Green, W J.
- 6 Some River and Creek Systems on Melville and Grant Islands  
Johnson River, Andranangoc, Bath, Dongau and Tingaroo Creeks and Pultoloc and Brenton Bay Lagoons on Melville Island, North and South Creeks on Grant Island  
Messel, H, Wells, A G and Green, W J
- 7 The Liverpool-Tomkinson Rivers System and Nungbulgarni Creek  
Messel, H, Wells, A G and Green, W J
- 8 Some Rivers and Creeks on the East Coast of Arnhem Land, in the Gulf of Carpentaria  
Rose River, Muntak Creek, Hart River, Walker River and Koolatong River  
Messel, H, Elliott, M, Wells, A G, Green, W J and Brennan, K G
- 9 Tidal Waterways of Castlereagh Bay and Hutchinson and Casell Straits  
Bennett, Darbilla, Djagala, Djapura, Ngandadauda Creeks and the Glyde and Woolon Rivers.  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 10 Tidal Waterways of Buckingham and Ukundurwi Bays.  
Buckingham, Kalarwoi, Warawuruwoi and Kurata Rivers and Sappery Creek  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 11 Tidal Waterways of Arnhem Bay  
Darwarunga, Habqod, Baralminar, Gopalpa, Goromuro, Cato, Peter John and Burungbrising Rivers  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J
- 12 Tidal Waterways on the South-Western Coast of the Gulf of Carpentaria  
Limmon Bight, Towns, Roper, Phelp and Wilton Rivers; Nayarnpi, Wungguayanga, Panyiyalya, Mangkurdurrungku and Yiwapa Creeks  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J and Johnson, A
- 13 Tidal Systems on the Southern Coast of the Gulf of Carpentaria.  
Calvert, Robinson, Wearyan, McArthur Rivers and some intervening Creeks.  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J and Johnson, A
- 14 Tidal Waterways of Van Diemen Gulf  
Ilamaryi, Iwalg, Saltwater and Minimini Creeks and Coastal Arms on Cobourg Peninsula  
Resurveys of the Alligator Region Rivers.  
Messel, H, Vorlicek, G C, Wells, A G and Green, W J.
- 15 Work Maps of Tidal Waterways in Northern Australia  
Messel, H, Green, W J, Wells, A G and Vorlicek, G C
- 16 Surveys of Tidal Waterways on Cape York Peninsula, Queensland, Australia, and their Crocodile Populations  
Messel, H, Vorlicek, G C, Wells, A G, Green, W J, Curtis, H S, Roff, C R R, Weaver, C M and Johnson, A
- 17 Darwin and Bynoe Harbours and their Tidal Waterways  
Messel, H, Vorlicek, G C, Elliott, M, Wells, A G and Green, W J
- \*18 Population Dynamics of *Crocodylus porosus* and Status, Management and Recovery Update 1979-1983  
Messel, H, Vorlicek, G C, Green, W J and Onley, J C

Appearing in the same series, and published by the Western Australian Government

1. The status of the salt-water crocodile in some river systems of the north-west Kimberley, Western Australia  
Dept. Fish. Wildl. West Aust. Rept. No.24 1-50 (1977).  
Messel, H, Burbidge, A A, Wells, A G and Green, W J
2. The status of the salt-water crocodile in the Glenelg, Prince Regent and Ord River Systems, Kimberley, Western Australia  
Dept. Fish. Wildl. West Aust. Rept. No.34 1-38 (1979)  
Burbidge, A A and Messel, H

TABLE 1

Number of *C. porosus* sighted within each size class on tidal waterways of Van Diemen Gulf, during night-time spotlight surveys carried out between 1977 and 1984. The midstream distance surveyed and density of non-hatchling crocodiles sighted on each waterway is shown, as are the 95% confidence limits for the estimate of the actual number of non-hatchlings present. The TYPE classification of each waterway is given also. Each of the waterways listed had been last surveyed 5 years previously.

Systems	Total	Size Class Numbers									km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	EO					
MONOGRAPH 3														
ADELAIDE														
July 77	417	48	24	88	116	47	35	33	26	226.3	1.6	566-644	1	
Sept 78	381	62	24	71	90	43	33	32	26	221.0	1.4	487-559		
Sept 79	374	53	8	46	75	58	47	64	23	231.6	1.4	490-562		
July 84	602	60	36	105	79	64	78	120	60	231.6	2.3	842-936		
MONOGRAPH 4(14)														
MURGENELLA														
Oct 77	95	1	1	8	33	13	6	18	15	45.9	2.0	135-173	1	
June 78	173	48	16	4	17	24	23	30	11	44.9	2.8	183-227		
Aug 79	198	47	24	12	22	24	27	26	16	45.6	3.3	223-273		
July 84	236	7	17	61	28	21	31	57	14	45.6	5.0	346-406		
EAST ALLIGATOR														
Oct 77	318	53	18	37	57	41	40	34	38	114.9	2.3	402-468	1	
June 78	329	39	14	63	51	42	31	51	38	118.9	2.4	442-510		
Aug 79	393	53	30	44	58	28	58	64	58	119.2	2.9	521-595		
July 84	411	22	51	72	35	24	47	60	100	119.2	3.3	598-678		
SOUTH ALLIGATOR														
Oct 77	142			12	24	24	25	31	26	113.8	1.2	209-257	1	
July 78	157	6	3	4	14	43	24	38	25	113.2	1.3	223-273		
Aug 79	164	4	1	4	12	24	31	51	37	114.0	1.4	237-287		
July 84	279	39	15	17	18	25	38	91	36	114.0	2.1	363-425		
WEST ALLIGATOR														
Oct 77	83	9	2	14	14	15	10	10	9	42.2	1.8	104-138	1	
July 78	85	23	5	12	9	13	10	6	7	40.4	1.5	86-118		
Aug 79	96	12	9	13	14	7	12	14	15	42.2	2.0	120-156		
June 84	120	17	2	33	21	18	6	12	11	42.2	2.4	149-189		

TABLE 1 (CONT'D)

Systems	Total	Size Class Numbers								km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	E0				
WILDMAN													
Sept 78	118	53	16	6	8	10	9	7	9	33.5	1.9	91-123	1
Aug 79	155	21	34	15	14	7	17	31	16	33.5	4.0	197-243	
June 84	226	26	60	46	20	23	24	13	14	33.5	6.0	300-356	
ALLIGATOR REGION EXCL. WILDMAN													
Oct 77	638	63	21	71	128	93	81	93	88	316.8	1.8	895-991	1
June 78	744	116	38	83	91	122	88	125	81	317.4	2.0	980-1080	
Aug 79	851	116	64	73	106	83	128	155	126	321.0	2.3	1151-1259	
July 84	1046	85	85	183	102	88	122	220	161	321.0	3.0	1514-1638	
ALLIGATOR REGION WITH WILDMAN													
June 78	862	169	54	89	99	132	97	132	90	350.9	2.0	1084-1190	1
Aug 79	1006	137	98	88	120	90	145	186	142	354.5	2.4	1366-1484	
July 84	1272	111	145	229	122	111	146	233	175	354.5	3.3	1836-1972	
SALTWATER													
Aug 79	29		1	1	6	4	6	9	2	14.1	2.1	37- 59	3
July 84	25	6		4	3	3	1	6	2	14.1	1.3	22- 40	
MINIMINI													
Aug 79	11			1	4	3	1	2		43.8	0.3	11- 25	3
July 84	9					2	3	1	3	43.8	0.2	9	
MIDDLE ARM													
Aug 79	6				3	2	1			28.5	0.2	6	3
July 84	10			1	1	4	2	1	1	28.5	0.4	10- 22	
IWALG													
Aug 79	10				3	1	2	2	2	53.5	0.2	10- 22	3
July 84	25			3	3	6	5	5	3	53.5	0.5	31- 51	
MINIMINI COMPLEX													
Aug 79	27			1	10	6	4	4	2	125.8	0.2	34-54	3
July 84	44			4	4	12	10	7	7	125.8	0.3	59-85	
ARM A													
Aug 79	5				3		1		1	26.7	0.2	5	3
July 84	9				1		4	4		26.7	0.3	9	
ARM B													
Aug 79	3				1		1	1		15.0	0.2	3	3
July 84	4						1	3		15.0	0.3	4	

TABLE 1 (CONT'D)

Systems	Total	Size Class Numbers									km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	E0					
ARM C														
Aug 79	7				3	1	1		2	29.3	0.2	7	3	
July 84	5				2				2	29.3	0.2	5		
ARM D														
Aug 79	9				1			3	2	19.8	0.5	9	3	
July 84	7					1		1	3	19.8	0.4	7		
ILAMARYI														
Aug 79	16				3	4	3	3	3	44.4	0.4	18-34	3	
July 84	7				1	1	1	2	2	44.4	0.2	7		
ILAMARYI COMPLEX														
Aug 79	40				11	5	9	6	9	135.2	0.3	53-79	3	
July 84	32				4	2	7	14	5	135.2	0.2	41-63		
COBOURG COMPLEX														
Aug 79	67			1	21	11	13	10	11	261.0	0.3	94-126	3	
July 84	76			4	8	14	17	21	12	261.0	0.3	107-143		
COBOURG COMPLEX & SALTWATER														
Aug 79	96		1	2	27	15	19	19	13	275.1	0.3	137-177	3	
July 84	101	6		8	11	17	18	27	14	275.1	0.3	136-176		
ALLIGATOR REGION + COBOURG COMPLEX & SALTWATER														
Aug 79	1102	137	99	90	147	105	164	205	155	629.6	1.5	521-645	1&3	
July 84	1373	117	145	237	133	128	164	260	189	629.6	2.0	989-2131		
ADELAIDE + ALLIGATOR REGION EXCL. WILDMAN														
July&Oct 77	1055	111	45	159	244	140	116	126	114	543.1	1.7	486-1610	1	
Sept&June 78	1125	178	62	154	181	165	121	157	107	538.4	1.8	491-1615		
Sept&Aug 79	1225	169	72	119	181	141	175	219	149	552.6	1.9	667-1797		
July 84	1648	145	121	288	181	152	200	340	221	552.6	2.7	287-2543		
ADELAIDE + ALLIGATOR REGION WITH WILDMAN														
Sept&June 78	1243	231	78	160	189	175	130	164	116	571.9	1.8	596-1724	1	
Sept&Aug 79	1380	190	106	134	195	148	192	250	165	586.1	2.0	683-2021		
July 84	1874	171	181	334	201	175	224	353	235	586.1	2.9	710-2876		
ABOVE + COBOURG COMPLEX & SALTWATER														
Sept&Aug 79	1476	190	107	136	222	163	211	269	178	861.2	1.5	2037-2181	1&3	
July 84	1975	177	181	342	212	192	242	380	249	861.2	2.1	2864-3034		

TABLE 2

This Table was prepared using the results given in Table 1 and groups the crocodiles sighted into the important size classes shown. 50% of the E0 size classes were distributed to the (3-6') size classes and the remaining 50% to the (>6') size classes. This weights the distribution heavily in favour of larger crocodiles, which are known to normally be the most wary. When the E0 is an odd number, the bias is also given to the (>6') size classes.

Survey	Totals	Hatchlings	(2-3')	(3-6')	Large (>6')	(3-6') Large
ADELAIDE						
July 77	417	48	24	264	81	3.26
Sept 78	381	62	24	217	78	2.78
Sept 79	374	53	8	190	123	1.54
July 84	602	60	36	278	228	1.22
MURGENELLA						
Oct 77	95	1	1	61	32	1.91
June 78	173	48	16	50	59	0.85
Aug 79	198	47	24	66	61	1.08
July 84	236	7	17	117	95	1.23
EAST ALLIGATOR						
Oct 77	318	53	18	154	93	1.66
June 78	329	39	14	175	101	1.73
Aug 79	393	53	30	159	151	1.05
July 84	411	22	51	181	157	1.15
SOUTH ALLIGATOR						
Oct 77	142	-	-	73	69	1.06
June 78	157	6	3	73	75	0.97
Aug 79	164	4	1	58	101	0.57
July 84	279	39	15	78	147	0.53
WEST ALLIGATOR						
Oct 77	83	9	2	47	25	1.88
June 78	85	23	5	37	20	1.85
Aug 79	96	12	9	41	34	1.21
June 84	120	17	2	77	24	3.21
WILDMAN						
Sept 78	118	53	16	28	21	1.33
Aug 79	155	21	34	44	56	0.79
June 84	226	26	60	96	44	2.18



TABLE 2 (CONT'D)

Survey	Totals	Hatchlings	(2-3')	(3-6')	Large (≥6')	(3-6') Large
ALLIGATOR REGION EXCL. WILDMAN						
Oct 77	638	63	21	336	218	1.54
June 78	744	116	38	336	254	1.32
Aug 79	851	116	64	325	346	0.94
July 84	1046	85	85	453	423	1.07
ALLIGATOR REGION WITH WILDMAN						
June 78	862	169	54	365	274	1.33
Aug 79	1006	137	98	369	402	0.92
July 84	1272	111	145	549	467	1.18
SALTWATER						
Aug 79	29	-	1	12	16	0.75
July 84	25	6	-	11	8	1.38
MINIMINI						
Aug 79	11	-	-	8	3	2.67
July 84	9	-	-	6	3	2.00
MIDDLE ARM						
Aug 79	6	-	-	5	1	5.00
July 84	10	-	-	6	4	1.50
IWALG						
Aug 79	10	-	-	5	5	1.00
July 84	25	-	-	13	12	1.08
MINIMINI COMPLEX						
Aug 79	27	-	-	18	9	2.00
July 84	44	-	-	23	21	1.10
ARM A						
Aug 79	5	-	-	3	2	1.50
July 84	9	-	-	1	8	0.13
ARM B						
Aug 79	3	-	-	1	2	0.50
July 84	4	-	-	-	4	0.00
ARM C						
Aug 79	7	-	-	5	2	2.50
July 84	5	-	-	2	3	0.67
ARM D						
Aug 79	9	-	-	2	7	0.29
July 84	7	-	-	2	5	0.40

TABLE 2 (CONT'D)

Survey	Totals	Hatchlings	(2-3')	(3-6')	Large ( <u>&gt;</u> 6')	<u>(3-6')</u> Large
ILAMARYI						
Aug 79	16	-	-	8	8	1.00
July 84	7	-	-	3	4	0.75
ILAMARYI COMPLEX						
Aug 79	40	-	-	20	20	1.00
July 84	32	-	-	8	24	0.33
COBOURG COMPLEX						
Aug 79	67	-	-	38	29	1.31
July 84	76	-	-	31	45	0.69
COBOURG COMPLEX & SALTWATER						
Aug 79	96	-	1	50	45	1.11
July 84	101	6	-	43	52	0.83
ALLIGATOR REGION + COBOURG COMPLEX & SALTWATER						
Aug 79	1102	137	99	419	447	0.94
July 84	1373	117	145	592	519	1.14
ADELAIDE + ALLIGATOR REGION EXCL. WILDMAN						
July&Oct77	1055	111	45	600	299	2.01
Sept&June78	1125	178	62	553	332	1.67
Sept&Aug79	1225	169	72	515	469	1.10
July 84	1648	145	121	731	651	1.12
ADELAIDE + ALLIGATOR REGION WITH WILDMAN						
Sept&June78	1243	231	78	582	352	1.65
Sept&Aug79	1380	190	106	559	525	1.06
July 84	1874	171	181	827	695	1.19
ABOVE + COBOURG COMPLEX & SALTWATER						
Sept&Aug79	1476	190	107	610	569	1.07
July 84	1975	177	181	870	747	1.16

TABLE 3

Combined results for the Blyth-Cadell and Liverpool-Tomkinson (including Toms Creek) Rivers Systems, Goomadeer and Glyde Rivers, and Nungbulgarri, Majarie, Wurugoiij and Ngandadauda Creeks (obtained using Table 1, page 114 Monograph 18). The results are given first in the form of Table 1 and then in the form of Table 2 to facilitate comparisons. Note that the 1983 survey was made after the 'dry wet' of 1982-1983 and hence animals were again concentrated into the tidal waterways, but not to the same degree as in 1979 when surveys were carried out after the 'driest wet' on record.

Survey	Total	Size Class Numbers								km Surveyed	Density	95% Levels	TYPE
		H	2-3	3-4	4-5	5-6	6-7	>7	E0				
June & July 1979	1253	487	125	156	139	100	69	66	111	414.9	1.8	1201-1312	1&3
July & July 1983	1199	345	198	180	145	92	49	40	150	411.5	2.1	1342-1459	

Survey	Totals	Hatchlings	(2-3')	(3-6')	Large (>6')	(3-6') Large
June & July 1979	1253	487	125	450	191	2.36
July & July 1983	1199	345	198	492	164	3.00

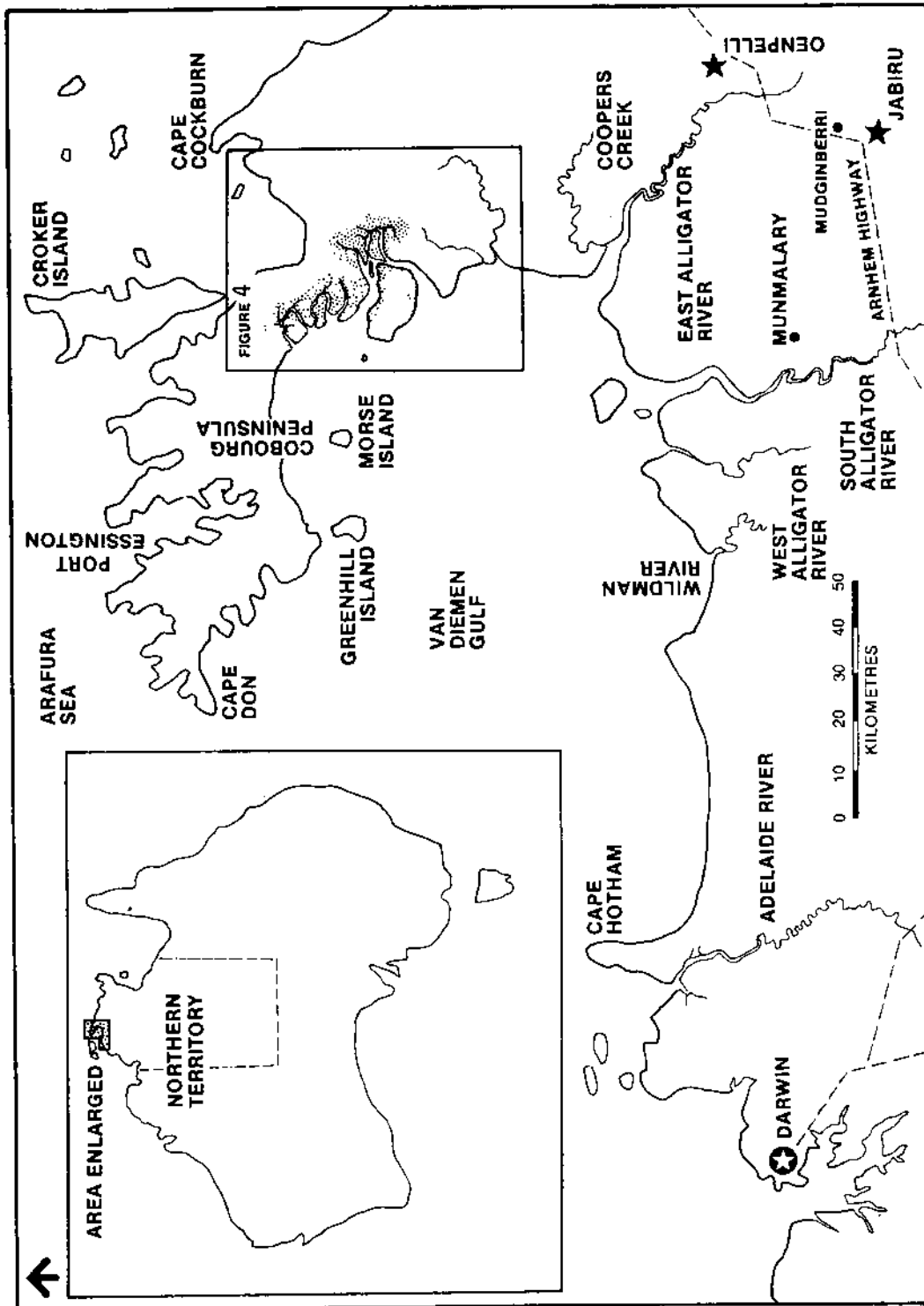


Fig. 1  
 General area map showing rivers and creeks on the Cobourg Peninsula and the Alligator Region. The dotted area shows the  
 Cohourg Mangrove Complex which is one of the largest in Australia.

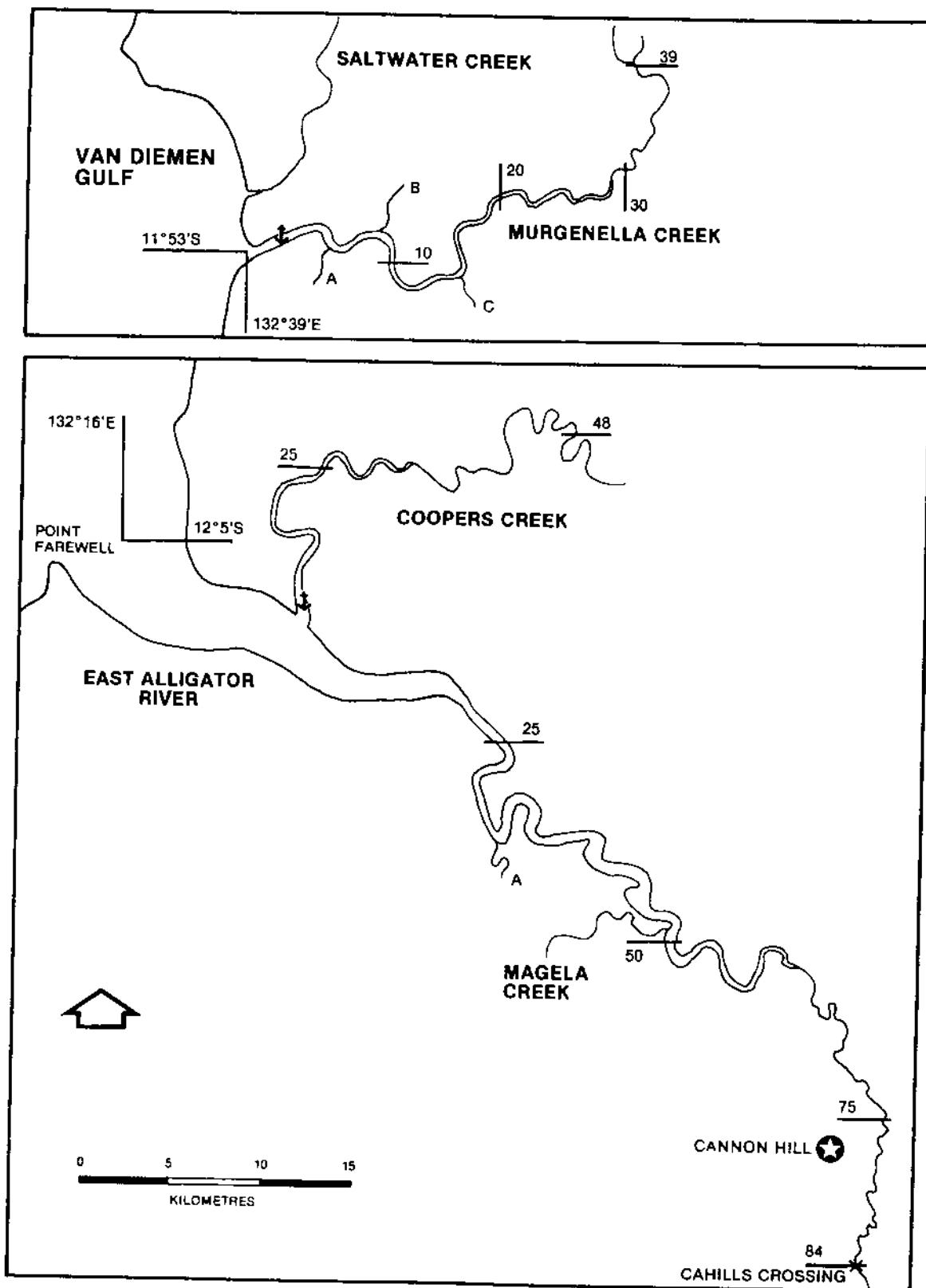


Fig. 2  
Map of Murgenella Creek, Coopers Creek and the East Alligator River. Distances in km.

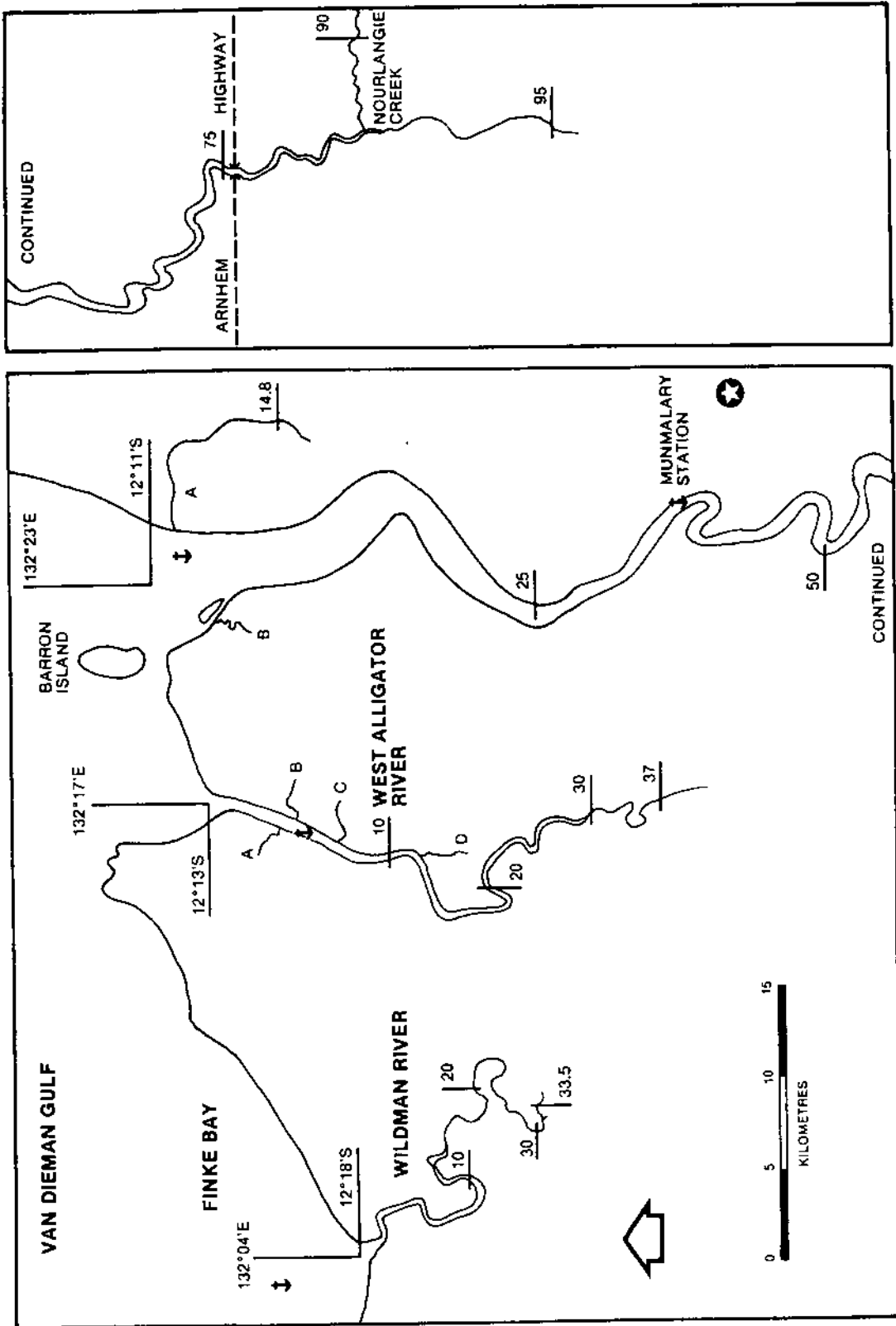


Fig. 3 Map of the South Alligator, West Alligator and Wildman Rivers. Distances in km.

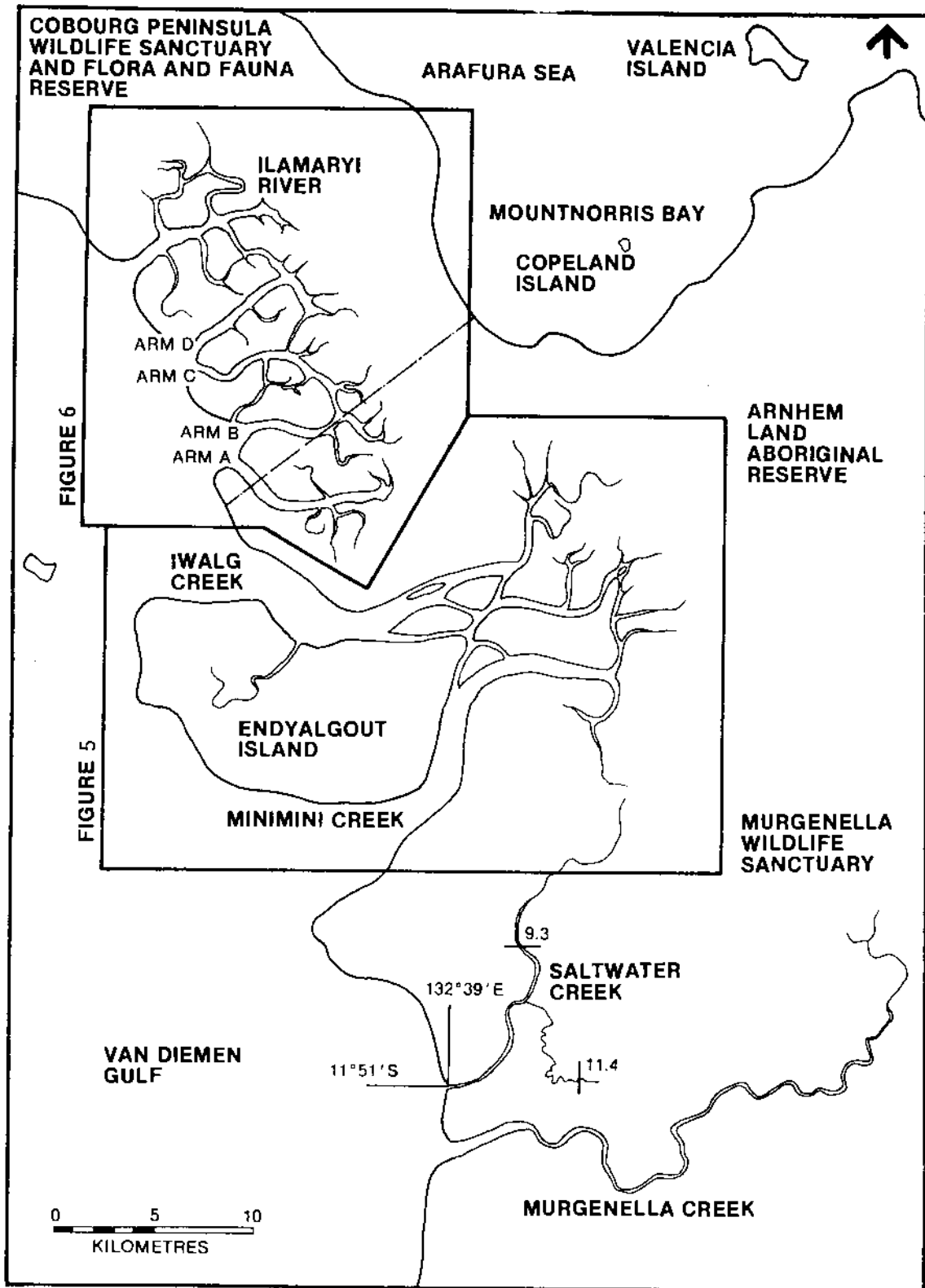


Fig. 4  
General area map showing the rivers and creeks on the Cobourg Peninsula. Distances in km shown for Saltwater Creek.

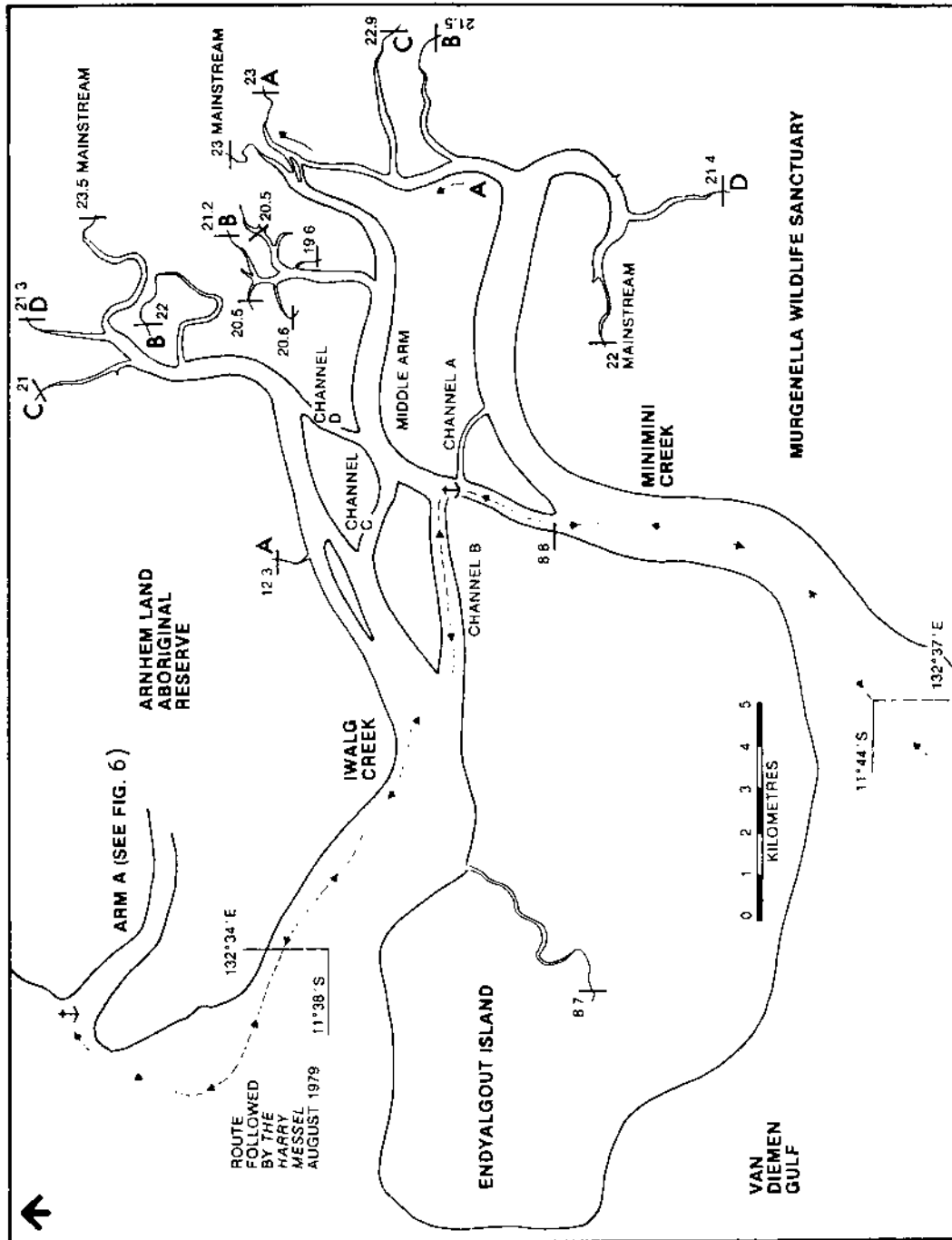


Fig. 5. Map of Mimimini and Iwalg Creeks, and Middle Arm. Distances in km. The route followed by the research vessel to the anchorages in Middle Arm and Arm A is shown also.



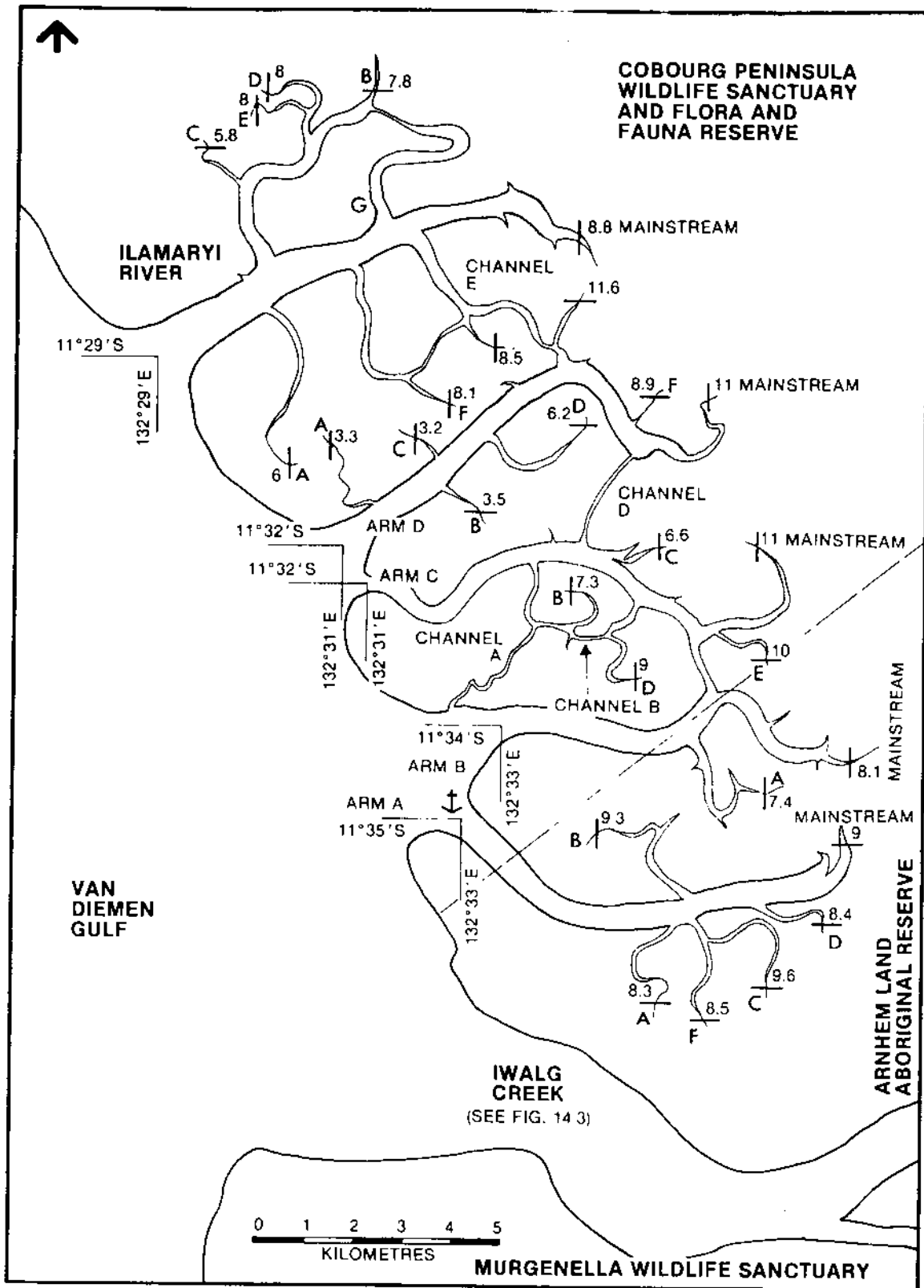


Fig. 6  
Map of Ilamaryi River and Coastal Arms A, B, C and D. Distances in km.

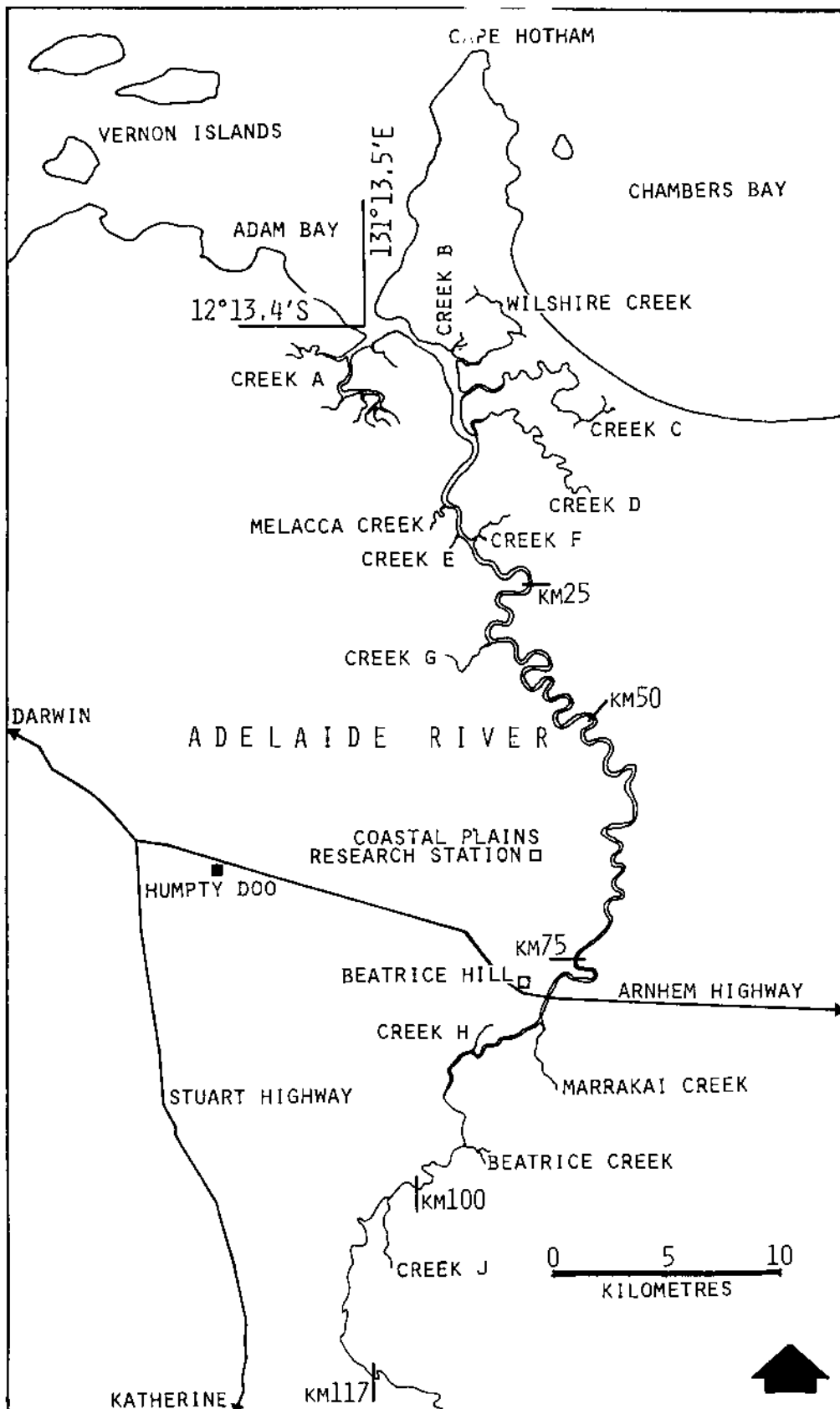


FIGURE 7 MAP OF THE ADELAIDE RIVER <sup>348</sup>

## COMMENTS ON INDOPACIFIC CROCODILE DISTRIBUTIONS

Charles A. Ross  
Department of Vertebrate Zoology  
National Museum of Natural History  
Smithsonian Institution  
Washington, D. C. 20560

### Introduction

The systematics and distribution of Indopacific crocodiles are confused and in part, unknown. Individual and geographic variation have been inadequately studied; insufficient museum holdings and the extinction of some populations ensure that basic questions of recent Indopacific Crocodylus speciation will remain only partly answered, and, their distributions poorly documented. This is particularly true for the numerous island populations of palustrine or "freshwater" Crocodylus which seemingly exhibit a high level of endemism in contrast to the widely distributed Indopacific Crocodile (Crocodylus porosus), with which most, if not all, are sympatric.

The distribution of the Philippine Crocodile (Crocodylus mindorensis) was reviewed recently and shown to include the islands of Luzon, Mindoro, Busuanga, Masbate, Samar, Negros, Mindanao and Jolo in the Philippine Archipelago (Ross and Alcala, 1983). In this note I continue to review Indopacific crocodile distributions by presenting data that indicate that New Guinea freshwater crocodiles are restricted to the island of New Guinea and map their known distribution. In addition island records of the Indonesian palustrine Crocodylus, referred to as "Crocodylus siamensis" in this note following Muller (1923), Hellmich (Hooijer, 1972) and Wermuth and Mertens (1977), are summarized briefly and the need for additional records and/or specimens is emphasized.

### New Guinea Freshwater Crocodiles

New Guinea freshwater crocodiles remain relatively abundant. Morphological analysis of a large sample shows that two disjunct and distinct New Guinea freshwater crocodile populations separated by the Owen Stanley, Central, and Wandammen mountain ranges exist (Hall, in prep.; Ross, in prep.). The northern, Sepik River, population was described by Schmidt (1928); whereas the other, restricted to the southern lowlands, is undescribed. The southern and northern populations can be distinguished by differences of cranial morphology and squamation: genetic exchange between these two forms seems unlikely on the basis of distribution data. The description of the southern population must be postponed pending examination of Irian Jayan (= western half of island of New Guinea) material at the Rijksmuseum van Natuurlijke Historie, Leiden.

Crocodiles have been reported from most of the islands surrounding New Guinea. In most instances, these locality records have been assigned to C. porosus. Neill (1956, 1971) suggested that a palustrine Crocodylus, either C. novaeguineae or a close relative of it, may occur in upland lakes on the island of New Britain. Whitaker (1980a) surveyed crocodiles and crocodile habitats of the island provinces of Papua New Guinea. He found from personal observation, skin dealer records and interviews with crocodile hunters "that C. porosus is the only species present". Crocodylus porosus is known to occur in freshwater lakes, marshes and inland rivers of mainland New Guinea and elsewhere (Dubois, 1896/97; Whitaker, 1980b; Ross and Alcalá, 1983). Neill based his species identification merely on the basis of habitat and such an association is known to be unreliable.

Wermuth and Mertens (1977) and Groombridge (1982) included the Aru Islands SSW of New Guinea in the range of C. novaeguineae. This locality record is based on specimen number 8115, a preserved young crocodile in Senckenberische Naturforschende Gesellschaft. Examination of photographs of this specimen clearly shows it to be a specimen of C. porosus. The following comparisons are the basis for this reidentification:

1. It has 30 transverse ventral scale rows whereas New Guinea freshwater crocodiles have 22 to 27 (N = 209; Ross, unpubl. data) and is within the observed range of variation of this scale count for C. porosus, 29 to 35 (N = 60; Ross, unpubl. data).
2. It has a reduced number of post-occipital scales, i.e., less than 4, as observed in all C. porosus examined (N = 72) and only 2.4% of 247 New Guinea freshwater crocodiles examined (Ross, unpubl. data).
3. It lacks the enlarged, often ossified, lateral scales and distinct dark caudal banding found in New Guinea freshwater crocodiles. These are typically absent in C. porosus where the lateral body squamation is composed of regular subequal scales, and the tail is spotted or blotched but rarely has solid bands.

Whitaker (1980b) reviewed the distribution of the freshwater crocodiles in Papua New Guinea but failed to note that C. novaeguineae occurs in the vicinity of Madang (based on a live juvenile at the Moitaka Crocodile Farm, Port Moresby, in 1977, marked by J. Lever as originating in Madang, and examined by me) and mistakenly attributed the Southern Highlands Province, Kiriowi Island (Kikori River) freshwater crocodile locality record to a specimen at the National Museum of Natural History, Smithsonian Institution. Actually the record is based on a photograph of a crocodile captured by me and later left at the Kikori Crocodile Farm.

Neill (1971) and Groombridge (1982) maintained that the distribution of New Guinea freshwater crocodiles in Irian Jaya is poorly known. Actually, their distribution in Irian Jaya is well documented. These authors failed to note papers by Brongersma (1958a and b, 1961, 1962) and the extensive collections of Irian Jayan Crocodylus of the Rijksmuseum van Natuurlijke Historie Leiden. Available records

indicate that freshwater crocodiles occur throughout suitable habitat in Irian Jaya.

The locality records presented by Whitaker (1980b), Brongersma (1968a and b, 1961, 1962) museum collections and this note, are summarized in Map 1.

No evidence exists that New Guinea freshwater crocodiles occur outside of New Guinea (with the possible exception of introduced populations in the Palaus). On the island of New Guinea they have a wide distribution, occurring in all areas of suitable habitat from Fak Fak to Abau in the southern Iowlands, and, from Mamberambo to Lae in the northern Iowlands. They are known from Oransbari in the Vogelkop Peninsula (Bernice P. Bishop Museum numbers 3942 and 5842). There are no records of freshwater crocodiles from Milne Bay in eastern Papua New Guinea.

#### Indonesian Freshwater Crocodiles

"Crocodylus siamensis" was apparently widespread in the Indonesian islands. It is easily confused with C. porosus owing to similarity of coloration, often reduced post-occipital squamation, and a similar number of transverse ventral scale rows. There is considerable inter-island variation, and at present, insufficient material available to differentiate all island populations. These crocodiles can be differentiated from C. porosus by a combination of cranial and squamation characteristics (Ross, in prep.) They are distinct from Crocodylus siamensis of mainland Southeast Asia on the basis of throat squamation (Ross, in prep.).

Distribution of Indonesian "C. siamensis" is now known to include Sumatra, Bangka Island, Java, Borneo and Celebes. Specimens on which these island records are based are in the collections of the Rijkmuseum van Natuurlijke Historie, Leiden (Sumatra, Bangka Island); Senckenberische Naturforschende Gesellschaft (Java); the Museum of Comparative Zoology, Harvard, and American Museum of Natural History, New York (Borneo); and the National Museum of Natural History, Smithsonian Institution (Celebes).

Examination of additional material in Indonesian and European museum collections will likely show that Indonesian "C. siamensis" is found on other islands in this region. As the reidentification of existing museum specimens or the examination of remaining wild populations increases the sample of island populations of freshwater crocodiles, it is likely that individual island populations will merit nomenclatural recognition (Dubois, 1908; Brongersma, 1941; Ross, pers. obs.).

#### Discussion

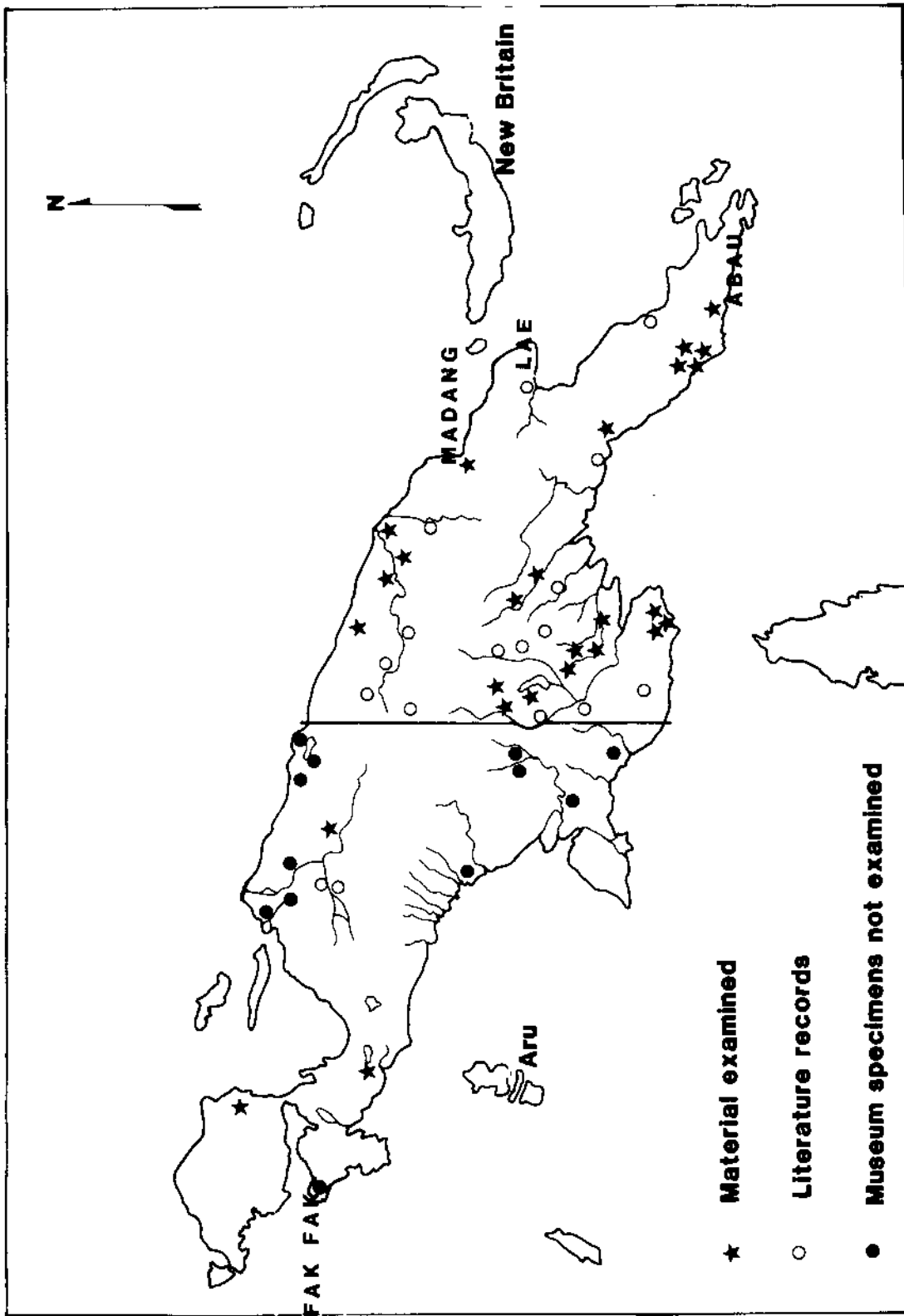
The study of Indopacific crocodiles indicates that many islands in the region harbored endemic Crocodylus that differ from the wide-ranging C. porosus in morphology, size, and perhaps (prior to disturbance by man) habitat. Any past ecological separation of palustrine crocodiles and C. porosus is unknown. Early accounts of Indopacific crocodiles did not differentiate between species,

but centered on crocodile predation on man. As early as 1779, bounties were paid for crocodiles killed in estuarine or riverine habitats in Southeast Asia (Koenig, 1984) and even Dyak tribesmen in Borneo who normally did not kill crocodiles owing to local superstitions, would slaughter large numbers of crocodiles when a crocodile took one of their group (Roth, 1896). The behavior and ecology of crocodilians is known to be influenced by hunting and habitat disturbance (Bustard, 1968; Medem, 1971; Ross, pers. obs.) and, as such, any ecological or habitat differentiation is now masked. The vicariant speciation observed in Indopacific palustrine crocodiles, which has resulted in numerous endemic but closely related species, can not be explained simply by geographic isolation. It is likely that their distribution was influenced by the occurrence of C. porosus in estuarine and coastal habitat where C. porosus might act as a barrier to their dispersal. Interspecific aggression may have had an influence on their distribution and subsequent speciation.

#### Literature Cited

- Brongersma, L.D. 1941. Age variations in the skulls of crocodiles. Arch. Neerlandaises Zool. 5(4): 505.
- Brongersma, L.D. 1958a. Over het voorkomen van Crocodylus novaeguineae in Nederlands Nieuw-Guinea. Lacerta 17(1-2): 3-5.
- Brongersma, L.D. 1958b. The Animal World of Netherlands New Guinea. J.P. Wolters, Groinigen.
- Brongersma, L.D. 1961. Zoological exploration of Netherlands New Guinea. Proc. 9th Pacific Sci. Congr. (Bangkok) 19: 68-71.
- Brongersma, L.D. and G.F. Venema, 1962. To the mountains of the stars. Hooper and Stoughton, London.
- Bustard, H.R. 1969. Rapid learning in wild crocodiles. (Crocodylus porosus). Herpetologica 24(2): 173-175.
- Dubois, E. 1896/97. On the occurrence of Crocodylus porosus far above the tideway in a Sumatran River. Notes Leyden Mus. 18(2/3): 134.
- Dubois, E. 1980. Das geologische alter der kendenigoder Trinil-fauna. Nederlandsch Aardrijkundig genootschap, Amsterdam. Tijdschrift. Ser.2, 25: 1235-1270.
- Groombridge, B. 1982. The IUCN Amphibia-Reptilia red data book., Part 1, Testudines, Crocodylia, Rhynchocephalia. IUCN. Gland.
- Hooijer, D.A. 1972. Pleistocene vertebrate from Celebes. XIV. Additions to the Archidiskodon-Celebochoerus fauna. Zool. Mededel. 46(1): 1-16.
- Koenig, J.G. 1894. Journal of a voyage from India to Siam and Malacca in 1779. Translated from his manuscripts in the British Museum. J. Straits Br. Roy. Asiatic Soc. (26): 58-201, and (27): 57-133.

- Medem, F. 1971. Biological isolation of sympatric species of South American Crocodylia. In: Crocodiles. IUCN Publ., New Ser., Suppl. Pap. 32: 152-158.
- Muller, L. 1923. Crocodylus siamensis Schneid. und Crocodylus ossifragus Dubois. Palaeont. Hungar. 1: 109-122.
- Neill, W.T. 1956. The possibility of an undescribed crocodile on New Britain. Herpetologica 12(3): 174-176.
- Neill, W.T. 1971. The last of the ruling reptiles. Alligators, crocodiles, and their kin. Columbia Univ. Press, New York and London.
- Ross, C.A. and A.C. Alcala. 1983. Distribution and status of the Philippine Crocodile (Crocodylus mindorensis). Kalikasan. Phil. J. Biol. 12(1-2): 169-173.
- Roth, H.L. 1896. The natives of Sarawak and British North Borneo. Truslove and Combe, New York.
- Schmidt, K.P. 1928. A new crocodile from New Guinea. Field Mus. Nat. Hist. Publ., Zool. Ser., 12(14): 177-181.
- Wermuth, H. and R. Mertens. 1977. Das Tierreich. Liste der rezenten Amphibien und Reptilien. 100. Testudines, Crocodylia, Rhynchocephalia. Walter de Gruyter, Berlin and New York.
- Whitaker, R. 1980a. A preliminary survey of the crocodile resource in the Island Provinces of PNG. Wildl. Div. Publ., 80/11.
- Whitaker, R. 1980b. The status and distribution of crocodiles in Papua New Guinea. FAO Ass. Croc. Skin Ind. PNG, Field Doc. (1).



**Map 1. Distribution of New Guinea fresh-water crocodiles**



## INDIA: STATUS OF WILD CROCODILES

L. A. K. Singh<sup>1</sup>, S. Kar<sup>2</sup> and B. C. Chaudhury<sup>3</sup>

<sup>1</sup>Government of India, Crocodile Research Centre  
Camp: National Chambal Sanctuary, Post Box 11  
Morena 476001, Madhya Pradesh

<sup>2</sup>Government of Orissa, Crocodile Project, Camp:  
Chandabali, Balasore, Orissa

<sup>3</sup>Government of India, Crocodile Research Centre  
of Wildlife Institute of India, Bahadurpura,  
Hyderabad 500264, Andhra Pradesh

### Introduction

At the First Working Meeting of the Crocodile Specialists Group in 1971 the following were the status given to the Indian crocodilians (Honegger, 1971).

1. Gharial (Gavialis gangeticus): "Extremely rare" (based on Seshadri, 1969).
2. Saltwater crocodile (Crocodylus porosus): No mention, apparently thought to be fairly safe.
3. Mugger (Crocodylus palustris): "Exterminated in most areas of its range" (Daniel, 1970). Extremely rare (Seshadri, 1969).

By the Fifth meeting in 1980 reports on the status were more clear and approximate number of crocodilians in the wild were known in most cases (Whitaker, 1982). The IUCN Red Data Book (1982) stated the status of Indian crocodilians as follows:

1. G. gangeticus: Endangered, extremely depleted.
2. C. porosus: Endangered, now seriously depleted and rare or extinct in most of its former ranges in India.
3. C. palustris: Vulnerable, now heavily depleted throughout the range.

At the last Working Meeting in 1982, the situations were accepted to be as before. The present paper provides updated information on the three species as regards their status before any release/rehabilitation took place through the Government's conservation management programme. Also given are the accepted population figures and the present locations of breeding populations.

### Present status of: *Gavialis gangeticus* (GMELIN)

#### I. LEGAL STATUS:

INDIA: 1. Wildlife (Protection) Act, 1972: Schedule I  
(Total Protection).

2. Export I Instruction N<sup>o</sup> 46/73: Export of animals and their products prohibited.
3. Instruction N<sup>o</sup> 57/75: Protection as religious symbol

INTERNATIONAL:

1. CITES: Appendix I (India is a party)
2. IUCN Red Data Book: Endangered

II. PRE-RELEASE POPULATIONS:

River	State	Adult	Juvenile	Total	Source
1. Brahmaputra	Arunachal	?	?	50	Mohanta, H., 1981 Choudhury, 1983
2. Chambal	Rajasthan	40	81	121	FAO, 1974; Anon, 1976; Whitaker and Daniel, 1980; Singh, V.B., 1978; IUCN, 1982; Whitaker and Basu, 1983
3. Girwa (1977)	Uttar Pradesh	9	19	28	Ramanand and Johri, 1982
4. Ken (1989)	Madhya Pradesh	1	0	1	Anon., 1976; Singh, 1980
5. Mahanadi	Orissa	4	4	8	Bustard and Singh, 1982
6. Ramganga	Uttar Pradesh	0	4	4	Anon, 1975 (?)
7. Son (1984)	Madhya Pradesh	18	0	18	Pandey, 1984

Total population: 230 including 72+ adults.

Although the above figures are improvements over Bustard, 1982 (60-70 nos) and Whitaker, 1982 (less than 50 adults), the overall status remains the same, "endangered".

III. BREEDING POPULATIONS (1984)

1. River Chambal: (Places vs. average number of nests as of (1982-1984) Baroli- 7, Bharrah- 7; Tigri-Rithaure- 2; Pureini- 10; Gyanpura- 2: Total = 28)
2. River Girwa: Within a stretch of about 12 km up to six nests.
3. River Mahanadi: Last successful breeding: 1974; recommenced: 1984; number of nests: one with 24 eggs at Majhipada.
4. Brahmaputra: Reports of breeding in the following tributaries are available but the exact status is unknown.
5. Ramganga: Uncertain.

IV. TOTAL POPULATION (1984)

River	Natural			Released	Grand* Total	Population trend
	Adult	Other	Total			
Brahmaputra	?	?	50	0	50	Inknown
Chambal	53	192	245	912	1157	Increasing
Girwa	9	19	28	85	113	Increasing
Ken	1	--	1	3	4	Stable
Mahanadi	6	2	8	150	158	Increasing
Ramganga	4	--	4	12	16	Unknown
Son	18	--	18	2	20	Stable (no male)
<b>TOTAL</b>	<b>141</b>	<b>213</b>	<b>354</b>	<b>1164</b>	<b>1518**</b>	<b>Increasing</b>

\* without considering losses among released gharial

\*\* and captive population about one thousand

Present status of: *Crocodylus porosus* Schneider

I. LEGAL STATUS:

INDIA: As for Gharial

INTERNATIONAL: As for Gharial

II. PRE-RELEASE POPULATIONS:

	Location	State	Adult	Juvenile	Total	Source
1.	Bhitarkanika (1977)	Orissa	34	64	95	Kar and Bustard, 1982
2.	Sundarbans (1978)	W. Bengal	4	96	100	Mail, Madras (27 Jan., 1978)
3.	Andaman and Nicobar			up to		Whitaker and Whitaker, 1978
	North A.		50	150	100-200	
	Middle A.		20	80	50-100	
	South A.		10	20	20-30	
	Nicobar		--	--	20-25	(Bhaskara, 1979)

Total population: up to 550 including 125 adults.

### III. BREEDING POPULATIONS (1984)

1. Bhitarkanika: Over an area of 176 sq.km. up to eight nests.
2. Sundarbans: A total of two nests every year.
3. Andamans: Most of the nests are predated in this wild (Choundhury and Bustard, 1980). Exact extents of reproductive effort uncertain.
4. Goa: Existence of viable population reported. Exact position unknown.

### IV. TOTAL POPULATION (1984)

Location	Total			Released	Grand* Population Total	Population trend
	Adult	Other	Total			
Bhitarkanika	38	130	168	350	518	Increasing
Sundarban	4	96	100	65	165	Increasing
Andamans	80	up to 250	up to 330	0	330	Unknown
Goa	?	?	?	0	?	Unknown
<b>TOTAL</b>	<b>118+</b>	<b>480+</b>	<b>598+</b>	<b>415</b>	<b>1013**</b>	<b>INCREASING</b>

\* without considering losses among released crocodiles

\*\* and captive population about 700

TOTAL POPULATION IN THE COUNTRY: 1713+

### Present status of: Crocodylus palustris Lesson

#### I. LEGAL STATUS:

INDIA: As for gharial

INTERNATIONAL:

1. CITES: Appendix I
2. IUCN Red Data Book: Vulnerable

#### II. PRE-RELEASE POPULATIONS:

Excepting the northern states of Jammu and Kashmir, Himachal Pradesh and Sikkim, mugger are reported to have occurred in all the other states during early 1970. Although no detailed census were conducted an accepted approximate population figure was around 1000 with a population trend "depleting faster than it could reproduce" (FAO, 1974). Based on the number of wild mugger some of the good states were in the order of Tamilnadu, Gujarat, Rajasthan, Andhra Pradesh, Karnataka and Maharashtra.

### III. MAIN BREEDING POPULATIONS (1984)

Tamilnadu:	Amaravati, Sathanur, Hogekekakal, Chidambaram, Kullikudu, Mettur, Mundanthurai. Total approx. 50 nests.
Gujarat:	Hiran and other lakes (Gir). Total approx. 12 nests.
Andhra Pradesh:	Ethipothala/Nagarjuna Sagar Sirisailam (Krishna), Kinnersani, Lanjamadugu, Manjira, Sileru. Total approx. 12 nests.
Karnataka:	Cauvery river at Ranganthitu-Sri Rangapatan, Tungabhadra and Bhima rivers. Total approx. 4 nests.
Maharashtra:	Tadoba National Park, Powai Lake (Bombay). Total up to six nests.
Bihar:	Bher river (Mutta), Kaimur Sanctuary, Damodar Valley. Total up to 6 nests.
Rajasthan:	Ranthambhore, Pushkar Lake. Total up to 8 nests.
Madhya Pradesh:	Rangawa Dam (Panna), Bandhavgarh. Total up to 5 nests.
Uttar Pradesh:	Corbett, Dudhwa, Girwa (Katarniyaghat). Total up to 6 nests.
Chambal river:	(Madhya Pradesh/Rajasthan/Uttar Pradesh). Up to 12 nests.
Haryana:	Kurukshetra.
Kerala:	Neyaar, Parambioulum. Up to 3 nests.
Orissa:	Koraput (Balimela Dam Project), Granjam (Bhanjanagar).
North-east rivers:	(Arunachal Pradesh, Assam, Nagaland and West Bengal). Occurrences reported but exact locations of breeding population not available.

### IV. TOTAL POPULATION (1984)

Natural	Approx. 1000 all sizes
Released:	600 (all from wild-collected eggs)
Captive:	From wild-collected eggs- 3000. By captive breeding- 2500
Total:	7100
Trend:	Increasing. (Extensive captive breeding in at least twelve centres).

## References

- Anon 1975 . Gharial Survey. Madras Snake Park Trust.
- Anon 1976 . Madhya Pradesh Gharial Survey. Newsletter of the Madras Snake Park 1(2): 2-3.
- Bhaskara, S. 1981 Travels in the Andamans and Nicobars. Hamadryad 6(1): 2-8.
- Bustard, H.R. and Singh, L.A.K. 1982. Status of gharial in Orissa, In Singh, L.A.K. and Choudhury, B.C. (1982). Indian Crocodiles - Conservation and Research. Forum of Crocodile Researchers, India, P. 7.
- Choundhury, B.C. 1983. Pers.Inform. from Arunachal Pradesh.
- and Bustard, H.R. 1980 Predation in natural nests of the saltwater crocodile (Crocodylus porosus Schneider) on north Andaman island with notes on the crocodile population. J. Bombay nat. Hist. Soc. 76 (2): 311-323.
- Daniel, J.C. 1970. A review of the Present Status and position of endangered species of Indian reptiles. IUCN Publ. (N.S.) N<sup>o</sup> 18: 75-76.
- F.A.O. 1979. India. A Preliminary Survey of the prospects for Crocodile farming. (Based on the work of Dr. H.R.Bustard). FO:IND/71/033, October 1974, 1-66 pps.
- Honegger, R.E. 1971. The Status of four Threatanded crocodylian species of Asia. IUCN Supplementary paper 33 (1): 44-53.
- IUCN 1982 a. Red Data Book. Amphibia and Reptilia.
- IUCN 1982 b. Crocodiles. Proc. 5th working meeting of the CSG/SSC, IUCN.
- Kar, S.K. and Bustard, H.R. 1982. Status of saltwater crocodile in Orissa. In Singh, L.A.K. and Choudhury, B.C. (Ed.) Indian Crocodiles - Conservation and Research, Forum of Crocodile Researchers, India.
- Mohanata, H.K. 1981. Pers. commu - to LAKS
- Pandey, S.P. 1984. Pers. commu - to LAKS
- Ramanad, S.P. and Johri, V.K. 1982. Results of a census of the gharial in Katerniyaghat Sanctuary by OCBMTI Trainees in 1979. In: (Ed.) Singh, L.A.K. and Choudhury, B.C. (1982): Indian Crocodiles - Conservation and Research, Forum of Crocodile Researchers, India.
- Seshadri, B. 1969. The twilight of India's Wildlife, London.
- Singh, L.A.K. 1980. Crocodile Survey in Ken River, Madhya Pradesh. Report to Forest Dept., Madhya Pradesh.

- Singh, V.B. 1978. Status of the gharial in Uttar Pradesh and its rehabilitation. J. Bombay Nat. Hist. Soc. 75 (3): 668-683.
- Whitaker, R. 1982. Status of Asian Crocodilians. In: IUCN (1982 b)
- Whitaker, R. and Basu, D. 1983. Gharial: A review. J. Bombay Nat. Hist. Soc. 80
- Whitaker, R. and Daniel, J.C. 1980. The Status of Indian Crocodilians. J. Bombay Nat. Hist. Soc. 75: 1238-1245
- Whitaker, R. and Whitaker, Z. 1978. A preliminary survey of the saltwater Crocodile (Crocodylus porosus) in the Andaman islands. J. Bombay Nat. Hist. Soc. 75 (1): 43-49.

## INDIAN CROCODILIANS: A 10-YEAR REVIEW OF MANAGEMENT

L.A.K.Singh<sup>1</sup>, S.Kar<sup>2</sup>, & B.C.Choudhury<sup>3</sup>

1. Govt. of India, Crocodile Research Centre of Wildlife Institute of India. Cam:National Chambal Sanctuary, Post Box-11, Morena-476 001
2. Govt. of Orissa, Crocodile Project, Camp;Chandbali, Balasore, Orissa
3. Government of India, Crocodile Research Centre of Wildlife Institute of India, Bahadurpura,Hyderabad 500 264, Andhara Pradesh

### Introduction

Indian crocodilians (Gavialis gangeticus, Crocodylus porosus and Crocodylus palustris) are known to have close association with the Indian culture as religious symbols and use in indigenous medicines. Crocodilians were also used as exhibits and even maintained as imperail executioner. Hunting of crocodilians as a sport was popular only among a few Indian sport-hunters and although sporadic commercial hunting for the luxury leather trade did occur such killings are considered as only one among the various other more serious causes that were responsible for the depletion of the populations during the post-independence era. One of the major causes was the introduction of nylon gill netting and the prejudice against crocodilians as the enemy of fisheries. Other causes were the construction of dams and barrages and increased number of human habitation near crocodilian habitats with better net-work of approach roads. These developments are reflected in a shrinkage or total loss of crocodilian habitats.

After the establishment of the Indian Board for Wildlife in 1952 efforts by some individual Forest Officers and naturalist are know to have been made for the 'protection' of crocodilian populations in areas under their jurisdiction. A proposal was under consideration during 1971 to start commercial farming of crocodiles but by 1974 it had been realised that Indian Crocodilian resources were so depleted that they were not a position to support the commercial exploitation. This was the period when UNDP/FAO collaborations in the form of technical expertise, soon followed with financial assitance, was made available to the Government of India to commence and promote the crocodile breeding and management programme in different States.

### Management Goals (1974-75) And Achievements

#### 1. Protection to remaining natural population

Objective: Location of all the best crocodilian areas and creation of a few special crocodile sanctuaries for habitat and species management.



All important habitats for the different species have been identified and if these were not already within a Sanctuary of National Park, were formally declared as Crocodilian Sanctuaries. Some of these protected areas have been identified for introduction or reintroduction. Two such sanctuaries are in Andhra Pradesh, one for the saltwater crocodile (Coringa sanctuary: reintroduction) and the other for the gharial (Papikonda: probably reintroduction since the species is now known to have occurred in the Godavari Bustard and Choudhury 1982). The number of areas in which active protection is given to Crocodilian is 34 (20399 sq. km) and the number of specially created Crocodilian Sanctuaries is 13 (8346 sq. km +) (Table 1, Fig. 1).

Although no special law or regulations were enacted since 1974, implementation of the existing regulations was vigorous. The best example of the present state of protection and management of sanctuaries is the resumption of breeding by the wild population of the gharial after a lapse of ten years. (Satkoshia Gorge Sanctuary, 1984). Regeneration of mangroves, especially seen in the Bhitarkanika Sanctuary, is yet another example of rehabilitation through protection.

## 2. Rebuild natural populations

Objective: To reduce natural losses through 'management'. The technique adopted was 'grow and release'. This involves collection of wild-laid eggs, incubation of egg in hatcheries, rearing, of the young crocodilians upto a 'releaseable' size (over a metre length) and release of the juveniles in sanctuaries or other protected viable habitats.

The total number of eggs handled so far is, Gharial: c. 6000; Mugger: c. 9000; Saltwater crocodiles: 2500.

The total number of hatchlings handled is, Gharial: c. 1700 and the total number released is Gharial: 1164; Mugger: c. 600; Saltwater crocodile: 415. The released Gharials are expected to commence breeding in 1985/86. Mugger breeding commercial with the population in Ethipothala in 1981 and Saltwater crocodiles are expected to commence breeding in 1985/86.

The post release monitor has been satisfactory. Recently, radio-tracking was used to monitor the movement and habitat preference in sample populations including the released juveniles. Based on these studies species-wise recommendations have been made on restocking sites and seasons and to extend the limits of the sanctuaries into certain tributaries that are used during monsoon.

While Gharial and Mugger have responded fairly well without causing any public concern stray incidents have come to notice where C. porosus juveniles have entered village ponds. In response to complaints prompt action has been taken to shift such juveniles either back to captivity or to a different point for release.

Studies are in progress in selected sanctuaries to determine the average survival among released crocodilians. The indications have

been very clear that the habitats have accepted the released juveniles and there are increasing trends in the populations, It is, however, felt particularly in the case of gharial that in the near future, as the recruitment into the adult group steadily increases, now areas may have to be developed to attract sub-adults to settle to form breeding groups. Studies are under progress to identify such potential areas and the extent of management requirements.

The public reaction has been indifferent to releases. Several local people have been provided employment under the schemes as boatman, crocodile/sanctuary guards, husbandry attendants, fish-suppliers and other general help for the upkeep of the centres and camps in the sanctuaries. The sanctuaries have attracted visitors from which the local people have definitely experienced an economic uplift (Singh 1980).

### 3. Promotion of captive breeding

Objective: To breed under simulated natural surroundings the available adults in certain zoos and similar organisations.

Mugger have responded the best to captive breeding attempts (Table 2, Fig. 2). At least:15 centres are being set up.

Gharial being a very specialised species in its breeding habitat requirements, has set a record by breeding in the Nandankanan Biological Park, Orissa since 1980. A special breeding pool holding 2.7 million litres of water has been used for breeding. The maximum depth of the pool is 10 metres.

Saltwater crocodile have bred in captivity at the Bhagabatpur centre and at the Madras Crocodile Bank (a non-Govt. Trust) (1983).

### 4. Research

Objective: To take up studies that will improve the ongoing management programme.

The aspects that were immediately relevant to the grow and release techniques and the management of the Sanctuaries were given priority. This has overlooked several biochemical or embryological studies which may involve or require to sacrifice eggs or young or both. Some of the important aspects that were studied are:

- interpretation of the various types of data collected during survey and census.
- determination of parameters for maximum hatching success; (This had overlooked the role of temperature on sex differentiation, an aspect that is now being studied).
- husbandry of young crocodilians including feeding prescription, food conversion and growth.

- behavioural biology including reproduction, thermoregulation, feeding, orientation, locomotion, and reproduction; and

- habitat features and population structures.

5. Build up levels of trained personnel

Objective: On the spot research/training guided through FAO expertise in collaboration with local Universities. On the spot infra-level training to persons like 'keepers'. Institutional training to in-service Government personnel who will manage sanctuaries and rearing/breeding projects. Six Ph.Ds, Foresters and over 200 other personnel have been trained.

Situation Overview

<u>Aspect</u>	<u>Prior 1974</u>	<u>1984</u>
1. Population status of all species	Endangered and depleting	Endangered and increasing
2. Status of conservation	Localised and dependent on individuals	Definite country-wide programme
3. Legal protection	Provided	Same but strongly endorsed
4. Killings in the wild	Sporadic	Stopped
5. Number of special crocodile sanctuaries	none	Thirteen
6. Surveys conducted	Few, not in detail	Extensive
7. Public attitude	Religious, or indifferent toward conservation	Religious, most favour conservation, others in the process of being weaned away from a negative attitude
8. Public media	Curious toward 'accidents' and sport killings	Constructive explanation to accidents, promote conservation need and programme
9. Crog-Fish relation	Widely misunderstood	Studies under progress toward a better understanding
10. Captive rearing	Zoos as exhibits	23 special unit for conservation

11. Captive breeding	3 Zoos (all mugger)	16 (all species) 9 other places making serious breeding attempts
12. Knowledge of ecology	very limited	Much better understood

### Future Priorities

The following priority programmes are suggested:

#### 1. SANCTUARY MANAGEMENT:

- (a) Develop more adult zones
- (b) Continue the search to identify other places where natural populations can be built up.
- (c) Orient management on eco-system basis (Extend the efforts to other flora and fauna, e.g. turtles, aquatic mammals and birds).

#### 2. CAPTIVE HUSBANDRY:

- (a) Produce appropriate number of crocodilians of either sexes and try restore a balanced ratio among the released populations.
- (b) Study stress factors and maximise captive breeding productions.

#### 3. RESEARCH:

- (a) Continue as needed in sanctuary and captive managements.

#### 4. TRAINING:

- (a) Extend specialised courses to persons already receiving general wildlife training.
- (b) Build up expertise to permanently man each crocodilian sanctuary.

#### 5. FARMING:

Commence the experimental pilot project with captive mugger.

### Other Efforts

The Bombay Natural History Society have undertaken or supported extensive surveys of Crocodilian habitats. The Society have also remained as the only international organisation with a very strong appeal for Conservation Programmes in India. The Curator of the Society, Mr.J.C. Daniel, was the first Indian representative at the SSC/Crocodile Specialist Group.

Another non-government organisation that has contributed to the cause of Crocodile Conservation in India is the Madras Snake Park and Crocodile Bank. The Park have not only bred mugger and saltwater crocodiles, but have also supplied several crocodiles to different States for restocking in the wild. The Park now aims to become an International Centre for breeding all species of Crocodylians.

#### Acknowledgements \*

The authors are grateful to Shri Samar Singh, Joint Secretary and Director (Wildlife) to Govt. of India, Shri V.V. Saharia, Director (Wildlife Instt. of India) and Shri J.C. Daniel, Curator (Bombay Nat. Hist. Soc.) for their critical reading through the manuscripts and suggestions for improvements. Mr. R. Whitaker provided information on the Madras Snake Park and Crocodile Bank.

#### References

- Bustard, H.R. and Choudhury, B.C. 1982. Occurrences of gharial in Andhra Pradesh. In Singh, L.A.K. and Choudhury, B.C. (Ed.) Indian Crocodiles - Conservation and Research. Forum of Crocodile Researchers, India.
- Singh, L.A.K. 1980. Sanctuary management as a tool in rural development. Paper presented at a Symposium on 'Wildlife Resources for Rural Development' held at Hyderabad, India, 7-11 July, 1980.

\* José Vargas (División de Cuencas e Hidrología, EDELCA) kindly redrew figures 1 and 2.

Table 1. Crocodylian Sanctuaries (\*\*) and other areas offering active protection to crocodylians, 1984. S, sanctuary; NP, national park; Gh, gharial; Mg, mugger; SWC, salt - water crocodile

Sl. No	Name	Area sq. km.	Year commenced	Species managed	Number released
1.	Bandovgarh NP Madhya Pradesh	437		Mg	
2.**	Bhitarkanika S, Orissa	650	1975	SWC	350
3.**	Chambal, National S. Madhya Pradesh/Rajasthan, Uttar Pradesh	1500 approx.	1978	Gh (Mg)	912 (10)
4.	Corbett NP, Uttar Pradesh	525		Gh, (Mg)	12, (nil)
5.**	Coringa S, Andhra Pradesh	236	1978	SWC	3
6.	Gir NP, Gujarat	1412	1975	Mg	
7.**	Hadgarh S, Orissa	191	1978	Mg	
8.	Hoggenakal, Tamilnadu			Mg	46
9.**	Jawaharsagar S, Rajasthan	100	1975	Gh	21
10.	Kaimur S, Bihar	1342	1969	Mg	
11.**	Katerniyaghat S, U. Pradesh	400 approx.	1976	Gh (Mg)	85
12.**	Ken S, Madhya Pradesh	45	1982	Gh (Mg)	3
13.	Kinnersani, Andhra Pradesh	635		Mg	33
14.	Krishnagiri, Tamilnadu			Mg	130
15.**	Lanjamodugru, Andhra Pradesh	20	1978	Mg	
16.	Lothian S, West Bengal	38		SWC	24
17.**	Manjira S, Andhra Pradesh	20	1978	Mg	
18.	Mudumalai S, Tamilnadu	321	1940	Mg	6
19.	Mundanthorai, Tamilnadu			Mg	21
20.	Muta S, Bihar	5	Proposed	Mg	
21.**	Nagarjuna Sagar S, A. Pradesh	3588	1978	Mg	154
22.	Neyyar, Korala	270	1958	Mg	
23.	Pakhal S, Andhra Pradesh	860	1952	Mg	15
24.**	Papikonda S, Andhra Pradesh	591	1978	Gh	
25.	Parambikulam, Kerala	285	1978	Mg	
26.	Renganthitu S, Karaataka	26		Mg	
27.	Renthambhore Tiger R., Rajasthan	392	1959	Mg	
28.**	Satkoshia Gorge S, Orissa	796	1976	Gh (Mg)	150 (2)
29.	Sharawathy S, Karnataka	348	1970	Mg	
30.	Similipal Tiger R, Orissa	2300		Mg	60
31.	Sivipuri MP, Madhya Pradesh	156		Mg	25
32.**	Soan S, Madhya Pradesh	209	1982	Gh (Mg)	2 (nil)
33.	Sundarban Tiger R., N. Bengal	2585		SWC	31
34.	Tadoba NP, Maharashtra	116	1955	Mg	

Table 2. Captive rearing/breeding schemes, 1984. \*\*Successful breeding commenced, \*successful breeding attempted; Gh, gharial; Mg, mugger; SWC, Saltwater crocodile

State and U.T.	Sl.no.	Location	Year	Species
Andaman Nicobar	1.	Port Blair	1979	SWC
Andhra Pradesh	2.	Hyderabad	1976	Gh, SWX, Mg**
	3.	Nagarjunasagar	1979	Mg
Bihar	4.	Nutta	1976	Mg*
Gujarat	5.	Sason Gir	1976	Mg
Karnataka	6.	Banarghatta	1980	Mg**, Gh*
Kerala	7.	Neyzar	1982	Mg
	8.	Peruvannamuzhy	1982	Mg
Madhya Pradesh	9.	Deori	1981	Gh
Maharashtra	10.	Tadoba	1977	Mg*
Orissa	11.	Dangamal	1975	SWC*
	12.	Nandankanan	1976	Gh**, Mg**, SWC*
	13.	Ramatirtha	1979	Mg
Rajasthan	14.	Tikerpada	1975	Gh, Mg**
Tamilnadu	15.	Kota	1975	Gh, Mg
	16.	Amaravati	1976	Mg**
	17.	Hogannakal	1976	Mg*
	18.	Masinagudi	1980	Mg
	19.	Madras	1975	Mg*
	20.	Sathanur	1976	Mg**
Uttar Pradesh	21.	Katerniyaghat	1975	Gh, Mg*
	22.	Kukrail	1975	Gh, Mg*
West Bengal	23.	Bhagabatpur	1976	SWC**
<u>Other Captive Breeding Records:</u>				
Andhra Pradesh	24.	Vishakhapatnam Zoo	1978	Mg**, SWC*
Delhi	25.	Delhi Zoo	1976	Mg
Gujarat	26.	Ahmedabad Zoo	1960	Mg**
	27.	Baroda Zoo	1965	Mg**
Rajasthan	28.	Jaipur Zoo	1967	Mg**
Tamilnadu	29.	Madras Snake Park/ Crocodile Bank	1975	Mg**, SWC**
<u>Other Interested States:</u>				
1. Arunachal Pradesh, 2. Assam, 3. Haryana**, 4. Magaland, 5. Goa**				

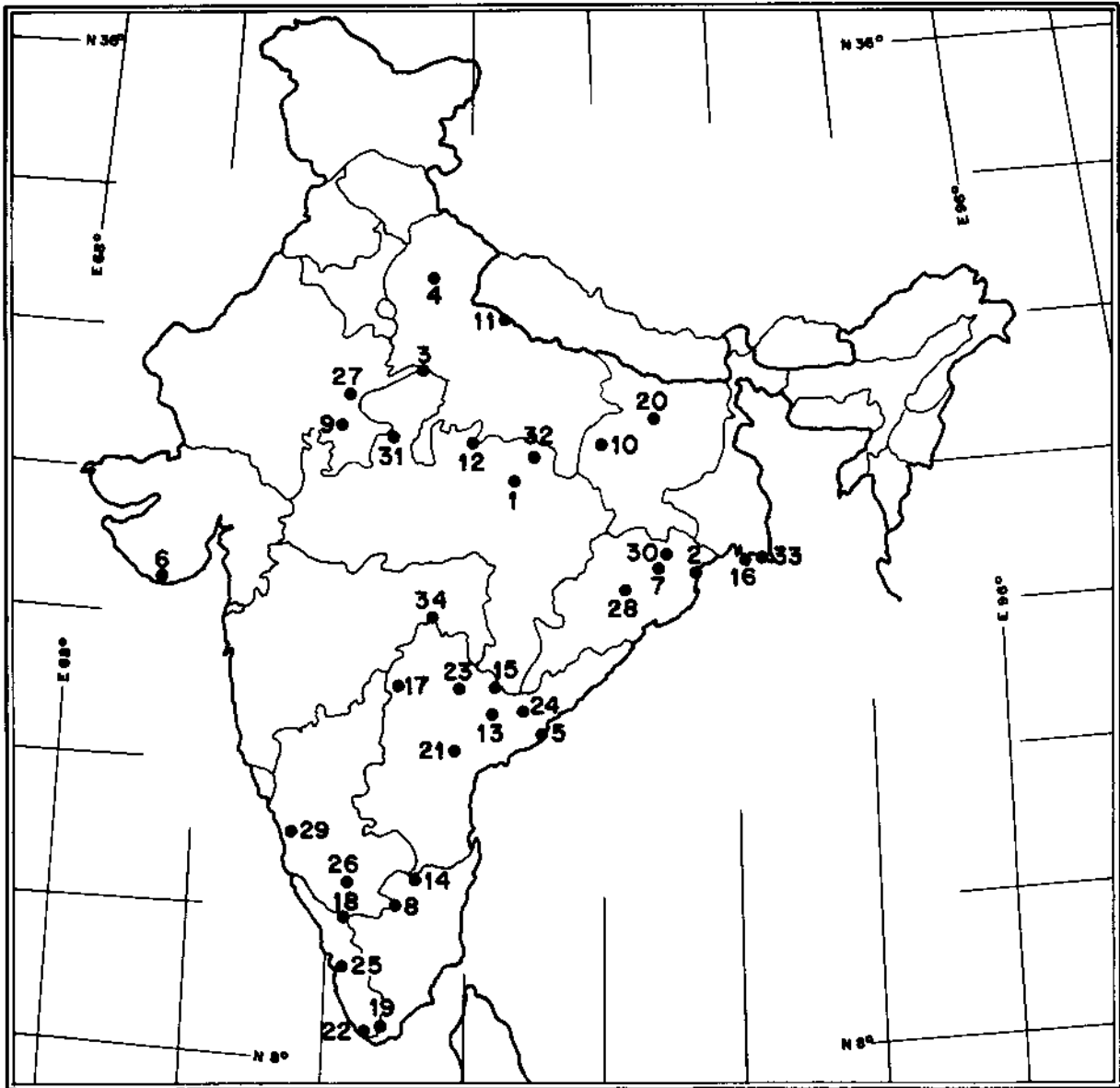


Figure 1: Crocodilian sanctuaries and other areas offering active protection to crocodilians, 1984. Numbers as in Table 1.



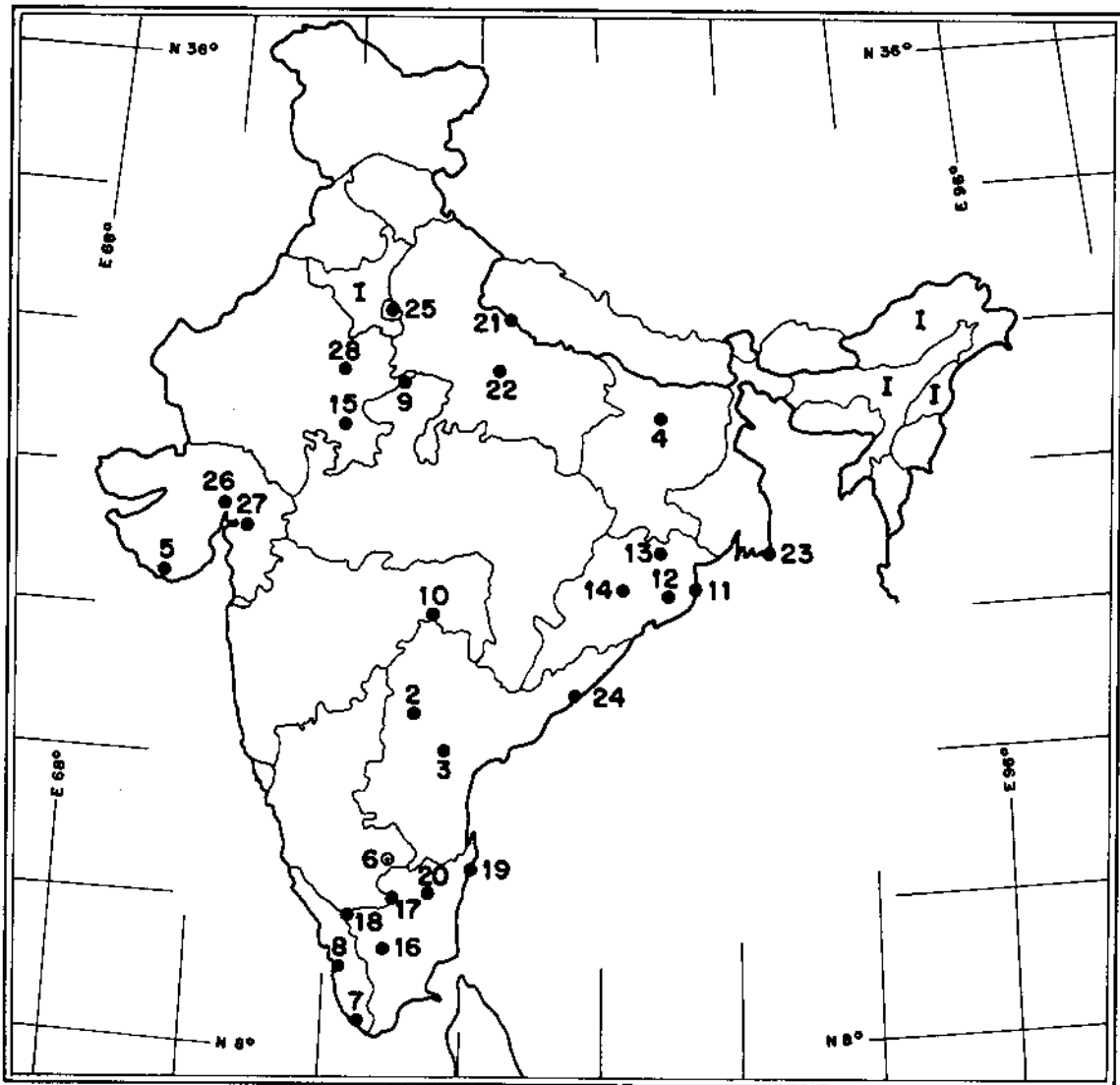


Figure 2: Captive rearing/breeding schemes, 1984. Numbers as in Table 2. 1, States that are interested in commencing schemes soon.

STATUS OF AFRICAN CROCODYLUS NILOTICUS POPULATIONS  
(BOTSWANA, MALAWI AND MOZAMBIQUE)

Kevin Van Jaarsveldt  
Binga Products, P.O. Box 2569, Harare, Zimbabwe

Following the 1984 CITES Conference in Botswana and the Technical Committee meeting of CITES, in Brussels in late June 1984, twenty four African countries are known to have or are preparing to petition the downlisting from Appendix I to Appendix II their C. niloticus populations either as individual countries or collectively.

This report intends to present to this Crocodile Specialist Group some known facts of the position of wild Crocodylus niloticus population, wild life authorities' management policies and commercial activities in Botswana, Malawi and Mozambique.

The task at hand however is to comment on the 24 African countries intentions to have their C. niloticus populations transferred from Appendix I to Appendix II.

The statement presented by Malawi is a similar argument used by the Crocodile Farmers Association of Zimbabwe in their meeting held in conjunction with the last Crocodile Specialist Group meeting in Victoria Falls, Zimbabwe in 1982.

Zimbabwe however were able to back many of its claims with hard facts after numerous years of serial and night surveys of selected population densities and twenty years of commercial ranching activities.

The problems facing Malawi and the other 23 African countries are familiar and in many cases true. The "Berne Criteria" makes it very difficult for African countries to meet the positive scientific evidence required. Some of the facts mentioned in this report in regard to conflict between human and livestock and loss of fishing grounds may well be the case in Malawi. However it can hardly be the case in all the 23 petitioning countries.

Further consideration should be given to the reason why these respective countries are applying to downlist their C. niloticus populations. The main reason is commercial; for the sale of wet salted or partly processed belly skins in return for foreign currency (foreign exchange is in short supply in most Southern African countries). This would be achieved by the following:

- a) Offering annual culling quotas
- b) Sale of hides from farming operations
- c) Tourism

The author views annual culling quotas as a contradiction to meaningful conservation trends (giving consideration of farming/ranching possibilities). This culling would further reduce wild populations of large breeding crocodiles (hunters are generally selective, reducing the larger crocodiles first).

The quality of these larger skins is not of the highest degrees and experience in the sale of hunted crocodile skins indicates quality selection to be approximately 50% first grade and 50% second and third grade skins.

Additionally accepted international market contracts allow for 25% reduction in second grade skin prices and 50% reduction in third grade skin prices.

Further assuming one accepts a healthy population to be 50/60 000 crocodiles (as was conservatively estimated by Zimbabwe Management Authorities after 7 years of population surveys). This number of skins could be tanned into saleable leather by the main three tanneries in France only (excluding Italy, West Germany, Japan and the United Kingdom) within 60 days of receiving the material.

The fashion large crocodile skins has changed due to supply and demand situation and the fashion today is for 20/60cm belly skins of high quality. (Main demand 25/35cm belly skins).

The sale of hides from farming operations affords the wild population good protection, in that eggs are taken from sustainable populations. (Hatching success in Zimbabwe is in the 90% area and skin rearing to sale size (2 1/2 /4 years is generally in the 70% area).

If one considers wild hatching percentages are no more than 10% (most cases as low as 3% in areas of conflict with humans and wild life predators).

Allowance should be made in farming permits for the return to the wild semi mature (three year old) crocodiles to those areas that require re-stocking.

Large crocodiles causing a "nuisance factor" should be captured where possible and used in breeding banks within commercial farms to supplement eggs collecting numbers, with long term emphasis on total dependance on internal breeding.

The establishment of crocodile farms is long term and capital intensive, however the author feels very strongly, is the only long term guarantees for Southern Africa's C. niloticus populations. At the same time renders the C. niloticus commercially utilizable, giving it value amongst the people of Southern Africa.

Tourism offers good foreign and local currency returns in those areas frequented by international tourists and crocodiles will always offer an attraction.

Owing to the high costs of establishing crocodile farming operations the following compromise may be considered: Realistic wild population census should be taken and very conservative quota systems implicated for the export of hunted skins. (Skins removed only under wildlife authorities supervision. where there is genuine conflict between crocodiles, man and his livestock).

### Conclusion

The question regarding the downlisting of C. niloticus populations in twentyfour African countries is a difficult and complex problem and frankly not possible collectively.

The author's views in this matter (not necessarily those views held by the CSG) are that these petitions should rather be dealt with individually.

Malawi and Botswana are both countries that, given the right guidelines, time and documented evidence, could be successful in their efforts. They should not however rely on the strength of their "assumed C. niloticus" wild population figures.

Recommendations should be made to the countries with the stronger cases to take advantage of the EEC offer of funding for an African survey of their wild populations which would strengthen their case with CITES after the following guidelines have been achieved:

- 1) Total national C. niloticus population figures and respective density, geographical areas.
- 2) Plan areas for total protection, in conjunction with National Parks and protected wild life areas.
- 3) Recognise sustainable population areas for the promotion and active support of commercial farming activities, in conjunction with long term water and feed supplies.
- 4) Plan harvest or capture programmes in those areas where C. niloticus populations are causing conflict with humans and livestock.
- 5) Plan cropping quotas to support commercial safari hunting and resident hunting operations.
- 6) Provide basis for research into effect of above mentioned activities on known wild population numbers.

Surveys of this size are expensive and lengthy, however if manpower, equipment and finance is available it must be done correctly in the first place, using where possible, the same methods, calculations and individuals. (Pilot, spotters, recorders, aircraft, etc.).

In finishing the opening paragraph of CITES document Conf. 1.2 (5.11. 1976) is relevant.

"Resolves that the deletion of a plant or animal taxon from Appendix I or II or the reduction of protection given to this taxon by transfer from Appendix I to Appendix II is a serious matter and should be approached with caution".

The author states that with many unknown quantities and unanswered facts, this meeting cannot support the downlist from Appendix I to Appendix II of any African countries wild C.niloticus populations.

## STATUS OF ASIAN CROCODILIANS: AN UPDATE

Romulus Whitaker  
Madras Crocodile Bank Trust  
Vadanemmeli Village  
Perur P.O.  
Mahabalipuram  
India

### Introduction

A more complete status report is given in the CSG Proceedings of the Gainesville Meeting (1980). The following report summarizes conservation and management activities concerning crocodiles in Asia since 1980.

### Current Status by Country

IRAN: No change. No conservation action reported.

PAKISTAN: Currently interests being shown to start a conservation/management programme.

INDIA: The State projects continue. Release of gharial in the Chambal, Girwa and other rivers continue with a total of over 1000 released so far and 2500 more being reared. A long term study has begun in the most important gharial abode: the tri-state National Chambal Gharial Sanctuary. Captive gharial breeding is only taking place at Nandankanan Biological Park in Orissa.

Restocking of mugger has nearly stopped and considerable resistance is building up by fisheries people against further releases in reservoirs under their control. State projects are rearing about 2000 mugger and the Madras Crocodile Bank about 1100. Successful mugger captive breeding is taking place at about 10 centres in India. The saltwater crocodile is under habitat pressure in the Sunderbans and Bhitarkanika on the mainland and particularly so in the Andamans due to illegal encroachment and forest clearance. Till 1983, 250 had been released in Bhitarkanika Sanctuary and 700 were being reared. Captive breeding has been successful at the Sunderbans Forest Dept. project and at Madras Crocodile Bank.

SRI LANKA: No change. In spite of the importance of this country's mugger and saltwater crocodile populations, no positive steps have been taken to protect or manage the rapidly dwindling populations outside the two main National Parks of Yala and Wilpattu.

NEPAL: Rearing and release of gharial is continuing at Chitawan National Park.

BHUTAN: No change.

BANGLADESH: The crocodilians were surveyed by Whitaker (1982) and the position is summarized thus: Small breeding population of gharial survive in Rajahahi District (Padma and Jamuna Rivers)

but elsewhere it has disappeared. The mugger has similarly vanished from Bangladesh except for about ten individuals at the Khan Jahan Ali shrine in Khulna District. The saltwater crocodile survives in small numbers in the Sunderbans Forest Division (3800 km<sup>2</sup> of mangrove forest with 1200 km<sup>2</sup> of waterways).

BURMA: No change. A proposed UNDP assisted crocodile project was cancelled for lack of funds. The existing project in the Irrawaddy is in need of technical and developmental assistance.

THAILAND: No change. Restocking C. siamensis in protected areas from captive bred stock continues to be a desirable priority.

KAMPUCHEA: No change, no new information.

VIETNAM: No change, no new information.

LAOS: No change, no new information.

CHINA: In 1983, 300 chinese alligators were hatched at the Anhui Province Alligator Farm under a continuing programme to rehabilitate the species. In 1984 a large natural enclosure is scheduled for completion.

TAIWAN: 30 farms rear perhaps 10,000 crocodilian mainly Caiman crocodilus for skin and meat. One large farm had about 8,500 animals in 1983. The source of their stock is unknown as is the number actually being bred in captivity.

MALAYSIA: No change. Whitaker (1984) did a two month survey in Sabah and reports: The Sabah crocodile population is severely depleted from over-hunting and aggravated by habitat destruction and disturbance. 1146 km of river were covered in night survey work and only 56 wild crocodiles seen. Extrapolated estimates indicate a population of 2600 crocodiles of all sizes in Sabah. Yearling crocodiles were seen in most of the areas surveyed, indicating the continuation of breeding, albeit on a small scale. A recovery scheme, followed by managed ranching is under consideration by Government. The survey confirmed that Tomistoma is not present in Sabah, nor, for geographical reasons, is it likely to have ever occurred there.

SARAWAK: Briefly visited and it was found that, though depleted, breeding populations of saltwater crocodiles are still present throughout most of the country. Tomistoma is also reportedly present in most inland rivers and permanent swamps which was encouraging news. A survey and management development proposal is under consideration.

BRUNEI: In general, claims of breeding crocodiles at the various tourist croc farms in Singapore can be discounted, though the occasional nest is produced. Young stock which are reared for slaughter come from various parts of Indonesia including Kalimantan and Sumatra. The presence of New Guinea crocodiles in the collections shows that Irian Jaya is also a source.

It is unfortunate that these people cannot foresee the drying up of these wild supplies and get into serious efforts to breed. Equally unfortunate of course is the Singapore Government's lack of control on trade in species in need of protection such as Tomistoma. The skin of this species is not valuable but young ones are still being killed and stuffed as curios for tourists along with thousands of hawkbill sea turtles.

INDONESIA: No change. Crocodiles are protected but exploited at all age classes moderately to heavily in most parts of Indonesia. Irian Jaya Province is planning a management programme based on ranching. The status of Tomistoma in Kalimantan (Borneo) is unknown and deserves urgent investigation.

PHILIPPINES: The Silliman University project continues, following extensive surveys by C.A. Ross. The Philippine freshwater crocodile was successfully bred this year.

#### References

- Brazaitis, Peter and Myrna Watanabe, IUCN/SSC Crocodile Group Newsletter. Vols. 2 and 3. 1983-84.
- Whitaker, R. Review of crocodile management options and practices in Asia, Proceedings Crocodile Specialist Group Meeting, 1980.
- Whitaker, R. Preliminary Survey of crocodiles in Sabah. Sabah Forest Dept. and World Wildlife Fund-Malaysia. Sandakan, 1984.
- Whitaker, R. Export prospects from commercial crocodile farms in Bangladesh. ITC/UNCTAD, Geneva, 1982.



AN ASSESSMENT OF THE CURRENT CROCODILIAN HIDE AND PRODUCT MARKET  
IN THE UNITED STATES

Peter Brazaitis  
New York Zoological Society  
Bronx, New York 10460  
USA

At the sixth working meeting of the IUCN Crocodilie Specialists Group, the report on the U.S. market in crocodilian hides and products (Brazaitis, 1982), based on market and manufacturing surveys, indicated a depressed U.S. market for crocodilian hides and products. Only three U.S. tanneries existed which could tan raw crocodilian skins, so U.S. importers and fabricators were largely dependent on foreign tanneries for materials at high prices. Importers experienced losses and penalties when goods were seized by wildlife agencies. Manufactured crocodilian products retailed at prices out of reach of the general buying public.

Prices paid for American alligator skins at that time, a good indicator for buying trends in classic skins with buyers from two completely different consumer interests (Japan and Europe), had fallen to between US\$7.00-US 10.00 per foot. Subsequent reports from Papua New Guinea indicated that prices had fallen there as well, threatening the continuation of farming programs. U.S. retail shops, while officially citing a "great" buying season in December 1982, independently confided that retail sales were off, that the U.S. consumer was largely buying useful quality items, and that they were "bargain hunting". We heard the same retail reports in 1983. Classic crocodilian products were pretty much excluded from general consumer interest. Fashion trends had also been diverted away from crocodilian products by the U.S. industry -- it promoted snake and lizard skin items and reptile skin prints on domestic leathers.

There were other factors at work as well in 1983 and 1984. With tightening international and national regulations, and the strengthening of the U.S. dollar, prices paid for classic raw skins rose slightly. A "shortage" of raw materials was voiced by some manufacturers and importers. Whether the shortage was real or not, contrived by European tanners to drive up the price and create a demand for caiman skins, or perhaps reflected bad hatching or collecting seasons, remains speculative. At the same time 1983 saw a "shortage" of classic crocodilian hides, and a related "dumping" of stocked finished Caiman crocodilus flanks on the market, perhaps in anticipation of the implementation of CITES by the European Common Market, as of 1 Jan 1984. The effect appeared to be the utilization of cheaper caiman flanks in the manufacture of high quality shoes and belts, and whole caiman skins for handbags, which sold retail at classic skin prices. These replaced much of the classic crocodilian skins in manufactured goods imported into the United States.

The Reptile Skin Industry Trade Association petitioned the U.S. Fish and Wildlife Service to remove Caiman crocodilus yacare, the mainstay of the crocodilian leather industry, from the U.S. endangered species list, in order to import directly from the main tanneries in Bolivia. This petition was denied for the time being. Imports originating from Bolivia and Paraguay remain forbidden from entry into the U.S. Responsible for the ban, were numerous altered, misrepresented and illegally issued export documents bearing improper or fictitious species names and originations, such as Caiman crocodilus fucus from "farms" in Bolivia. Citations for Caiman latirostris originally imported from Colombia and "farmed" in Italy only served to reinforce the need for restrictions.

A major central South American study of the status and systematics of caiman was initiated to address some of the systematic and populational problems. Major sources of confusion to both the industry, trying to fulfill import requirements, and wildlife enforcement agencies, are the numerous old synonyms and new scientific names which have been coined for populations of Caiman crocodilus crocodilus, caiman crocodilus yacare, and for Crocodylus niloticus, in industry trade journals and European scientific publications (Fuchs, 1974; Wermuth and Fuchs, 1978; Wermuth and Mertens, 1977). The confusion will further be exacerbated by the inclusion of scientifically undefined subspecific names such as Caiman crocodilus matogrossiensis, Caiman crocodilus paraguayensis, Crocodylus niloticus africanus, Crocodylus niloticus chameses, Crocodylus niloticus cowiei, Crocodylus niloticus madagascariensis, Crocodylus niloticus pauciscutatus and Crocodylus niloticus suchus in the 1983 CITES identification manual. These taxa, based on commercial hides, largely ignored the authorative works of South American and U.S. herpetologists, and in many instances refuted the years of study and conclusive works eminent European scientists (Brazaitis, 1973; King and Brazaitis, 1971; Medem, 1981, 1983; Wermuth, 1953; Wermuth and Mertens, 1961; Mertens, 1943). Some of these authors published widely accepted and corroborated conclusions prior to conducting studies in cooperation with commercial interests (Wermuth and Fuchs, 1978; Wermuth and Mertens, 1977), which led to the extensive subjective subspeciation of Caiman crocodilus and Crocodylus niloticus based on commercial hides. The infusion of these taxa, which lack scientific basis, into the literature, has been the subject of much critical review (Frair and Behler, 1983; Medem, 1983). The result has been to present even greater difficulties for importers and brokers who must present documentation, and manufacturers and merchants who find themselves with goods seized based on improper citations taken from industry publications.

A major case brought by the U.S. Fish and Wildlife Service against MEG Import Corp., in 1984 made the U.S. industry even more acutely aware of the problems inherent in dealing with crocodilian hides and products. The U.S. owners of the company, highly respected by their peers as eminent members of the Reptile Skin Industry Trade Association, were convicted on 14 counts each of violations of the Endangered Species Act. The

company itself was found guilty on 14 counts. It was disclosed that the company was owned in part by Curtiembre "Alligator", a Bolivian tannery. MEG Imports had conspired to deliberately circumvent CITES regulations and the U.S. ESA, and had arranged the sale or engaged in the sale of over 2000 Melanosuchus niger skins from 1976 to 1983, invoicing the hides as those of Caiman c. fuscus or caiman from Bolivia. Penalties were reported to include a fine of \$75,000 and a possible prison term for at least one owner as a second offender. Fines in excess of \$300,000 and a one year or more prison term could have been imposed.

Three seizures of over 2000 finished Caiman crocodilus yacare flanks from Zollo Co., owned by the president of the Reptile Skin Industry Trade Association, resulted in an out of court settlement including fines and loss of merchandise. Zollo Co. was not convicted of any wrongdoing. The company decided not to contest the seizure after attending, with its attorneys, a presentation on caiman identification, sponsored by the U.S. Fish and Wildlife Service and given by CSG Chairman F. Wayne King and Peter Brazaitis. Owners cited the European supplier with sending endangered species contrary to their purchase order.

Confusion in the use of proper scientific names, citations of fictitious countries of origins of skins by European suppliers and manufacturers, changing national regulations in hide producing countries, and the implementation and enforcement of CITES, the ESA, and greater penalties for violators of the U.S. Lacey Act, all have served to undermine the willingness of U.S. importers and merchants to deal in volume with crocodilian products. Some importers complained that they were being forced to accept caiman flank shipments from overseas suppliers, if they were going to receive lizard and snake skin, which were in vogue. Even if a seizure of caiman skin goods was later rescinded, the merchant still suffered delays in filling orders, great emotional aggravation at the least, high legal fees, and uncertainty in meeting the needs of customers and consequently damaged business reputations.

In 1982 through 1984, the exotic reptile products trade turned to "safer" skins and merchandise, and was again "burned". The industry turned to snake and lizard skins, which were cheaper to buy, were available in great quantity, and appeared to be without import restrictions of any consequence. A fashion promotion was mounted that equaled the crocodilian product promotions of 1980. In 1984, the U.S. Fish and Wildlife Service, based on the prohibition from export, by India, of most of the common species of snakes utilized commercially, began seizing or refusing to allow the entry of snake or lizard skin products that did not have proper scientific names and CITES documents showing the correct country of origin. This has created an impossible situation for importers in that it is often doubtful if the person that kills the snake knows the species he is killing; skins come primarily from Southeast Asia, and are

indiscriminately mixed with every species imaginable; and again various names were made up by suppliers in Europe and Asia. Importers were again shaken by having spent millions of dollars in promotions, created a fashion, made sales and contracts, and now find the same problems they experienced with crocodilian products again upon them. The effect has been a degree of disenchantment with exotic leathers. It is no wonder that the snake and lizard skin trend also has peaked, and appears to be waning.

Some farsighted designers took a different approach beginning in 1982, and have further explored consumer interest in the leather market in 1983 and 1984. They began to use domestic leathers once again, in new and "exotic" ways. Exquisite domestic calf leather became fashionable in 1983, followed by woven leathers in 1984. New and exciting permanently printed domestic leathers depicting animals in natural poses are on the fashion design tables. The unusual honeycomb pattern of the stomach linings of sheep has been tanned to an interesting extremely soft pleasing suede, and may soon appear. Products made from codfish and eel skin appeared on the market, but have not "caught on" with consumers or manufacturers. Manufacturers and merchandisers are a very conservative group, with few major houses willing to take the lead, and the financial chances by introducing promotions for unusual and unique leathers.

The demand for some exotic reptile leather will always be there in the luxury market. New or revitalized fashions, such as those in products made from crocodilian skins, are not generated by the consumer but are maintained by the consumer. It is the designers, promoters, manufacturers and merchandisers of fashion who create it. However, merchants and importers will probably not broaden the present U.S. minimal demand with new promotions unless they can be assured that the raw materials are going to be available on a long term basis, that the skins or products are absolutely legitimate and without import problems, and that there is a sufficient quantity of raw materials at a price where products can be manufactured both on a high quality luxury basis and on a moderately priced volume basis.

The near future for the market in crocodilian hides and products will be an interesting one. Dozens of countries are racing to deregulate crocodilian species in order to capitalize on this natural resource in the form of much needed foreign exchange. Farms and ranches are springing up all over the world, largely producing classic skins for the luxury market which many fashion conscious consumers may not be disposed to buy. Taiwan is already farming caimans for meat and hides, at present for domestic use. New tanning practices, based on modern biotechnology and computerized procedures may mean that skins can be tanned more cheaply, with consistent quality, and perhaps by any country that chooses to make the investments. New forensic identification techniques may ensure the accurate declaration of species and their origins in trade.

The adequate supply of legally "safe" and acceptable raw materials produced by accredited private or government sanctioned farms and ranches, combined with conservation programs to manage and ensure the continuation and increase of wild populations as a renewable national resource, is essential, if the legal trade in crocodilian hides and products is to grow, and endangered species are to be excluded from exploitation.

What of the 1985-1986 market? Not much different from right now, with more emphasis on promoting new looks in domestic leathers. Nineteen eighty six and beyond? I think that depends on the cooperation between industry, farmers, conservationist, and governments in recognizing the problems and moving ahead together.

#### Referencies

- Brazaitis, Peter. 1973. The identification of living crocodilians. *Zoologica* 58: 59-101.
- Brazaitis, Peter. 1982. U.S. trade in crocodilian hides and products: a current perspective. 6th Working Meeting, IUCN, Crocodile Specialists Group, Victoria Falls, Zimbabwe. (In press).
- Frair, Wayne and John L. Behler. 1983. Book review: Liste Der Rezenten Amphibien Und Reptilien. Testudines, Crocodylia, Rhynchocephalia by H. Wermuth and R. Mertens. 1977. *Herpetological Review*, 14: 23-25.
- Fuchs, Karljeinz. 1974. Die Krokodilhaut. Eduard Roether Verlag, Darmstadt. 183. pp.
- King, F. Wayne and Peter Brazaitis. 1971. Species identification of commercial crocodilian skins. *Zoologica* 56: 15-70.
- Medem, Federico. 1981. Los Crocodylia de Sur America. Volumen 1. Los Crocodylia de Colombia. Colciencias, Bogota, 354 pp.
1983. Los Crocodylia de Sur America. Volumen 2. Colciencias, Bogota. 270 pp.
- Mertens, Robert. 1943. Die resenten Krokodile des natur-Museums Senckenberg. *Senckenbergiana* 26: 252-312.
- Wermuth, H. 1953. Systematik der Rezenten Krokodile. *Mitt. Zool. Mus. Berlin* 29: 374-514.
- and K. Fuchs. 1978. Bestimmen von Krokodilen und ihrer Haute. Gustav Fischer Verl., Stuttgart, New York, 100 pp.
- and Mertens, R. 1961. Schildkroten, Krokodile, Bruckenechsen. Gustav Fischer Verl., Jena. 422 pp.
- , 1977. Liste der rezenten Amphibien und Reptilien. Testudines, Crocodylia, Rhynchocephalia. *Das Tierrich*. 100: 133-151.

BIOCHEMICAL TECHNIQUES: NEW TOOLS FOR THE FORENSIC IDENTIFICATION  
OF CROCODILIAN HIDES AND PRODUCTS

Peter Brazaitis  
Department of Herpetology  
New York Zoological Park  
Bronx, New York 10460  
USA

The effective conservation of a crocodilian species is often based upon the ability to determine the identification of living individuals, as well as those parts of the animal which are utilized commercially. The commercial use of meat, raw skins, hides at various stages of processing, tanned and finished products, bones, teeth and claws, all pose special identification problems for governments, regulatory agencies and wildlife law enforcement officers. The effective prosecution of violators of wildlife protective regulations is contingent upon conclusive proof that the artifact in question is indeed the species which the law seeks to protect. Too often, there is not a sufficient sample upon which a determination can be made utilizing morphological characteristics alone, or the sample is not from the part of the animal's body which displays definitive characteristics (King and Brazaitis, 1971).

In recent years, new biochemical techniques and technologies have been developed which may be adapted to aid in forensic identifications. Some of these techniques are being utilized both in the forensic examination of human and animal parts, and in general taxonomic work (Avisé, 1974; Densmore, 1983; Harrap and Woods, 1966; Shi et al., 1984; Wolf 1984). The results of biochemical assays of human blood, semen, skin and other tissues, have long ago been established as weighty reliable evidence in the prosecution of offenders in criminal cases.

Protein electrophoresis is a technique developed nearly 20 years ago, which is currently used in taxonomic studies to determine the relationship between species. It is based on the principle that proteins in a buffer separate according to their net electrical charge and size in the presence of an electric current. Only a minute sample of protein is required, often as little as five to ten micrograms is sufficient. There are a variety of recently developed electrophoretic techniques, each with its advantages and disadvantages in specific applications. In a basic method (Fig. A), a prepared protein sample is applied to a starch gel or polyacrylamide gel plate. A direct current is applied across the gel plate. The most negatively charged proteins migrate most rapidly through the plate towards the anode or negative side. The porosity of the gel may also separate proteins by the size of molecules. Each protein has its own characteristic pattern of migration. The resulting electrophoretogram or "fingerprint" may be used to identify a particular species. Most of the work using this technique has utilized blood serum as the source of protein (Scopes, 1982). The work of Densmore (1983) on crocodilian species relationships is a major contribution.

A simple immunodiffusion technique has also proven useful. If we take a protein containing sample, such as serum from one species (e.g., a caiman), and inject it into a totally different species, such as rabbit, the second species will produce antibodies to those proteins. The antibodies will best "recognize" the specific proteins they were produced against, and will recognize to a lesser degree proteins of a similar but not exact form. This "recognition" takes the form of a precipitant between the antibody and the antigen it recognizes. If a variety of antigens are placed in a series of wells in an agar plate, surrounding a well containing a specific antibody, a line of precipitation will be formed only between the antibody and the antigen of the species it recognizes. The same technique may be applied to the determination of proteins of different species of reptiles (Chen et al., 1983) including crocodylians (Densmore, 1983; Chen et al., 1983).

Combinations of electrophoretic and immunodiffusion techniques may prove even more useful (Chen et al., 1983).

Recent advances in the use of DNA probes which have been developed to identify specific genes, infectious agents and human genetic diseases may possibly be used for species or populational determinations. The strands of DNA from a gene to be identified are separated, cut into fragments by restriction enzymes, hybridized and tagged with heavy metal, radioisotopes or enzymes. These tagged DNA fragments will reassociate only with the precise sequence of nucleotides in the DNA of the gene from which they were originally hybridized. At present, only living or frozen fresh samples have been used to develop nucleic acid probe techniques, and many problems in probe and sample preparation remain (Kingsley, 1984).

Whenever new biochemical assay techniques have been developed, the development of commercial test kits has soon followed in order to make the assay more readily available, standardize the technique and simplify its use, ENZO Biochem, Inc., N.Y., recently announced the marketing of a tissue origin identification kit. The kit utilizes monoclonal antibodies (antibodies of a predetermined specificity) to recognize specific proteins, including some keratins.

There are considerable advantages in developing identification techniques based on biochemical assays. Most significant is that the size of the sample need not be large. Often, a sample barely a few millimeters in diameter or micrograms in weight is sufficient. In the case of a costly product, the sample required may be inconsequential and not result in unnecessary damage and loss of value. A comprehensive resource library of standard samples may occupy a few shelves in the storage unit of a forensic laboratory, and may be duplicated in other laboratories as needed, in a minute fraction of the space required for a comparative museum collection. Samples for assay standards may be taken from living as well as dead specimens, and need not require the sacrifice of the donor, an important consideration in the case of endangered species.

There are some initial disadvantages. The cost of developing biochemical techniques is considerable, often in the hundreds of thousands or even millions of dollars. On the plus side, techniques borrowed from human medical research, which is often elaborately funded, may be modified at a minimal cost. Laboratories running biochemical assays may require specialized trained technicians or costly equipment. However, once the standards of assay are established, the equipment and technicians found in most modern commercial and police crime laboratories may be adequate, with a minimum of upgrading and invested capital.

There are also advantages for the industrial private sector in developing biochemical techniques for identification purposes. Assay standards could be established by which crocodilian skins could be pretested and certified by the exporter, in accordance with CITES accepted protocols, before shipment to a buyer in another country. Commercially developed "test kits" may make such testing economically acceptable. It may also make the undetected trade in protected species a thing of the past.

In the United States in 1980, approximately 32 states reported using some form of immunoassay technique to establish the identity of meat or blood in wildlife related cases. Only 15 reported the use of some method of protein electrophoresis. Most reported some dissatisfaction in the lack of research data with to support their findings in court proceedings. Tests were largely performed in state crime laboratories, and were directed at endemic species (Oates and Dent, 1980). In 1982, the U.S. Fish and Wildlife Service entertained the concept of a national wildlife forensic laboratory, which would specialize in the modern forensic identification of all types of wildlife, both native and exotic species. The concept is still under consideration.

Canadian wildlife enforcement agencies also concern themselves largely with the determination of meat, blood or hair of protected from nonprotected or domestic species. Most of the analysis is referred to the crime laboratories of the Royal Canadian Mounted Police (Alberta Energy and Natural Resources, Fish and Wildlife Division, 1982).

Clearly, the application of modern biochemical technology in the identification of endangered species and their detection in illegal trade is still in its infancy. The potential for biochemical applications in the conservation and management of crocodilians is limited only by our vision and interest.

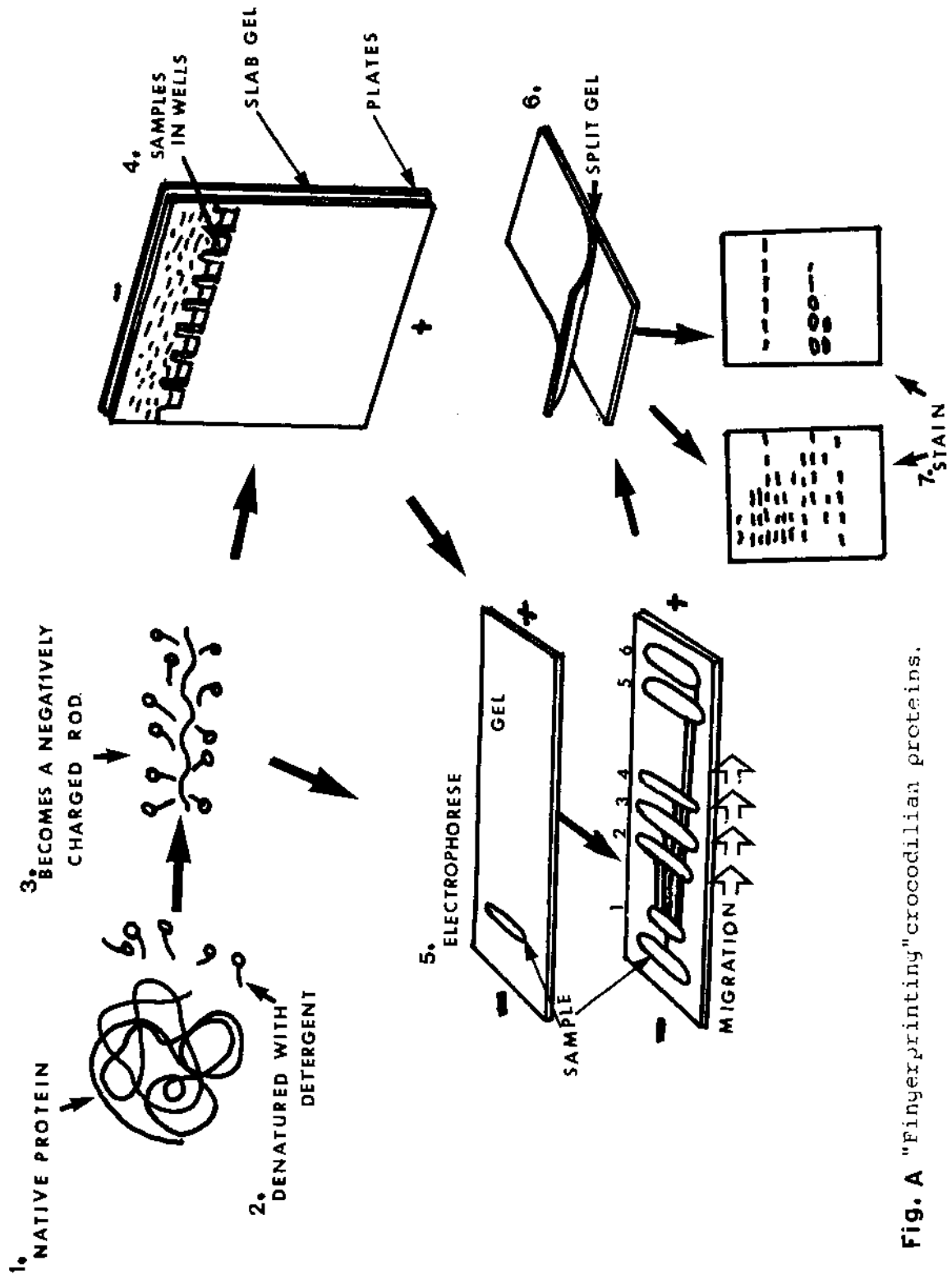
#### Acknowledgments

My thanks to Drs. Dennis Curley, Myrna Watanabe, and the U.S. Fish and Wildlife Service, for providing information and help in the preparation of this manuscript. My thanks also goes to the New York Zoological Society for its continued support and assistance.



## References

- Alberta Energy and Natural Resources, Fish and Wildlife Div., Enforcement, Liaison and Standards. 1982. A summary of forensic research capabilities, techniques and requirements of the members of the Western Association of Fish and Wildlife Agencies. Edmonton, Alberta, Can. 32 pp.
- Avise, John C. 1974. Systematic value of electrophoretic data. Syst. Zool. 23: 465-481.
- Chen Yuancheng, Wu Xiangfu and Zhao Ermi. 1984. Classification of Aekistrodon species in China. Toxicon 22: 53-61.
- Densmore, Llewellyn D. III. 1983. Biochemical and immunological systematics of the Order Crocodylia. In, Evolutionary Biology, Vo. 16, eds. Max K. Hecht, Bruce Wallace and Ghilleen T. Prance. pp. 397-465.
- Harrap, B.S. and E.F. Woods. 1967. Species differences in the proteins of feathers. Comp. Biochem. Physiol. 20: 449-460.
- King, F. Wayne and P. Brazaitia. 1971. Identification of commercial crocodylian skins. Zoologica 56: 1570.
- Kingsbury, David T. 1984. DNA probes-their role in diagnostics and research. Presented at BIOTECH '84 USA, Online Publications, Pinner, UK. pp.629-638.
- Oates, David W. and Nancy L. Dent. 1980. A survey of techniques used by state fish and game agencies for blood and tissue identification. Nebraska Game and Parks Comm. 19 pp.
- Scopes, Robert. 1982. Protein Purification: Principles and Practice. SpringerVerlag, NY. 282. pp.
- Chi Yingxian, Li Shipeng, Gao Qingsheng, Huang Zhujian, Gao Yuru, Liu Weixin, Ma Lianke, and Chen Lidong. 1984. Comparative studies on serum protein, hemoglobin and LDH between Alligator sinensis and A. mississippiensis. Acta Herpetologica Sinica 3: 21-24. (Chinese with English abst).
- Wilson, Michael, ed. 1978. Bibliography of forensic science in wildlife law enforcement. Suppl. to Proc. Forensic Sciences Symp., Calgary, Alberta, April 13-15, 1977. Alberta Recreation, Parks and Wildlife, Fish and Wildlife Div. 171 pp.
- Wolfe, James R. 1984. Enzyme phenotyping of Alaskan bears for wildlife law enforcement. J. Forensic Sci. 29: 910-914.



**Fig. A** "Fingerprinting" crocodilian proteins.

(Adapted from Protein Purification: Principles and Practice, by Robert Scopes, Springer-Verlag, New York, 1992)

MANAGEMENT, REPRODUCTION, AND GROWTH OF Caiman crocodilus  
yacare AT THE NEW YORK ZOOLOGICAL PARK

Peter J. Brazaitis  
Department of Herpetology  
New York Zoological Park  
Bronx, New York 10460  
USA

Introduction

Caiman crocodilus yacare, often called the Paraguayan or yacare caiman, is the largest member of the species Caiman crocodilus, and frequently attains lengths in excess of 2 m. The species is found throughout eastern Bolivia and Paraguay, southwestern Brazil bordering Bolivia and Paraguay and northeastern Argentina. Because of its large size and wide flank regions composed of round, largely unkeeled scales, the yacare caiman has historically been under intense commercial hunting pressure throughout its range. Trade in the species is regulated under Appendix II of CITES, and the species is listed as endangered under the U.S. Endangered Species Act, and is prohibited from trade in the United States (Groombridge, 1982). Some investigations have been done on the reproductive biology of yacare caiman in the wild (Crasshaw and Schaller, 1979). While some reproduction has occurred under captive conditions at the St. Louis Zoo in the U.S. (Anon., 1981/82), little is known about the growth, reproductive biology and management of the species under captive conditions. No data are available on the growth of the species either in the wild or in captivity.

For many years, the New York Zoological Society has been interested both in the status of this species in the wild (Crasshaw and Schaller, 1979) and in its captive propagation as an endangered species. Although Caiman c. yacare as well as other caiman species have historically been represented in the collections of the Department of Herpetology at the New York Zoological Park, it was not until 1971, with the acquisition of 10 young individuals, that a potential breeding group could be considered. Prior attempts to breed Alligator sinensis at the N.Y. Zoological Park had been unsuccessful, and it was considered futile to pursue the breeding of tropical crocodylians indoors in a temperate climate. Most temperate climate zoological institutions are limited by lack of space, the high cost of energy needed to provide adequate temperatures, and a general lack of experience with the territorial and reproductive behavior of wild crocodylians. The data presented here, reports these initial experiences in the captive breeding of a crocodylian and the innovative techniques employed in solving some of the problems.

### Management and Reproduction

Six male and four female Caiman crocodilus yacare were acquired in September, 1971, via the U.S. Fish and Wildlife Service. Their country of origin is unknown. On arrival, animals ranged in size from 50.2 cm to 97.2 cm in total length, and were estimated to be between two and three years of age. These animals were initially housed in large galvanized cattle tanks approximately 2 m long, 75 cm wide and high, containing approximately 20 cm of standing water continually heated to 27° to 30°C.1. No natural sunlight was available (All crocodilians at the New York Zoological Park are maintained at all times in indoor facilities).

Three to four times per week the animals were fed a readily available diet consisting largely of frozen salt water fish, frozen rats and mice, and on occasion, some fresh mice and chicks. The diet was supplemented with varying amounts of vitamin E and pediatric multivitamins. Animals were fed to satiation at regular feedings.

As the animals grew in size, and competitive interactions became apparent, they were moved to larger quarters, and associated with animals of comparable size and similar feeding habits.

In 1977, one of the females acquired in 1971 (NYZP#714831), 145 cm long, and estimated to be approximately 10 years of age was transferred to an exhibit pool measuring 3 m long, by 1.5 m wide and 0.75 m deep. The exhibit contained only a small basking area. Although other environmental conditions remained the same, lighting in this exhibit consisted entirely of artificial fluorescent light on a 12 hour photoperiod. The female laid a first clutch of 18 infertile eggs in May of the same year. Ten infertile eggs were laid in May, 1979, followed by an unknown number of eggs which were laid in the pool water in April, 1980.

Diets were modified in late 1979. Frozen saltwater fish were eliminated and replaced with fresh chicken parts. The remainder of the diet stayed the same.

In 1979, female NYZP #71482 was transferred to the same exhibit pool containing female #71483, with two males from the 1971 group of about the same age and size, and a large male approximately 14 years of age and measuring approximately 1.6 m. Although water temperatures were normally maintained at 27° to 30°C, the installation suffered from occasional temperatures as low as 25°C. On 10 April, 1980, at 11 years of age and a length of 137 cm, female #71482 laid four apparently fertile banded eggs (Ferguson, 1979) in the pool water. This was the first crocodilian to successfully mate and produce fertile eggs at the New York Zoological Park.

Because of the low environmental temperatures which prevailed in the exhibit at the time the eggs were laid, the female was removed from the exhibit pool and was placed in a large holding tank containing a soft substrate of dampened wood chips to prevent the breaking of any eggs during oviposition. Her body temperature was gradually increased to 30° under warming lights.

One hundred and fifty IU of oxytocin (Schein Inc., Port Washington, New York 11050) (Huff, 1976), administered at a dosage of one IU per 100 g of body weight, was injected intramuscularly at the base of a hind limb. Approximately 30 minutes later, the female began lateral pelvic movements, and elevated the cloaca off of the substrate. The first egg was laid one hour and 30 minutes post injection; two additional eggs were laid at 3 hours and 15 minutes post injection and another two minutes after that. Egg # 5 was laid four hours post injection, followed by # 6 hours and 25 minutes post injection.

The female assumed a specific stance during egg deposition: a "tripod" position with the front legs braced in a standing position, forming two support points to elevate the body off the substrate. The tail was extended back and stiffened against the ground, providing a third support point, which allowed for free movement of the hind legs. The palms of the hind feet were then turned inward, palm upwards towards the cloaca, and cupped. Egg # 6 was laid within the cupped palms, and then dropped onto the sawdust substrate. Laying was followed by alternate scraping of the substrate towards and under the body with the hind limbs, in a mounding motion.

The female did not appear to show concern for her surroundings during oviposition. Egg # 7 was laid in the author's hand, when he placed his hand, palm up, in the cupped palms of the female. Mounding and scraping motions were repeated between each laying. Eggs 8, 9 and 10 were similarly laid in the author's hand. Body arching and laying could be induced by lightly touching the cloaca. Oviposition ended 8 hours post injection.

Figure 1 is a radiograph taken at 10 M.A.S. 67 KV, showing the female still retaining 15 eggs on the following day. An additional 150 IU of oxytocin was administered, and resulted in the laying of 6 additional eggs within three hours after injection. The following day the female was again radiographed, revealing 8 whole and one broken egg. No additional oxytocin was administered while the animal was hydrated. An additional 150 IU of oxytocin were injected on the fourth day, resulting in the laying of two eggs one hour and 45 minutes later. No additional eggs were forthcoming. Oxytocin injections of 150 and 300 IU were given on the 8th and 10th days respectively, without result. Although a third radiograph showed the female still retained five eggs, she was returned to a warm water pool. These eggs were never expelled and it is assumed that they were reabsorbed.

In total, 20 eggs were laid, of which 17 were incubated. The remainder either were crushed or badly damaged during laying. Banding was not noted on all eggs, but all eggs were laid with a mucus like clear covering. Thirteen days after laying, eggs measured 61 mm to 74 mm in length by 39 mm to 42 mm in width, and weighed 52.5 to 70.4 g. Average weight was 61.9 g. All eggs were initially incubated in a covered pan containing moistened paper towels, at a temperature of 30° to 31°C, and a humidity of 80 to 90 percent. Twenty four days after laying, all eggs were transferred to dampened moss at the same temperature and humidity. Eggs were sprayed periodically with warm water.

On day 44 of incubation, several eggs were selected, and were experimentally examined using computerized axial tomography (CT Scan) to determine if this technique could be used to evaluate the viability of developing eggs. Eggs 4, 6, 10, 13 and 15 contained what appeared to be developed but dead embryos (Fig. 2). Figure 3, shows the undeveloped yolk contained in three Crocodylus palustris eggs of approximately the same age for comparison.

Flaking of the outer calcareous shell was noted in the days immediately preceding emergence of the embryo. On 8 July, 1984, eggs 3 and 12 hatched after 82 days of incubation. Eggs 4, 6, 10, 13, and 15, previously examined by CT Scan, contained nearly full-term dead embryos. Seven eggs appeared to have been infertile, or did not develop beyond the initial stages. The remaining three embryos appeared to have perished within the first 30 days of incubation, based on the minimal development of the embryos (Ferguson, 1981).

Hatchling (egg 3: 70 mm x 39 mm, 61.3 g) NYZP #800199, a male, measured 230 mm total length, 113 mm snout vent, and weighed 42 g. Egg 12 (64 mm x 41 mm, 62.2 g) also a male, NYZP #800198, measured 238 mm total length, 120 mm snout vent, and weighed 44 g. on hatching.

Beginning in 1981, the diets and some environmental conditions for crocodylians were modified. From that time onward, young crocodylians have been fed living goldfish (Carassius auratus) and small or neonate mice (Mus). Larger animals and adult crocodylians have been fed freshly killed pigeons, domestic chicks and small mammals. All frozen foods and fish, and vitamin supplements, were eliminated from the diets. The effect was a dramatic increase in reproduction in the crocodylian collection, including the successful breeding of Crocodylus siamensis, C. rhombifer and Alligator sinensis.

The management protocol for rearing young fast growing crocodylians was modified in 1980 to include exposure to black light in the near ultraviolet range of 310 to 400 nanometers for at least 12 hours per day, on an experimental basis (Jay Cole, personal communication, 1978; Townsend, 1979; McCrystal and Behler, 1982).

changes in diet and exposure to black light have appeared to be beneficial in the rearing management of young crocodylians, and has had a beneficial effect on their growth, including the growth of Caiman crocodilus yacare NYZP #'s 800198 and 800199.

Figure 4. indicates the weight to total length relationship of Caiman c. yacare # 800198 and # 800199 raised under exposure to black light and fed a fresh food diet from hatching. Figure 5 shows the age/growth rate relationship of both animals, indicating an average rate of growth of 3.33 cm per month for the first four years.

#### Acknowledgments

I would like to take this opportunity to thank the staff of the New York Zoological Park, and the New York Zoological Society for support and assistance. Thanks particularly to Bruce Foster and Bob Brandner who handled the animals for the collection of data. Special recognition goes to Dr. Helen Morehouse of the staff of Albert Einstein College of Medicine for enabling the CY scan to be done, and for her expertise and many innovative ideas; and to my wife Myrna Watanabe: without her help, nothing would get done. Photos of yacare caiman hatching were taken by Bill Holmstrom, and I thank him for their use.

#### Footnotes

1. Water from the municipal water supply is used for changing and cleaning, and was introduced at comparable temperature. Municipal water is treated with chlorine and fluoride for human consumption. The pH rarely deviates more than one or two tenths of a point from 7.0, and the water usually contains less than 50 ppm dissolved mineral solids and less than 10 ppm suspended solids.

#### References

- Anon. 1981-82. Reptile reproduction report. Zudus (St. Louis Zoo) Dec. 81/Jan 82: S6.
- Crawshaw, Peter Gransden, Jr. and George B. Schaller, 1979, Nesting of Paraguayan caiman (Caiman yacare) in Brazil. Repor to IBDF 11: 1-17.
- Ferguson, M.W.J. 1979. A macroscopic, SEM and EDAX study of the eggshell and embryonic membranes of Alligator mississippiensis. Proc. Anat. Soc. Gr. Britain and Ireland Dec. 1979: 25 (Abst).
- Groombridge, Brian, ed. 1982. The IUCN Amphibia-Reptilia Red Data Book. Part 1: Testudines, Crocodylia, Rhynchocephalia. Species account, Yacare Caiman. pp. 301-304.
- Huff, Thomas A. 1976. The use of oxytocin to induce labour in a Jamaican boa. Int. Zoo Yb. 15: 82.
- McCrystal, Hugh K. and John L. Behler. 1982. Husbandry and reproduction of captive gaint ameiva lizards Ameiva ameiva the New York Zoological Park. Int. Zoo Yb. 22: 159-163.
- Townsend, C.R. 1979. Establishment and maintenance of colonies of parthenogenetic whiptail lizards. Int. Zoo Yb. 19: 80-86.

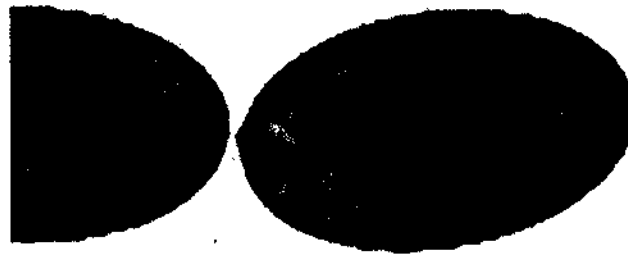


Fig. 1 Radiograph of female Caiman c. yacare retaining eggs.





**Fig. 2** Arrows indicate developed embryo (CT Scan) within an egg of Caiman c. yacare.



**Fig. 3** Arrows indicate undeveloped yolk (CT Scan) within an egg of Crocodylus palustris.

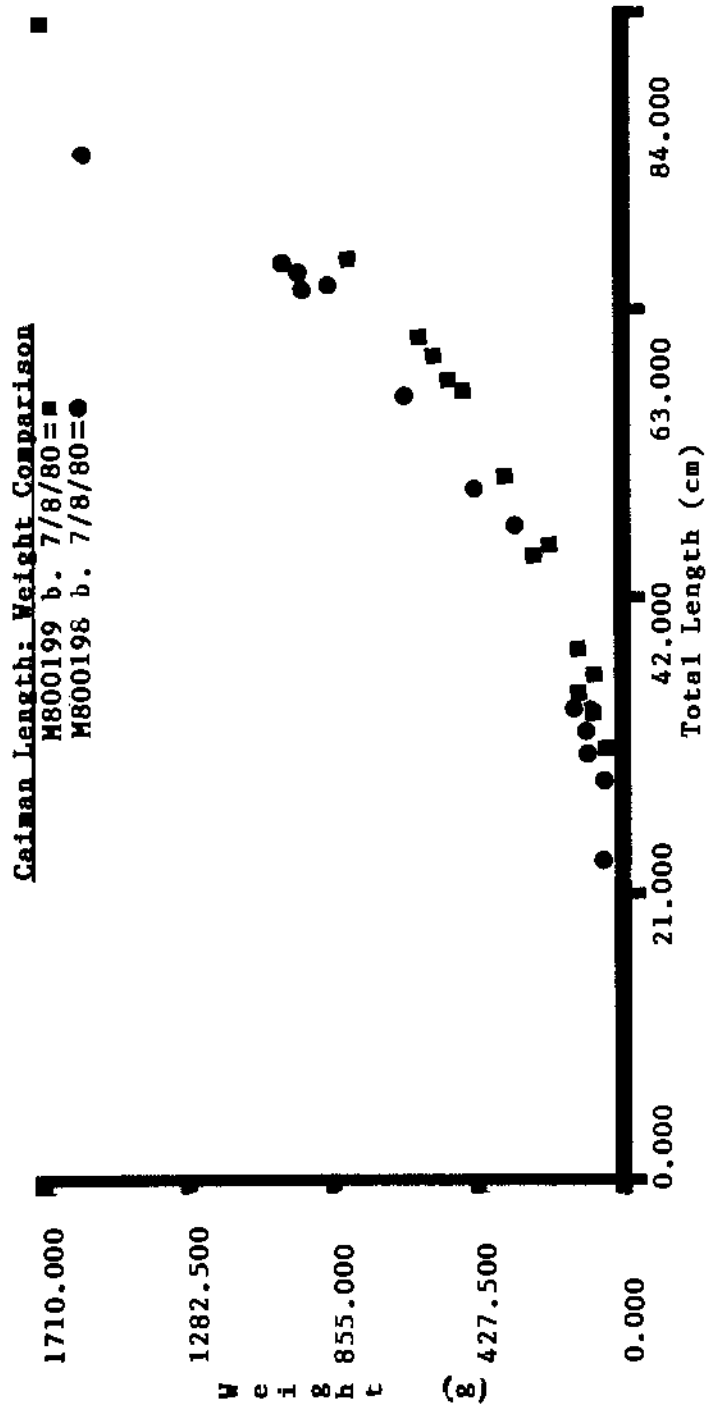


Fig.4

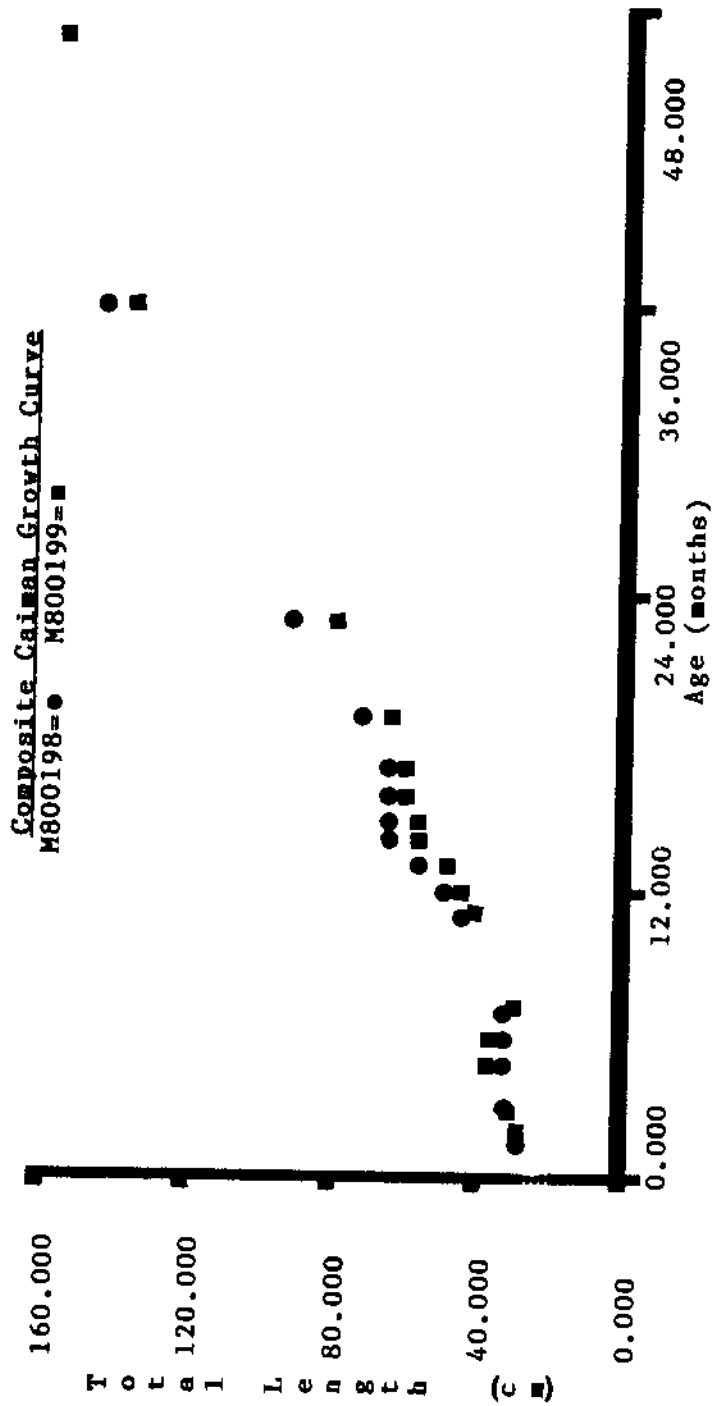


Fig. 5

# THE CROCODILE SKIN TRADE SINCE 1979

by

Ginette Hemley  
TRAFFIC(U.S.A)  
1601 Connecticut Ave, N.W.  
Washington, D.C. 20009

and

John Caldwell  
Wildlife Trade Monitoring Unit  
219c Huntingdon Road  
Cambridge CB3 0DL  
United Kingdom

## Introduction

The international crocodile skin trade has changed dramatically over the last three decades. Peaking in the late 1950s and early 1960 when an estimated 5 to 10 million skins a year were involved (Inskipp and Wells, 1979), world trade today probably amounts to no more than 1.5 million skins annually. The focus has generally shifted away from the larger and more valuable species, many of which are now endangered, to smaller species -- particularly the spectacled caiman Caiman crocodilus. In recent years national laws protecting crocodylians have been implemented around the world, and all 21 species in the order Crocodylia are afforded some degree of protection by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Fifteen crocodylian species and two subspecies are listed on CITES Appendix I, which generally forbids commercial trade\*. All remaining species are included on Appendix II and can be traded commercially through a permit system.

To date 87 countries have become party to CITES, including most major crocodile-producing and consuming nations. Trade controls are improving, yet overall enforcement and implementation of the Convention is erratic. In central South American, for example, illegal caiman hunting and trade abound (Menghi, pers. comm.). The problems are not limited to the producing countries, however. Singapore, a major trade center for wildlife products, has yet to sign the Convention. France, one of the world's leading crocodile skin importers, has not entirely fulfilled its CITES reporting obligations, making it difficult to ascertain the full scope of that country's trade. Japan, an increasingly prominent country in the crocodile trade, shows signs of not fully implementing the Convention.

CITES has become a prevalent force over its decade of existence, and despite certain compliance problems, it currently provides the best available mechanism for tracking the overall crocodile

skin trade. This report presents an analysis of CITES-reported world trade in crocodylian skins from 1979 to 1982, focusing on what appear to be the most important trade species: Alligator mississippiensis, Caiman crocodilus, Crocodylus cataphractus, Crocodylus niloticus, Crocodylus novaeguineae, and Crocodylus porosus. Additional trade information from sources other than CITES is also included.

### Methods

Most of the data included in this report come from annual reports supplied by CITES parties. The information has certain inherent limitations: for example, many crocodile-producing countries have never issued an annual report, while other countries have only recently become party to the Convention. As a result, the trade data are based largely on the reports supplied by importing nations. In addition, units of measurement are not always consistent in CITES reports. Unless otherwise noted, this analysis covers trade in whole skins only, and excludes transactions that were reported in units of weight or area.

CITES reports are entered into a Wang VS computer by the Wildlife Trade Monitoring Unit at IUCN's Conservation Monitoring Centre in Cambridge, United Kingdom, under a consultancy contract with the CITES Secretariat. The data are analyzed in two ways: 1) to calculate both gross and net imports and exports of all countries reported in trade, and 2) to compare imports of one country with exports/re-exports of another country. This allows the minimum number of skins of each species entering trade each year to be estimated. The sources of skins are generally determined by the countries of origin/export listed on imports, or in some cases, on re-exports.

The trade data presented here should be interpreted with caution. They may not accurately reflect original export patterns from year to year and they do not distinguish between stockpiled skins and recently-harvested skins. It should be noted that the worldwide trade patterns for crocodylian skins are extremely complex, as skins may move among several intermediate countries over a period of years before they are used for manufacture.

### Results and Discussion

**IMPORTING COUNTRIES:** Well-developed leather industries have made France and Italy the leading importers of crocodylian skins for many years. In addition, FR Germany (especially for Caiman crocodilus), Japan, Switzerland, Austria, Hong Kong, Singapore, and the United States have become prominent crocodylian skin importers.

\* A SPECIAL EXEMPTION BUILT INTO THE CONVENTION ALLOWS PARTIES TO TRADE IN APPENDIX I SPECIES SIMPLY BY ENTERING A "RESERVATION" WHEN THE SPECIES IS LISTED OR WHEN CITES ENTERS INTO FORCE IN THAT COUNTRY. THIS LIBERTY HAS BEEN EXERCISED BY SEVERAL IMPORTANT CROCODYLIAN IMPORTERS, NOTABLY FRANCE, ITALY, AUSTRIA, AND JAPAN.

EEC Regulation 3626/82 became effective 1 January 1984, and requires Italy and France (including overseas departments) to cease importing Appendix I species on which they had previously held reservations. According to the CITES Secretariat, only Italy has officially withdrawn its reservations; however, the Regulation does not require withdrawal and contains no basis for maintaining reservations. For most of the period covered by this report, reservations on Appendix I crocodylian species had entered by the following CITES Parties:

<u>Caiman latirostris</u> :	Italy
<u>Melanosuchus niger</u> :	France
<u>Crocodylus acutus</u> : (U.S. population)	Switzerland (withdrawn 6/6/81)
<u>Crocodylus cataphractus</u> :	Austria, France, Italy, Zambia
<u>Crocodylus niloticus</u> :	Botswana, France, Italy, Sudan, Zambia, Zimbabwe
<u>Crocodylus porosus</u> : (excl. PNG population)	Austria, France, Italy, Japan, Switzerland (withdrawn 1/1/83)
<u>Osteolaemus tetraspis</u> :	France

Although all major crocodylian-importing countries except Singapore are party to CITES, calculating the precise number of skins in trade remains problematic. This is partly because France, a major trader, includes few imports in its annual reports, so analysis of its consumption is based largely on reported re-exports. Clearly, no reliable estimate can be made for consumption of skins within France. In addition, Japan lists most trade in Appendix II crocodylians simply as "Crocodylidae spp." or "Alligatoridae spp.", therefore the only clue of species involved is the reported country of origin.

The total declared value of U.S. crocodylian skin imports in 1982 was just over \$2 million. In Japan, the total declared value of imported crocodile and alligator skins and leather amounted to the equivalent of \$7.1 million in 1982, and \$6.2 million in 1983.

#### MAJOR SPECIES IN TRADE:

##### Alligator mississippiensis (American Alligator)

The range of Alligator mississippiensis extends across the southeastern United States from North Carolina to Florida and Texas. The largest numbers occur in Louisiana, while populations continue to recover from previously reduced numbers in other areas, notably Florida and Texas. The species was transferred from CITES Appendix I to Appendix II in 1979 and revisions of U.S. Endangered Species Act protections allow a state-managed harvest in Louisiana. Limited hunting of "nuisance" alligators is allowed in Florida and the status of the Texas population was recently changed, allowing for some controlled hunting. The same status change may be applied to Florida alligators in the near future.

In 1979, after A. mississippiensis was transferred to Appendix II, a total of 5,404 skins were exported from the United States. During the following three years the net number of skins entering trade from the U.S. increased to 28,400 in 1981, decreasing slightly to less than 26,000 skins in 1982 (Table 1).

Table 1: U.S. Exports of Alligator mississippiensis Skins

<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
5,404	13,087	28,400	25,835	72,726

Source: Annual reports by CITES Parties

The average number of alligator skins exported annually from 1979 to 1982 (18,182 skins per year) is slightly more than the average number of alligators taken annually under Louisiana's harvest program (16,501 alligators per year, Table 2). Total U.S. exports include some stockpiled skins as well as alligator skins from Florida, where 1,500 to 2000 alligators were taken annually from 1979 to 1982 as "nuisance" animals. A small number of skins from alligators raised on farms are also exported.

Table 2: Results of the Alligator Harvest Program in Louisiana, 1979 to 1982

<u>Year</u>	<u>N<sup>a</sup> Tags Issued</u>	<u>N<sup>a</sup> Taken</u>	<u>N<sup>a</sup> Sold</u>	<u>Price Paid for Skins</u>	<u>Avg. S/Foot (o.3 m)</u>
1979	17,516	16,300	14,955	\$1,711,500	\$15.00
1980	19,134	17,692	17,592	\$1,609,972	\$13.00
1981	15,534	14,870	14,482	\$1,774,045	\$17.50
1982	18,188	17,142	16,000*	\$1,512,000*	\$13.50

\*estimated

Source: Office of the Scientific Authority, U.S. Fish and Wildlife Service.

The major importer of these skins was France, followed by Italy and Japan. Japanese buyers are apparently becoming increasingly competitive in the alligator skin market (Brazaitis, 1984). The U.S. re-imported approximately 30,000 tanned alligator hides during the four years.

#### Caiman crocodilus (Spectacled Caiman)

Over the last decade Caiman crocodilus has emerged as the dominant crocodylian in the skin trade. The species is extant throughout much of South and Central American to Mexico and in Trinidad and Tobago (Groombridge, 1983). The subspecies C. c. apaporiensis from southeastern Colombia is listed on CITES Appendix I; all other subspecies are on Appendix II. C. c. yacare is listed as "endangered" by the U.S. Endangered Species Act. In addition, C. crocodilus is afforded some degree of protection in most of the countries in which it occurs.

Some disagreement and confusion exist over the taxonomy of the C. crocodilus complex, adding to a variety of reporting discrepancies at the subspecies level. For example, in 1981 more than 65,000 skins of C. c. crocodilus were imported into the U.S. listed as originating in Bolivia or Paraguay (Roeper & Hemley, 1982). This subspecies reportedly does not occur in commercially-exploitable quantities in Bolivia, and these imports were most probably C. c. yacare (Brazaitis, pers. comm.). Investigation into the range and status of the various C. crocodilus subspecies is seriously needed. For simplicity, this analysis addresses trade only as C. crocodilus (Table 3).

Table 3: Minimum World Trade in Caiman crocodilus Skins\*

<u>Year</u>	<u>Gross</u>	<u>Net</u>
1979	528,986	423,766
1980	1,268,750	785,637
1981	1,211,709	671,329
1982	892,758	537,400

\* Includes imports into Japan of "Alligatoridae spp." from South American countries.

Source: Annual reports of CITES Parties

Over the four years 1979 to 1982 a minimum of 2.4 million C. crocodilus skins entered international trade, according to CITES reports. It appears that world trade peaked in 1980 when at least 785,000 skins were traded, dropping to a minimum of 537,000 skins in 1982. In addition, 3,596 sides or flanks, 38,145 kg of skins, and 139,177 sq ft of skins were reported in trade. Some of the trade reported in units of weight or area probably overlaps with the trade reported as skins or sides, as an importer and exporter may report the same shipment differently.

The primary countries of origin of C. crocodilus skins reported in trade from 1979 to 1982 are, in order of importance; Paraguay, Colombia, Panama, and Bolivia (Table 4). Of these, Paraguay is the reported source of about one-third of all skins entering trade, in spite of national legislation (Decreto N° 18.796 of 1975) prohibiting the commercial hunting and export of C. crocodilus. The ban on commercial trade was officially reaffirmed in 1981 and the Paraguayan CITES Management Authority has stated that the law does not allow import or re-export of wildlife (Fuller & Swift, 1984). However, significant trade apparently continues today and much of what is leaving Paraguay probably originates in Brazil (Menchi, pers. comm.; King, pers. comm.).



Table 4: Origin of Caiman crocodilus Skins\*

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
Argentina	140	15,944	632	547	17,263
Bolivia	36,509	160,183	177,119	72,836	446,647
Brasil	-	-	4	-	4
Cayman Is.	-	2,800	-	-	2,800
Colombia	268,211	171,766	105,554	26,765	572,296
Fr. Guiana	13,127	8,250	8,079	7,810	37,266
Guyana	-	-	-	2,136	2,136
Honduras	2,931	-	-	-	2,931
Nicaragua	228	-	-	4,000*	4,228*
Panama	30,155	224,307	128,400	127,954	510,816
Paraguay	19,752	228,979	293,870	266,937	809,538
Peru	-	-	3,000	6,351	9,351
Venezuela	30,155	44,322	-	-	74,477
<b>T o t a l</b>	<b>401,208</b>	<b>856,551</b>	<b>716,658</b>	<b>513,336"</b>	<b>2,389,753*</b>

\* Includes imports into Japan of "Alligatoridae spp. "from Latin American countries.

Source: Annual reports of CITES Parties

Colombia was the reported origin of 268,211 C. crocodilus skins in 1979, but the number decreased steadily to 26,765 by 1982. During 1980 and 1981 over 110,000 additional caiman skins were imported into Colombia from Panama and subsequently re-exported, presumably under the so-called "Plan Vallejo" which was established to stimulate foreign trade and exchange. Although a general commercial wildlife trade ban has been enacted (Decreto Ley N° 2811 (1974)/Decreto N° 1608 (1978) , export of inventoried stocks of caiman skins has been allowed to continue. Still, controls have been weak: CITES reports show that over 105,000 C. crocodilus skins entered trade from Colombia in 1981, although INDERENA (Instituto de Recursos Naturales y del Ambiente) and INCOMEX (Colombian Institute for Foreign Trade) report no exports of C. crocodilus during that year (Medem. 1982). In addition, Plan Vallejo has apparently been much abused, and in the past caiman skins originally from Colombia were re-imported into Colombia from Panama with Panamanian certificates of origin (Donadio, 1982). At this point Colombia reports to have depleted nearly all the stocks of C. crocodilus skins inventoried when the general trade ban came into effect, and authorities there say that only two firms, Mendal Hermanos and Prodelta Limitada, are authorized to export the remaining hides (Fuller & Swift, 1984).

Panama is reported as the source of at least 510,000 C. crocodilus skins traded between 1979 and 1982. In spite of Resolucion N°002 of 1980 prohibiting the commercial hunting of C. c. fuscus, the only subspecies reported to occur in the country, an annual average of 160,220 C. crocodilus skins left Panama in the three years since the law came into force.

More than 446,000 C. crocodilus skins were reportedly exported from Bolivia between 1979 and 1982, with trade apparently reaching its highest level in 1981. Bolivian laws (Decreto Supremo 16605 (1979)/Resolucion Ministerial 14316-74 (1974) apparently prohibit the export of skins of wild-caught caimans and untanned hides (Fuller & Swift, 1984). As with Paraguay, many of the caiman skins exported from Bolivia probably originated in Brazil (Menghi, pers. comm.; King, pers. comm.).

It should be noted that CITES-reported figures do not give a complete picture of the trade in C. crocodilus. According to recent reports, large-scale caiman hunting continues in parts of South America, primarily in Paraguay, southwestern Brazil, and eastern Bolivia, despite protective legislation. Most hides leaving the region are apparently exported via Paraguay and Bolivia (Menghi, pers. comm.). It has been estimated that this region supplies the world market with at least 1,000,000 skins a year (King, pers. comm.). Most of this commerce is apparently illegal. (See also Japanese Customs information below).

#### Crocodylus cataphractus (African Slender-snouted Crocodile)

Crocodylus cataphractus is widespread throughout west and central Africa from Senegal to Tanzania (Groombridge, 1983). Distribution and status of populations are in general poorly known, but the species has declined overall as a result of hide-hunting, habitat loss and local utilization for food. Although the hides of C. cataphractus are generally regarded as commercially inferior, the species may be under increasing pressure as a result of the severe decline of many C. niloticus populations (Groombridge, 1982). CITES Parties holding a reservation on this Appendix I species are Austria and Zambia, and until 1 January 1984, France and Italy.

CITES data show that a net minimum of 32,151 C. cataphractus skins entered trade from 1979 to 1982, or an average of about 8,038 skins per year. The net minimum trade apparently increased from about 3,700 skins in 1979 to over 9,000 skins in 1982 (Table 2).

Table 5: Minimum World Trade of Crocodylus cataphractus Skins

<u>Year</u>	<u>Gross</u>	<u>Net</u>
1979	3,736	3,736
1980	11,246	11,196
1981	8,420	8,192
1982	9,105	9,027

Source: Annual reports of CITES Parties

Congo, the major source of C. cataphractus skins traded between 1979 and 1982 (Table 6), joined CITES in May 1983 and did not enter a reservation for the species. The country reports exporting 4,870 skins to France during 1983, but these exports may have occurred before Congo acceded to CITES or may have been regarded as pre-convention stocks.

Table 6: Origin of Crocodylus cataphractus Skins

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
Congo	3,165	9,209	6,509	6,663	25,546
Gabon	-	811	1,612	585	3,008
Mali	-	-	-	980	980
Togo	571	779	4	-	1,354
Zaire	-	-	289	616	905
<b>Total</b>	<b>3,736</b>	<b>10,799</b>	<b>8,414</b>	<b>8,841</b>	<b>31,793</b>

Source: Annual reports of CITES Parties

It should be noted that both Togo and Zaire have been CITES Parties since 1979 and since neither entered a reservation they should not be trading C. cataphractus commercially. Neither Gabon nor Mali are party to the Convention.

Crocodylus niloticus (Nile Crocodile)

Crocodylus niloticus is widely distributed throughout Africa south of the Sahara, with the possible exception of Djibouti, Guinea, Guinea Bissay, and Equatorial Guinea. C. niloticus is one of the most valuable crocodile skins in trade and four producing countries, Botswana, Sudan, Zambia, and Zimbabwe, have reservations on its CITES Appendix I listing. France and Italy, the major importing countries, both had reservations effective until 1 January 1984, and it is possible that France may have imported up to 100,000 skins in 1983 alone. The minimum number of skins in trade estimated from CITES data is well below this level because of the severe limitations mentioned above, particularly regarding the lack of import data from France (Caldwell, 1984) (Table 7).

Table 7: Minimum World Trade of Crocodylus niloticus Skins

<u>Year</u>	<u>Gross</u>	<u>Net</u>
1979	7,572	3,706
1980	24,082	22,094
1981	30,003	22,253
1982	27,108	20,099

Source: Annual Reports of CITES Parties

At least 64,446 skins reportedly entered trade between 1980 and 1982 with a country of origin listed for over 90 percent of them. The figures in Table 8 suggest that over 58 percent of the skins came from just two countries, Nigeria and Sudan, with smaller but significant numbers reported from Mali, Togo, and Cameroon. They further suggest that export from Botswana, Liberia, Congo, Gabon, and Somalia have declined in recent years. It should be noted that Nigeria, Togo, and Zaire do not have reservations for C. niloticus, although they apparently exported significant numbers of skins from 1979 to 1982.

Table 8: Origin of Crocodylus niloticus Skins

	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
Botswana	6	3	2	11
Cameroon	174	1,781	1,718	3,673
Congo	834	442	65	1,341
Egypt	-	-	2	2
Gabon	476	620	-	1,096
Liberia	-	230	143	373
Madagascar	-	4	20	24
Mali	1,785	2,781	3,137	7,703
Nigeria	5,868	10,304	3,547	19,719
Somalia	1,266	847	-	2,113
Sudan	7,520	5,015	2,788	15,323
Togo	1,806	818	2,817	5,441
Zaire	-	-	603	603
Zimbabwe	15	689	1,667	2,371
Total	19,750	23,471	16,509	59,793

Source: Annual Reports of CITES Parties

The C. niloticus population of Zimbabwe was transferred to CITES Appendix II on 29 July 1983 in recognition of that country's crocodile conservation program and ranching operations. Data from CITES annual reports indicate that imports from Zimbabwe have increased steadily to over 1,600 skins in 1982; this trend will no doubt continue.

#### Crocodylus novaeguineae (New Guinea Crocodile)

Crocodylus novaeguineae occurs on the island of New Guinea, in the Ary Islands, and in the Philippines (Groombridge, 1983). While some regard the Philippine form as a separate species C. mindorensis, CITES recognizes the two subspecies: C. novaeguineae novaeguineae from Papua New Guinea, listed on Appendix II, and C. novaeguineae mindorensis from the Philippines, included on Appendix I.

From 1979 to 1982 at least 114,000 C. novaeguineae skins entered trade. Although the net number of skins traded averaged almost 28,600 skins per year, exports appear to have decreased considerably during the same period (Table 9).

Table 9: Minimum World Trade of Crocodylus novaeguineae Skins

<u>Year</u>	<u>Gross</u>	<u>Net</u>
1979	53,057	42,046
1980	29,932	27,610
1981	31,941	31,286
1982	13,463	13,417

Source: Annual reports of CITES Parties

About three-quarters of all skins reported in trade had country of origin listed; of these, about 90 percent came from Papua New Guinea (Table 10). Indonesia reportedly supplied about 9,000 skins. Of the remaining 29,000+ skins, some 22,000 were declared as originating in Singapore.

Table 10: Origin of Crocodylus novaeguineae Skins

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
Indonesia	1,154	3,851	1,455	2,581	9,041
PNG	41,160	13,989	15,023	5,791	75,963
Philippines	-	-	60	-	60
Totals	42,314	17,840	16,538	8,372	85,064

\* May include some skins exported in 1980 as PNG's annual report covered June 1979-1980.

Source: Annual reports of CITES Parties

Papua New Guinea has not submitted a CITES annual report since mid-1980, thus the CITES data are incomplete. Information recently received from the Department of Primary Industry in Papua New Guinea, however, gives a better idea of Papua New Guinea's actual C. novaeguineae exports (Table 11). This information differs significantly from the CITES data for both 1980 and 1982, although the difference for 1981 is only 2 skins.

Table 11: Declared Exports of Crocodylus novaeguineae Skins from Papua New Guinea\*

<u>Source</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
Wild	34,836	27,249	14,290	23,259	13,807
Ranched	646	460	731	1,474	1,304
Total	35,482	27,709	15,021	24,733	15,111

\* A small number of additional skins ( 1% of total) may have been exported illegally.

Source: Hollands, in litt., 1984

#### Crocodylus porosus (Saltwater Crocodile)

Crocodylus porosus has an extensive distribution, ranging from Sri Lanka and the East Indian coast across Southeast Asia to Papua New Guinea, Indonesia, northern Australia and the Solomon Islands.

(Groombridge, 1983). All populations except Papua New Guinea are listed on CITES Appendix I, and are considered in many areas to be very seriously depleted. CITES Parties holding reservations

on this species were France and Italy (until January 1, 1984), and Austria, Japan, and Thailand. C. porosus is the only crocodylian species for which Japan has a reservation.

Table 12: Minimum World Trade in Crocodylus porosus Skins

<u>Year</u>	<u>Gross</u>	<u>Net</u>
1979	13,804	9,188
1980	3,691	3,391
1981	7,196	5,122
1982	2,147	2,017

Source: Annual reports of CITES Parties

The CITES data indicate that net world trade in C. porosus skins fell from just over 9,000 skins in 1979 to about 2,000 skins in 1982 (Table 12). Of a total of almost 20,000 skins reported in trade during the four years, about 75 percent had the country of origin listed (Table 13). Most of the remaining skins has Singapore listed as the source country (some of these may be accounted for in the original reported exports).

Table 13: Origin of Crocodylus porosus Skins

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>Total</u>
Australia	-	35	-	-	35
Indonesia	375	-	1,160	26	1,561
Malaysia	74	-	186	-	260
PNG	7,422	1,794	3,012	640	12,868
	<u>7,871</u>	<u>1,829</u>	<u>4,358</u>	<u>666</u>	<u>14,724</u>

Source: Annual reports of CITES Parties

CITES data show that about 65 percent of all C. porosus skins recorded in trade came from Papua New Guinea. However, as with C. novaeguineae, the CITES data are incomplete because they lack figures supplied by Papua New Guinea. The Department of Primary Production has furnished additional information which gives a more realistic picture of C. porosus trade from Papua New Guinea (Table 14).

Table 14: Declared Exports of Crocodylus porosus Skins from Papua New Guinea\*

<u>Source</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
Wild	7,442	5,717	3,915	3,926	3,155
Ranched	184	80	366	927	301
Total	<u>7,626</u>	<u>5,797</u>	<u>4,281</u>	<u>4,853</u>	<u>3,456</u>

\* A small number of additional skins ( 1% of total) may have been exported illegally.

Source: Hollands, in litt., 1984.

MISCELLANEOUS TRADE: The following notes briefly summarize CITES-reported trade in various crocodylian species during 1981 and 1982.

Caiman latirostris (Broad-nosed Caiman)

In 1981, Italy apparently imported 9,836 C. latirostris skins from Paraguay, and 1,000 skins from Colombia. The following year an additional 3,218 skins were imported from Paraguay. Until January 1 1984, Italy had taken a reservation on this Appendix I species, although Colombia and Paraguay have not.

Melanosuchus niger (Black Caiman)

U.S. Fish and Wildlife Service enforcement officials seized a shipment of 254 Melanosuchus niger skins upon attempted importation into the U.S. from Bolivia in 1981. In addition, 162 skins were sent from Hong Kong officials to U.S. authorities in 1982 as part of an on-going investigation which resulted in the June 1984 conviction of two American citizens for violations of the U.S. Endangered Species Act. At least 13 separate commercial transactions of M. niger reportedly occurred between 1977 and 1979 when the convicted individuals exported at least 2,692 black caiman skins from Bolivia to Switzerland, Italy, and Hong Kong (Anon., 1984). The offenders and their company were recently sentenced with fines totalling \$76,000 and suspended sentences of one year each.

Crocodylus acutus (American Crocodile)

Over 8,300 skins of C. acutus were reported in trade in 1981, although some of these (4,505 skins) were declared to be from Paraguay where the species does not occur. The remaining skins apparently originated in Colombia and Panama, and were traded by Italy, Switzerland, and FR Germany\*. In 1982, 420 skins were apparently traded in Europe; most of these were reportedly pre-Convention skins imported by Switzerland from Italy and France.

Crocodylus siamensis (Siamese Crocodile)

In 1981 and 1982, Japan reportedly imported a total of 500 C. siamensis from Thailand. Thailand, which joined CITES in April 1983, is the only country with a reservation on this Appendix I species. The Samutprakan farm reports exporting 1,500 crocodile skins to Japan and 1,000 to France between 1980 and 1982 (Samutprakan, in litt.). Most of these were probably C. siamensis, but it is possible that the shipments included some C. porosus skins.

\* THE U.S. POPULATION OF C. ACUTUS WAS TRANSFERRED TO CITES APPENDIX I IN 1979, WITH SWITZERLAND ENTERING A RESERVATION AGAINST THE LISTING. IN JUNE 1981, ALL OTHER POPULATIONS WERE TRANSFERRED TO APPENDIX I AND SWITZERLAND WITHDREW ITS RESERVATION.

Osteoleamis tetraspis (West African Dwarf Crocodile)

In 1981 a total of 273 skins of Osteolaemis tetraspis from Mali were re-exported by France to Italy and Spain. France was the only country holding a reservation on this species, and that became ineffective on 1 January of this year. Spain and Mali are not party to CITES.

OTHER SOURCES OF TRADE DATA: For Japanese wildlife trade, customs statistics are often considered more reliable than the CITES figures recorded in Japan's annual reports. Their use is limited, however, because commodities are grouped into general categories. Crocodylian skin imports are reported in kilograms and divided into two groups, "Alligator Skins and Crocodile Skins" and "Alligator and Crocodile Leather" (Tables 15 and 16). Nevertheless, these statistics are useful for trend analysis not only because they include countries of origin but also because occurred.

Table 15: Japanese Imports of "Alligator Skins and Crocodile Skins" (in Kilograms)

<u>Origin</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u> (thru 6/84)
Belgium	944	-	-	-	-	-
Colombia	17,409	16,778	7,992	6,290	6,111	671
Fr. Guiana	5,832	-	-	-	-	-
Indonesia	9,543	7,476	9,554	15,22	19,348	11,835
Malaysia	-	-	1,375	1,000	-	-
Neth. Antlls.	15,785	1,080	-	-	-	-
PNG	16,311	17,862	20,310	14,274	21,827	7,282
Panama	-	856	-	-	-	-
Pakistan	-	64	-	-	-	-
Paraguay	52,343	35,546	49,558	138,576	158,676	62,935
Philppns.	1,479	215	110	55	193	54
Sabah	-	382	621	100	-	960
Singapore	4,244	6,552	3,434	424	91	1,779
Solomon Is.	-	-	72	772	874	269
So. Africa	-	-	-	-	380	-
Suriname	29,870	-	-	-	-	-
Swtzlnd.	496	-	-	-	-	-
Thailand	6,035	4,008	2,885	1,299	-	1,656
U.S.	1,255	256	9,035	25,519	26,064	2,023
Zimbabwe	-	-	470	-	-	128
M M CAR*	247	119	-	-	-	-
Totals	161,793	91,194	105,416	188,309	233,564	89,592

\* Marianas, Marshall and Carolina Islands (U.S.)

Source: Japanese published government statistics.



The Customs data reflect Japan's growing involvement in the crocodile skin trade. Apparently, imports reached a peak in 1979 before Japan acceded to the Convention. After falling in 1980, imports increased steadily to reach an all-time high in 1983. Much of the trade other than from Latin America, the U.S., and Papua New Guinea, while not addressed by species, probably involves Appendix I crocodylians.

Over the last five years Japan's crocodylian imports have apparently been dominated by skins from one country -- Paraguay. Over half of all reported imports between 1979 and mid-1984, more than 497,000 kg of skins, came from Paraguay. Most skins from Asian sources came from Indonesia, while, smaller quantities were reported from Thailand and Malaysia. After Papua New Guinea, the largest quantity of skins from Oceania were imported from the Solomon Islands; trade from that source appears to be increasing.

Japanese customs statistics also list imports of "Alligator Leather and Crocodile Leather" (Table 16). The most important sources of what are presumably tanned hides are Paraguay and Bolivia.

Table 16: Japanese Imports of "Alligator and Crocodile Leather" (in Kilograms)

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u> (thru 6/84)
Argentina	168	-	-	-	-	-
Bolivia	2,693	3,222	2,888	1,631	975	478
Colombia	290	-	-	145	6	-
France	520	420	256	179	869	344
Germany, FR	-	230	-	-	-	-
Hong Kong	-	-	-	-	49	-
Indonesia	-	-	-	105	-	-
Italy	48	47	-	406	231	13
Mexico	-	50	-	-	-	-
Panama	2,661	92	-	-	-	-
PNG	-	-	-	50	-	-
Paraguay	13,972	7,349	9,989	2,034	521	767
Singapore	97	86	46	14	17	145
Spain	-	66	-	-	-	-
Sudan	60	-	-	-	-	-
U.K.	-	12	-	-	-	-
U.S.	1	-	-	272	311	62
<b>Total</b>	<b>20,510</b>	<b>11,574</b>	<b>13,179</b>	<b>4,836</b>	<b>2,979</b>	<b>1,809</b>

Source: Japanese published government statistics.

## Summary and Conclusion

Since 1979 the international crocodile skin trade has involved primarily six species, and probably no more than 1.5 million skins total have entered world commerce each year. At least three-quarters of this trade probably consisted of Caiman crocodilus skins. CITES reports suggest that the overall trade tapered off slightly in 1982 from higher levels in 1980 and 1981. According to Japanese customs data, however, crocodile skin imports into that country increased steadily until 1984. A new EEC regulation effective 1 January 1984 requires two other major consumers, Italy and France, to curtail imports of CITES Appendix I crocodilians for which they had previously held reservations.

CITES data show the following average MINIMUM number skins entering trade annually from 1980 to 1982: Alligator mississippiensis -- 22,400; Caiman crocodilus -- 695,500; Crocodylus cataphractus -- 9,300; Crocodylus niloticus -- 19,900; Crocodylus novaeguineae -- 25,100; Crocodylus porosus -- 5,400. These figures are incomplete, however, as some countries trading crocodile skins, such as Singapore, are not party to the Convention. In addition, some CITES members, especially among the producer nations, have not submitted annual reports, and others, like France, report only a portion of their total CITES trade.

It should be noted that a significant number of crocodilian skins are apparently entering trade illegally each year. For example, recent reports suggest that, despite protections, at least one million skins of Caiman crocodilus leave South America each year, primarily from Paraguay, Bolivia, and Brazil. In addition, some CITES parties (e.g. Indonesia, Nigeria, Togo and Zaire) appear to be exporting skins of Appendix I crocodilians commercially although reservations have not been entered for those species.

## References

- Anon., 1984. TRAFFIC (U.S.A.) Newsletter 5 (4): p. 14.
- Brazaitis, P. 1984. IUCN/SSC Crocodile Specialist Group Newsletter. February 1984.
- Caldwell, J. 1984. Nile Crocodile Skin Trade (1975-1982). Traffic Bulletin 6 (2).
- Donadio, A. 1982. Wildlife Legislation and Enforcement in Colombia. TRAFFIC (U.S.A.) Newsletter 4 (3 & 4).
- Fuller, K. and B. Swift. 1984. Latin American Wildlife Trade Laws World Wildlife Fund-U.S./CITES Secretariat.
- Groombridge, B. 1982. The IUCN Amphibia-Reptilia Red Data Book. Part 1. IUCN. Gland, Switzerland.
1983. World Checklist of Threatened Amphibians and Reptiles Nature Conservancy Council of Great Britain. London.
- Inskipp, T. and S. Wells. 1979. International Trade in Wildlife. Earthscan publication. IIED. London.
- Medem, F. 1982. Caiman Trade a "Tradition". TRAFFIC (U.S.A.) Newsletter, Vol. 4, No 3 & 4.
- Roeper, N. and G. Henley. 1982. Crocodile and Alligator Trade by the United States. TRAFFIC (U.S.A.) report.

## A WORLD SURVEY OF CROCODILIAN FARMING

R.A. Luxmoore, J.G. Barzdo, S.R. Broad and D.A. Jones  
Wildlife Trade Monitoring Unit  
IUCN Conservation Monitoring Centre  
219c Huntingdon Road, Cambridge, UK

### Introduction

In the last few years great expansion has taken place in the farming of crocodilians, both captive-breeding and ranching, the rearing of wild-caught young or eggs. Economics factors have undoubtedly played a major part in this but CITES restrictions must also be implicated. The majority of crocodilians are on Appendix I of CITES, and commercial trade in these is therefore only permitted for captive-bred populations. In addition the transfer from Appendix I to Appendix II of populations that are no longer endangered and would benefit from ranching is allowed for under the terms of the Convention. It was largely the need to know what farming operations were in progress, for the implementation of CITES controls, that motivated a survey of crocodilian ranching and captive-breeding around the world.

In 1982 the CITES Secretariat sent a Notification to all CITES Management Authorities of the need to register commercial captive-breeding operations involving Appendix I species (Notification N<sup>o</sup> 233, 13 October). At the fourth Meeting of the Parties in Botswana in 1983 a resolution (Conf. 4.15) was adopted that trade in captive-bred Appendix I species should only be permitted from operations registered with the Secretariat in this way. To date there is only registered operation breeding crocodilians; this is in Madagascar.

One of the arguments levelled against crocodile farms is that they can be used to conceal illegal skin trade, and suspicions have been expressed that wild-caught skins have been "laundered" through farms. This survey has not been able to confirm this but it is clearly a problem which requires closer scrutiny in the future.

### Methods

The survey was undertaken during 1983 and the early part of 1984. In addition to the Notification to Parties sent by the CITES Secretariat, the Wildlife Trade Monitoring Unit also approached the wildlife management authorities of non-CITES governments. Contact was made with members of the SSC Crocodile Specialist Group and with sent to the farms themselves requesting details of their stocks, breeding, wild capture, commercial production and husbandry. The results presented in this paper are drawn from the responses to these enquiries and also from published and unpublished material and press reports. In the following section the results are arranged by country.

## Results

AUSTRALIA: Crocodile farming has been practised in Australia since 1973. In 1982 there were farms in the Northern Territory (Bishaw, in litt. 1984) and further two in Queensland (Lever, in litt. 1983; Onions, 1982). The oldest farm, at Edward River, Queensland, run by Applied Ecology Pty Ltd, a Government-funded organisation, keeps only Crocodylus porosus (Onions, 1982), while the remainder are privately owned and keep a mixture of C. porosus and Crocodylus johnsoni. The total stocks held in 1983 were 6612 C. johnsoni and 4351 C. porosus. The animals were obtained as juveniles and from eggs collected in the wild under licence, with the addition of a few "rogue" adults. The Conservation Commission of the Northern Territory has supervised the wild-capture of the animals in the state. They have organised trials to quantify a sustainable level of annual harvest within specified management areas. A number of animals have been removed from areas in which they were considered a potential hazard to the public. It is expected that annual harvests of C. johnsoni from the management areas will be composed of 30% eggs and 70% hatchlings, with a total annual harvest of 3500 units (Bishaw, in litt. 1984). All wild animals in the N.T. remain the property of the Government which retains complete control of the resource (Graham, in litt. 1983). Captive breeding was planned at all farms (Bishaw, in litt. 1984, Lever, in litt. 1983) but by 1984 had only occurred at Edward River, which bred 769 C. porosus in 1983. Commercial skin production at this farm was expected to begin in 1984 and to rise to a target figure of 3000 skins a year (Onions, in litt. 1983). The three farms in the Northern Territory were planning to start commercial production in 1985 (Bishaw, in litt. 1984).

BANGLADESH: In 1982 Whitaker (1982b) proposed the establishment of a Central Crocodile Hatchery and Nursery and four model crocodile demonstration ranches. The main species involved would be Crocodylus porosus and Gavialis gangeticus. Breeding would be carried out on an experimental basis. The major part of the operation would involve taking C. porosus eggs from the wild in the Sunderbans and rearing them to 1.5 m for skin trade and to 1 m for release to the wild. Crocodylus palustris and G. gangeticus are considered unsuitable for this sort of ranching in Bangladesh because of their low populations. However, some C. palustris might be reared from eggs collected at Bagerhat, near Khulna, and some G. gangeticus from eggs collected at Rajshahi. It was proposed that the system should be established by the Sunderbans Forest Department with the central hatchery situated at Dhangmari, Sutar Khali, Chandpai and the four model demonstration farms at Khulna, Dacca, Chittagong and Syihet. The Demonstration farms' eventual output would be 250 skins a year, plus a number of yearlings for restocking the Sunderbans (Whitaker, 1982b).

BOLIVIA: ASICUSA, a group of four medium-sized companies involved especially in the tanning and processing of caiman skins in Bolivia, established a crocodilian farm in 1975. A total of about 2000 animals were reported to be kept, of Caiman crocodilus crocodilus, Caiman crocodilus yacare, Melanosuchus niger and "another species

of Caiman" (Bejarano, in litt. 1983). Further confirmation of this farm is needed.

**BOTSWANA:** A crocodile farm was established in the Okavango swamps in January 1983. It holds 70 adult breeding Crocodylus niloticus, 80% of which are male. They were captured in local drought areas where they were thought to be under threat. It was anticipated that in 1984 there would be another severe drought and facilities were being built to cater for a larger number of crocodiles. The plan is to collect 2000 eggs a year over the next three seasons. It is also planned to reinstate 5% of the 1-m sized crocodiles in the wild. The crocodiles have just started breeding. It is hoped that the breeding stock can be built up to 300 over the next three years (Seaman, in litt. 1983).

**BURMA:** The People's Pearl and Fisheries Corporation established a crocodile farm in 1978. It had about 900 Crocodylus porosus in 1980 (Caughley, 1980). The main aim of the farm is to produce skins but it is thought that by 1983 no animals had reached marketable size (Salter, in litt. 1983). Young animals are taken as hatchlings or yearlings from the eastern side of the Irrawaddy Delta where the PPFC has set up a number of collection centres. There is evidence that the total recruitment of crocodiles was being taken by the PPFC in the Tawbaing Chaung area (Caughley, 1980). From 1978 to 1983 an average of 465 hatchlings were obtained from the wild each year (Salter, in litt. 1983). The farm is intended to be self-sustaining when its breeding programme is fully established. Successful breeding was expected by 1983 (Caughley, 1980). The farm has recently been successful in inducing nesting but most of the stock of hatchlings continues to come from the remaining wild population in the Irrawaddy Delta (Salter, in litt. 1983).

The PPFC has also proposed to turn Meinmahla Kyun, an island of some 50 square miles in the Irrawaddy Delta, into a 'crocodile sanctuary' where re-introductions from the crocodile farm would supplement the remaining wild population and provide the basis for eventual sustained yield harvest (Salter, in litt. 1983).

**CHAD:** An experimental programme to evaluate the possibilities of crocodile farming (presumably Crocodylus niloticus) was undertaken from 1972 to 1973 under the auspices of the Centre Technique du Cuir, Lyon (Le Francois, 1974). Although much valuable information was obtained during this experiment, it was not intended to be a commercial proposition but merely to assess the possibilities of breeding crocodiles under controlled conditions. It is understood that the experiment was discontinued in 1973 (Wallis, 1980).

**CHINA:** A substantial investment has been made in alligator ranching/farming by both national and local authorities in China. There is a growing number of operations, mainly intended as conservation measures, but there is considerable potential for sale of live animals or products derived from them (Watanabe, in litt. 1983). There are unconfirmed reports that sales of alligators may have taken place (Anon., 198c).

Huang Chu-Chien names five operations managing Alligator sinensis: Anhui Xuancheng farm, Chekiang Anchi farm, Chekiang Changhsing farm, Chekiang Ningpo zoo, Shanghai zoo. The first of these was the only one operating on a large scale, having 100 adults and 380 juveniles (Huang Chu-Chien, in litt. 1983). Charoon Youngprapakorn of Samutprakan Crocodile Farm, Thailand, reports having given assistance in the establishment of a farm for Crocodylus siamensis called the Swato Crocodile Farm (Watanabe, in litt. 1983). The Chinese Government is also reported to have expressed interest in establishing a farm for Crocodylus porosus in southern China (Anon., 1983c).

COLOMBIA: No commercial crocodylian farming is known to occur in Colombia, but there are at least two crocodile breeding centres concerned with research and conservation. The first, Roberto Franco Station, operated by INDERENA (Instituto de Recursos Naturales y del Ambiente), keeps 4 Crocodylus intermedius (Medem, 1980b), 17 Caiman crocodilus, 12 Paleosuchus palpebrosus and 5 Paleosuchus trigonatus. Caiman crocodilus and Paleosuchus palpebrosus have both bred several times at the station (Medem, in litt. 1983).

The second, Los Cocos Breeding Station on Salamanca Island, also operated by INDERENA, had 30 Crocodylus acutus in 1980 but had not had any breeding success by that time (Medem, 1980a). A third, Cienaga Grande Management Station, has now closed down (Medem, 1980a).

CUBA: The Ministerio de la Industria Pesquera runs a crocodile farm at Laguna del Tesoro in the Zapata Swamp. It was established in 1965 (Harrison, 1981) and in 1981 had a total population of about 1000 adult crocodiles of which about 80% were Crocodylus rhombifer, 5% were Crocodylus acutus and 15% hybrids of these two species. There were also about 5000 immature crocodiles of a similar species composition (Chabreck, 1982).

The main aim of the farm is conservation but there are reports that some of the large crocodiles have been slaughtered for hides (Varona, 1980) and meat which is sold locally (Harrison, 1981).

The two species have inter-bred in the past, but recently attempts have been made to keep the two stocks apart. Most eggs are laid on islands in the lagoons. Up to 25 eggs are collected from each nest and hatched in incubators (Harrison, 1981). In 1981 eggs were collected from 600 nests. The hatching rate for all groups was similar and averaged 46%. The total number of young hatched was about 10,000 (Chabreck, 1982). Some of the C. rhombifer were moved to another breeding centre at Tasajera, south-west of Zapata, in 1978 or 1979 to breed pure individuals of the species (Varona, 1980). It is hoped to release pure-bred C. rhombifer into Zapata Swamp (Harrison, 1981).

INDIA: The Government of India initiated a Crocodile Breeding and Management Project in 1975 with preliminary surveys being undertaken in 1974. The project operated on advice from a UN/FAO Chief Technical Adviser with finance from UNDP (Groombridge, 1982).

Crocodile rehabilitation stations have been established throughout the country and crocodiles have been released in 13 specially created sanctuaries and a further 21 National Parks or other sanctuaries. Up until 1984 a total of 1185 Gavialis gangeticus, 408 Crocodylus porosus and 500 Crocodylus palustris had been released to the wild (Singh *et al.* 1985). More than 2000 eggs a year are collected for captive hatching by different state crocodile projects in India. Captive breeding projects exist at Madras, Nanadankanan (Orissa), Bannerghatta National Park and Bangalore (Groombridge, 1982).

Although it is not currently Government policy to promote commercial crocodile farms in India, the rehabilitation schemes which have taken place within India have shown the potential of C. palustris as a subject for commercial utilisation through farming or free range sustained yield exploitation (Groombridge, 1982).

INDONESIA: Crocodiles have been exploited in Irian Jaya for some time and there is evidence that the wild populations have declined through over-hunting (Petocz, *in litt.* 1983). Farming was started in 1976 but the Government stopped further expansion until the ability of wild stocks to support a farming industry had been assessed. In 1980 there were 4000-5000 crocodiles on farms in Irian Jaya. An indication of the species composition might be obtained from the skins exported to Singapore which are about 10% Crocodylus porosus and 90% Crocodylus novaeguineae (Lever, 1980). Everywhere in the Mamberamo delta and along the river up to Kasonoweja (Pioniersbivak) local people are reported to keep crocodiles in often very dirty enclosures fenced by corrugated iron. Skins of crocodiles reared by the villagers are often bought by the local Government employees who then sell them to the large trading companies (King, *et al.* 1979). The farms were reported to be of varying size and were, on the whole, poorly managed and uneconomic. Most of the farms started because the Government obliged all companies wanting to export skins to operate a crocodile farm. Therefore economics has not been of prime importance, rather the farms have been established to comply with Government regulations. However, by 1980 it was realised that farms would have to be more efficient as the wild population would not support indiscriminate hunting indefinitely. At that time it was found that management was poor on the existing farms, pen design and general health of the crocodiles was only fair and that there was a great need for management training and advice (Lever, 1980).

It is the aim of the Government to institute a farming programme similar to that of Papua New Guinea (Boonsong, 1981). At present a project is being carried out under the title 'Crocodile conservation and industry development in Irian Jaya', involving a number of consultants, which started in October 1984 for an initial period of four months (Petocz, *in litt.* 1984). The purpose is to promote the conservation of crocodiles by utilizing their resources to benefit the indigenous communities. The primary aim is to establish the most suitable areas to set up collecting farms, determine the numbers of crocodiles that will need to be collected, investigate the economics, and recommend appropriate legislation. It is proposed that skin exporters will only be able to obtain live crocodiles from collection farms, and that strict quotas will be set for the exploitation (Anon. 1984d).

Lever (1980) listed 13 farms operating in 1980 and a list of 15 registered crocodile farming companies was supplied by the Director General of Forest Protection and Nature Conservation in 1984 (Rubni, in litt. 1984). No captive-breeding takes place in Irian Jaya (Petocz, in litt. 1984).

Outside Irian Jaya there are also a few rearing farms in the vicinity of Jakarta, which are similarly dependent on eggs and young taken from the wild (King, et al. 1979). The species kept are C. porosus, C. novaeguineae, and Tomistoma schlegelii (Lever, in litt. 1983). Farms have also been established in Kalimantan but most of these were closed by the mid-1970s because the growing rarity of the wild crocodiles made it difficult to secure the eggs and young needed (King, et al. 1979).

ISRAEL: A crocodylian farm was set up at Hammat Gader Hot Springs in 1981. It held a stock of 302 Alligator mississippiensis, 4 Crocodylus niloticus suchus and 3 Osteolaemus tetraspis osborni in 1983. (Ben-Mosche, in litt. 1983). At present it is run solely for tourists but it is intended that live sales to zoos and commercial operations will take place. The initial stock of A. mississippiensis was obtained from farms in the USA (Perry, in litt. 1983). Seven animals were obtained from the University of Tel Aviv. 180 A. mississippiensis were successfully hatched in 1983 (Ben-Mosche, in litt. 1983). A second farm has started in 1984 with 205 C. niloticus (Ranot, Pers. Comm.).

ITALY: The Compagnia Internazionale Allevamento Animali Esotici (CIAAE) established a farm near Brindisi in 1980. It purchased 3000 Caiman latirostris reportedly from Colombia but these suffered severe mortality owing to poor shipment conditions, low winter temperatures and disease. The remaining 406 animals were still being kept in poor conditions at the time the farm was surveyed in January 1981 and it was estimated that 100-150 were on the verge of death. It was suggested to the Managing Director of the firm to postpone the further order of caimans from Colombia (Pooley, in litt. 1981). C. latirostris is not native to Colombia (Groombridge, 1982) and no captive sources are known; it is therefore likely that the species was C. crocodylus.

IVORY COAST: It was reported in 1980 that there were plans for establishing crocodile farms for commercial production (Pooley, 1980).

JAPAN: The Atagawa Tropical Garden and Alligator Farm applied to export 8 Crocodylus moreletii from the USA in 1984 (Anon, 1984e). It is not known whether the export took place, nor whether the "farm" has any commercial function other than public display.

KENYA: In 1977 Kenya passed a law forbidding the sale of most wild animal products in the country. This has prevented farms from operating commercially but crocodile farming is being developed for future production when allowed.



A large crocodile farm was started in 1983 by an Israeli-owned company in a 20-acre (8.1 ha) disused quarry at Nyali, north of Mombasa. It plans to carry a stock of 20,000 Crocodylus niloticus by 1986. Full production, once achieved, should be 3000 skins a year with a value of about US\$70,000. The original stock of 650 crocodiles was trapped along the Tana River in a three-month exercise (Anon., 1984a).

An experimental operation is run by the Baobab Farm near Mombasa. The farm is primarily concerned with arable crops, domestic stock and fish (tilapia) culture, but experimental work began on antelopes in 1975 and on crocodiles in 1982 when it acquired 200 eggs from which 189 C. niloticus were successfully hatched (Haller, *in litt.*, 1983). Future production would probably be based on skin sales.

MADAGASCAR: Madagascar has one crocodile farm, established in 1969 at Antsobolo; this is the only captive-breeding operation for crocodiles registered with the CITES Secretariat in accordance with CITES Resolution Conf. 4.15. Commercial production started in 1974. In April 1983 the farm held a total of 454 Crocodylus niloticus (Berney, *in litt.* 1983). Crocodiles are killed at about 3.5 years of age. About half the skins are tanned in Madagascar for use in the manufacture of goods. The remainder are used for taxidermy. None is exported by the farm (Anon., 1980), but the operation is self-financing from the sale of skins (De Lanessan, *in litt.* 1983). The original stock was taken from the wild in the form of animals less than one year old. These have been raised to form a captive breeding stock. In 1980 the capture of wild animals ceased (Berney, *in litt.* 1983). It took about 10 years to produce the first captive-bred generation in 1980 (De Lanessan, *in litt.* 1983). About one hundred juveniles are now born on the farm each year and it is hoped that this figure will improve as the breeding stock continues to mature (Berney, *in litt.* 1983).

MALAYSIA: In Sabah eggs and young of C. porosus are taken from the wild for rearing in hide farms, but the wild populations are so reduced that this trade has decreased in recent years (King, *et al.* 1979), and it is now illegal (Andau, *in litt.* 1984). One rearing farm, located just outside Sandakan, Sabah has been rearing C. porosus for export since about 1970 (Anon., 1980). It had 1035 C. porosus in 1984 but no breeding had taken place (Andau, *in litt.* 1984).

Rearing farms exist in Sarawak which raise wild C. porosus hatchlings obtained from local fishermen. About 10 Tomistoma schlegelii are also thought to be present in the farms, the skins of which will probably eventually be sent to Singapore (Groombridge, 1982).

MALAWI: Crocodiles were being trapped in 1984 on the Shire River for a proposed farm on Lake Malawi (Van Jaarsveldt, *in litt.* 1984). Seventy-two crocodiles were also supplied to South Africa for a new farm in Natal in 1984 (Pooley, *in litt.* 1984).

MALI: A private company named Mali Reptiles plans to operate a crocodile farm near Bamako, in Mali, involving Crocodylus niloticus but the farm is not yet of commercial status. A small pilot scale farm has been operated since 1979 with 34 C. niloticus captured from Ségou. The crocodiles are held in pods with feeding installations and provision for cleaning the water. Research carried out since 1980 with FAO co-operation has shown the project to be viable. Projected production is between 1000 to 3000 skins by 1986. The farm is financed by a private grant of MF90 000 000 put up by European partners (Sanogho, in litt. 1983).

MEXICO: The Mexican Government has established several farms for Crocodylus moreletii in Chiapas, Tabasco and Oaxaca. Other farms are planned in Yucatan and Quintana Roo, the latter hoping to breed Crocodylus acutus. Another farm is planned for both species in the Lacadon Jungle, Chiapas. It is to be managed by the local people and breeding for both conservation and commercial purposes is planned (Lazcaro-Barrero, 1984).

MOZAMBIQUE: In 1981 a small crocodile 'fram' was in operation in the Zambezi Wildlife Utilization Area of Mozambique, situated on the south bank of the Zambezi River delta and covering approximately 20,000 km<sup>2</sup>. It was planned to expand this at a later date, but no further details have been received (Tello, 1983). The species is presumably Crocodylus niloticus.

NEPAL: A gharial breeding farm exists in the Royal Chitwan National Park which has a stock of 255 Gavialis gangeticus (Maskey, in litt. 1983). It is not at present a commercial operation, however future commerce does not appear to have been ruled out. Eggs are collected within Nepal and animals are subsequently returned to the wild (Groombridge, 1982).

PAKISTAN: IGUANA, a leather company in Pakistan, stated the intention of setting up a commercial breeding programme involving Crocodylus palustris and Gavialis gangeticus, and that advice had been sought from WWF headquarters. The farm was planned to follow the pattern of Samutprakan, Thailand, but was not to be started until a similar project, of greater priority to the company, involving Varanus griseus (desert monitor) had been established (Aftab Alam, in litt. 1980).

PAPUA NEW GUINEA: Crocodile ranching has expanded greatly in Papua New Guinea in recent years, largely as a result of the Government Wildlife Division's newly-adopted National Policy on Crocodile Farming. There were estimated to be about 21,000 Crocodylus novaeguineae and 9000 Crocodylus porosus on ranches in 1983. These range from small village pens, which might never hold more than 25 animals, to large commercial ranches with up to 15,000 and which are still expanding. The two such commercial ranches, both established in 1979, now hold some two thirds of the total stock. There are at least 9 intermediate-sized ranches each with 400-3000 animals, and an unspecified number of village ranches, but the latter have declined in numbers since their peak between 1975 (Hollands, in litt. 1984).

By 1983 no breeding had occurred although some was planned for the future, and the entire stock derived from wild-caught juveniles, mostly in the range of 50-90 cm total length. By Government control of the price system it was ensured that prices of live animals were kept high enough to encourage hunters to spend their time to catch live stock instead of just skins. The numbers of animals collected from the wild are shown in Table 1.

Table 1. Crocodiles collected from the wild for farms in PNG (Hollands, in litt. 1984)

YEAR	<i>C. novaeguineae</i>	<i>C. porosus</i>	Total
1979	3,958	974	4,932
1980	7,669	2,141	9,810
1981	8,118	2,178	10,296
1982	8,602	2,799	11,401
1983	2,518	1,901	4,419
TOTAL	30,865	9,993	40,858

Villagers are encouraged to collect young crocodiles and to sell any that they do not require themselves to the intermediate-sized Government -or privately-run farms. When these have accumulated 300-400 surplus animals, representatives of one of the commercial ranches fly in by light aircraft to collect them. Specially designed cardboard tubes and boxes allow the efficient loading of the animals, and their transport with extremely low mortality. Some of the intermediate ranches derive their entire income from such sales of live animals, while others also rear crocodiles themselves. The Government is actively encouraging the development of these "midi-ranches" at abattoirs and fish plants throughout the country. The two already established at such localities are running very successfully; other operations in this category run well on locally caught fish (Hollands, in litt. 1984).

Exports of farm-produced skins totalled 301 *C. porosus* and 1304 *C. novaeguineae* in 1983 for markets mainly in France and Japan (Goudie, in litt. 1983). This compares with an annual wild harvest during the 1970s and early 1980s of 15 - 35,000 *C. novaeguineae* skins, and 7 - 11,000 *C. porosus* skins. This earned the country approximately US\$2 million a year. (Hollands, in litt. 1984). Skin production was expected to exceed 7,700 in 1984 for farms (Goudie, Pers. Comm).

PHILIPPINES: A crocodile breeding project, run by the Silliman University Marine Laboratory was started on Negros Island in 1981 in conjunction with the Smithsonian Institute and WWF. In 1982 it had a stock of 17 *Crocodylus mindorensis* (referred to as *Crocodylus novaeguineae mindorensis* in CITES) and one *Crocodylus porosus*. The operation is an experimental project investigating conservation techniques and the viability of commercial farming. At present there is no commercial production. All of the crocodiles have been obtained from captive sources, including both private collections and Government projects on Mindanao and Luzon Islands.

In 1982 14 young were produced by one female, the first known captive propagation of C. mindorensis (Anon., 1983b).

The Japan Crocodile Farming Institute in the Philippines (Palawan) has submitted a proposal to start breeding C. mindorensis with an initial stock of 200. The aim of the project is to conserve the near-extinct crocodile population in the area, eventually to re-introduce it to suitable areas to produce a sustainable yield of crocodile products. The Institute intends to train project personnel and local residents in crocodile farming techniques. The 6-year project is being jointly negotiated between the Japanese and Philippine Governments (Anon., 1984b).

There are also reports of a farm established in 1981 at San Ramon, Floridablanca, Pampanga with a stock of 28 Crocodylus porosus (Alvarez, in litt. 1983).

SAMOA: According to a newspaper report in 1981 a West German proposed to build a crocodile farm on the island (Anon., 1983a). No more has been heard of the proposal, but the Director of Agriculture and Forests declared that there was no wildlife farming of any kind in 1983 (Reti, in litt. 1983).

SENEGAL: It was reported in 1983 that there was a proposal to establish a crocodile farm (presumably Crocodylus niloticus) in Casamance and that funds were being sought (Fall, in litt. 1983).

SINGAPORE: A survey of crocodile farming operations, carried out by internationaler Reptillieder-Verband E.V. established that there were three crocodile farms in Singapore (Diehl, in litt. 1983).

The first, Tan Moh Hong Reptile Skind and Crocodile Farm, has a stock of about 600 Crocodylus porosus and Tomistoma schlegelii (Anon., undated). The second, Singapore Crocodilarium Pte Ltd., has several hundred Crocodylus porosus and a few dozen Tomistoma schlegelii (Inskipp, pers. comm.). A third farm is reported to exist in Singapore which is operated by Leah Liang Joo. This farm started in 1970 with 60 crocodiles and by 1976 the stock had increased in size to 3000. Most of the crocodiles are probably C. porosus although some are reported to have been obtained from South America (Youngblood, 1976). There are reports that Crocodylus novaequineae and Caiman crocodilus may also be farmed (Chandler, in litt. 1983).

It is reported that many other crocodile skin businesses kept or have kept young wild crocodiles in back-yard enclosures, raising them until they are about two years old. Some of these establishments kept as many as 400 animals (Singapore Trade, June 1961, vide Anon., 1979). According to King et al. (1979), a large number of rearing flourish in Singapore by importing eggs and young from other Asian and Pacific areas. Stock is known to have been imported from Indonesia, Malaysia, Papua New Guinea, Australia, and the Philippines. Some limited breeding is done on the farms. Output from these farms is expected to decline as surrounding stocks decline.

Skin products are sold in Singapore and are also exported to FR Germany, France, Japan and other countries (Anon. undated). Some of the skins processed in Singapore are imported (Anon., 1979a). Crocodile meat is also sold, both as a delicacy and for medicinal use (Anon., undated).

**SOUTH AFRICA:** The first crocodile farm in South Africa was established by J. Kuhlmann in 1968 outside Pretoria with 14 "nuisance" crocodiles (Kuhlmann, in litt. 1983). This farm currently has 600-700 Crocodylus niloticus (Van Jaarsveldt, in litt. 1983), having bred them regularly since 1970 (Kuhlmann, in litt. 1983). From 1977 onwards several more farms were established around the country, and in 1983 formed themselves into the South African Crocodile Farmers' Association. In 1983 there were 10 farms with a total stock of about 1900 C. niloticus, mostly juveniles obtained from farms in Zimbabwe and South Africa, with the addition of a few adult problem animals (Arnold, in litt. 1983) and stock from the Caprivi Strip, Namibia (Slowgrove, pers. comm.). Another large farm was being set up in Natal in 1984, having arranged to import 72 adult animals from Malawi (Pooley, in litt. 1984). Breeding is planned at all farms but so far, apart from Kuhlmann's farm, has only occurred at two, with a total of 51 hatchling produced in 1982/83 (Arnold, in litt. 1983, Bond, in litt. 1983). Many of the farms obtain income from tourists but none except Kuhlmann's anticipates being able to sell skins until at least 1988 (Arnold, in litt. 1983). It is not clear whether the latter has yet done so. Some of the farms have sold live animals (Bond, in litt. 1983, Kuhlmann, in litt. 1983, Pooley, pers. comm.).

**SPAIN:** A company known as Iberia Enterprises Ltd. requested "as many crocodiles as could be supplied" from the Natal Park Board, Republic of South Africa, for unspecified purposes in 1980. The request was turned down (Pooley, in litt. 1980).

**SRI LANKA:** The CITES Management Authority stated in 1983 that there were no crocodile farms or ranches in Sri Lanka, although there have been several attempts to start such operations (De Alwis, in litt. 1983).

**SURINAME:** There is one commercial crocodilian farm in Suriname, at Groningen, District Saramacca, which is reported to keep Caiman crocodilus for the production of skins. The final destination of the skins is most likely France, but possibly also the Netherlands and FR Germany (Reichart, in litt. to N. Duplaix 1979).

**TAIWAN:** There are 35 crocodilian farms in Taiwan, the first established in 1976, with a total stock of around 8000 Caiman crocodilus, 300 "Indian sharp-mouthed crocodile" (?Gavialis gangeticus) and 300 of other species, including Crocodylus porosus (Tsai, in litt. 1984). Total annual production amounts to 12,500 kg of skins with a value of NT\$10 million (US\$1 = NT\$39), 30,000 kg of meat, worth NT\$12 million, and 7,500 kg of other products worth NT\$8 million. Most is sold within Taiwan but a little is exported to Korea and Japan. Captive-breeding is undertaken, approximately 2000 juvenile crocodiles being produced each year. Each mature female lays about 25-45 eggs with a hatching rate of 45% (Tsai, in litt. 1984).

One of the larger farms, Taiwan Crocodile Ltd., in 1983 had 5200 Caiman crocodilus crocodilus, 30 C. porosus and 15 Tomistoma schlegelii. Some 2700 eggs are laid each year on the farm with a hatching success rate of 13% to 15%. It appears that 300 of the breeding stock were bred on the farm. The animals are killed at two years old when they are about 1.5 m long and weigh about 15 kg. Meat is an important product of the farm as well as skins (Fuchs, 1983). Another company wanted to purchase 1000 live hatchling Crocodylus niloticus from the Natal Parks Board, Republic of South Africa, for import to Taiwan in 1980; purpose unspecified (Pooley, in litt. 1980).

TANZANIA: There is one crocodile farm in Tanzania, established in 1981, which has a total stock of between 1200 and 1500 Crocodylus niloticus. Animals were obtained from the Ruvu and Rufiji Rivers, Tanzania. Prior to April 1983 80 adults and 1400 eggs had been taken from the wild (Katalihwa, in litt. 1983).

THAILAND: The Samutprakan Crocodile Farm and Zoo, managed by Charoon Youngprapakorn, was established in 1950. It carries a stock of 30,000 (Youngprapakorn, in litt. 1983) comprising about 11,700 Crocodylus siamensis, 8550 Crocodylus porosus, 4100 hybrid Crocodylus siamensis x Crocodylus porosus, 88 Tomistoma schlegelii and smaller number of Caiman crocodilus, Crocodylus novaeguineae, Alligator sinensis, Caiman latirostris, Paleosuchus palpebrosus and Crocodylus rhombifer (Suvanakorn and Youngprapakorn, Unpublished).

The crocodylians are bred for meat, skins and teeth, and are a tourist attraction. In 1980 1500 skins were produced and in 1981 900. In 1982 only 200 were slaughtered owing to the low market price for skins (Anon., 1979a). Sixty percent of the skins are processed and sold locally, mostly to tourists, while the other 40% are salted and shipped abroad (Suvanakorn and Youngprapakorn, Unpublished). In 1974 the farm was supplying 80% of the Thai crocodile skin trade.

From 1980 to 1982 approximately 1200 C. porosus and 3600 C. siamensis were hatched in each year. In Crocodylus porosus hatch rate is 40-50%; in C. siamensis hatch rate is 50-60%. From 10-15% of hatchlings (or up to 30% according to Leather magazine (Anon., 197b) die in their first year, then mortality drops to below 5% (Suvanakorn and Youngprapakorn, Unpublished).

TOGO: A crocodile farming project (presumably Crocodylus niloticus) was expected to be set up "in the near future" in 1983 (Dogbi-Tomi, in litt. 1983).

UNITED STATES OF AMERICA: Alligator "farming" in the USA started at least as long ago as 1891 but these early ventures were purely for the purpose of attracting visitors. It was not until 1964 that the Louisiana Department of Wildlife and Fisheries began research into ranching Alligator mississippiensis. Small experimental farms were established in Louisiana and Florida utilising wild stock. These farms grew at a very slow rate and it was only in the summer of 1978 that alligator farmers in Florida sold their first captive-

raised skins. In 1980 there were five active alligator farms in Florida holding a total of 7000 animals. Less than 15% of these were breeding stock, the remainder being at various stages of rearing. In Louisiana in 1980, there were eight alligator farms keeping a total of 13,000 animals (Ashley, 1980). In 1983 there were 14 breeders in Louisiana and 12 in Florida (Goodwin, in litt. 1983).

Only one farm had started selling skins in 1980 (Ashley, 1980). By 1982 at least two farms were involved, one of which was also selling meat (Boonsong, 1981; Keller, in litt. 1983). A fully operational farm producing 100 marketable skins a year would have to maintain a stock of 3500 to 5000 animals.

The Louisiana farm stocks are being supplemented with wild-caught animals during their first five to seven years of operation to help them acquire breeding stock and expand their operations. In 1979 the Department of Wildlife and Fisheries provided the Louisiana farms with about 1700 wild hatchlings under a management project designed to supplement new alligator farmers (Ashley, 1980).

In 1980 the five active Florida farms were collectively producing about 2500 hatchlings a year. Many of the Louisiana farms are small and in 1980 were collectively only producing about 1500 hatchlings a year. The long term goal of the Louisiana programme at least is to become primarily orientated towards captive-breeding (Ashley, 1980).

URUGUAY: A project involving the captive-breeding of Caiman latirostris for conservation purposes was planned in 1977 (Anon., 1977) but had not been implemented by 1983 (Achaval, in litt. 1983).

VENEZUELA: The Ministerio del Ambiente y de los Recursos Naturales Renovables has recently proposed a possible multi-level management scheme for wild Caiman crocodilus. This includes ranching in which eggs would be collected from the wild for incubation. The hatchlings would be kept in 1 m by 3 m tanks and fed on small fish, finely chopped meat and insects. After one year they would be returned to semi-wild conditions in the form of fenced-off natural lakes and rivers where again they would be fed on fish and meat. The animals would be harvested after three years for their skins, the meat being fed back to the younger stock (Anon., 1982b).

ZAMBIA: There are two operational crocodile farms in Zambia, the Kariba Crocodile and Fish Farm which has about 200 Crocodylus niloticus (Parker, in litt. 1984), and another on Lake Tanganyika which has around 500 crocodiles (Van Jaarsveldt, in litt. 1984). The first skins were expected to be ready for marketing by the end of 1983 (Anon., 1982b). All stock has been obtained from the wild. Eggs have been collected in Zambia under Government licence and hatched at the farm. The Government controls the number of eggs allowed to be taken and the areas from which this can be done. It then demands the release of 10% of the stock after two years. 1417 eggs were hatched in 1981 and 794 in 1982 (Parker, in litt. 1983). The first farm hoped to be permitted to catch adult animals for breeding purposes in 1984 but no breeding has yet occurred (Parker, in litt. 1984).

A third farm, Lauangwa Crocodile and Safaris, is not operational yet (7/84), but hopes to collect about 5000 eggs to operate along the lines of the farms in Zimbabwe (Van Jaarsveldt, in litt. 1984).

ZIMBABWE: Nile crocodiles have been ranched in Zimbabwe since 1965; there are now five crocodile ranches in existence there. Two further ranches existed in the 1960s but were both short-lived (Blake, 1982). The five ranches held a total of nearly 26,000 Crocodylus niloticus in December 1982, comprising 10 360 hatchlings, 16 308 rearing stock and 227 broodstock (Cumming, in litt. 1983).

Crocodile ranching was experimentally introduced into Zimbabwe with the emphasis placed on collecting eggs from good breeding population areas, artificially incubating them and rearing the hatchlings (Ashley, 1980). From 1967 to 1973 a total of 22 679 eggs were collected and 16 679 were hatched, giving a mean hatching success rate of 73.6% (Ashley, 1980). The stocks come from "government egg supplementary programmes" and each ranch is annually designated an egg-collecting areas and a quota of between 2000 and 2500 eggs that may be collected (Van Jaarsveldt, in litt. 1983).

The ranches have breeding facilities with a potential production of 3000 eggs in 1982 (Van Jaarsveldt, 1982). Actual hatchling production from captive-bred eggs in the year was 1807 (Cumming, in litt. 1983). The hatching percentage and numbers are expected to increase significantly each year, but it will still be necessary to supplement the breeding stocks with the collection of eggs from the wild to retain genetic viability (Van Jaarsveldt, 1982).

In 1981 season 2890 skins were produced for export from ranches in Zimbabwe. All skins are marked with numbered tags and are currently exported through the Crocodile Farmers Association of Zimbabwe; records are also kept by Zimbabwe Department of National Parks and Wild Life Management (Van Jaarsveldt, 1982).

Crocodile farmers in Zimbabwe must provide the Department of National Parks and Wild Life Management with a monthly return of stock on hand, hatchlings, deaths, killings, eggs collected and hatches. Government policy requires that 5% of suitably-sized crocodiles be made available for conservation purposes. This availability "is in the form of crocodiles of a size suitable for restocking denuded habitats, augmenting wild populations, research or the meeting of international obligations" (Van Jaarsveldt, 1982).

#### Discussion

Commercially-orientated crocodylian farms have been located in twenty-two countries using eight main species of crocodylian. The numbers of each species are summarised in Table 3. Crocodylus niloticus is the most widespread with a total of about 33 000 being kept in ten different countries, followed by Crocodylus porosus, some 25 000 of which are kept in eight countries. These two species are the most highly valued by the leather industry. 8000 Caiman crocodylus are kept in Taiwan, but it seems that meat and other products may be the main incentive here as together they produce twice the value of the skins.



Crocodylian farming for skins is a relatively new industry, the oldest farm having started in 1950, and the majority in the last five years. Most farms are still building up their stocks, few have started commercial skin production, and captive-breeding capacity is limited by the lack of mature broodstock. This is reflected in the figures presented in Table 4, which summarise the most recent available data. Skin production from farms is in the region of 7000 a year from a farm stock of some 142 000 crocodylians. In full production this total stock could potentially produce about 28 000-35 000 skins a year. Added to this most farms report planning to increase their stocks, and so there is clearly considerable expansion to be expected.

In spite of the early stage of development of captive-breeding, the total number of hatchlings produced on farms is about 14 000, which, if the figures are to be believed, represents over a third of the total numbers collected from the wild each year. Papua New Guinea, Zimbabwe and Australia are the main countries where farms rely on wild-caught stock, and of these Zimbabwe and Australia both have substantial and expanding captive-breeding programmes.

#### Acknowledgements

This survey would have been impossible without the willing assistance and co-operation of the numerous correspondents who replied to letters and filled in questionnaires. Their help has been credited wherever possible in the references, and the authors would here like to express their gratitude. Funds for this survey were generously provided by the International Fur Trade Federation and IUCN.

#### Literature Cited

- Anon. 1977. Comprehensive action programme for the conservation of crocodiles. Draft Project 3: Conservation of Caiman latirostris in Uruguay, Argentina and Southern Brazil. IUCN/SSC Crocodile Specialist Group.
- Anon. 1979a. Croc it to me. The Singapore Visitor February 17 - March 2.
- Anon. 1979b. The crocodile: a vanishing or a developing resource. Leather (April): 63-66.
- Anon. 1980. IUCN Crocodile Specialist Group Newsletter N° 18, 6pp.
- Anon. 1982a. Aprovechamiento Racional de la Baba o Babo (Caiman crocodylus). Ministerio del Ambiente y de los Recursos Naturales Renovables, Venezuela.
- Anon. 1982b. Zambia's crocodile firm. The Standard (Zambia) 21 May.
- Anon. 1983a. IUCN Crocodile Specialist Group Newsletter 2(1): 8.

- Anon. 1983b. Breeding success at crocodile farm. WWF Monthly Report. September.
- Anon. 1983c. Managing tropical animal resources. Crocodiles as a resource for the tropics. National Research Council. National Academy Press, Washington D.C.
- Anon. 1984a. Kenya plans a home for 20,000 crocodiles. New York Times. 4 May.
- Anon. 1984b. Asia-Pacific Forestry Commission country reports Philippines. Tigerpaper 11(2): 11-13.
- Anon. 1984c. Nang Fang Ribao (People's Republic of China) 10 April.
- Anon. 1984d. USAID co-financing grant proposal. Crocodile conservation and industry development in Irian Jaya; preparatory phase I consultancy, 8pp.
- Anon. 1984e. US Fish and Wildlife Service, Endangered Species Permit; receipt of applications. USA Federal Register 49(91): 1974.
- Anon. unated. Tah Moh Hong Reptile Skin and Crocodile Farm. Publicity brochure, 2pp.
- Ashley, J.D. 1980. Crocodilian farming: past, present and future. Paper presented to the Society for the Study of Amphibians and Reptiles (USA) and to a meeting on crocodile conservation of the International Union for Conservation of Nature and Natural Resources, Gainesville, Florida, USA.
- Blake, D.K. 1982. Crocodile ranching in Zimbabwe, The Zimbabwe Science News 16(9).
- Boonsong Lekagul 1981. Wildlife resources for rural community development. Tigerpaper 8(3).
- Caughley, G. 1980. Crocodiles in Burma. FAO Report.
- Chabreck, R.H. 1982. Crocodile management programmes in Cuba. FAO. Inpublished report, 8pp.
- Fuchs, K.H. 1983. Crocodile farming and ranching in Taiwan, IUCN SSC Crocodile Specialist Group Newsletter 2(2): 13.
- Groombridge, B. 1982. The IUCN Amphibia - Reptilia Red Data Book, Part 1. IUCN, Gland, Switzerland, 426pp.
- Harrison, G.H. 1981. Raising crocs, not cane. Animal Kingdom (June/July): 27-29.
- King, F.W., Campbell, H.W., Messel, H. and Whitaker, R. 1979. Review of the status of the estuarine or saltwater crocodile, Crocodylus porosus. (Unpublished Report).

- Lazcano-Barrero, M.A. 1984. Area reports, Mexico. IUCN SSC Crocodile Specialist Group Newsletter 3(2): 9-10.
- Le Francois, R. 1974. Report- L'élevage du Crocodile du Nile. Centre Technique du Cuir.
- Lever, J. 1980. Crocodile conservation and industry development in Irian Jaya. Report on consultancy, sponsored by FAO, prepared for the Directorate of Nature Conservation, Directorate General of Forestry, Bogor, Indonesia, 53pp.
- Medem, F. 1980. Caimans & crocodiles - a tale of destruction. Oryx 15(4): 390-391.
- Medem, F. 1980. Sanctioned exportation of caiman hides from Colombia. TRAFFIC (International) Bulletin 2(9&10): 95-96.
- Onions, J.T.V. 1982. Crocodile farm project- Edward River, Queensland. Australia. Proceedings of the 5th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources convened at Florida State Museum, Gainesville, Florida U.S.A. 12-16. August 1980.
- Pooley, A.C. 1980. The decline of crocodiles in Africa. Traffic (International) Bulletin 11 (9&10): 94.
- Singh, L.A.K., Kar, S., Choud B.C. 198? Indian crocodiles: a 10 year review of management. (This volume).
- Suvanakorn, P. and Youngprapakorn, C. Undated. The breeding of crocodiles in captivity at Samutprakan, Thailand.
- Tello, J. L. 1983. Mozambique's cropping scheme in the Zambezi Delta Area. Report presented to 59th SSC meeting of the International Union for Conservation of Nature, Harare, Zimbabwe, 16 April 1983.
- Van Jaarsveldt, K.R. 1982. The present trade in skins of Crocodylus niloticus ranched and reared in Zimbabwe. Paper presented to symposium on crocodile conservation and utilisation, and the sixth working meeting of the IUCN/SSC Specialist Group 18/30 Sept., Victoria Falls, Zimbabwe.
- Varona, L.S. 1980. Protection in Cuba. Oryx 15(3): 284.
- Wallis, B.E. 1980. Marketing assistance programme for agricultural products from least developed countries. Market prospects for reptile leathers. UNCTAD/GATT International Trade Centre ITC/DIP/12.
- Whitaker, R. 1982a. Crocodile conservation in India. The Zimbabwe Science News 16(9): 211-213.

Whitaker, R. 198b. Export prospects from commercial crocodile farms in Bangladesh. International Trade Centre/UNCTAD/GATT, Doc. ITC/DIP/63.

Youngblood, R. 1976. Baby crocodiles become big business. Jakarta, December, (Files of IUCN Wildlife Trade Monitoring Unit).

Table 2. Species of crocodylian kept in different countries.  
 KEY: F: farmed on a large scale, f: farmed on a  
 scale, c: conservation/research operations, s: mainly  
 conservation but some sales may take place, p:  
 proposed operations, ?: status uncertain.

	<u>A. mississippiensis</u>	<u>Alligator sinensis</u>	<u>Caiman crocodilus</u>	<u>Caiman latirostris</u>	<u>Melanosuchus niger</u>	<u>Paleosuchus palpebrosus</u>	<u>Paleosuchus triconatus</u>	<u>Crocodylus acutus</u>	<u>C. intermedius</u>	<u>C. johnsoni</u>	<u>C. mindorensis</u>	<u>C. moreletii</u>	<u>C. niloticus</u>	<u>C. novaeguineae</u>	<u>C. palustris</u>	<u>C. porosus</u>	<u>C. rhombifer</u>	<u>C. siamensis</u>	<u>Osteolaemus tetraspis</u>	<u>Tomistoma schlegelii</u>	<u>Gavialis gangeticus</u>
Australia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bangladesh	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bolivia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Botswana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bruma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chad	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
China	.	s	.	.	.	.	.	.	.	.	.	.	p	.	.	.	.	.	.	.	.
Colombia	.	.	c	.	.	c	c	.	.	.	.	.	.	.	p	.	.	.	.	.	.
Cuba	.	.	.	.	.	.	.	s	c	.	.	.	.	.	.	.	.	s	.	.	.
India	.	.	.	.	.	.	.	.	.	.	.	.	.	.	p	c	.	.	.	.	.
Indonesia	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.
Israel	f	.	.	.	.	.	.	.	.	.	.	.	s	.	.	.	.	.	s	.	.
Italy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ivory Coast	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Japan	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kenya	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Madagascar	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.
Malaysia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mali	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	s	.
Mexico	.	.	.	.	.	.	.	p	.	.	.	.	.	.	.	.	.	.	.	.	.
Mozambique	.	.	.	.	.	.	.	.	.	.	.	.	.	c	.	.	.	.	.	.	.
Nepal	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.
Pakistan	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PNG	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.	p	.	.	.	.	p
Philippines	.	.	.	.	.	.	.	.	.	.	c	.	.	.	.	.	.	.	.	.	.
Samoa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senegal	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Singapore	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
South Africa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	f	.
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sri Lanka	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Surinam	.	.	f	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taiwan	.	.	f	.	.	.	.	.	.	.	.	.	p	.	.	.	.	.	.	.	.
Tanzania	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thailand	.	s	s	s	s	.	.	.	.	.	.	.	.	s	f	s	f	.	f	.	.
Togo	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
USA	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Uruguay	.	.	.	p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Venezuela	.	.	p	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zambia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zimbabwe	.	.	.	.	.	.	.	.	.	.	.	.	f	.	.	.	.	.	.	.	.

Table 3. Approximate numbers of each species of crocodylian kept on commercial farms in different countries. "?" represents present, but numbers unknown.

	<u>Alligator mississippiensis</u>	<u>Caiman crocodilus</u>	<u>Melanosuchus niger</u>	<u>Crocodylus johnsoni</u>	<u>Crocodylus niloticus</u>	<u>Crocodylus novaeguineae</u>	<u>Crocodylus porosus</u>	<u>Crocodylus siamensis</u>	<u>Tomistoma schlegelii</u>
Australia	-	-	-	6612	-	-	4351	-	-
Bolivia	-	?	?	-	-	-	-	-	-
Botswana	-	-	-	-	70	-	-	-	-
Burma	-	-	-	-	-	-	900+	-	-
Indonesia	-	-	-	-	-	4500	500	-	-
Israel	302	-	-	-	4	-	-	-	-
Italy	-	-	-	-	-	-	-	-	-
Kenya	-	-	-	-	839	-	-	-	-
Madagascar	-	-	-	-	454	-	-	-	-
Malaysia	-	-	-	-	-	-	1035+	-	10
Mali	-	-	-	-	34+	-	-	-	-
Mozambique	-	-	-	-	?	-	-	-	-
PNG	-	-	-	-	-	21000	9000	-	-
Singapore	-	-	-	-	-	-	3600+	-	10+
South Africa	-	-	-	-	1900	-	-	-	-
Surinam	-	?	-	-	-	-	-	-	-
Taiwan	-	8000	-	-	-	-	300	-	15
Tanzania	-	-	-	-	1200	-	-	-	-
Thailand	-	-	-	-	-	-	8550	11700	88
USA	20000	-	-	-	-	-	-	-	-
Zambia	-	-	-	-	2500	-	-	-	-
Zimbabwe	-	-	-	-	26000	-	-	-	-
TOTAL	20302	10000	2000	6612	33001	25500	28236	11700	123

Table 4. Summary of most recent figures for the stock, annual production, breeding and wild-collection of commercial crocodilian farms in different countries.

	Number of farms	Total crocodilian stock	Current production of skins	Intake of eggs/adults from wild	Farm-bred hatchlings
Australia	5	10 963	0b	3 500 +	769
Bolivia	1	?	0	-	-
Botswana	1	70	0e	2 000 c	0
Burma	1	900 +	0b	465	? a
Indonesia	15	5 000	?b	?	0
Israel	1	309	-	0	180
Italy	1	406	-	-	-
Kenya	2	839	0	650	189
Madagascar	1	454	?	0	100
Malaysia	9 +	1 600	?	?	0
Mali	1	34 +	0d	-	0
Mozambique	1	?	-	-	-
PNG	11 +	30 000	7 700	11 400	0
Singapore	3	3 600 +	?	?	?
South Africa	10	1 900	0e	60	51 +
Surinam	1	?	?	-	-
Taiwan	35	8 000	2 000	-	2 000
Tanzania	1	1 200	0c	1 480	0
Thailand	1	30 000	200	0	4 800
USA	26	20 000	200	1 700	4 000
Zambia	2	2 500	?a	1 417 +	0
Zimbabwe	5	26 000	2 890	9 421 +	1 807
TOTAL	134	142 175	12 990	32 093 +	13 896 +

? Believed to occur, numbers unknown

- No information

a Planned for 1983

b Planned for 1984

c Planned for 1985

d Planned for 1986

e Planned for 1988

THE PECULIARITIES OF CROCODILIAN POPULATION DYNAMICS AND THEIR  
POSSIBLE IMPORTANCE FOR MANAGEMENT STRATEGIES

William E. Magnusson  
Departamento de Ecologia, Instituto Nacional  
de Pesquisas da Amazonia  
Caixa Postal 478, 69000 Manaus, Amazonas, Brasil

The concept of r- and K- selection has provided a useful framework to compare life-history strategies (Pianka, 1970). It is possible to identify species that contain long lived individuals and which produce small numbers of young each of which receives a large investment in terms of energy from the parent. Populations of these species are generally considered to be relatively stable and limited by resources, resulting in competition between juveniles (K-selected). Species which are subjected to unpredictable conditions will not reach the carrying capacity of their habitat. Juveniles will suffer high mortality regardless of the investment by the parent so selection is for the production of large numbers of inexpensive young which can disperse in search of favorable conditions (r-selection). The uncritical use of r- and K- selection and its various definitions have been criticized (Parry, 1981), but the concept is logical and groups which do not fit on the r-/K-continuum deserve careful scrutiny. Crocodilians are one such group.

Adult crocodilians are large (masses of adult females range from about 10 kg for Paleosuchus to over 150kg for Crocodylus) and are amongst the most long-lived vertebrates (Gibbons, 1976). However, clutch sizes are large (ranging from about 15 for Paleosuchus to over 60 for some species of Crocodylus) and neonate sizes are tiny in comparison to the mother. A neonate of Paleosuchus trigonatus (a small species with a small clutch size) weighs only about 0.5% as much as its mother. Larger species have relatively smaller neonates. This is the paradox. The theory of r-/K-selection says that large, long-lived animals should invest their reproductive effort in few, large young. Crocodilians are large and long-lived, but produce many young that are amongst the smallest relative to the mother, of any reptile.

Why crocodilians are different is of more than academic interest. The management strategies appropriate for r- and K-selected species are usually quite different, especially under exploitation. Here I will try to synthesize what is known of a number of species of crocodilians from many different habitats in an attempt to identify patterns and indicate areas which are in need of more research.

Attempts have been made at modelling the population dynamics of Alligator mississippiensis (Nichols et al., 1976) and Crocodylus niloticus (Blomberg et al., 1982). Those models have considered the physical factors affecting recruitment (mainly water levels) and their interaction with one biological factor, non-selective density-dependent cannibalism on the smallest size classes. These models and other, less explicit, management schemes (Bolton and



Laufa, 1982; Whitaker, 1982; Blake and Loverdige, 1975) assume that crocodilians produce an excess of "expendable" young which can be cropped without influencing adult populations levels. Assuming that crocodilians did not evolve this strategy purely for the benefit of wildlife managers, there must have been selective advantage for females which produced many small young. Why not produce a few, large, competitively-superior young? Such young would be immune to attack by many of the predators known to take hatchling crocodilians. The logical conclusions are that those predators are not important, or that larger young are not competitively superior. With whom would the young crocodilian be competing? Food limitation has not been shown to be a major factor in crocodilian population dynamics (though it has been little studied) so the resources for which the young compete would most probably be space, mates, or both in the case of territorial species.

Could a young strong individual in a population of crocodilians displace on a old weak individual from a territory as might occur in a population of mammals? Almost certainly it could not. Crocodilians continue to grow long after they reach sexual maturity. A recently mature animal will always be at a critical weight disadvantage. It is very unlikely that it will survive, much less win, an encounter with an older individual.

Adult crocodilians are long-lived and have few predators. Unhunted populations of adults probably increase until they are limited by resources (food, space, mates). Under natural conditions there is probably intense competition for these resources and it is the small, recently mature animals which will lose out in this competition. The only chance a young adult has of establishing itself in the population is to find a place in which the resident adult has died, which is a relatively rare occurrence. The crocodilian reproductive strategy can now be seen to be reasonable. In the absence of any chance of making her young competitively superior when are seeking to enter the adult population, the best strategy for a female is to produce large number of small young, and hence increase the chance that at least some will happen upon a vacant area. It is the stability of the adult populations that makes the environment unpredictable for young crocodilians.

The ideas outlined above differ substantially from the models of Nichols *et al.* (1976) and Blomberg *et al.* (1982) in which most mortality due to conspecifics is thought to be a result of cannibalism on the very smallest size classes. What is the evidence? Cannibalism of hatchlings does occur, especially under conditions of extreme crowding in zoos, but there is ample evidence that crocodilians have complex behavioral repertoires which normally result in the protection of sub-adults by adults rather than cannibalism (e.g. Hunt, 1977; Pooley, 1977, 1982). Cannibalism in the wild has been reported for Caiman crocodilus (Staton and Dixon, 1975; Medem, 1981), Alligator mississippiensis (Giles and Childs, 1949; Valentine *et al.*, 1972), Crocodylus niloticus (Cott, 1961; Pooley, 1969), Crocodylus porosus (Worrell, 1964; Webb and

Messel, 1977), Crocodylus acutus (Schmidt, 1924), Paleosuchus palpebrosus and P. trigonatus (Medem, 1981). However, these records are comparatively rare considering the number of detailed studies that have not revealed cannibalism. Graham (1968) and Blomberg (1977) examined 239 and 493 stomachs, respectively, of C. niloticus, many of which were adults. Neither author reported remains of crocodiles in the stomachs. Taylor (1979) found no evidence of cannibalism in 239 stomachs of subadult C. porosus, Seijas and Ramos (1980) reported no canibals among the 49 C. crocodilus they examined, and Webb et al. (1982) found no crocodilian remains in the stomachs of 153 C. johnstoni. Clearly, members of their own species normally are not important items in the diets of crocodilians.

Sizes of cannibals and their victims are rarely reported, but there is strong evidence that most cannibalism is coincidental to social interactions between adults or between adults and almost mature subadults. Giles and Childs (1949) reported a 45cm A. mississippiensis from the stomach of another individual. That is the only documented case of cannibalism of a small juvenile by a crocodilian in the wild that I have been able to locate. Cott (1961) and Pooley (1969) report cases of Crocodylus niloticus about 1m in length being eaten by individuals about 4m long. Only 2 of 17 cannibals recorded by Cott were less than 3m long. Schmidt (1924) reports a 120-150cm C. acutus that was eaten by a 3m conspecific. Staton and Dixon (1975) report two 40-50cm SVL (80-100cm total length) C. crocodilus that were apparently cannibalized. Medem (1981) reported the lengths and sexes of two C. crocodilus, a P. palpebrosus and a P. trigonatus which cannibalized conspecifics. All were large adult males. Carr (in foreward to the 1976 reprint of McIlhenny 1935) referring to a large female alligator resident on his property said: "Young alligators, her own or others that wander in from time to time, always disappear when they get to be five or six feet long". Webb and Messel (1977) reported higher injury rates of C. porosus when they approach sexual maturity and report a 58cm SVL individual (about 115cm total length) that was apparently killed but not eaten by a larger conspecific. The evidence for little cannibalism on very young animals, but intense social interactions between adults and large subadult young which often lead to the deaths, but not necessarily cannibalism, of the latter, is strong. Strangely the only population model of crocodilian population dynamics to consider this aspect is that of Messel et al. (1981). The models of Nichols et al. (1976) and Blomberg et al. (1982) include exactly the opposite process: cannibalism for the first 3 years and none thereafter.

Hunting mortality (at reasonable levels) is compensatory for natural mortality, rather than additive to it, for many species (Anderson and Burnham, 1976; Burnham et al. 1984). It is not known whether hunting mortality is compensatory or additive in crocodilian populations but the two models describe above differ in the degree to which hunting mortality is likely to be compensatory. If almost all natural mortality occurs before the animals reach commercial size (the models of Nichols et al., 1976, and Blomberg et al., 1982), hunting mortality must be additive. If there is significant mortality of subadults after they reach commercial size (Messel et al. 1981, this paper) hunting mortality may be partly compensatory.

Most models of the population dynamics of hunted species assume that mortality is positively related to population density, but is this necessarily so for crocodylians? The evidence given above strongly suggests that many subadults die in conflicts with larger individuals, but the tolerance of adults for conspecifics is not fixed for a species, it varies with the experience of the animals. Captive-raised alligators (Alligator mississippiensis) can be kept at densities ten times higher than animals captured from the wild (Joanen and McNease, 1980). Over long periods of time the minimum exclusive area demanded by individuals within the population probably contracts as similar sized individuals take up areas within the territories of large conspecifics that have died. The limit will be determined by the resources available (food, nesting ponds etc.).

Hunting for extended periods (10-20 years) may severely affect the densities and size distributions of crocodylian populations. The few wary animals that survive may become accustomed to the exclusive use of very large areas (superterritories). At the cessation of hunting, reproduction should supply recruits to the breeding population but will the resident adults which are very large (they have been growing throughout the period of hunting), and used to the exclusive use of large areas, allow the large subadults to survive? In some situations such as the tidal rivers of northern Australia (Messel et al., 1981) it appears that they do not. Nonetheless, other species of crocodylians that were heavily hunted recuperated quickly (e.g. Alligator mississippiensis - Palmisano et al., 1973). It is likely that the structure of the habitat influences the ability of large animals to maintain exclusive use of large areas. In simple habitats such as rivers and streams animals may patrol their entire territories in a single night (of the order of 1km of water course for Paleosuchus trigonatus and possibly tens of kms of tidal rivers for Crocodylus porosus). It would take much more time, and cost much more in terms of lost feeding opportunities for an Alligator mississippiensis to patrol an area of marsh with similar linear dimensions. The more complicated the habitat, the less likely that altered social systems in hunted populations will influence the rate of recovery. Garrick and Lang (1977) suggested that the difficulty of encountering conspecifics in marsh habitat has led to the evolution of calls as a major social signal in marsh crocodylians. River and lake species use visual signals. The costs associated with trying to maintain exclusive use of large areas probably resulted in little selection for territoriality in species that live in marsh and swamp systems even before the advent of intensive hunting.

Another important difference between Alligator mississippiensis and other species of crocodylians is the occurrence of habitat segregation between the sexes. If the hypothesis I presented at the beginning of this paper (that juvenile survival is largely independent of adult density in crocodylians) is true the most efficient management strategies would aim at cropping juveniles before the bottleneck when they try to enter the adult population,

and maximise adult densities (e.g. management programs of Zimbabwe (Blake and Loveridge, 1975) and Papua New Guinea (Bolton and Laufa, 1982). Conventional wildlife management wisdom that the maximum sustained yield is obtained at about half natural densities (Caughley 1977: 180) probably does not apply to crocodilians. Harvesting adults of Alligator mississippiensis is efficient only because hunting mortality can be concentrated on males, and hence has little effect on recruitment (Palmisano et al. 1973). Hunting reduces the nesting female cohort of Crocodylus nilotus to about 7% of equilibrium levels in the model of model of Blomberg et al. (1982). The model population is then unable to maintain sufficient recruitment to sustain commercial hunting. The authors suggested that egg collection and captive raising was the only viable management alternative for this population. However, such schemes are costly and likely to involve techniques not suited to the technological abilities of the local people (Magnusson, 1984). A different hunting system concentrating on large subadults, that avoided mortality of adults or at least of adult females, could well yield very different results.

The initial effect of hunting on a species depends on the value of its skin, its population dynamics, and the ease of hunting the area. The rate of recovery after hunting may depend on behavioral factors such as those outlined earlier. It is not possible to differentiate the effects of these factors with the data presently available, but it is obvious that in concert they have resulted in riverine crocodilians suffering more from hunting than species in other habitats. All species of crocodilians that are intensively hunted are listed in the IUCN Red Data Book (Groombridge, 1982) as endangered, vulnerable or recovered (out of danger). "Endangered" indicates that the species has suffered badly from hunting. "Vulnerable" indicate that the hunting, although not presently endangering the species, is uncontrolled. "Recovered" applies only to the American alligator. Table 1 shows the status and habitats of crocodilian species important for the leather industry that are affected primarily by hunting. Other species (Alligator sinensis, Caiman latirostris, Crocodylus mindorensis and C. rhombifer) listed in the Red Data Book, but for which it was not possible to differentiate the effects of hunting from habitat destruction, were not included. Crocodylus niloticus may be considered to have as its primary habitat rivers, lakes, swamps or savannas depending on the population, and some populations migrate between habitats (Pooley, 1982). Likewise, the populations are variously endangered, vulnerable or recovered. As it was not possible to obtain reliable data for each population, this species was not included in the table. The many subspecies of Caiman crocodilus occur in a variety of habitats, but most of the commerce in the species is presently based on populations in savanna habitats, so it was included as primarily a savanna species. Species such as Osteolaemus tetraspis and Crocodylus cataphractus, listed in the Red Data Book as "indeterminate" were not included. Designation of a particular habitat as the primary habitat for a species is subjective in

some cases, but the overall pattern is obvious. Most endangered species live in rivers or lakes, and most species that have resisted the deleterious effects of hunting live in swamps or savannas.

Rivers and lakes are relatively simple systems and are easily hunted, whereas hunting in swamps and marshes is much more difficult. Savanna habitats are easily hunted in the dry season, but the two savanna species have comparatively low grade skins. Nonetheless, these simple observations may not be sufficient to explain the slow natural recovery of some species after protection is enforced. We need to know more about the effects of hunting on the social structures of populations in different habitats. Population models based on Alligator mississippiensis, the best studied crocodylian, may not be applicable to crocodylians living in other habitats.

In summary: Indeterminate growth of adults may lead to low and unpredictable recruitment of juveniles into adult populations of crocodylians. However, there is little evidence that survival of juveniles, up to the point that they are almost mature, is dependent on adult densities. Therefore hunting strategies that minimize mortality of adult females should maximize recruitment of animals to the juvenile and, potentially, the hunted population. The effects of adults on large, almost mature, subadults appear to be severe, so hunting should take place before the juveniles reach the size at which adults no longer tolerate them (about 1.0 - 1.5, for most species). More work needs to be done on the effects of hunting and habitat on crocodylian social systems in order to efficiently manage recovering stock of crocodylians.

#### Literature Cited

- Anderson, D.R. and K.P. Burnham 1976. Population ecology of the mallard: 6. The effect of exploitation on survival. U.S. Fish Wildl. Serv. Resour. Publ. 128: 66pp.
- Blake, D.K. and J.P. Loveridge 1975. The role of commercial crocodile farming in crocodile conservation. Biol. Conserv. 8: 261-272.
- Blomberg, G.E.D. 1977. Feeding ecology, nesting ecology and habitat preference of Okavango crocodiles. Botswana Notes Rec. 2: 131-139.
- Blomberg, G.E.D., B.C. St Pierre, K.D. Smith, S.M. Caddell and S.R. Pett 1982. Simulated population dynamics of crocodiles in the Okavango River, Botswana. Pp. 343-375 In D. Dietz, F.W. King and R.J. Bryant (eds) Crocodiles: Proc. 5th Working Meet. Croc. Spec. Group of the SSC/IUCN.
- Bolton, M. and M. Laufa 1982. The crocodile project in Papua New Guinea. Biol. Cons. 22: 169-189.

- Burnham, K.P., G.C. White and D.R. Anderson 1984. Estimating the effect of hunting on annual survival rates of adult mallards. *J. Wildl. Manage.* 48(2): 350-361.
- Caughley, G. 1977. *Analysis of Vertebrate Populations*. John Wiley and Sons, London.
- Cott, H.B. 1961. Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (Crocodylus niloticus) in Uganda and northern Rhodesia. *Trans. Zool. Soc. London* 29(4): 211-356.
- Garrick, L.D. and J.W. Lang 1977. Social signals and behaviors of adult alligators and crocodiles. *Amer. Zool.* 17: 225-239.
- Gibbons, J.W. 1976. Aging phenomena in reptiles. Pp. 453-475 In M.F. Elias, B.E. Eleftheriou and P.K. Elias (eds). *Special Review of Experimental Aging Research*. EAR Inc., Bar Harbour.
- Giles, L.W. and V.L. Childs 1949. Alligator management on the Sabine National Refuge. *J. Wildl. Manage.* 13: 16-28.
- Graham, A. 1968. The Lake Rudolf crocodile (Crocodylus niloticus Laurenti) population. Report to the Kenya Game Department by Wildl. Services Ltd.: 146pp.
- Groombridge, B. 1982. The IUCN Amphibia - Reptilia Red Data Book. Part. 1. Testudines, Crocodylia, Rhynchocephalia. IUCN, Gland: 426pp.
- Hunt, H.R. 1977. Aggressive behavior by adult Morelet's crocodiles (Crocodylus moreleti) toward young. *J. Herpetol.* 33(2): 195-201.
- Joanen, T. and L. McNease 1980. Reproductive biology of the American alligator in southwest Louisiana. Pp. 153-159 In J.B. Murphy and J.T. Collins (eds) *Reproductive Biology and Diseases of Captive Reptiles*. SSAR, Lawrence.
- Magnusson, W.E. 1984. Economics, developing countries and the captive propagation of crocodylians. *Wildl. Soc. Bull.* 12: 194-197.
- McIlhenny, E.A. 1976. *The Alligator's life history*. Facsimile Reprint by the Society for the Study of Amphibians and Reptiles of the 1935 edition published by Christopher Publishing House, Boston: XVIII = 117pp.
- Medem, F. 1981. *Los Crocodylia de Sur America vol 1. Los Crocodylia de Colombia*. Colciencias, Bogotá: 354pp.
- Messel, H., G.C. Vorlicek, A.G. Wells and W.J. Green 1981. Surveys of Tidal River Systems in the Northern Territory of Australia and Their Crocodile Populations. Monograph 1. The Blyth-Cadell Rivers System Study and the Status of Crocodylus porosus in Tidal Waterways of Northern Australia, Methods for Analysis, and Dynamics of a Population of C. porosus. Pergamon Press, Sydney: 463pp.

- Nichols, J.D., L. Viehman, R.H. Chabreck and B. Fenderson. 1976. Simulation of a commercially harvested alligator population in Louisiana. Louisiana State Univ. Agr. Exp. Station Bull. 691: 59pp.
- Palmisano, A.W., T. Joanen and L. McNease 1973. An analysis of Louisiana's 1972 experimental alligator harvest program. Proc. Ann. Conf. Southeastern Assoc. Game Fish Comm. 27: 184-206.
- Parry, G.D. 1981. The meanings of r- and K-selection. Oecologia 38: 260-264.
- Pianka, E.R. 1970. On r- and K-selection. Am. Nat. 105: 592-597.
- Pooley, A.C. 1969. Preliminary studies on the breeding of the Nile crocodile Crocodylus niloticus, in Zululand. Lammergeyer 3(10): 22-44.
- Pooley, A.C. 1977. Nest opening response of the Nile crocodile Crocodylus niloticus, J. Zool. London 182: 17-26.
- Pooley, A.C. 1982. Discoveries of a crocodile man. William Collins, London: 213pp.
- Schmidt, K.P. 1924. Notes on Central American crocodiles. Field Mus. Nat. Hist. Publ., Zool. Ser 12(6): 79-92.
- Seijas, A.E. and S. Ramos 1980. Características de la dieta de la Baba (Caiman crocodilus) durante la estación seca en las sabanas modulas de Estado Apure, Venezuela. Acta Biol. Venez. 10(4): 373-389.
- Staton, M.A. and J.R. Dixon 1975. Studies on the dry season biology of Caiman crocodilus crocodilus from the Venezuelan Llanos. Mem. Soc. Ci. Nat. La Salle 35(101): 237-265.
- Taylor, J.A. 1979. The foods and feeding habits of subadult Crocodylus porosus Schneider in Northern Australia. Aust. Wildl. Res. 6: 347-359.
- Valentine, J.M., J.R. Walther, K.M. McCartney and L.M. Ivy 1972. Alligator diets on the Sabine National Wildlife Refuge, Louisiana. J. Wildl. Manage. 36: 809-815.
- Webb, G.J.W. and H. Messel 1977. Abnormalities and injuries in the estuarine crocodile, Crocodylus porosus. Aust. Wildl. Res. 4: 311-319.
- Whitaker, R. 1982. Crocodile conservation in India, Zimbabwe Science News 16(9): 210-213.
- Worrell, E. 1964. The Reptiles of Australia. Angus and Robertson, Sydney: 207pp.

SPECIES	STATUS	RIVER	LAKE	MARSHES,		SAVANNA
				SWAMPS		
<u>Melanosuchus niger</u>	E	X	●	X		
<u>Crocodylus acutus</u>	E	●	X			
<u>Crocodylus intermedius</u>	E	●				
<u>Crocodylus moreletii</u>	E		X	●		
<u>Crocodylus porosus</u>	E	●	X	X		
<u>Crocodylus siamensis</u>	E	X	●	X		
<u>Tomistoma schlegelii</u>	E	●	X			
<u>Gavialis gangeticus</u>	E	●				
<u>Caiman crocodilus</u>	V	X	X			●
<u>Crocodylus johnstoni</u>	V	X				●
<u>Crocodylus novaeguinae</u>	V	X	X	●		
<u>Crocodylus palustris</u>	V	X	X	●		
<u>Alligator mississippiensis</u>	R		X	●		
E:VR ratio		5:0	2:0	1:3		0:2
%E		100	100	25		0

Table 1. Status of crocodilian species important to the leather industry and the habitats in which they occur. E- Enlargered, V-Vulnerable, R-Recovered. Solid circles indicate the primary habitat for the species, crosses indicate other habitats in which the species occurs.



## THE INTERNATIONAL CROCODILE BANK

Romulus Whitaker  
Madras Crocodile Bank Trust  
Vadanemmeli Village, Perur P. O.  
Mahabalipuram Road, Chingleput Dist  
Madras-603 104

In 1975 the Madras Crocodile Bank was established under the management of a non-profit Trust with the support of the Madras Snake Park, the World Wildlife Fund and the Tamil Nadu Government. The main objective of the Trust was conservation of India's three crocodilians by captive breeding for release and public education. These ongoing objectives are also being carried out by several State and Central Government projects, originally sided by FAO/UNDP. The status of Indian crocodilians is not yet satisfactory but most of the work to be done now is habitat protection by the State Forest Departments.

In 1977 the Trustees approved a move to establishing the Madras Crocodile Bank as an international bank with the main objective of establishing a gene pool of every species of crocodilian. The following year at the IUCN/SSC Crocodile Specialist Group meeting held at the Crocodile Bank the Group members also approved of the proposal.

The tropical climate, feed and water availability and low overhead costs all contribute to making Madras an ideal locality for the Crocodile Bank. The breeding records of three species (Table 1) indicate the suitability of the Bank to establish breeding groups of the other crocodilians.

Already over 400 mugger offspring have been supplied to State restocking and breeding projects in India (Table 2). While several countries are not, at present looking after their crocodile resource, it is always hoped that times will change and enlightened conservation/management policies implemented. At such a time, the value of a source of young crocodiles of the desired species for restocking protected habitats cannot be underestimated.

The ultimate success of the Bank will depend on the co-operation and assistance of crocodile and zoo people world-wide. Surplus, non-breeding animals are better used in a breeding programme than as displays.

Table 1 Breeding records for three crocodylians at Madras Crocodile Bank

Species	Years nested	Number of females	Number of eggs produced	Number of hatchlings	%	Overall hatchling mortality
<u>C. palustris</u>	7	8	2433	1534	63	6%
<u>C. porosus</u>	2	1	106	49	46	2%
<u>Caiman crocodilus</u>	3	4	341	114	33	4%

Table 2 C. palustris offspring supplied to restocking and breeding projects in India

Year	State	No supplied
1976	Tamil Nadu	143
1977	West Bengal	6
1979	Andhra Pradesh	30
1979-83	Orissa	112
1976-82	Kerala	60
1982	Bihar	102
1982	Madhya Pradesh	10
1982	Uttar Pradesh	2
1982	Bihar	50
	Eggs	

MULTIPLE CLUTCHING: CONSERVATION AND COMMERCIAL IMPLICATIONS

Romulus Whitaker  
Madras Crocodile Bank Trust  
Vadanemuli Village, Perur Post  
Mahabalipuram Road, Madras-603 104

Among the reptiles some lizards and turtles produce successive clutches of eggs throughout an extended breeding season (such as Anolis sp., Chelonia mydas) or multiple clutches per season (such as Pseudemys sp., Chrysemys sp.).

Unlike any other crocodylian studied, mugger (Crocodylus palustris) at the Madras Crocodile Bank have demonstrated a capacity to nest twice in a single reproductive season. Eight females in two different enclosures (one at Madras Snake Park, 40 km. north) lay a second clutch of eggs about 40 days after the first. Clutch size and hatching success is only slightly lower in the second clutch (see Table 1) and clutch size averages are similar to those recorded in the wild.

A single male is involved in both breeding pens but it is not yet known whether a single mating fertilizes both clutches. As mating is still regularly seen during and after the first laying period (February-March) it is guessed that the females are fertilized twice in the season.

Factors which may promote the production of multiple clutches in mugger are not known but it is surmised that the relatively high year round temperature and abundance of food made available to the captive mugger are important.

The double clutching phenomenon is being studied at Madras Crocodile Bank and it is hoped to be able to quantify and standardize the factors contributing to the doubling of the annual egg yield. Assuming that other crocodylians have the same capability, the implications of doubling production are obvious both for a) conservation programmes, wherein numbers of endangered crocodylians urgently need building up and b) commercial usage wherein the object is to produce as many viable eggs as possible.

Table 1 Double clutching in mugger (*C. palustris*) at Madras Crocodile Bank (MCB)

Year	Number of females	Clutch I Total Number of eggs	Average Clutch size	success (%)	Clutch II Total Number of eggs	Hatching success (%)	Average Clutch size
1979	6	170	28	59.29	160	43.12	27
1980	6	178	30	73.15	127	60.42	21
1981	7	177	25	84.74	218	63.75	31
1982	4	131	32	45.8	89	59.55	22
1983	3	107	36	61.68	64	56.25	21
1984	6	205	34	74.14	171	35.08	29