IUCN/Species Survival Commission

The species survival commission (SSC) is one of the six volunteer commissions of IUCN – The World Conservation Union, a union of sovereign states, government agencies and non-governmental organizations. IUCN has three basic conservation objectives: to secure the conservation of nature, and especially of biological diversity, as an essential foundation for the future; to ensure that where the earth's natural resources are used this is done in a wise, equitable and sustainable way; and to guide the development of human communities towards ways of life that are both of good quality and in enduring harmony with other components of the biosphere.

The SSC's mission is to conserve biological diversity by developing and executing programs to save, restore and wisely manage species and their habitats. A volunteer network comprised of nearly 7,000 scientists, field researchers government officials and conservation leaders from 188 countries, the SSC membership in an unmatched source of information about biological diversity and its conservation. As such, SSC members provide technical and scientific counsel for conservation projects throughout the world and serve as resources to governments, international conventions and conservation organizations.

IUCN/SSC also publishes an Action Plan series that assesses the conservation status of species and their habitats, and specific conservation priorities. The series is one of the world's most authoritative sources of species conservation information available to nature resource managers, conservationists and government officials around the world.

IUCN
The World Conservation Union
SSC
Species Survival Commission

Proceedings of the 18th Working Meeting CSG Montélimar, France, 19-23 June 2006

Crocodile Specialist Group, species Survival commission

CROCODILES

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(Unedited and Unreviewed)

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The Crocodile Specialist Group

The Crocodile Specialist Group (CSG) is a worldwide network of biologists, wildlife managers, government officials, independent researchers, NGO representatives, farmers, traders, tanners, fashion leaders, and private companies actively involved in the conservation of the world's 23 living species (alligators, crocodiles, caimans, and gharials) in the wild.

The CSG has 350 members and eight regional subdivisions, and operates under the auspices of the Species Survival Commission (SSC) of IUCN-The World Conservation Union. Its administrative and publishing budget is raised entirely from private donors.

The CSG network of experts advises governments and wildlife management agencies. These experts evaluate the conservation needs of crocodilian populations, initiate research projects, conduct surveys of wild populations, estimate population numbers, provide technical information and training, and initiate conservation programs.

The group Is headed Professor Graham Webb and can be reached through its Executive Office, csg@wmi.com.au. PO Box 530, Sanderson, NT 0812, Australia. Tel: (61) 8 922 4500. Fax: (61) 8 8947 0678.

Forwords

For the many people who work on crocodilians around the world, the biennial working meeting of the IUCN-SSC Crocodile Specialist Group is something special. Working with crocodilians is not easy. They tend to live in remote and inhospitable areas, where access is difficult. They range in weight from less than 50 g to over 500 kg, so that developing and using appropriate catching and handling gear is always a challenge. Most important, it is often a thankless task. Crocodilians are high on the list of animals that spark people's interest, but not so high on the list that they really seem to want in *their* backyard.

This all changes at the CSG working meetings, where groups of like-minded people, from all around the world gather in formal and informal sessions. These are people who go to a great deal of effort to share one week together, each two years. It recharges batteries, stimulates interest, fosters camaraderie, creates new friendships, puts faces on names, provides genuinely sympathetic ears for discussion of problems, and most important, provides an opportunity to pass on new results and findings.

The core business of CSG working meetings occurs mainly in the Steering Committee meeting. What unites us is a commitment and determination to help the IUCN and SSC achieve their conservation missions with crocodilians, which is advanced in the Steering Committee meeting. As the complexity of the world expands, so the "biopolitics" of crocodilian conservation becomes more challenging. But we adapt well. We do a great job. We do it quickly, honestly, transparently and usually by consensus. We do it largely as volunteers, with very few paid staff. An important key to our success is that the CSG membership includes good representation from industry. Industry members are a critical part of each step we make. They help keep us focused on attainable goals, and add a wealth of real knowledge about trade.

The 18th CSG working meeting, held in Montélimar, France, is the first to be held in Europe. It provided the first real opportunity to focus the attention of all CSG members on crocodilian conservation issues in the francophone countries of West Africa. It brought experts from the European crocodilian leather industry together, to see how the CSG functions and to learn more of what it is achieving.

We are of course all greatly indebted to La Ferme aux Crocodiles at Pierrelatte, and especially to Mr. Luc Fougeriol and his family, for the considerable support that they provided in order to host the meeting. It is never an easy task. Our thanks also go to Samuel Martin, who did a wonderful job in organizing the meeting. All the staff who worked on this project deserve our special thanks. Their efforts made a major contribution to the CSG, and through the CSG to the SSC and IUCN.

Graham Webb, Chairman CSG

18th CSG Working Meeting Summary

The 18th Working Meeting of the IUCN-SSC Crocodile Specialist Group (CSG) was held in Montélimar, France, from 20-23 June 2006, and was preceded by a CSG Steering Committee meeting on 19 June.

The meeting was hosted by la Ferme aux Crocodiles at Pierrelatte, and the CSG is extremely grateful to Mr. Luc Fougeirol and his family's [Marie-Claire (mother) and Eric (brother)] considerable support for the meeting. Samuel Martin, Technical and Scientific Director at la Ferme aux Crocodiles was the chief co-ordinator for the meeting, and expended considerable effort in the months leading up to and during the meeting to ensure that everything ran smoothly – he did a wonderful job.

Professor Grahame Webb (CSG Chairman) and Luc Fougeirol welcomed around 240 participants from 43 countries to the first CSG meeting convened in Europe. CSG working meetings, held every two years, are the primary international meeting dedicated to crocodilian conservation, management and research. They have become the major forum for discussion of conservation issues, new findings and new directions, and the 18th meeting was no exception.

A number of important issues were addressed by the CSG Steering Committee, and a range of topics were later covered by oral presentations over the 4-day working meeting, which was organised into the following sessions:

- Research stimulated by la Ferme aux Crocodiles;
- Crocodilian trade; Conservation of African crocodiles;
- Conservation of crocodilians in Francophone countries and territories;
- Crocodilians as key animal species for wetland conservation and sustainable development;
- Crocodiles in zoos - a contribution to their conservation;
- Conservation of crocodilians in other parts of the world;
- Poster session;
- What is new in crocodilian biology research?; and,
- Husbandry techniques and crocodilian health issues applied to conservation and commercial husbandry.

A series of workshops were also held: veterinary; skin quality; community participation; Tomistoma Task Force; trade; and, human-crocodile conflict.

One of the objectives was to establish a stronger relationship with West Africa and its francophone countries. Recognising the general lack of information on crocodilians from this important sub-region, a major outcome was the decision to hold a sub-regional meeting in West Africa in October-November 2007. This meeting will aim to bring together information on the population status of the three crocodilian species (*Crocodylus niloticus*, *C. cataphractus*, *Osteolaemus tetraspis*) in the subregion, and to improve the technical capabilities of local personnel with regard to survey methodology, reporting, etc. An African regional meeting in South Africa is also being considered, and is likely to take place after the West African meeting. Of particular interest is the taxonomy of crocodilian species in West Africa, with the possibility that *C. niloticus* could comprise a separate species.

A team of CSG members has been involved in reviewing Brazil's draft proposal to CITES to transfer its Black Caiman (*Melanosuchus niger*) population from Appendix I to Appendix II. Brazil was applauded for its efforts to implement a conservation program based on sustainable use. The Black Caiman population in Brazil appears to have recovered from overexploitation in the period 1950-70, and is now abundant throughout most of its range. Additional comments were provided to the Brazilian participants at the meeting. A number of other Range States for *M. niger* may also be interested in similar use programs.

The situation with the Indian Gharial (*Gavialis gangeticus*) in West Asia was discussed in detail. In India, the situation in captivity is good, but the status of the wild population has worsened, and it is likely that the species merits reclassification from "Endangered" to "Critically Endangered". Major threats are lack of enforcement in some habitats, riverine fisheries, agriculture, habitat degradation, water extraction, human and livestock disturbances and loss of basking sites due to sand mining. Similar threats exist in Nepal. A small working group undertook a rapid assessment of information available on the species, and it appears that the case for a "Critically Endangered" listing may be justified. Task Force Gharial is planning to be more active over the next two years.

The CSG Tomistoma Task Force has been very active since its formation at the 16th working meeting (Gainesville, 2002), with surveys undertaken in West and Central Kalimantan in 2004 and 2005. Successful breeding in captivity of *Tomistoma schlegelii*, especially in Thailand, has resulted in a large and increasing captive population, and the possibility of a re-introduction program in southern Thailand is now under discussion with the Thailand Department of Fisheries.

The status of the remaining wild populations of Siamese Crocodile (*C. siamensis*) in Cambodia and Indonesia (Kalimantan) remains a serious concern for the CSG. A CSG review of crocodile conservation and management in Cambodia in early 2005 developed a number of recommendations to improve the program. Cambodian representatives at the meeting provided an update on progress made with these recommendations, many of which have been addressed. The formation of a Crocodile Management Unit within the Department of Fisheries is considered a positive step to improve the management of both captive and wild populations. The wild population in Cambodia remains small (estimated to be no more than 200 adults).

The Castillos Award for crocodilian conservation, a hand-made Mexican silver pitcher, was presented to Merlijn van Weerd for work undertaken by the Crocodile Rehabilitation, Observance and Conservation (CROC) Project. The CROC Project was chosen unanimously as 2006 winner for its innovative work under very difficult conditions for the Philippine crocodile (*C. mindorensis*), a species for which many had already given up hope in the wild.

Karlheinz Fuch's book "The Crocodile Skin" ("Die Krokodilhaut" in German) was updated and translated into English with CSG support and encouragement, and was launched at the CSG meeting. The revised edition will assist identification and enforcement at all levels: export and import, and within tanning and manufacturing facilities. For customs officers at the point of export, import and re-export, who do not necessarily have the skilled scientific knowledge needed for fine forensic identification, it should at least allow preliminary determinations to be made, based on key characters described and illustrated in the book. Skins at least should be easily identifiable to species.

The evening social activities included the inaugural reception at la Ferme aux Crocodiles, a North African dinner with traditional dancers, an African dinner with African percussionist, and a Provencale dinner with traditional dancing and markets. An auction of gifts donated by participants was a highlight of the farewell dinner and some $USD3550 was raised to go towards the proposed West African sub-regional meeting.

Various field trips were arranged throughout the region, including regular visits to la Ferme aux Crocodiles, Montélimar (cultural discover), Orange (the Roman City) and Avignon (papal and emblematic city of the Province). On Saturday following the closure of the meeting, participants were able to visit the Baronnies, a rocky area dominating the Aygues Gorges in the Drôme Provençale, where a program of reintroduction and conservation of griffon vultures (*Gyps fulvus*) and black vultures (*Aegypius monachus*) has been operating since 1987. The program is a great success and it has been crowned by the spontaneous return of the Egyptian vulture (*Neophron percnopterus*) and the recent visit of bearded vultures (*Gypaetus barbatus*). The observation of these magnificent birds was completed by excellent information provided by Christan Tessier, the representative of the association "Vautours en Baronnies".

The great success of the CSG Working Meeting would not have been possible without the support and contributions of many people and organisations, including: the Drôme's General Council, the Rhône-Alpes' Regional Council, Point Afrique travel agency, Areva Tricastin (Nuclear power plant), Pierrelatte and Montélimar town councils and French tanners and manufacturers - Dan Lewkowicz (France Croco), Hervé Loubert (Gordon-Choisy) and Philippe Roggwiller (Tanneries des Cuirs d'Indochine et de Madagascar).

Thanks must also go to the Organising Committee: Luc and Eric Fougeirol, Samuel Martin, Jenny Tibola (la Ferme aux Crocodiles), Emmanuelle Rivas, Florianne Pontier, Béatrice Tarriotte, Christine Girard (Montélimar Tourist Office), Jean François Siaud, (Drôme General Council), Mr Bernard Gervy his team (Domaine de La Valdaine & Hôtel Restaurant le Monard). Thanks are also extended to all of the staff of la Ferme aux Crocodiles who assisted in various aspects of the meeting and associated activities.

Samuel Martin earned the respect and admiration of the CSG Executive and has subsequently been appointed as joint Regional Chair for Europe. It is hoped that he will play an important role with expansion of CSG activities into West Africa and its francophone countries.

The 19th CSG Working Meeting will be held in Santa Cruz, Bolivia, in mid-2008.

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Organising committee:

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Research Stimulated By "La Ferme Aux Crocodiles"

Experimental Ichnology: Crocodiles As A Model.

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Abstract: The Pterosaur Beach of Crayssac (Lot, France) is a paleontological site known to yield numerous vertebrate and invertebrate tracks and trackways. It corresponds to an ancient mud-flat, dated from the Lower Tithonian (Late Jurassic, -147 million years). Dinosaurs, pterosaurs, crocodilians, turtles have walked on this "beach" and let locomotion prints in the fine mud. These prints have been fossilised with a high quality of preservation, some of them showing unexpected details, such as skin imprints or claw drags. Pterosaur trackways are numerous and led to demonstrate that these flying reptiles easily walked, with quadupedal stance and gait. This site also yields the most ancient well-preserved crocodilian trackways, probably belonging to Thalattosuchian.

In order to calculate the velocity of these Jurassic crocodilians from their trackways, we have initialised a series of experimentations at La Ferme aux Crocodiles of Pierrelatte, using young specimens of *Crocodylus niloticus* walking on muddy substratum. The real velocity of each specimen has been controlled by filming, while the biometry of each corresponding trackway has been measured (pace, stride, angle of pace). These biometrical data will be used to provide a general equation which should be used to calculate the theoretical velocity of ancient quadruped reptiles, from their fossilised trackways.

Crocodilians On Late Jurassic "Beaches" Of Western Europe

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Abstact: At the end of the Jurassic period (about 150 million years ago), some crocodilians with different supposed life styles (marine, coastal, continental) were preserved in coastal marine deposits of shallow carbonate platforms throughout Western Europe.

Here we present the crocodilians from six Late Jurassic “beaches” (Fig.1), based mainly on skeletal remains and to a lesser degree on ichnological evidence. New data are reported for the crocodilian fauna of Porrentruy (Kimmeridgian, Switzerland), where excavations are in progress in the Swiss Jura Mountains (along the future course of the Transjurane highway). For the locality of Crayssac (Tithonian, France), the crocodilians are represented by teeth, bones, but also by well-preserved trackways and isolated prints. A small sized crocodilian has been identified as the trackmaker by means of experimental ichnology, using juvenile specimens of *Crocodylus niloticus* at “La Ferme aux Crocodiles” (Pierrelatte, France). The life style and the palaeobiogeographic range of these Late Jurassic crocodilians are discussed.

	POR	SOT	CER	SOL	CRA	CAN
Teleosauridae						
Steneosaurus	x	x		x	x	x
Machimosaurus	x	x			x	
Metriorhynchidae						
Dakosaurus	x			x		
Geosaurus				x		
Atoposauridae						
Alligatorellus			x	x		
Alligatorium			x	x		
Goniopholididae						
cf. *Goniopholis*					x	
Mesosuchia *incertae sedis*						
Crocodileimidae						
Crocodileimus			x			
Crocodylia indet. (ichnites)					x	

Fig.1. Presence / absence of crocodilians in six Late Jurassic coastal marine environments of Western Europe. Abbreviation: CAN: Canjuers (Tithonian, France); CER: Cerin (Kimmeridgian–Tithonian, France); CRA: Crayssac (Tithonian, France); POR: Porrentruy (Kimmeridgian, Switzerland); SOL: Solnhofen (Tithonian, Germany); SOT: Solothurn (Kimmeridgian, Switzerland).

Comparisons, Adaptations And Evolving Convergences Between Fossil Amphibians And Living Crocodiles.

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Abstract: Living amphibians (or lissamphibians, i.e. frogs, salamanders and apodians) are mostly protected species and unfortunately correspond to a decline group. Their morphologies do not resemble those of the living crocodilians.
However, in the past, fossil amphibians (as non-amniotic tetrapods) correspond to a very diverse group of numerous organisms appeared before crocodilians, i.e. about 370 Million years ago (Upper Devonian) if not before (Middle Devonian?). They showed a various range of morphologies which “prefigured” the diversity of the living crocodilians. They are not (directly) related to the crocodilians (phylogenetically), but they exhibit striking similar morphologies and adaptations.
For instance, the stegocephalians (fossil amphibians) were mainly represented by aquatic or semi-aquatic carnivorous which reached giant sizes during the Mesozoic, up to 6 meters long. They also shared with the emerging crocodilians various evolving convergences, like a brevi-, a semi- or a longi-rostral cranial anatomy. These closed ecomorphological similarities between fossil amphibians and living crocodiles will be presented in the context of their palaeoenvironmental history and evolution. It seems that ecological competitions with (amniotic) crocodilians probably led to extinctions of the major (non-amniotic) amphibians like the temnospondyls.
The presence of an institution in France such as “La Ferme aux Crocodiles” of Pierrelatte is a great opportunity for European palaeontologists to observe extend crocodilians in order to dress ecomorphological comparisons with extinct taxa (i.e. without living representatives).

Acoustic Communication In Crocodilians: From Behaviour To Brain

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Abstract: In spite of the central place occupied by sound communication in the life of crocodilians, knowledge on their acoustic world remains surface. Calls functional and structural classification attempts are debatable since very few experimental studies have been conducted.
Indeed, few evidence make it possible to conclude as for the emitted calls precise role. Moreover, no systematic study of vocalizations acoustic structure based on repeated recordings in a significant number was still published. With regard to sounds production and detection processes as well as the underlying neurophysiological processes, once again crocodilians were studied very little. In spite of their narrow phylogenetic proximity with birds, the state of current knowledge concerning the acoustic world of these reptiles is indisputably very thin compared to the extent of knowledge in birds. The interest of the study is however not the least and it offers a vast field of investigation.

1. Introduction

Acoustic communication is largely used in the animal kingdom, as well in invertebrates (Arthropods in particular) than in vertebrates. In the last, one finds sound signals users in fishes, amphibians, birds and mammals. Curiously, reptiles seem to make exception: among snakes, very few species produce sounds (Young, 2003) ; tortoises limit their sounds production at coit (Galeotti et al., 2004) ; lizards seldom communicate with sounds (Frankenberg, 1982) and generally use chemical or visual signals (Zuri & Bull, 2000 ; Cooper et al., 2002). Only crocodilians make use of acoustic communication (Neill, 1971; Campbell, 1973; Herzog & Burghardt, 1977; Magnusson, 1980; Garrick et al., 1982; Britton, 2001). Indeed, all the crocodilians having been studied until now have a varied repertoire of acoustic signals. As we will see, crocodilians acoustic signals seem to play a major part at the first ages of life, in particular at the time of interactions between young and adults (Campbell, 1973), like later at the time of bridal parades and territorial defenses (Garrick et al., 1982).
In spite of the supposed importance of these vocalizations, their acoustic structure, their mode of production, the processes of hearing and the neurophysiological treatment of information which they carry as well as their precise roles in the biology of these animals remain badly understood even completely unknown. Indeed, on all these aspects, the literature presents primarily data of observation, for the majority rather anecdotic, and few experimental facts.
The aim of the present paper is to briefly review our current knowledge about crocodilian acoustic communication.

2. Crocodiles repertoire

2.1 Young calls

Crocodilians first vocalizations take place in egg, little time before hatching (Pooley, 1962; Lee, 1968; Magnusson, 1980). These calls would play a crucial part for young survival enabling to request parental protection (McIlhenny, 1935; Cott, 1971; Pooley, 1974; Staton & Dixon, 1977). While growing, the young crocodilians vocal repertoire increases. One then describes (1) distress calls, produced in event of danger (Campbell, 1973; Herzog & Burghardt, 1977), (2) threat and disturbance calls allowing to make flee ennemies (Britton, 2001), and (3) contact calls produced in varied situations. These last calls would allow cohesion maintenance between a group of young (Campbell, 1973; Herzog & Burghardt, 1977; Magnusson, 1980).

Unfortunately, this functional repertoire of emitted calls rests on classification criteria which are often not very objective. In many cases, an experimental step would be necessary to specify the biological role of these vocalizations. As for a possible distinction on the basis of their acoustic structure, one runs up against the small quantity of available data in the literature. Although the basic acoustic structure of the whole vocalizations seems very close from one call to another (Figure 1): they are complex sounds, i.e. composed of a fundamental frequency (lowest) accompanied by multiples which are the harmonics, only future analyses will allow to know if the young emit different sounds according to the emission context.

2.2 Adults calls

With the passing of years, young crocodilians emit less and less calls. Perhaps due to a reduction in the number of their natural predatory and their increasingly large capacity to defend by themselves, thus decreasing the benefit of an adult intervention (Staton, 1978). However, adults even use acoustic communication. Sound signals, in theory accompanied by particular postures, play an important role in particular at the time of bridal parades and territorial defenses (Garrick et al., 1982; Britton, 2001). There is no established terminology to characterize the emitted calls. Moreover, the structural and functional studies of the adult calls are even fewer than in the young. The literature distinguishes: (1) the “bellowings” emitted by both sexes and which would seem to be important during courtship and to establish hierarchy within a group; (2) the “maternal growls” which would make it possible to maintain cohesion within the offspring; and (3) the “hissings” which would play a part in defense against enemy. We also find sub-audible sounds signals (Garrick et al., 1982). However, hardly anything is known about these adult vocalizations. descriptions are very few and even the sub-audible sounds existence has never been shown elsewhere.

3. Signal production and detection

Sounds production mechanisms are still badly known in crocodilians. Until now no specialized vocal body has been highlighted. In addition, no reliable data makes it possible to quantify possible differences related on sex, size or age of the animal. It seems however that young calls change quickly with age becoming increasingly louder (Vergne et al., *in press*).

With regard to sounds detection, crocodilians seem to be rather powerful as well in air as in water.

Indeed, at the same time predatory and ready to vocalize, the crocodilians benefit of developed auditory capacities for the search of food and for the communications between individuals. The ear and the auditory sensitivity of these reptiles present many common points with those of birds (Dooling et al., 2000). Crocodilians auditory capacities seem to be generally rather good between 30 Hz - to the minimum- and 4 kHz.
Detecting a sound source is a thing, locating it is another quite as important. Unfortunately, no ethological test makes it possible to conclude on the crocodilians abilities to locate a sound source. Thus, in spite of the close phylogenic links between birds and crocodilians, the extent of knowledge on the physiological processes implied in sounds production and detection do not have anything common between these two groups. Whereas many studies were carried out in birds, research is at its beginning in crocodilians.

4. Auditory processing by the central nervous system

The crocodilians nervous system presents great similarities with that of birds and the auditory pathways are remarkably close (Dooling et al., 2000). However, many uncertainties remain as for the auditory areas localization and for the different connections in the telencephalon. Indeed, the current knowledge on the crocodilians nervous system and the neurosensory mechanisms implied in the acoustic communication is once again quite thin compared to that of birds. Very often, information suffers of the lack of demonstration. A better comprehension of the neurophysiological mechanisms of sounds production and detection in crocodilians request many new investigations and suggest the need for a multidisciplinary approach. Indeed, until now, knowledge was limited to dissection observations, electrophysiology results and some histo- and cytochemical labellings (Pritz, 1974a; 1974b).

5. Conclusions and research perspectives

As well for young as for adult crocodilians, the weakness of acoustic analyses carried out until now added to the absence of experimental step aiming at understanding the biological role of vocalizations makes quite surface our comprehension of these reptiles acoustic world. Thus, from the functional and structural classification of calls to the neurophysiological processes involved in sounds production and detection, current knowledge in crocodilians raises many questions so much about (1) their vocal repertoire (what calls and for what information?) ; that on (2) the sound signals production (what are the ways of the vocalizations ontogenesis and how these last are produced?) ; and on (3) the information reception methods (how information is decoded and which are the subjacent neurophysiological mechanisms?).
Among the range of the raised questions, our team of research began a first neuro-ethological investigation in collaboration with La Ferme aux Crocodiles (Pierrelatte, France) aiming at identifying:
(1) The young calls frequential and temporal parameters on whom the calls specific recognition is based.
For that, playback experiments using modified signals are managed and will come to clear up our comprehension of the coding-decoding system of information used by these animals.

(2) The telencephalic zones activated during auditory perception.
For the first time, experiments using functional magnetic resonance imagery (MRIf) are launched on young crocodilians. This technique of imagery which allows to follow *in vivo* the cerebral zones activation is particularly used in birds and mammals. Identification of auditory areas activated following an acoustic stimulation in crocodilians will thus improved considerably our knowledge.

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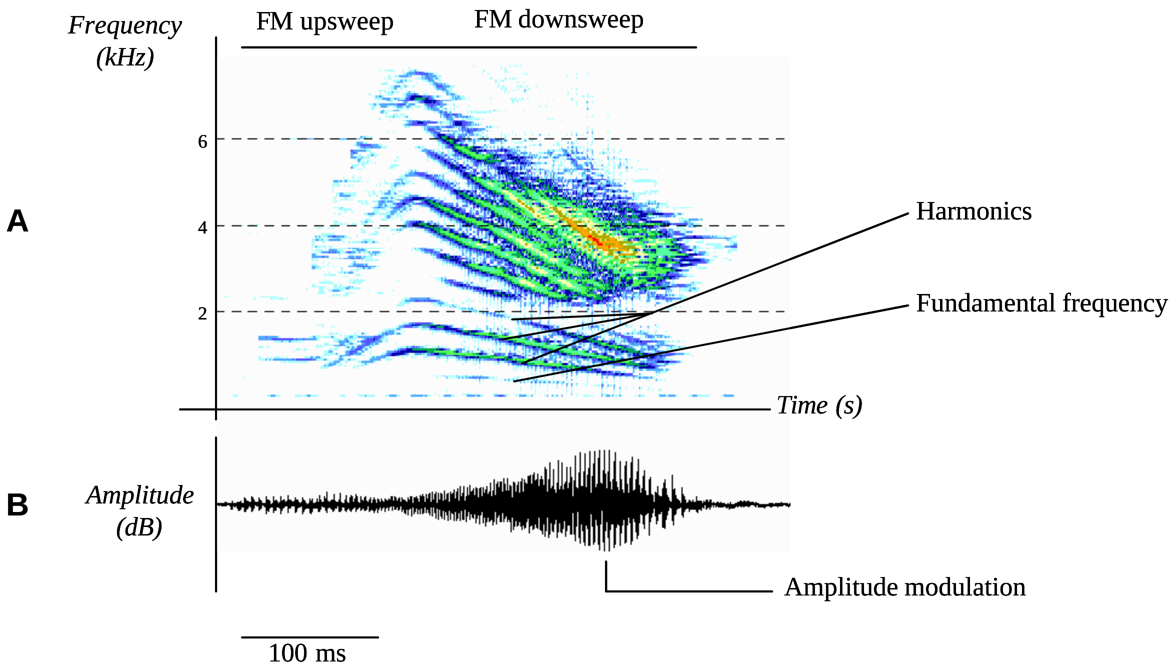
Fig. 1 Young Nile crocodile' distress call

A. Spectrogram (window size: 1024). Many young crocodilians' calls share the same basic acoustic structure: a fundamental frequency strongly modulated, accompanied by 12 to 20 harmonics. See (Vergne et al. 2006). 26% of the crocodiles distress calls show two temporal segments: an initial part characterized by an ascending frequency modulation (FM upsweep) and a second part with a descending one (FM downsweep). 73% of the calls present only the FM downsweep.
B Oscillogram.



Crocodilian Trade

L'application De La CITES Dans L'UE

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Résumé : Les dispositions de la CITES sont renforcées et harmonisées dans tous les États membres de l'Union européenne par le règlement (CE) n° 338/97 du Conseil du 9 décembre 1996 et les règlements de la Commission associés. Cette réglementation communautaire, plus stricte que la CITES, soumet à permis d'importation les spécimens de l'annexe II et facilite les échanges à l'intérieur de l'Union européenne. Tous les crocodiliens relèvent de l'annexe B du règlement 338/97, à l'exception des espèces incrites à l'annexe I de la CITES qui figurent à l'annexe A. Le commerce intracommunautaire portant sur les spécimens de l'annexe B est libre de tout document spécifique, dès lors qu'ils ont été légalement importés ou acquis dans la Communauté. En revanche, le commerce des spécimens de l'annexe A dans l'Union européenne est interdit, y compris à l'intérieur d'un même Etat membre, sauf dérogation prenant la forme d'un certificat délivré au cas par cas. Concernant les importations ou réexportations d'objets personnels, la réglementation communautaire prévoit certains allègements ou dérogations. Les États membres de l'Union européenne ont la possibilité de prendre des mesures nationales plus strictes, qui priment alors sur la réglementation communautaire.

Abstract: The provisions on CITES (i.e. the **C**onvention on **I**nternational **T**rade in **E**ndangered **S**pecies of Wild Fauna and Flora) are strengthened and harmonized in all Member States of the European Community (EC) through Council Regulation (EC) No. 338/97 of 9th December 1996 and the respective Commission regulations. These Community provisions, which are stricter than CITES itself, subdue all imports of species listed in CITES Appendix II to the issuance of EU import permits but facilitate on the other hand trade within the EC. All crocodilians with the exception of those listed in Annex A of Council Regulation 338/97 are listed in Annex B of this regulation. The intracommunity trade of specimens listed in Annex B does not require any specific CITES documentation as long as these specimens have been imported or aquired legally within the Community. On the other hand any trade in specimens listed in Annex A is forbidden within the EC including the trade within one member state as long as it has not been exempt on a case by case basis for which an EU certificat must be issued.

Regarding the import or re-export of personnel belongings the EU regulations provide for certain deviations or alleviations.

The Member States of the EC have (hoever in a rather limited scope) the possibility of taking stricter measures which than may have priority over the community legislation.

Sustainability And Trade: CITES Requirements Trough A Verification System

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Abstract: The spectacled caiman (*Caiman yacare*) has been commercially wild harvested in Bolivia for almost 10 years, this harvest is made through a National Program based on a quota system developed on the basis of annual data on the caiman productive potential. This process is supervised by the CITES Administrative Authority, which is in charge of following up the harvesting process and delivering the guides and certificates for the mobilization and export of the skins. The Bolivia BioTrade Program (BBTP) seeks to strength the value chain of *C. yacare* in order to promote the use of spectacled caiman in a more sustainable way, generating economic benefits and assuring the ecological sustainability of the species, supporting the Caiman Program of Bolivia. In support to the value chain, The BBTP is supporting the definition and implementation of "good practices" involving all the processes along the supply chain. These good practices are being developed to assure the sustainability of the harvest, comply with CITES requirements and implement traceability and documentation systems. The good practices defined and the tools developed for their implementation, are the basis for a verification system that could promote the differentiation of skins in the market and support the implementation of CITES.

Trade And Management Of Crocodiles: The Role Of Knowledge

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Abstract: The conservation and management of crocodile populations is influenced by harvest and trade considerations. Trade in crocodiles and crocodilian-products occur at both domestic and international levels. The consequences of harvest and trade are difficult to predict.

Concentrating on the example of Australian crocodiles, it is shown that this unpredictability is inherent to wildlife management. The key is the separation of knowledge into two types. Some knowledge is codifiable, such as that discovered by scientific research. Other types of knowledge are difficult or impossible to codify. Tacit knowledge for instance, cannot be codified. Where management success depends on the level of non-codified knowledge present, conservation strategies are often unable to be designed or imposed on local human populations. Managers cannot know *ex ante*, the specific conditions for success.

Crocodile management in Australia has gone through three distinct phases. These are an initial open-access harvest regime, then protection, followed by a sustainable harvest and trade regime. The following points can be established. First, the eventual structure of the crocodile industry and its diversity was unpredicted by both supporters and opponents of the new trade regime. Second, management regimes that exploit tacit and dispersed knowledge are generally more successful. Those that are reliant on codified knowledge only, waste resources on issues that are often not relevant to success. Hence, trade, conservation and management of crocodiles is akin to a discovery process, rather than a design-task.

1. Introduction

The management of wildlife often occurs alongside significant knowledge problems. A manager, may have very little information about the basic biology of a species (e.g. its distribution or reproductive strategies). For instance, many crocodilians are the top-predator in their ecosystem, yet how this affects the density and diversity of other species is often unknown.

Very little may also be known about how the species will respond to different management regimes. This means predicting the effects of opening up trade, or implementing a trade ban, is inherently unpredictable. Managers may simply be unaware of relevant information when they have to implement policy. Nonetheless, if the objective is to improve conservation (and economic) outcomes, then there should be some basis to prefer some management strategies over others.

Managers or policy-makers need to comprehend that all management regimes will be accompanied by a number of unpredictable 'surprises'. Nonetheless, management regimes that make greater use of existing 'knowledge' are likely to be more successful than those that make little use of such knowledge.

2. The Problem of Knowledge

The key point derived from social science literature, is that knowledge is not homogenous. That is, there are various forms of knowledge and this difference has important outcomes.

The first important distinction is between knowledge and information. Information is akin to data or observations. Information is acquired by observation or data collection. In order to make use of information, the person has to have some theory of the system that can explain the data (Langlois, 2001). It is thus possible for someone to observe something, but have no understanding of it.

Knowledge is manifested when information can be understood and utilised by a person. It represents the 'can do' step. It clearly requires the person to have some model or theory that fits this information. . For instance, several ecological surveys in New Zealand on offshore islands consist of simple checklists. These lists catalogue the species (or higher taxa for troublesome groups) present on the island. With no accompanying population or ecological data (population size, distribution, theats), they can be regarded as information only. It does not generate input into any management models. Such catalogues are just lists of observations that do not inform managers.

Knowledge is also contingent where it depends on particular circumstances of time and place (Hayek, 1945). This is partly why management of wildlife is accompanied by surprises. For instance, the kakapo parrot (*Strigops habroptilus*) generated a reproductive surprise, in the sense that it leks. It is the only parrot species that leks. This unique reproductive strategy had major implications for managing breeding. It was also a significant surprise that made some prior knowledge on parrot reproduction redundant. What was know before about parrots, was in this sense, still contingent.

Knowledge is also divided into other categories. While there is no unanimous agreement on these forms, the following schema is useful. This is to treat knowledge as either explicit or implicit or tacit (Polanyi, 1962, 1967).

Explicit knowledge exists in a codified form. That is, it can be written or presented (codified) in a way that makes it obvious. This property is what makes it explicit. Published scientific papers are one example of explicit knowledge.

Implicit knowledge is not codified. It is often employed by researchers however. For instance, the Watson and Crick (1954) paper on discovering the structure of DNA was 17 pages long. The later book by Watson (1968) on discovering the structure of DNA was over 200 pages long. Much of this difference relates to those parts of discovery that are not reported (codified).

These differences have lead to scientific discovery being compared to an iceberg (Jackson, 1971). What is made explicit is the tip of the iceberg. What is implicit is the part of the iceberg that is underwater. This implicit knowledge is sometimes regarded as the main driver of scientific inspiration and creativity (Polanyi, 1962, 1967). It is this total immersion in the phenomena (implicit knowledge) to be explained that generates the research activity.

Implicit knowledge can be potentially codified. It is however, often not practical to do so. For instance, it may be too costly to do so. This may relate to its very dispersed nature. Rather than such knowledge being collected and concentrated in a single location, it exists dispersed amongst many different people. One person may know some detail about the density of crocodiles in their area. Another person may have knowledge about potential demand for crocodile leather in their domestic market. Collating or centralising this knowledge is simply too expensive, as exemplified the failure of Soviet-style planning agencies to set meaningful prices. Given that the Russian Goskomtsen was trying to track 24 million different prices, gross production failures such as those reported in Smelev and Popov (1989) are not surprising.

Problems of codification may be caused by other hindrances. For instance, firms may wish to conceal their knowledge of certain processes by way of 'trade secrets'. Hunters may be unwilling to reveal the location of their preferred hunting sites. Rural people may be reluctant to confess to illegal destruction of wildlife they consider to be pests. Related to this may be forms of traditional knowledge. This may be embedded in rituals and beliefs that are simply incomprehensible to others.

Tacit knowledge is knowledge that cannot be codified (Polanyi, 1962, 1967). It is the type of knowledge that is only gain through experience. An example of this is 'how to ride a bicycle'. Most people lean to ride a bicycle by experience. They don't learn by reading a book.

Example

Taxonomic work often involves these different classes of knowledge. For instance, many experienced taxonomists learn to identify species informally, rather than draw on a formal identification process. The specimen simply has some inexplicable combination of shapes, colours and structures that make such identification possible. Without prior experience with working with this taxa, it is not possible to make these sorts of informal identifications. Hence, the ability to accurately and informally identify say, cryptozoic taxa is an example of tacit knowledge being applied.

Anyone who has had to use a taxonomic key for a taxa they are unfamiliar with, confronts the problem of implicit knowledge. It is very difficult to use such a key accurately without prior knowledge of the biology of the group. The ability of taxonomists to use keys accurately for the groups they are familiar, is a product of their implicit knowledge.

The taxonomic key and its associated species' descriptions are an example of explicit knowledge.

3. Application

The Australian saltwater crocodile *Crocodylus porosus* or saltie encompasses three different management regimes. These ranged from an initial open-access (trade) regime, then to full legal protection (no trade) and finally sustainable harvest (trade). These regimes had different impacts on crocodile populations and the crocodile industry. These impacts can be predicted on the basis of their ability to draw upon 'knowledge' about crocodiles.

The saltie was heavily hunted in the post-war period for its leather. The condition of open-access coincided with a collapse in crocodile numbers and by the late-sixties, the species was becoming legally protected across the north of Australia. Legal protection was sought by hunters concerned about decline, and met little opposition because the animal was no longer considered a pest. The Australian saltie predates on people and livestock. Such attacks, however ceased as the saltie population collapsed. In the absence of human-crocodile conflicts there was no opposition to protective legislation.

Open-access had a predictable impact. This is a management system that utilised very little 'knowledge' about crocodiles. This poor use of knowledge meant that neither the industry nor the wild population could be sustained. Indeed one of the more perilous aspects of this regime was the destruction of local knowledge about co-existing with crocodiles. By the time crocodiles recovered, people were no longer taking precautions in rivers.

Knowledge that was not acted on included hunter awareness of crocodile population declines. The scope for innovation was restricted. Innovation that did occur was limited to technology that expanded harvest. This accelerated the decline of crocodilians. For instance, the salties' cousin the freshie (*Crocodylus johnstoni*) was ignored by hunters until tanning technology advanced to eliminate the poor leather quality problem. The freshie has many more osteoderms which mar the leather quality. In addition, no information on the population distribution or biology of the species was collected nor converted into knowledge. Local Aboriginal knowledge of crocodile biology was similarly inaccessible to managers and unused.

This highlights a number of points. The problems with open-access were knowledge-based. Open-access made poor use of existing knowledge. Declines were first observed by locals but this knowledge was dispersed and under-utilised. Further, tacit knowledge of how to co-exist with crocodiles was actually destroyed as crocodile populations retreated to inaccessible regions. Open-access also hindered a discovery process being initiated. There is no payoff to innovative conservation efforts in these conditions. This reinforced the perception that the species had little value or was a pest.

Cortado (2004) claims that open-access is leads to conflicts between humans competing over the resource. This did not hold true of the 'saltie'. Extirpation of the species was widely seen as a desirable outcome. This perception that the saltie was a pest, inflated the harvest levels beyond what could be sustained at an economic level.

At a management level, open-access led to the ignoring of implicit knowledge about potential values of the crocodile, not limited to the role it played as a top-predator in local fisheries. Local extinctions of crocodiles eliminated the risk of predation to people and livestock. Hence the steady contraction of the hunting industry was not a concern for many participants. Entry and exit of the crocodile industry was straightforward, with the technology (boats, rifles) easily transferred to other uses. Some crocodile hunters left the industry permanently, with one hunter in Queensland (Bill Phillips) ending up as a Professor at the London School of Economics (Leeson, 1974).

Protection is a more interesting case. The immediate consequence of protection was that crocodile populations recovered and then spread back into waterways they had been eliminated from. This increase in population density led to several attacks by crocodiles on people. In 1979-80 there were five serious attacks in Australia and two of these were fatal (Webb, 1997). These attacks led to calls for a switch in management away from protection back to destructive-harvests. These attacks also revealed that a purely protective approach was not free of problems. These threatened to halt the recovery of the species, and ultimately led to a shift in management to sustainable use (although could have led to destructive culls instead).

Protection was the favoured conservation strategy of the time. For many environmental groups it remains as the preferred approach. For this reason, it is worth exploring its ultimate failure in the case of crocodiles. This in part rests with the confusion of knowledge with information (Boetkke, 2002).

The protectionist approach generated several obstacles to the effective use of information. One of these was the preference for information generated by Federal scientists over local (dispersed) knowledge on rebounding crocodile populations. This led to the discounting of reports from Northern Australia of a recovery of the crocodiles. Federal scientists were more circumspect and slow to accept that a recovery had occurred.

This was an era when protection was regarded as the only viable conservation strategy (Webb, 1997). This created incentives to employ very pessimistic or overly cautious population data for management decisions. This was manifested in the Federal Government's initial refusal to support the Northern Territory Government's bid to downlist Australian crocodiles to Appendix II of CITES (permitting commercial harvest).

Reinforcing this poor use of knowledge was the perception that conservation is a biological problem. This leads to research undertaken by biologists having high influence with policymakers. This distorts the discovery process in two ways. The first is that it creates blocks to utilising information or knowledge from other sources. Local or traditional knowledge is not used. This can create delays while scientists rediscover or verify local knowledge. For instance, Aborigines were aware that the number of nests constructed by crocodiles was usually limited by the availability of sites, rather than the number of female crocodiles. Discovering this fact had to be duplicated by crocodile researchers.

The fact that growth rates were limited by nesting site availability rather than crocodile density was one reason why harvest prompted crocodile populations to expand. The increase in nesting sites offset the removal of eggs from the wild, increasing crocodile numbers generally.

This hindrance to the employment of local knowledge about wildlife often occurs. It is partly caused by policy-makers assuming that biologists can provide knowledge at a high level of certitude (Murphree, 2003). Local knowledge is not couched in scientific terms, however, as its tacit or dispersed nature defies easy codification. The problem is that in complex bio-economic systems, biologists are also unable to provide knowledge at a level of certitude policy-makers seek. This gap between what information biologists can generate and what information policy-makers require before making a decision causes lags in management decisions.

The second distortion was that the protectionist strategy generated no knowledge about dealing with high abundance. Knowledge is contingent on time and space. As changes occur over time, some knowledge becomes redundant. Protectionism was a strategy for dealing with low abundance. New solutions had to be discovered yet protectionism was inimical to such discoveries. A consequence of legal protectionism is the common belief that the conservation problem has been solved. This results in little resources being devoted to studying the population.

The poor generation of knowledge occurs frequently with protected species (Moyle, 2003). For instance, in a subsequent study of the Red-Tailed Black Cockatoo in the Northern Territory, legal protection was not associated with any research to verify its impact on this species' population (Vardon et al., 1997). Indeed, practically no information at the governmental level existed on the distribution and status of this population. This is a natural outcome of legal protection being treated as sufficient to solve the conservation problem, making research a redundant exercise. This is a similar to the problem of 'paper parks' (Soulé and Sanjayan, 1998). In a 'paper park', the reserve exists largely as lines dawn on a map and with inadequate enforcement, provides no real protection to the wildlife. Unsanctioned harvests occur, with the park encroached by subsistence farmers or illegal foresters.

Another problem with protection and the elevation of scientific expertise is that there is a mismatch between the research that is conducted and the research questions requiring an answer. For instance, there was inadequate research by Federal scientists into the growth rates of crocodiles (assumed to be low). When dispersed knowledge of crocodile densities showed that recovery rates were higher than that presumed (on a theoretical basis) biologists were slow to accept a rapid recovery had occurred. Recovery rates were not a research problem that had been analysed. In effect, reliance on a single source of information- removed from communities who have tacit or implicit knowledge of wildlife distribution or growth- meant that scientific research was capricious. There was little guarantee that the biological research would address the issues facing communities living with wildlife. Indeed, as was shown in the case of the Australian crocodile, the problem was that this scientific research would perversely contradict local knowledge of wildlife issues.

Such research shows confusion between information and knowledge. Knowledge is required to manage resources effectively. Biological research may instead emphasise information-gathering. For instance, checklists of species known in a landscape are a common survey tool but generate very little knowledge that has utility for managers. A checklist provides information, not knowledge. Converting information into knowledge requires connections to communities that co-exist with wildlife. It cannot be done in isolation by bureaucratic organisations.

Third, the drivers of extinction are essentially economic. Biologists in general, have poor knowledge of these drivers. For instance, there was a widespread fear that resuming the harvests of crocodile for leather would ignite an illegal trade in crocodile leather. That the legal trade would drive out the illegal was not predicted by many involved in these policy debates (Webb, 1997). This is not surprising. Many biologists simply did not have the necessary knowledge. They could observe poaching activity (information) but had no economic model to make sense of these observations.

Management of Australian crocodilians then changed in the early 1980s. This involved a resumption of harvest and international trade. Nonetheless there were some important differences with the earlier open-access regime. Rather than adults being targeted, eggs were instead collected for ranches (or adults used on farms to generate the eggs). Land-owners were paid a royalty for the number of fertile eggs collected. The eggs were hatched and juveniles then raised for two to three years, whereupon they were harvested. The ranch or farm environment enhanced skin quality by reducing the numbers of scratches or scars that mar leather quality.

In economic terms, this involved establishing private property rights over part of the population during part of its life cycle. In biological terms, it shifted harvest from a cohort with low natural mortality (large adult crocodiles) to cohorts with high natural mortality (eggs). Almost 90% of eggs are destroyed by flooding on an annual basis and juvenile crocodiles also suffer high predation rates. An adult saltie grows to 5-7 metres long, weighs about a tonne, has a jaw-line like broken glass and is firmly on top of the food-chain. Mortality rates are naturally low for this cohort (in the absence of human harvest effort).

It is appropriate to analyse the use of knowledge. This management regime exploited local and dispersed knowledge of crocodilian populations better. Farmers would now fence their stock from waterways inhabited by crocodiles, rather than destroy the crocodile population. This increased crocodile numbers as one of the limiting factors was the availability of nest-sites. Protecting riverbanks increased the number of nesting sites, allowing animals that would not normally breed to do so. Farmers also began to protect their populations from illegal shooting (Webb, 1997).

Another beneficiary of this policy was Aborigines whose traditional knowledge of egg-collecting (an Aboriginal food) gave them a competitive advantage in egg-harvest. This was enhanced by innovation. Landowners (including Aborigines) began incubating eggs they collected and selling the hatchlings on to ranches. One community in the remote Arafura swamp (Arnhem Land) earned over $A180,000 from egg-collection in the 1994-5 season (Webb, 1997).

Innovation in the industry has continued. There is now a tourism industry associated with the crocodile ranches and farms in northern Australia. Once this connection was made, it was then enhanced by a number of river-boat operations that took tourists to see crocodiles in the wild. New products, such as crocodile meat were developed for local markets. In a short space of time, crocodiles went from being a dangerous pest to a valued resource. Accompanying this rise in economic value was a sustained increase in the population of crocodiles (Webb, 1997). This rise was in contrast to pessimistic predictions of decline under a resumption of harvest.

4. Conclusions

Many wildlife species are subject to different management regimes. Management often interacts with human socio-economic systems. The main obstacle to designing optimal recovery programmes is the levels of implicit and tacit knowledge. Few problems in conservation can be so narrowly prescribed to rule out human impacts. Where non-codified knowledge is dominant and the key factor that determines management outcomes, predicting the outcomes of different management regimes is almost impossible. Neither the outcomes of the protectionist regime, nor the sustainable-trade regime, were actually predicted. The rapid recovery under protection, and the development of tourism and meat industries with trade, was not predicted.

The lack of predictability has two major policy implications. First, if a management regime cannot be designed, it needs to be discovered over time. Adapative management is thus a sensible option for managers. An explicit determination of the threats and opportunities before a shift in management regime, will often be beyond the scope and resources of managers. A requirement that these threats be identified and ameliorated before such a shift, becomes in effect a ban on this shift. The second policy implication is that where there is significant implicit or tacit knowledge, management regimes that employ this knowledge are more likely to succeed.

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Les Crocodiliens : Débouchés Et Opportunités

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Résumé : Le but de l'exposé sera de faire un tour exhaustif des marchés actuels existant pour les peaux de crocodiliens et d'envisager des axes de valorisation possibles pour le futur.

Introduction : Marché du luxe dans le monde

A – Les différentes utilisations des peaux
1- La Maroquinerie
2- La Chaussure
3- Le Bracelet Montre
4- L'Habillement
5- Autres

B – Opportunités futures
1- Les pays émergents
2- L'impact de la qualité
3- Commerce équitable et label environnemental
4- La viande

C – Réponse aux questions diverses

Abstract: The goal of the presentation is to have an exhaustive outlook of the current markets existing for crocodilian skins and to consider possible axes of valorisation for the future.

Introduction: Worldwide Luxury market

A – Various uses of the skins
1- Leather goods
2- Shoes
3- Watch Strap
4- Clothing
5- Others

B – Future Opportunities
1- Emerging markets
2- Impact of quality
3- Equitable trade and environmental label
4- Meat

C – Answer to the various questions

Tannage Et Gestion De La Qualité Des Peaux De Crocodiliens Au Nord Du 45ème Parallèle

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Résumé : Les tanneries françaises de peaux exotiques disposent d'un capacitaire installé suffisant pour la transformation de plus de la moitié des peaux brutes de crocodiliens collectées dans le monde.
Les défauts présents sur le brut persistent sur le produit fini et sont quelquefois mis en évidence par le long processus de transformation des peaux brutes.
Ces défauts sont répertoriés en fonction de leur origine présumée, de leur impact financier sur la filière (importance et fréquence) et de la provenance des peaux de crocodiliens.
Un nouveau type de bague CITES est également proposée qui permettrait de faciliter la traçabilité produit à l'échelle mondiale.

Abstract: French Tanning Capacity is set to handle more than half of the main crocodilian skins produced world-wide.
Defects of the raw skins remain visible on the finished product and can sometimes be enhanced during the tanning and post-tanning processes.
Such defects are classified according to their presumed origin, their financial impact on the trade (frequency and importance) and the skins'origins.
A new CITES tag system is also proposed that could directly assist in product tracability on a global scale.

1. Introduction

La transformation des peaux de crocodiliens est organisée en deux parties:

1. Le tannage irréversible des peaux et la réalisation d'un produit intermédiaire standardisé communément appelé « croûte »
2. La finition des croûtes pour la réalisation des commandes clients

Cette stratégie de production est justifiée par les contraintes suivantes :

? La conservation

Les peaux brutes étant sensibles à la putréfaction, il convient de les stabiliser au plus tôt par le tannage. Les réceptions de brut sont donc mises en travail sans délai, immédiatement après leur inspection.

? La gestion du temps

Les nombreuses étapes du process de tannage et de la mise en croûtes requièrent beaucoup de temps : huit semaines sont nécessaires en moyenne selon les tailles et les origines. Il est donc nécessaire pour le tanneur de constituer un stock de marchandises semi-ouvrées (croûtes) pour pouvoir satisfaire à sa demande client dans des délais acceptables.

? La nécessité d'un tri en choix et taille précis

Les peaux en croûtes sont sèches, faciles à manipuler et à stocker ; elles présentent une bonne aptitude au tri en taille et en choix. Les défauts sont alors beaucoup plus facilement identifiables qu'au stade du brut. Les commandes clients sont constituées à partir des stocks de croûtes dans un souci permanent de valorisation des choix disponibles, de respect du cahier des charges client, des besoins spécifiques du marché concerné et des articles à réaliser certains défauts étant particulièrement mis en évidence sur certaines finitions et/ou teintes.

2. Le process de tannage

2.1. La réception des peaux brutes

Afin d'assurer une traçabilité sans faille de chacune des peaux tout au long de leur processus de transformation et de commercialisation, Une étiquette code-barres individuelle est fixée à l'extrémité de la queue (cf. photos P1) au stade initial de la réception. Les deux modèles illustrés sur les photographies P1 et P2 sont couramment utilisés

Photo P1- Etiquette code-barres individuelle agrafée

Photo P2- Etiquette code-barres individuelle fixée par perforation

Les données en choix et taille peuvent alors être saisies individuellement dans la base de données informatique de la tannerie.

Les peaux, conservées par salage, sont très souvent victimes d'une prolifération bactérienne marquée (« red heat ») que l'on espère toujours superficielle.
Ce phénomène devenu tristement banal est d'autant plus préoccupant qu'il se concerne l'ensemble des origines et que des foyers d'infection semblent se généraliser dans les magasins de salage.
Des études réalisées sur les peaux d'ovins et de bovins concernées par le même phénomène de développement de bactéries halophiles, ont révélé que cette présence bactérienne pouvait avoir un lien direct avec la production d'enzymes protéolytiques responsables d'une dégradation partielle des fibres de collagène.
Ce phénomène, potentiellement préjudiciable à la qualité de nos peaux, est illustré sur la photo P3 représentant une peau salée brute dont les chairs sont recouvertes de « red heat ».

Photo P3 – Attaque de « Red Heat » visible sur la chair de la peau (la zone ovoïde plus claire au centre de la photo a été nettoyée pour plus de contraste)

2.2. Mise en croûtes des peaux brutes

Ce long processus de transformation doit, d'une part permettre une homogénéisation optimale de la production pour lisser les variations saisonnières et les différences relatives aux conditions d'élevage afin que les caractéristiques du produit obtenu soit aussi constantes que possible pour chacune des origines, et d'autre part, être ajusté pour que la croûte soit suffisamment versatile pour satisfaire les demandes

spécifiques des nombreux marchés en fini.
Ce process est composé de nombreuses étapes de traitements mécaniques et chimiques de la matière première brute :

? Le lavage, la réhydratation des peaux conservées par salage et l'élimination des protéines solubles indésirables présentent au cœur de la peau.
? L' « écharnage » pour éliminer les chairs encore adhérentes sur la partie en contact avec la carcasse de l'animal et permettre une pénétration homogène des produits chimiques utilisés dans les étapes suivantes
? Le « pelain » avec la dégradation chimique de la kératine recouvrant la partie superficielle de la peau et des autres protéines non désirables encore présentent à ce stade.
? Le « déchaulage », le « confit » et le « picklage » et éventuellement le « décornage » permettant la préparation des peaux au tannage.
? Le tannage, dont la finalité est la réticulation irréversible des fibres de collagène permettant la stabilisation du produit. Il peut être réalisé à l'aide d'extraits végétaux ou sur une base « organique » avec l'utilisation de molécules de synthèse. Il est cependant généralement conduit sur une base minérale (utilisation de sels de chrome trivalents) car ce procédé bien maîtrisé aujourd'hui, est connu pour les bonnes performances physiques qu'il confère au produit final.
  A ce stade du process, les peaux ne sont plus putrescibles et peuvent être à nouveau examinées pour vérification des choix. La couleur impartie par le tannage et l'humidité des peaux peuvent, dans certains cas, rendrent l'examen des choix parfois délicat.

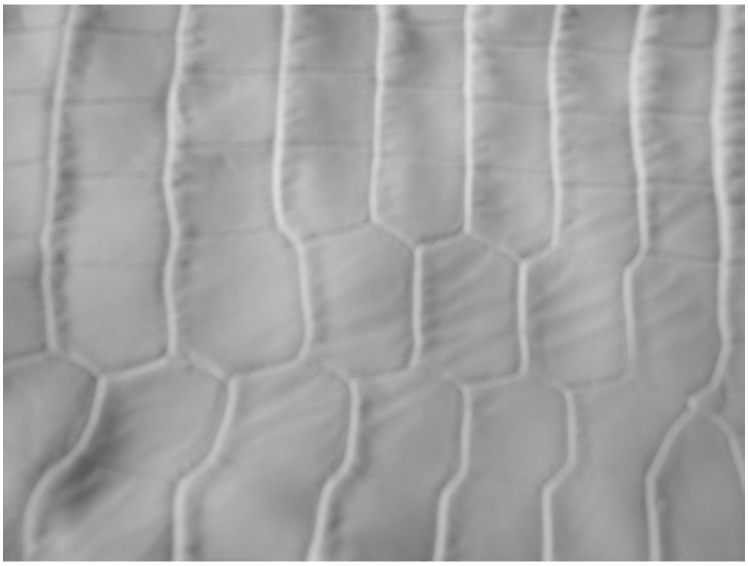


Photo P4- « Wrinckles » visibles sur alligator tanné au chrome

? Le « mûrissement » qui permet d'optimiser le taux de réticulation de l'agent de tannage et par conséquent son efficacité.
? Le « dérayage » dont l'objectif est de régulariser l'épaisseur des peaux. Cette opération mécanique, précise au 1/10ème de mm) et réalisée en humide permet d'éliminer l'excédent de matière dermique en fonction des tailles de peaux

considérées. L'épaisseur des peaux sera une nouvelle fois rectifiée au stade de la croûte, en fonction des besoins clients.

? La « décoloration », qui est très souvent réalisée, permet l'élimination des taches de mélanine sur les flancs. Elle est obtenue par un traitement oxydatif puissant.
? Le « retannage, nourriture » permet de compléter le tannage, d'éclaircir la nuance des peaux et d'autoriser une sèche réversible des peaux.
? Un dégraissage à sec est ensuite réalisé pour extraire les matières grasses naturelles encore présentes à ce stade et permettre la réalisation d'un stock homogène constituant alors la matière première utilisée pour la réalisation des commandes clients.
? Les peaux en croûte sont alors triées soigneusement en choix et taille.

2.3. Réalisation des commandes clients

C'est à ce stade de la transformation, que les caractéristiques finales du produit sont conférées aux peaux : souplesse, élasticité, couleur, état de surface, performances physiques, etc…
Les lots en travail correspondent aux détails des commandes et le matériel utilisé dans cette deuxième partie de la production, doit donc être adapté à un nombre de peaux particulièrement variable.
Les principales étapes qui constituent ce process sollicitent la majorité de la main d'œuvre de la tannerie et se décomposent comme suit :

? La «teinture », accompagnée des opérations de «retannage et de nourriture » qui contribuent à conférer aux peaux les spécificités attendues par le client.
? La « sèche », souvent réalisée sous tension afin de permettre une bonne stabilité dimensionnelle des peaux.
? Les opérations mécaniques de « dérayage », et éventuellement de « ponçage », pour ajuster l'épaisseur finale et la présentation des peaux.
? La « finition » avec la réalisation du film de surface permettant la mise en valeur de la peau et sa protection de surface.
? Le « tri final » avant l'expédition au client

Certaines finitions et certaines couleurs révèlent d'avantage les défauts naturels ; c'est le cas par exemple de certains articles mats réalisés dans des teintes pastelles.
Le choix des croûtes mises en œuvre pour la réalisation d'une commande client est donc ajusté en fonction de l'expérience du tanneur mais il se révèle toujours limité par l'inadéquation entre les choix disponibles et les exigences client.

3. Classification et ponderation des defauts naturels visibles en fini

Ces défauts ont de nombreuses origines ; les tanneurs s'efforcent d'ajuster continuellement la performance et le contrôle de leur production pour limiter l'impact des incidents de fabrication et les défauts présents sur le brut sont aujourd'hui à l'origine de la majorité des déclassements de peaux en fini.

Un tableau résumant les principaux défauts naturels présents sur les différentes origines est présenté ci-dessous :

Défauts du Brut	**Niloticus**	**Alligators**	**Porosus**	*Priorité*
Griffures et cicatrices	✍	✍✍	✍	**1**
Wrinckles	✍✍	✍✍	✍✍	**2**
Piques	✍✍	✍✍	✍✍	**3✍**
Double écaille	✍✍		✍✍	**4**
Parasites	✍✍	✍✍	✍	**5**
Couttelures	✍✍	✍✍	✍	**6**

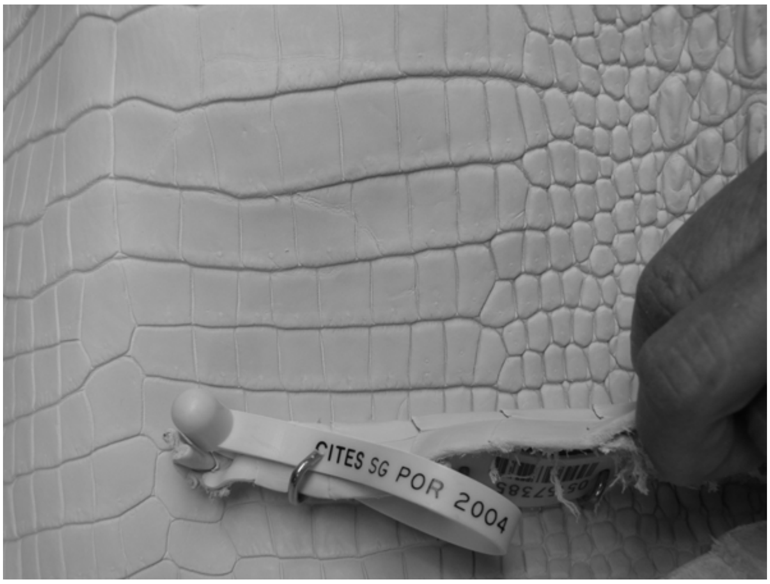
Tableau T1 – Comparaison des différents types de défauts naturels

Ces défauts, qui ne sont pas toujours clairement visibles en brut apparaissent très nettement sur croûte après le retrait des écailles au cours des opérations précédant le tannage:

3.1. Griffures et cicatrices

Ce sont les défauts les plus fréquemment rencontrés avec plus de 60% d'impact sur l'ensemble des origines (surtout les Niloticus et les alligators) ; Elles restent visibles sur les peaux finies même lorsqu'elles sont tout à fait cicatrisées.

Photos P5 – Cicatrices sur alligator brut



Photos P 6– Cicatrices sur Porosus en croûte

3.2. Les « wrinckles »

Elles ne sont pas toujours clairement visibles en brut, existent sur l'ensemble des origines mais sont particulièrement présentes sur les Porosus (35/+ principalement) et les Niloticus et peuvent toucher jusqu'à 60% des lots de brut; l'impact économique de ce type de défaut est donc particulièrement important.

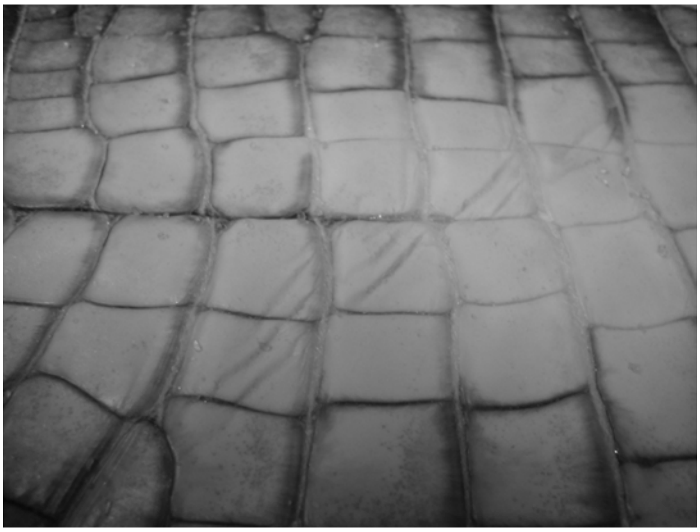


Photo P7- Wrinckles sur Alligator brut

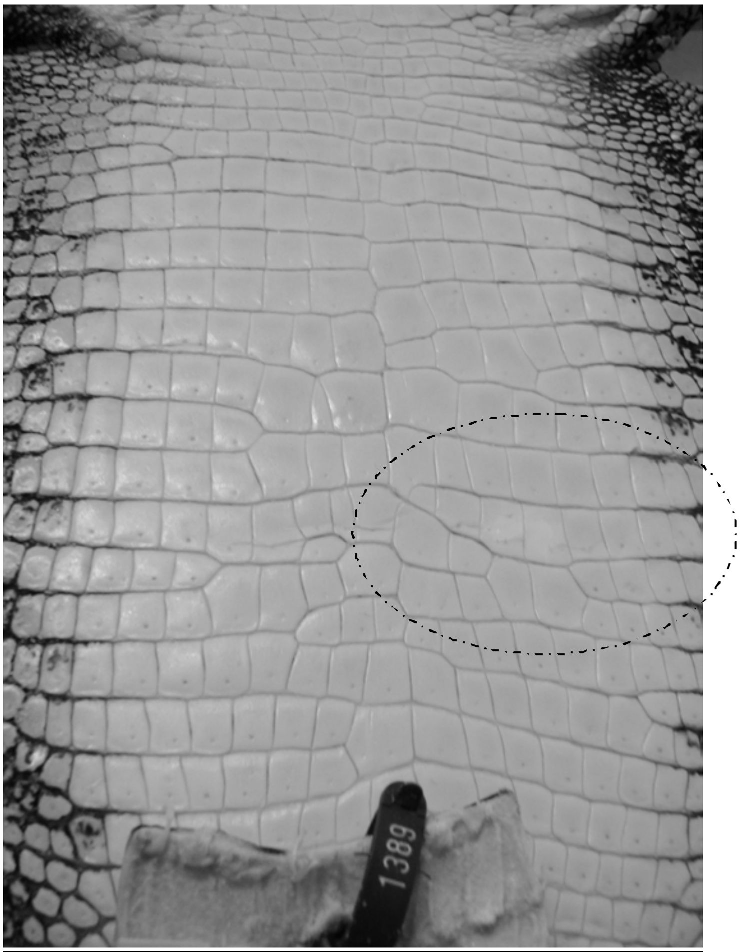


Photo P8 - « Wrinckles » sur Porosus brut visibles également sous l'écaille soulevée (zone plus claire)

3.3. Les piqûres

Elles sont aujourd'hui principalement présentes sur l'alligator (Floride essentiellement) ; on ne les retrouve que peu sur les Porosus et les Niloticus.

3.4. La double écaille

Elle devient un véritable problème principalement sur le Niloticus (jusqu'à 20% quelque soit les tailles) et sur le Porosus (jusqu'à 10/15 % des lots). Ce défaut est en effet de plus en plus rejeté par la clientèle.

3.5. Les attaques de parasites

Elles sont difficilement visibles en brut. 10/15% des peaux d'alligators sont concernées (surtout dans les tailles 35 à 49 cm). Elles sont beaucoup plus rares sur le Porosus et le Niloticus

4. Impacts financiers des differents defauts naturels sur la filiere, par marches

4.1. Maroquinerie

L'étude du déclassement pour présence de défauts naturels sur plusieurs lots de Porosus finis (lissés) destinés à la maroquinerie a donné les résultats suivants :

N°du lot	Pourcentage de déclassement pour défauts naturels	Nombre de peaux concernées
1	27%	186
2	34%	68
3	31%	75

Tableau T2 – Déclassement pour défauts naturels sur Porosus finis

Les même études portant sur des lots de Niloticus lissés ont donné des résultats comparables :

N°du lot	Pourcentage de déclassement pour défauts naturels	Nombre de peaux concernées
1	31%	285
2	26%	650
3	63% (lot non pré-trié en croûtes)	211

Tableau T3 – Déclassement pour défauts naturels sur Niloticus finis

L'impact de ces défauts (griffures et cicatrices principalement) est donc évident. Il faut noter que ces peaux avaient déjà fait l'objet d'un pré-tri en croûtes avant teinture mais que des défauts ont été rendus visibles par la finition. Ces peaux déclassées ont été vendues avec une décote supérieure à 20% ce qui représente une perte sèche pour la filière.

4.2. Bracelet montre

Le même type d'études réalisées sur des lots d'alligators finis pour la fabrication de bracelets montre a donné les résultats suivants :

N°du lot	Pourcentage de déclassement pour défauts naturels	Nombre de peaux concernées
1	33%	200 (noir lissé)
2	19%	101 (couleur lissé)
3	46%	155 (rose pastel mat)
4	33%	350 (noir mat)

Tableau T4 – Déclassement pour défauts naturels sur Alligators finis

Le déclassement est ici encore très important, surtout si l'on considère que les lots ont été pré-triés en croûtes. La décote est ici de 15% de perte sur ces marchandises.

5. Conclusions

L’impact des défauts naturels sur la gestion financière et commerciale de nos matières premières est d’autant plus regrettable, que contrairement aux autres filières de tannage pour lesquelles la peau est un sous-produit de l’industrie de la viande, et n’est par conséquent pas maîtrisable en qualité et en quantité, nous devrions être en mesure de mieux satisfaire aux attentes de nos marchés et valoriser notre matière première.

Une attention toute particulière doit donc être apportée à la résolution des défauts au stade de l’élevage, de la préparation et de la conservation des peaux brutes.

6. Propositions d’amelioration des bagues CITES actuelles

6.1. Cas des Matières Plastiques Utilisées

Les codes CITES sont quelquefois réalisés dans des matières plastiques cassantes provoquant la perte du code et des dégâts à la surface des peaux en travail (cf. photo P9). Notre filière pourrait directement bénéficier d’une homogénéisation du type de bagues CITES utilisées avec en particulier le retrait des matériaux inadaptés et posant un risque direct sur la qualité de nos produits.

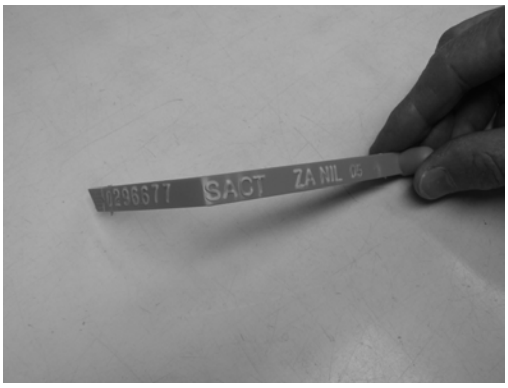


Photo P9 – Code CITES en matière plastique bleue cassante

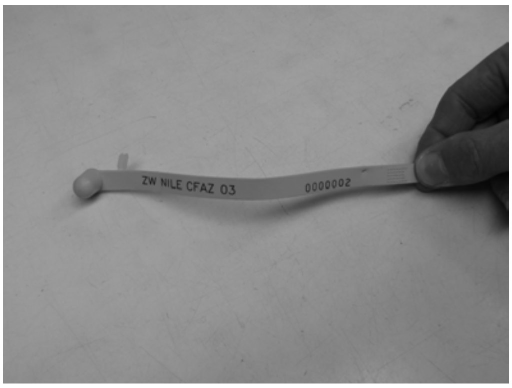


Photo P10 – Code CITES en matière plastique rose souple et résistante

Les Tanneries des Cuirs d’Indochine et de Madagascar ont mis en place depuis 1995 un dispositif de code-barres systématique en complément des bagues CITES.

D’autres tanneries ont également adapté ce moyen de gestion complémentaire qui permet une identification rapide et complète de chaque peau.

Les code-barres apportent entres autres avantages :

? Une traçabilité en cas de problème
? Une localisation aisée des peaux en cours de production.
? Une gestion rapide et précise des stocks
? Un suivi statistique de la production, des achats, des ventes, …
? Un transfert de données entre sociétés
? Un historique des peaux travaillées

Les difficultés techniques rencontrées ont concerné :

? La qualité de l’étiquette code barre dont le plastique doit pouvoir résister aux acides, au sulfure et au perchloroéthylène
? Le marquage au laser des étiquettes
? La lecture du code après teinture avec la sélection d’un lecteur approprié
? La mise en place d’un réseau informatique
? La création d’un logiciel de base de données adapté à nos besoins spécifiques

6.2. Proposition d’impression des code-barres sur les bagues CITES

L’impression des code-barres sur les bagues CITES actuelles présenterait, pour l’ensemble de notre filière, les avantages suivants:

? Possibilité pour chacun de mettre en place une gestion informatique à partir d’un système simple, fiable, et rapide
? Diminution du coût pour les utilisateurs actuels de code barres et allègement du poids de la queue au profit d’une meilleure gestion qualité en production
? Standardisation du système
? Extension de la traçabilité à toute la filière.
? Transfert d’informations facilité entre fournisseurs et clients.
? Simplification et automatisation de la gestion des CITES, pour une plus grande rapidité et un moindre risque d’erreurs et de fraudes.

World Trade In Crocodilian Skins, 2002-2004

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1. Introduction

This is the thirteenth report produced by UNEP-WCMC for the International Alligator and Crocodile Trade Study (IACTS) and examines the international trade in crocodilian skins from 1980 to 2004. As in the previous reports, the data used in this report have been obtained from the *CITES Trade Database* that UNEP-WCMC maintains on behalf of the CITES Secretariat, with additional information provided by the Crocodile Farmers Association of Zimbabwe. The present report is intended to update the earlier reports by detailed analysis of information for the years up to 2004. It also attempts to identify problem areas and to recommend, where possible, workable solutions.

As in the IACTS reports for 2001 - 2003, this report presents information on trade levels in classic skins (alligators and true crocodiles) and caimans and also trade in other products such as live animals and meat.

2. Methods

This report is based on an analysis of the annual reports submitted by the Parties to CITES for all years up to 2004, and if applicable, 2005. A list of annual reports for 2002-2004 that had been received at UNEP-WCMC at the time of writing is given in Table 1. In order to be comparable with previous IACTS reports, all trade in whole skins and sides of crocodilian species has been analysed with two sides being considered to be equivalent to one skin. Trade in skins reported in units of weight, area, length or sub-units such as 'tails' has been mainly excluded. Wherever possible, data reported by the producer countries have been used in preference to that reported by importing countries because small differences in the manner of reporting, or the time lag between export and import, may lead to double-counting and thus an overestimation of trade volume. However where producer countries have failed to submit annual report data on exports of crocodilians, importers' data have been used. Many of the transactions have been analysed at the export permit level. As with previous reports that covered the years 1995-2003, re-export trade has not been included in the estimation of annual production.

3. Limitations of data

Late submission or complete failure to submit CITES annual reports continue to be the biggest problems in conducting trade studies using CITES annual report data.

In the IACTS 2002 report we drew attention to measures taken by the CITES Standing Committee that resulted in many Parties providing their missing reports however the situation appears to slipped back since then.

A further problem with annual reports is the basis on which they are compiled. According to CITES Notification to the Parties No. 2002/022 of 9 April 2002 (now replaced by No. 2006/030 of 2 May 2006), Parties may report on the basis of the permits and certificates they have issued if they are unable to report on the actual number of specimens that entered or left the country. However, reporting on the basis of permits issued may lead to overestimates of trade volume as permits are frequently issued for quantities in excess of those actually traded and indeed, some of the permits may not even be used. Despite frequent reminders from the CITES Secretariat, the majority of Parties still fail to provide any details concerning the basis on which their annual reports are compiled and although UNEP-WCMC has access to the export permits routinely sent by several Parties to the CITES Secretariat, few of these are currently from crocodilian exporting countries.

Most CITES annual reports are compiled on a shipment-by-shipment basis and many include the exporters' permit numbers. This allows for very accurate cross-checking of data, particularly where an export may be reported in one year and the import of the same shipment reported the following year, and enables potential reporting or typographical errors to be traced. In recent years only Switzerland, a significant importer of crocodilian skins, has failed to report in this way.

All annual reports for the years up to 2004 should have been submitted by 31 October 2005 but, at the time of writing (June 2006), several reports that might contain important data have still not been received by the CITES Secretariat. These include Honduras (2002), Kenya (2003), Malawi (2002), Nicaragua (2004), Panama (2002), Uganda (2002, 2003 and 2004), Venezuela (2004) and Viet Nam (2003, 2004). The potential effect of such omissions has been commented upon during the analysis. However Japan, a major importer of crocodilian skins that has consistently failed to report on time, has now caught up with its backlog of reports thus allowing better estimation of trade involving major exporters that have failed to submit reports.

Table 1. CITES annual reports for 2002-2004 available for analysis

Country	2002	2003	2004
Algeria	*	*	*
Antigua and Barbuda	*	*	-
Argentina	*	*	*
Australia	*	*	*
Austria	*	*	*
Azerbaijan	*	*	*
Bahamas	*	-	-
Bangladesh	*	*	*
Barbados	*	*	*
Belarus	*	*	*

Country	2002	2003	2004
Belgium	*	*	*
Belize	*	*	–
Benin	*	–	*
Bermuda	*	–	–
Bhutan		*	–
Bolivia	*	*	*
Botswana	*	*	–
Brazil	*	*	*
Brunei Darussalam	*	*	–
Bulgaria	*	*	*
Burkina Faso	*	*	*
Burundi	*	*	*
Cambodia	*	*	*
Cameroon	*	–	–
Canada	*	*	*
Central African Republic	*	*	–
Chad	*	*	*
Chile	*	*	*
China	*	*	*
Colombia	*	*	*
Comores	–	–	–
Congo	*	*	–
Costa Rica	*	*	*
Côte d'Ivoire	*	*	*
Croatia	*	*	*
Cuba	*	*	*
Cyprus	*	*	*
Czech Republic	*	*	*
Democratic Republic of the Congo	*	*	*
Denmark	*	*	*
Djibouti	*	–	–
Dominica	*	–	–
Dominican Republic	*	–	–
Ecuador	–	–	*
Egypt	*	*	*
El Salvador	*	*	*
Equatorial Guinea	*	*	*
Eritrea	*	–	–
Estonia	*	*	*
Ethiopia	*	*	*
Finland	*	*	*
France	*	*	*
Gabon	*	*	*
Gambia	*	*	*
Georgia	*	*	–
Germany	*	*	*
Ghana	*	*	*

Country	2002	2003	2004
Greece	*	*	*
Greenland	*	*	–
Grenada	*	–	–
Guatemala	*	*	–
Guinea	*	*	–
Guinea Bissau	*	*	–
Guyana	*	*	*
Honduras	–	*	*
Hong Kong, SAR	*	*	*
Hungary	*	*	*
Iceland	*	*	*
India	*	*	*
Indonesia	*	*	*
Iran	*	*	*
Ireland	*	*	*
Israel	*	*	*
Italy	*	*	*
Jamaica	*	*	*
Japan	*	*	*
Jordan	*	*	*
Kazakhstan	*	*	–
Kenya	*	–	*
Kuwait		*	*
Latvia	*	*	*
Liberia	*	*	*
Liechtenstein	*	*	*
Lithuania		*	*
Luxembourg	*	*	*
Macao, SAR	*	*	*
Macedonia	*	*	*
Madagascar	*	*	*
Malawi	–	*	*
Malaysia	*	*	*
Mali	*	*	*
Malta	*	*	*
Mauritius	*	*	*
Mexico	*	*	*
Moldova	*	*	*
Monaco	*	*	*
Mongolia	–	–	–
Morocco	*	*	*
Mozambique	*	*	*
Myanmar	*	*	*
Namibia	*	*	*
Nepal	*	*	–
Netherlands	*	*	*
New Caledonia	*	*	

Country	2002	2003	2004
New Zealand	*	*	*
Nicaragua	*	*	–
Niger	*	*	–
Nigeria	*	*	*
Norway	*	*	*
Pakistan	*	*	*
Panama	–	*	*
Papua New Guinea	*	*	*
Paraguay	*	*	–
Peru	*	*	*
Philippines	*	*	*
Poland	*	*	*
Portugal	*	*	*
Qatar	*	*	*
Republic of Korea	*	*	*
Romania	*	*	*
Russian Federation	*	*	*
Rwanda	*	–	–
Saint Kitts and Nevis	*	*	*
Saint Lucia	*	*	*
Saint Vincent and the Grenadines	*	*	*
Saudi Arabia	–	*	*
Senegal	*	*	*
Serbia and Montenegro	*	*	*
Seychelles	*	–	–
Sierra Leone	*	*	*
Singapore	*	*	*
Slovakia	*	*	*
Slovenia	*	*	*
South Africa	*	*	*
Spain	*	*	*
Sri Lanka	*	*	*
Sudan	*	*	*
Suriname	*	*	*
Swaziland	*	*	*
Sweden	*	*	*
Switzerland	*	*	*
Thailand	*	*	*
Togo	*	*	*
Trinidad and Tobago	*	*	*
Tunisia	*	*	*
Turkey	*	*	*
Uganda	–	–	–
Ukraine	*	*	–
United Arab Emirates	*	*	*
United Kingdom	*	*	*

Country	2002	2003	2004
United Republic of Tanzania	*	*	*
United States of America	*	*	*
Uruguay	*	*	*
Uzbekistan	*	*	*
Vanuatu	*	*	–
Venezuela	*	*	–
Viet Nam	*	–	–
Yemen	*	*	*
Zambia	*	*	*
Zimbabwe	*	*	*

* = report available; – = report not received; no symbol denotes country not party to CITES

The accuracy of the data provided in CITES annual reports is a further limitation to perfect analysis. In previous IACTS reports it has been noted that skins have been reported as live animals, skin pieces such as back strips, necks, flanks and tails have been reported as whole skins and, in the case of the Zimbabwe annual reports, mixed shipments of belly skins, hornbacks and backskins on multiple permits have been confused to the extent that the reported exports on those permits were overestimated by 450 per cent. Possibly the greatest cause of confusion are "backskins" that are frequently reported simply as "skins". Considerable effort has again been made during the compilation of this report to clear up these inconsistencies by close cross matching of imports with the original export permit information and the results are discussed in the various species accounts.

4. Skins species accounts

4.1. *Crocodylus acutus* / American crocodile

The first recorded trade in this species since 1989 was two shipments, each of 50 skins from captive-bred animals, exported from Colombia to France in 2001. Both the importer and the exporter reported this trade. No further trade was reported as occurring in 2002, however France reported importing 130 skins (two shipments) from registered captive-breeding operations in Colombia in 2003. Colombia has two farms registered with CITES for production of this species and confirmed the exports to France. A further 30 skins were reported as exports to France by Colombia in 2004. Honduras has one registered farm producing this species and it appears the first reported import was of 500 skins by Japan in 2003. This was followed by an export of 197 skins to Panama in 2004 that were apparently subsequently re-exported back to Honduras.

4.2. *Crocodylus johnsoni* / Australian freshwater crocodile

Figure 1. Australian exports of *Crocodylus johnsoni* 1988 - 2003

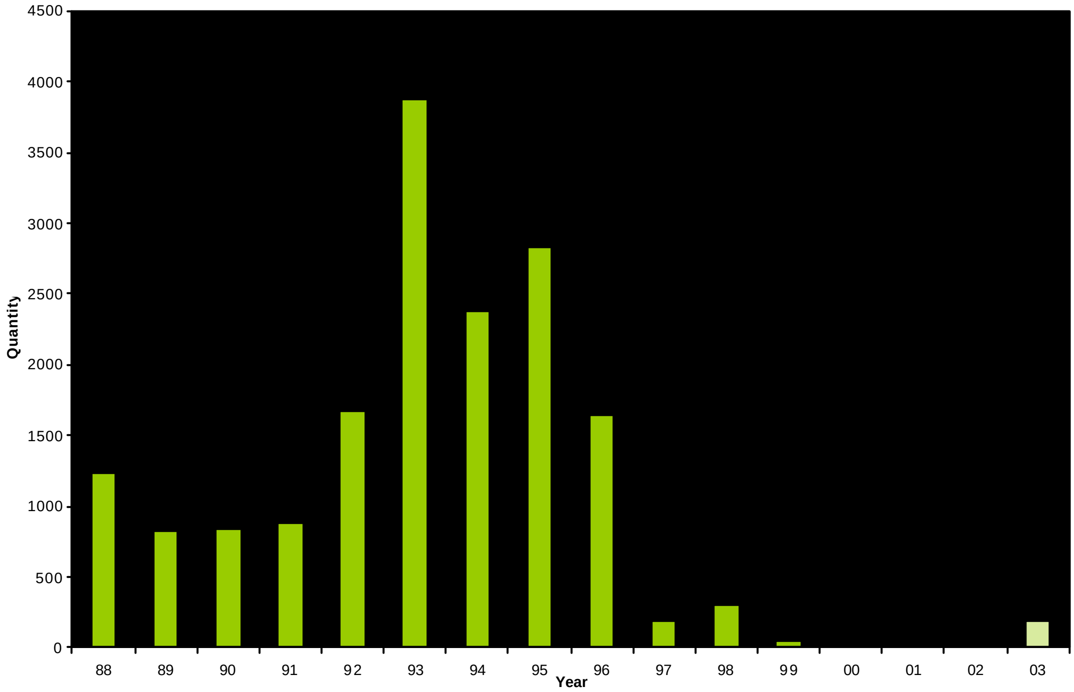


Figure 1 shows that exports from Australia peaked at 3875 in 1993, remained high between 1994 and 1996 but have since fallen to insignificant levels. No direct exports in skins of this species was reported in 2001 or 2004 and only two, exported to Japan, in 2002. Japan reported the import of 184 skins in 2003 but the format of the export permit numbers would suggest the trade was in manufactured products rather than whole skins. In 2004 Singapore reported re-exporting 1581 of the skins exported by Australia in 1994 and 1995 to China.

4.3. *Crocodylus moreletii* / Morelet's Crocodile

Mexico has three captive-breeding operations for this species registered with the CITES Secretariat. Exports began in 1997 with 146 skins going to France, Italy and Panama. This was followed by exports of 193 skins in 1998 and a further two in 1999. In 2000 exports increased to 1228 skins and again to 3643 in 2001. Exports then decreased to 1588 skins in 2002, to 1037 in 2003 and further to 609 in 2004. Japan has been the main importer since 2002 with lesser quantities going to France, Italy and Spain.

4.4. *Crocodylus niloticus* / Nile crocodile

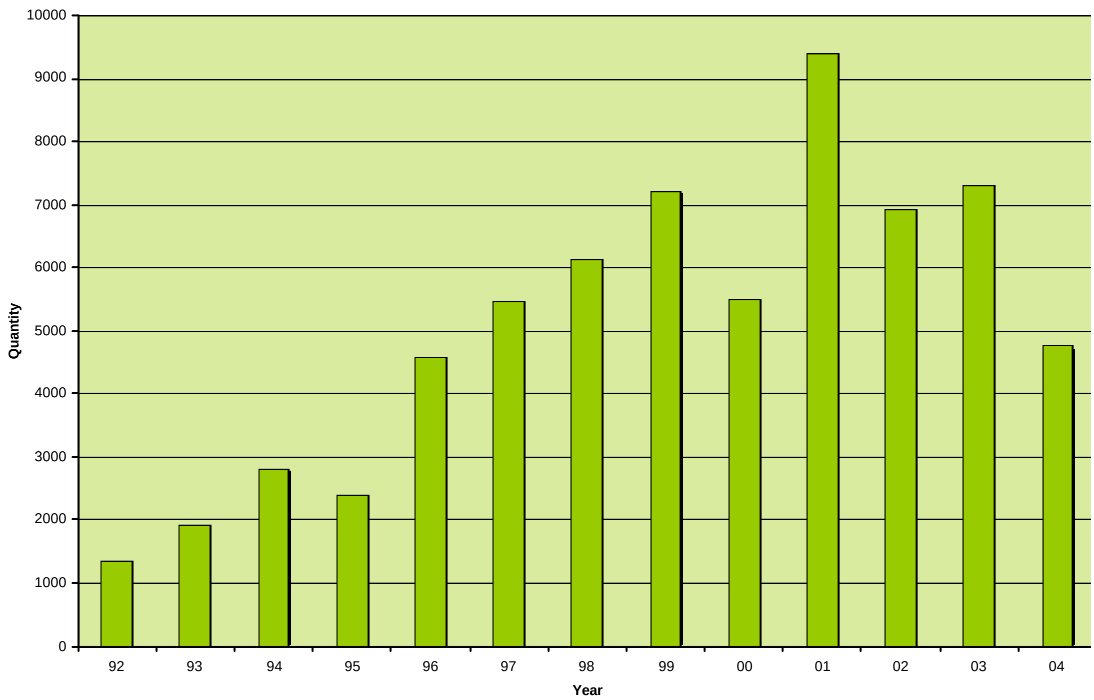
The major analysis of the data for this species, based on available permit numbers that was initiated with the IACTS 2002 report has continued with the aim of eliminating misinterpretation caused by the variety of terms used to describe the skins. For the purposes of this report, bellies, skins and hornbacks have been treated as representing entire skins. A summary of the trade data from 1997-2003 can be found in Table 2.

4.4.1. Range States exporters

- **Botswana:** although Botswana reported exports of over 9000 skins between 1992 and 1994, there have been no commercial exports of skins between 1997 and 2004 apart from 152 skins from captive-bred individuals that South Africa reported importing in 2001.

- **Central African Republic:** apart from an import of 35 skins reported by France in 1986 there have been no commercial exports.
- **Congo:** small numbers of skins were exported to France during the 1980s but there have been no commercial exports reported since 1989.
- **Ethiopia:** is an intermittent exporter and the crocodile breeding operation is not currently registered with the CITES Secretariat. The only importer appears to be the United Kingdom who reported importing 220 skins in 2002. In 2003 Ethiopia reported exports of 1354 skins and a further 446 in 2004.
- **Guinea:** Guinea has not reported exporting skins since 1991, nor have there been any reported imports from that country apart from a seizure of 100 skins reported by Spain in 1995.
- **Kenya:** Singapore reported importing 1687 skins from Kenya in 2003 (no report has been received from Kenya for that year) and Kenya reported exports of 2850 skins in 2004. All trade was in ranched material.
- **Liberia:** a few commercial exports to France, amounting to almost 1500 skins, were reported between 1981 and 1984 but none since.
- **Madagascar:** Madagascar's exports since 1992 are shown in Figure 2 and indicate a steady increase until 2001. Reported exports then dropped to 6936 skins of which 500 were reported to be from the wild in 2002, and then increased slightly in 2003 to 7300, of which 700 were from the wild. Reported exports fell further to 4760 in 2004, of which 2110 were reportedly captive-bred, 2150 ranched and 500 from the wild. It should be noted that Madagascar had a quota of 7600 skins from ranched animals and 500 skins from wild nuisance animals in 2002, 2003 and 2004.

Figure 2. Exports of *Crocodylus niloticus* skins from Madagascar 1992 - 2004



- **Malawi:** In 2003 Malawi reported exporting a total of 301 skins, to France, Singapore and Zimbabwe, and a further 20 to France in 2004. However France reported the import of 80 skins in 2004 on a Malawi export permit not reported by Malawi in either year so it seems likely that Malawi's true export figure was 100 skin in 2004. All skins were reported to be of wild origin.
- **Mozambique:** In 2003 Mozambique reported exporting 3160 skins, mostly going to South Africa with a few (338) going to Singapore, all but 195 from ranched animals. The annual reports of the importing countries confirmed most of these shipments. The 2004 report from Mozambique only indicates exports of 2000 back skins to Singapore in that year and there are no reports from importers to indicate to the contrary.
- **Namibia:** No exports of skins have been reported since 2000. Namibia has one crocodile ranching operation registered with the CITES Secretariat.
- **Nigeria:** as noted in previous IACTS reports, Italy reported importing 10,304 skins from Nigeria in 1981 and a further nine in 1983. No further commercial shipments have been reported although seizures of items from tourists returning from that country occur regularly.
- **Somalia:** as noted in previous IACTS reports, a total of 2189 skins were reported as imports by Italy and Japan in 1980 and 1981 but no further commercial shipments have been reported since.
- **South Africa:** reported exports up to 2002 indicated a steady expansion of the trade from 29,698 skins for in 2000, 33,335 in 2001 and 45,755 in 2002. Reported exports decreased to 31,321 in 2003 and increased again to 35,760 in 2004. Almost all of the skins were reported to be from captive-bred animals. It should be noted that South Africa has been a major re-exporter of skins produced in Zambia and Zimbabwe.
- **Sudan:** as previously reported in IACTS 2004, the only recorded commercial trade involving Sudan was in 1992 when Egypt reported importing 7900 skins. However, there have been no records of re-exports of Sudanese crocodile skins by Egypt and it seems likely that they may have actually been skins of Nile monitor, *Varanus niloticus*, and misreported by Egypt.
- **Togo:** as noted in previous IACTS reports, no trade in skins has been reported since the early 1980s when 6377 were exported to France between 1982 and 1983.
- **Uganda:** The first trade since 1994 began in 2000 and continued in 2001 with a total export of 1408 skins, all to Italy. Italy reported importing a further two skins in 2002 but none in 2003. In 2004 the Republic of Korea reported importing 300 skins from captive-bred animals. Uganda has not yet submitted reports for 2002, 2003 or 2004.
- **United Republic of Tanzania:** although commercial exports increased steadily between 1997, when Tanzania reported exporting 275 skins, and 2001 when 1498 were reported being exported, commercial trade appears to have stabilised with totals of 1359 in 2002, 1439 in 2003 and 1067 in 2004, all from wild origin. Serious doubt has emerged that Tanzania has included all of their crocodile export data in their latest annual reports so these figures have been taken from the reports of the importing countries, notably France and Singapore.

- **Zambia:** In 2002, Zambia reported exports of 22,259 skins, a further 28,019 in 2003 and 26,353 in 2004. All of appear to be from ranching operations. Singapore and Japan were the main destinations, with Spain and South Africa taking lesser amounts.
- **Zimbabwe:** In 2003 CFAZ reported exporting 73,707 skins, a slight decrease from the year before. The CITES M.A. recorded a similar figure (70,378) for that year, which may suggest an improvement in reporting as comparisons for earlier years had shown significant discrepancies. In 2004 the Management Authority reported exports of 60,185 skins and CFAZ 68,263. Comparison between the two datasets indicates that the Management Authority have failed to report some 30 shipments reported by CFAZ that can be confirmed by data from the importing countries. In table 2 we have used the CFAZ figure to calculate the total number of skins.

4.4.2. Exporters from other countries (out of range states)

- **Brazil:** Brazil reported exporting one skin to the United States in 2003 and a further 44 in 2004.
- **Israel:** reported exporting 699 skins to France in 2002, a figure confirmed by the importer, No further exports were reported for 2003 0r 2004.
- **Mauritius:** first reported exporting skins (30) from captive-bred individuals in 2000. This gradually increased to 93 in 2001, 178 in 2002, 118 in 2003 and 400 in 2004. The importers have been Madagascar, Singapore and Zimbabwe.

Table 2. Reported trade in *Crocodylus niloticus* skins, 1997-2004

Country	1997	1998	1999	2000	2001	2002	2003	2004
Botswana	337	0	0	0	152	0	0	0
Brazil	1	2082	720	1477	50	0	1	44
Ethiopia	0	0	0	926	42	203	1354	446
Israel	0	0	552*	811*	2289*	699	0	0
Kenya	1445	400	3350	3460	3713*	2317	1687*	2850
Madagascar	5464	6520	7207	5506	9408	6936	7300	4760
Malawi	600*	200*	170	360*	1256	120*	301	100*
Mauritius	48	59	266	30	93	178	118	400
Mozambique	1430	810	813	718	477	293	3160	0
Namibia	120	53	115	100	0	0	0	0
South Africa	13,573	8863	27,641	29,968	33,335	45,755	31,321	35,760
Uganda	0	0	0	508*	900	2*	0	300*
U.R.Tanzania	275	777	827	1302	1498	1259*	1439*	1067*
Zambia	12,238*	14,299	23,448	19,906*	20,887	22,259	28,019	26,353
Zimbabwe	54,037 (46,456?)	45,654 (40,720?)	68,230 (63,064?)	74,567* (82,168?)	59,096* (76,657?)	69,075* (79,932?)	70,378 (73,707?)	60,185 (68,263?)
Total	89,568	79,717	133,339	147,240	150,757	159,953	148,407	140,343

Key: * Figure derived partly or in full from import data ? Data supplied by CFAZ

4.5. *Crocodylus novaeguineae novaeguineae* / New Guinea crocodile

Table 3 shows the total number of skins of this species exported by the main producers, Indonesia and Papua New Guinea, between 1996 and 2004.

- **Indonesia:** exports in 2002 amounted to 11,951 skins, decreased to 8826 skins in 2003 and then increased again to 10,481 in 2004. The main destinations in earlier years were Japan and Singapore, however all the 2003 production appears to have gone to Japan. The proportion of wild collected skins increased from 28 per cent of the total in 2002 to 35 per cent in 2003.
- **Papua New Guinea:** exports of 18,798 skins were reported in 2002 and a further 18,482 in 2003. In 2004 trade increased dramatically to 29,315 skins and this is confirmed by data from the importing countries.

- The majority of the skins were exported to Japan with smaller quantities being imported by Australia, France and Singapore. In 2000 wild-collected skins accounted for 83 per cent of the production, increasing to 93 per cent in 2001 and to 100 per cent in 2002 and 2003. In 2004 only four skins of animals bred in captivity were exported.

Table 3. Reported trade in *Crocodylus novaeguineae novaeguineae* skins, 1996-2004

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004
Indonesia	0	100	8506	6574	7215	9946	11,951	8826	10,481
Papua New Guinea	14,234	32,912	16,985	15,617	16,018	20,688	18,798	18,482	29,315
Total	14,234	33,012	25,491	22,191	23,233	30,634	30,749	27,308	39,796

4.6. *Crocodylus porosus* / Saltwater crocodile

- **Australia:** reported exports in 2002 amounted to 7205 however import country data suggested this figure should have been higher and it is known that there were severe problems with new computer software used to produce the Australian report. Close examination of both importer and exporter data suggest the real figure to be in the region of 10,423. In 2003 Australia reported exports of 14,544 skins and in 2004 12,322 skins. The destinations were mainly France, Japan and Singapore with smaller quantities going to Indonesia, Italy, the Republic of Korea and the United States.
- **Indonesia:** exports of 3277 skins to Japan and Singapore were reported in 2002 and 2732 skins to the same destinations in 2003. In 2004 reported exports increased to 3968. Whereas the majority of skins exported in 2002 were reported to be from animals bred in captivity, most of those exported in 2003 and 2004 were reported to be from ranching operations.
- **Malaysia:** Singapore reported importing 662 skins in 2002 and 618 in 2003, all from registered breeding operations of which Malaysia has five. In 2004 the number of skins had apparently increased to 1450. From the sparse export data available, it appears that Malaysia may have difficulty in collecting the information which may be the result of having three separate CITES Management Authorities responsible for Peninsular Malaysia, Sabah and Sarawak respectively.
- **Papua New Guinea** reported exporting 9332 skins in 2002,a further 8000 in 2003 and 11,043 in 2004 The proportion of wild-sourced skins was reported to be 25 per cent in 2002 but increased to 39 per cent in 2003 and to 42 per cent in 2004.
- **Singapore** reported commercial exports of 584 skins from registered captive-breeding operations in 2002, 470 in 2003 and 1136 in 2004. The sole importer in 2002 and 2003 was Japan but exports also went to Australia, France and Thailand in 2004.
- **Thailand:** reported exporting 805 skins to Japan in 2001 and a further 300 in 2004.

Table 4. Reported trade in *Crocodylus porosus* skins, 1997-2004

Country	1997	1998	1999	2000	2001	2002	2003	2004
Australia	8777	9896	5048	13,296	11,849	10,423*	14,544	12,322
Indonesia	150	3141	1087	3172	3397	3277	2732	3968
Malaysia	120*	320*	320*	559*	675*	662*	618*	1450*
Papua New Guinea	8771	10,255	9396	8336	10,676	9332	8000	11,043
Singapore	296	211	60	438	762	584	470	1136
Thailand	440	300	60	0	805	0	0	300
Total	18,554	24,123	15,971	25,791	28,164	24,278	26,364	30,219

Key: * Figure derived from import data

4.7. *Crocodylus rhombifer* / Cuban crocodile

No trade has been reported for this species since 1998 apart from one skin reported as a personal import by Denmark in 2004.

4.8. *Crocodylus siamensis* Siamese crocodile

Cambodia: Singapore reported importing 30 skins from Cambodia in 2001, the first reported trade involving that country. The skins were subsequently re-exported to Japan in 2002 but no further trade in skins from that country has been reported. Cambodia has six crocodile farms registered with the CITES Secretariat for the commercial production of this species.

Thailand: has 17 crocodile farms registered with the CITES Secretariat for commercial production. Reported exports were 5459 skins in 1999, 2417 in 2000, 4392 in 2001 and 3580 in 2002. However, reported exports increased dramatically to 10,982 in 2003 and further to 20,105 in 2004. The main importer in both 2003 and 2004 was Japan, with smaller quantities going to China, Germany, France, Hong Kong, Italy and the Republic of Korea.

4.9. *Crocodylus siamensis x C. porosus* / Crocodile hybrid

No international trade in skins of this hybrid species has been reported since 1995 when Thailand exported 250 to Singapore, however Thailand does export meat and a small quantity of manufactured items annually.

4.10. *Osteolaemus tetraspis* / West African dwarf crocodile

There is no international trade in skins of this Appendix-I species, however seizures of small numbers of manufactured items, mainly emanating from Nigeria, are reported annually. Unfortunately very few of these seizures are reported to species level so it is impossible to estimate the scale of the problem, or even if it is this species that is involved.

4.11. *Alligator mississippiensis* / American alligator

Only gross export data reported by the United States have been used for this analysis as it has been demonstrated previously that using data reported by importing countries can lead to a significant overestimate of trade volume.

Figure 3 shows reported exports between 1986 and 2004 and indicates a steady increase from around 30,000 skins in 1986 to 210,000 in 1994. Exports then appear to have declined to around 160,000 in 1996 and have then increased steadily to a peak of over 340,000 in 2001. Exports fell to 237,840 in 2002 but increased to nearly 343,000 in 2003 and further to nearly 370,000 the following year. The reasons for the high level of exports in 2001, 2003 and 2004 are as yet not understood.

Table 5. Exports of *Alligator mississippiensis* reported by USA 1986-2004

1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
31,235	45,177	50,303	76,963	120,419	128,447	155,264	192,286	210,236	185,929
1996	1997	1998	1999	2000	2001	2002	2003	2004	
163,936	198,649	206,620	239,519	248,922	343,110	237,840	341,734	368,409	

Four countries, France, Germany, Italy and Singapore import 95 per cent of production with smaller quantities being imported by Mexico and Panama.

It has been noted in the IACTS reports since 2003 an that the compilers of the CITES annual report of the United States were probably using the code ‘C’ (bred in captivity) for ranched animals rather than the more correct ‘R’. Other codes used are ‘F’ – animals born in captivity, (F1 or subsequent generations) that do not fulfil the definition of ‘bred in captivity’ in Resolution Conf. 10.16 (Rev.), and ‘W’ – wild. This appears to have continued in the annual report for 2004 where 58 per cent of exports were reported as coming from captive-bred individuals. A breakdown of the reported source of skins between 1997 and 2004 is shown in Figure 4.

This species is also bred in captivity in Israel who reported exporting 233 skins to France in 2000. Only six skins were exported, again to France, in 2001 and none have been reported subsequently.

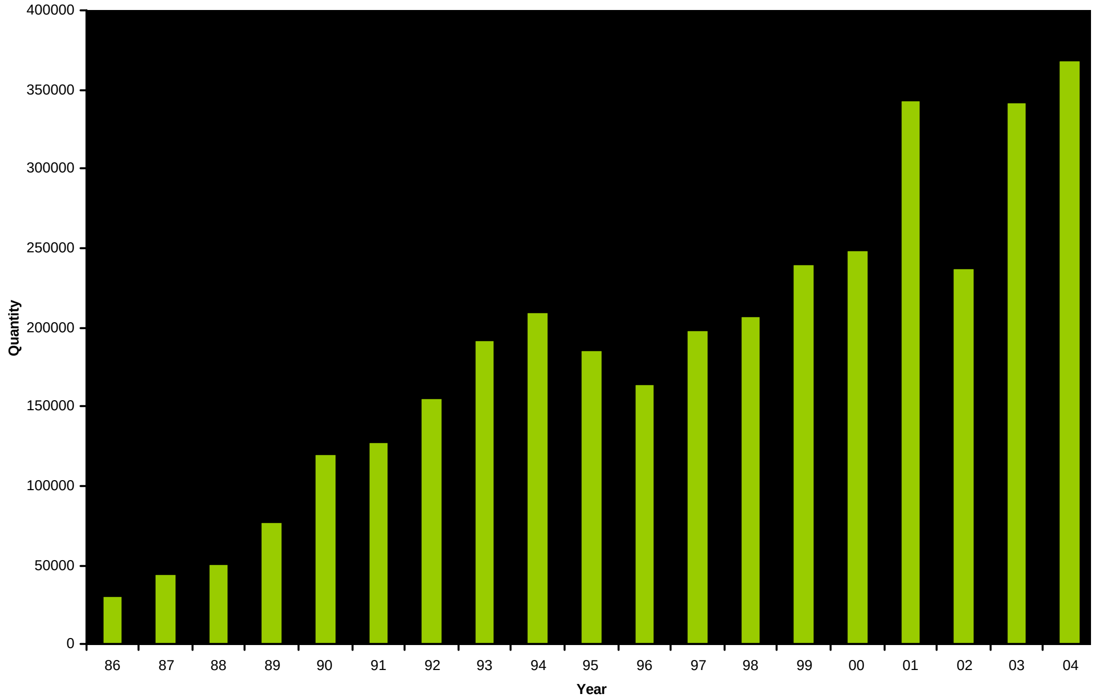


Figure 3. Gross exports of *A. mississippiensis* skins from the United States of America 1986-2004

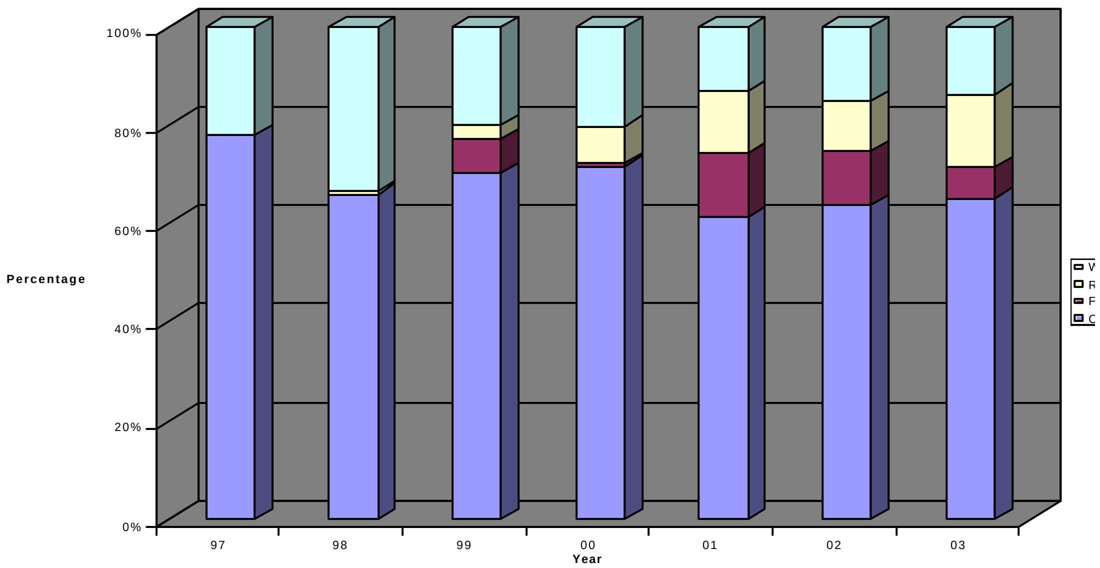


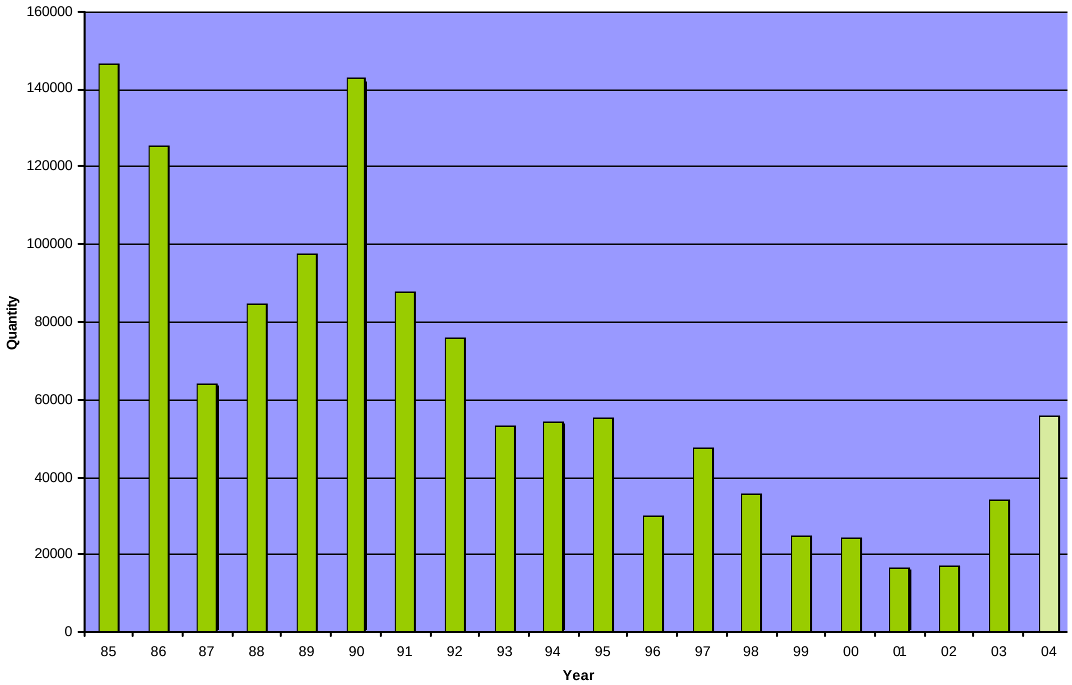
Figure 4. Reported source of alligator skins from the United States of America 1997-2004

4.12. *Caiman crocodilus crocodilus* / Spectacled caiman

Venezuela is the main supplier of skins of this species, almost all from wild-collected animals. Exports peaked in the late 1980s and early 1990s with quantities exceeding 100,000 skins in several years. More recently exports have gradually declined, possibly as a result of the farming of massive numbers of *Caiman crocodilus fuscus* in Colombia, but also because of high taxation of the caiman hunting industry. In 2003 Venezuela reported exports of 33,942 skins mainly to Europe, a considerable increase on exports of 2001 and 2002. However, no annual report has been submitted for 2004 and data from importing countries gives a figure of over 53,000 skins in that year. The quantity of skins exported annually from Venezuela is shown in Figure 5 below.

Guyana was the supplier of more than 350,000 skins between 1984 and 1989 but exports dwindled during the 1990s and there are no records of skins being exported between 1998 and 2000. However 395 skins were exported in 2001, to Italy and Mexico, and a further 1000 to Panama in 2002. In 2003 Panama reported importing another 2000 skins and both Guyana and Panama recorded the export of 620 skins in 2004. Colombia also exports small quantities amounting to 692 in 2002, 3000 in 2003 and 6200 in 2004.

Figure 5. Exports of *Caiman crocodilus crocodilus* skins from Venezuela 1985-2004



4.13. *Caiman crocodilus fuscus* / Brown caiman

As with *C. crocodilus crocodilus*, the history of the trade in skins of *C. crocodilus fuscus* has been well documented in recent IACTS reports and Colombia remains the major exporter with exports increasing from around 70,000 skins in 1990 to over 820,000 in 2000.

In 2001, exports dropped by 125,000 to 698,413 and again to 540,579 in 2002. A very slight increase occurred in 2003 to 552,219 and again to 605,841 in 2004. Exports from Colombia between 1990 and 2004 are shown in Figure 6. Details of the countries reportedly exporting this species from 1994 to 2002 are shown in Table 6.

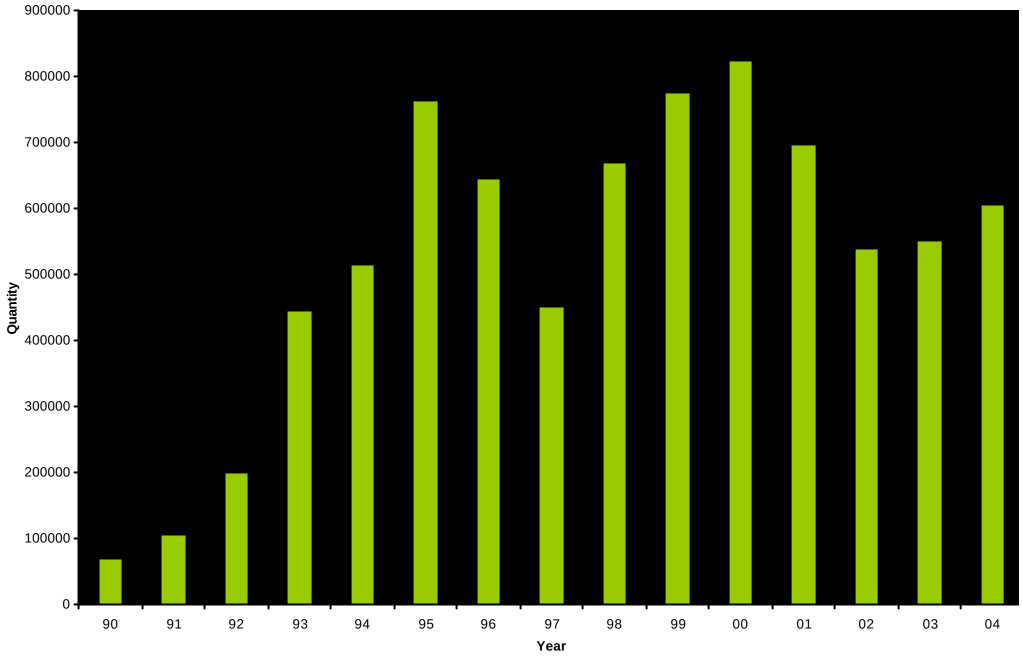
Table 6. Reported trade in *Caiman crocodilus fuscus* skins, 1995-2004

Exporter	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Colombia	764,358	646,832	451,307	669,269	777,529	824,303	698,413	540,579	552,219	605,841
Costa Rica	0	0	0	40	0	0	0	0	0	0
Cuba	12	302	500	5	2	0	0	0	0	0
El Salvador	1	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0	0
Honduras	2,000	5,656	22,000	18,104	0	0	0	0	0	0
Nicaragua	4328	3795	1246	3927	250	6440	0	0	0	0
Panama	0	0	0	0	10	10,250	11,700	11,047*	19,840	15,850
Total	770,609	656,585	475,053	691,345	777,791	840,993	710,113	551,626	572,059	621,691

Key: * Figure derived from import data.

No exports have been reported from Honduras since 1998 and it seems likely that the reported exports between 1995 and 1997 were in fact re-exports. Nicaraguan production has fluctuated from year to year and exports in 2000 of 6440 went to Panama and Spain. No report was submitted by Nicaragua for 2001 or 2004 and there were no imports from Nicaragua reported in those years; no exports of skins were recorded in Nicaragua's 2002 report. Although an important entrepôt State, Panama clearly distinguishes between exports and re-exports in its annual report. Exports of 10,250 skins were reported in 2000 and 11,700 in 2001. No report has been received from Panama for 2002 but importers data suggest this was again around 11,000. Exports were reported in both 2003 and 2004 amounting to some 19,840 and 15,850 skins, all from captive-breeding operations.

Figure 6. Exports of *Caiman crocodilus fuscus* from Colombia 1990-2004



Singapore imported 51 per cent of Colombia's skin production in 2003 and 55 per cent in 2004, a steady annual increase. Most of the skins are then re-exported. The other major importers are the United States and Mexico who imported 12 per cent and 18 per cent respectively in 2004. Direct exports to Thailand have decreased each year from 1997 (30 per cent) to 2004 (6 per cent).

4.13. *Caiman latirostris* / Broad-snouted caiman

The Argentine population of this species was transferred from CITES Appendix I to Appendix II in 1997 and the first skins from ranched animals were reported by Argentina in 2001, a shipment of 88 to Italy. A further 90 skins were exported to Italy in 2002, 165 to Italy and Germany in 2003 and 215 mostly to Germany and Japan in 2004.

4.14. *Caiman yacare* / Yacaré

Table 7 shows the fluctuations in exports of *C. yacare* skins from the major producing countries between 1992 and 2004. Trade data for earlier years was presented in IACTS reports 2000 and 2002.

- **Bolivia:** reported exports of 28,170 skins in 2001 but the figures increased significantly to 63,725 skins in 2002. Subsequent exports decreased to 43,028 in 2003 and further to 34,878 in 2004.
- **Brazil:** reported exports of 6048 skins in 2002, 12,851 in 2003 and 7004 in 2004. Most of the skins were destined for Mexico with some to the United States of America.
- **Paraguay:** regular exports of wild-collected skins have occurred since 1994. Paraguay reported exports of 2980 skins in 2001, 9038 in 2002 and 4409 in 2003 but voluntarily imposed a moratorium on exports of wildlife in September 2003 as a result of a technical mission from the CITES Secretariat.

Table 7. Reported trade in *Caiman yacare* skins, 1992-2004

Exporter	1992	1993	1994	1995	1996	1997	1998
Bolivia	0	0	0	0	0	15,961	1757
Brazil	233	7034	43,573	366	536	4961	295
Paraguay	0	3	5466	17,206	725	503	4445
Total	233	7037	49,039	17,572	1261	21,155	6497

Exporter	1999	2000	2001	2002	2003	2004	
Bolivia	0	4116*	28,170	63,725	43,028	34,878	
Brazil	615	1763	978	6048	12,851	7004	
Paraguay	0	9750	2980	9038	4409	0	
Total	615	15,629	32,128	78,811	60,288	41,882	

Key: * Figure derived from import data

4.15. Other Species

There has been no reported commercial exports from origin countries between 2000 and 2002 of skins of the following species: *Crocodilus cataphractus*, *C. intermedius*, *C. palustris*, *Alligator sinensis*, *Melanosuchus niger*, *Palaeosuchus palpebrosus*, *P. trigonatus*, *Gavialis gangeticus* or *Tomistoma schlegelii*. The United States of America reported the seizure of one skin of *Crocodylus cataphractus* from France, of unknown origin, in 2000, and Gabon exported one skin, two stuffed specimens and four leather items of that species as personal items to France in 2002.

5. Trade in Live Animals

As noted in previous IACTS reports, the commercial export of live crocodilians outside of their range States poses a potential threat to the natural biological diversity of the importing countries. The effect these alien animals may have on native populations of crocodilians is inestimable should they establish breeding populations, a serious possibility given suitable environmental conditions and habitat. It has also noted that the continued growth of the crocodilian farming industry would probably mean that such exports would continue for the time being.

Live crocodilians are traded for many reasons. Enthusiasts popularly keep young animals as personal pets; circuses and zoos regularly exhibit such creatures, farms and ranches import animals to supplement their gene pool and some are imported in order to strengthen wild populations. This variety of use, and the limited number of possible purpose codes used in CITES annual reports, means that some conclusions drawn from analysis of CITES data are only tentative. For example, the purpose code 'T' which indicates a commercial transaction would apply equally if the animals were destined for either the pet trade or the farming industry. Below we consider the reported trade on a species by species basis.

5.1. *Alligator mississippiensis*

Israel reported exporting nine animals to Spain in 2002 and a further 94 in 2003. Spain similarly reported importing nine animals in 2002 but 105 in 2003. In 2004 Spain reported importing 151 from Israel whereas Israel only reported 94. Another 10 animals were reported by Israel as being exported to Ukraine in both 2003 and 2004. There were limited exports (< 50 per annum) from the United States of America during the period under study, mostly destined for zoos.

5.2. *Alligator sinensis*

China reported exporting 30 to Japan in 2000, 64 to Czech Republic, Denmark and Spain in 2001, 10 to Japan in 2002 and a further 16 to Japan in 2003. The only trade in 2004 was two imported by Canada from the United States. All were captive-bred specimens.

5.3. *Caiman crocodilus*

- **Guatemala** reported exporting 3300 *Caiman crocodilus crocodilus* to the United States in 2000 and 470 *C. c. fuscus* to Spain in 2003. All specimens were reported to have been bred in captivity. In 2002 Guatemala reported exporting 205 hybrid *C. c. crocodilus* x *C. c. fuscus* to the United States.

- **Guyana** reported exporting 4161 animals in 2001, 4298 in 2002, a further 3373 in 2003 and 2797 in 2004, all presumably destined for the pet industry. All were wild-caught and the main destinations were Europe, Japan and North America.
- **Suriname** regularly exports wild-caught animals for the pet industry: 94 in 2001, 420 in 2002, 102 in 2003 and 39 in 2004. The main destinations used to be Europe and North America, however in 2002, 2003 and 2004 most of the animals were destined for the Russian Federation.
- **Venezuela** reported exporting 3000 to Thailand and 4500 to Taiwan, Province of China, in 2000, all of ranched stock. Exports to the latter destination increased to 11,100 in 2001, 10,512 in 2002 and 11,140 in 2003. The United States reported importing animals from Venezuela in 2001 and 2003. China reported importing 4000 live captive-bred specimens of C. c. crocodilus from Thailand in 2000 but it is not known if they originated in Venezuela and it has not been possible to confirm the transaction via the annual reports of Thailand.

5.4. *Caiman yacare*

Guatemala reported exporting 50 captive-bred specimens to the United States in 2000 and Paraguay reported exporting 200 wild caught specimens to Canada, who also reported the import, in 2002.

5.5. *Melanosuchus niger*

Fifteen captive-bred specimens were exported from Ecuador to Denmark in 2004.

5.6. *Palaeosuchus palpebrosus*

Guyana has an export quota of 500 live wild specimens annually and reported exporting 352 in 2002, 480 in 2003 and 381 in 2004. The animals all appear to be for the pet industry with the main importing country being the United States. Smaller quantities go to Canada, Europe, Japan, Malaysia, Mexico, the Republic of Korea, the Russian Federation and Ukraine.

5.7. *Palaeosuchus trigonatus*

As with *P. palpebrosus*, Guyana has an export quota of 500 live wild specimens annually and reported exports of 224 in 2002, 354 in 2003 and 210 in 2004. The main importing country was the United States, with smaller quantities going to Canada, Europe, Japan, Malaysia and Thailand.

5.8. *Crocodylus mindorensis*

In 2002 the Philippines reported exporting six animals to Australia for breeding purposes, their source being listed as 'F'. No further trade in this species has been reported.

5.9. *Crocodylus moreletii*

In 2000 Mexico reported exporting 100 captive-bred animals to Spain and a further 10 to Germany. Four more were reported being exported to Spain in 2001 and in 2003 five were exported to Canada and another 10 to Indonesia. Twelve were exported to Morocco in 2004.

5.10. *Crocodylus niloticus*

South Africa is the main importer of live specimens of this species, importing mainly from the neighbouring range States of Botswana, Mozambique and Namibia. Although 2003 saw the first major import from Kenya, this was not repeated in 2004. Details are shown in Table 8.

Table 8. South Africa's imports of live *Crocodylus niloticus* 1997-2004

	1997	1998	1999	2000	2001	2002	2003	2004
Botswana	1700	2050	3827	3300	3670	720		0
Kenya	0	0	0	0	0	0	4000	0
Mozambique	0	4000	0	49	0	7000	5600	25,000
Namibia	800	2150	0	2603	1000	1100		1000
Zimbabwe	0	0	0	0	0	50	6	0
Total	2500	8200	3827	5952	4670	8870	9606	26,000

The 2005 annual report has already been received fom Mozambique and indicates exports of 24,200 animals to South Africa in that year. Zimbabwe reported exporting 120 wild-caught specimens to Mauritius in 2003 and there are exports from South Africa numbering several hundreds to Spain and the Republic of Korea in 2004.

5.11. *Crocodylus porosus*

China was the main destination for this species in 2000 with 65 reported as exports by Malaysia, 210 by Myanmar and 330 by Thailand. In 2001 Singapore reported exporting 299 to Thailand but trade has declined since then. In 2003 Thailand reported exporting a total of 30 to Japan (20) and the Republic of Korea (10) and in 2004 Bangladesh reported importing 75 from Malaysia.

5.12. *Crocodylus siamensis*

China began importing this species from Thailand in 1997 and from Cambodia in 2000 and, as shown in Table 9, has imported over 220,000 live specimens from Cambodia, Thailand and Viet Nam in the eight-year period to 2004. Imports decreased in 2003 but increased again in 2004. The annual reports for 2003 and 2004 from Viet Nam, an important producer of this species, have not yet been received. Thailand also reported exporting 1000 animals to Viet Nam in 2004. As noted in the section on skins, Cambodia has six crocodile farms, and Thailand 17, registered with the CITES Secretariat for the commercial production of this species

Table 9. China's imports of live *Crocodylus siamensis* 1997-2004

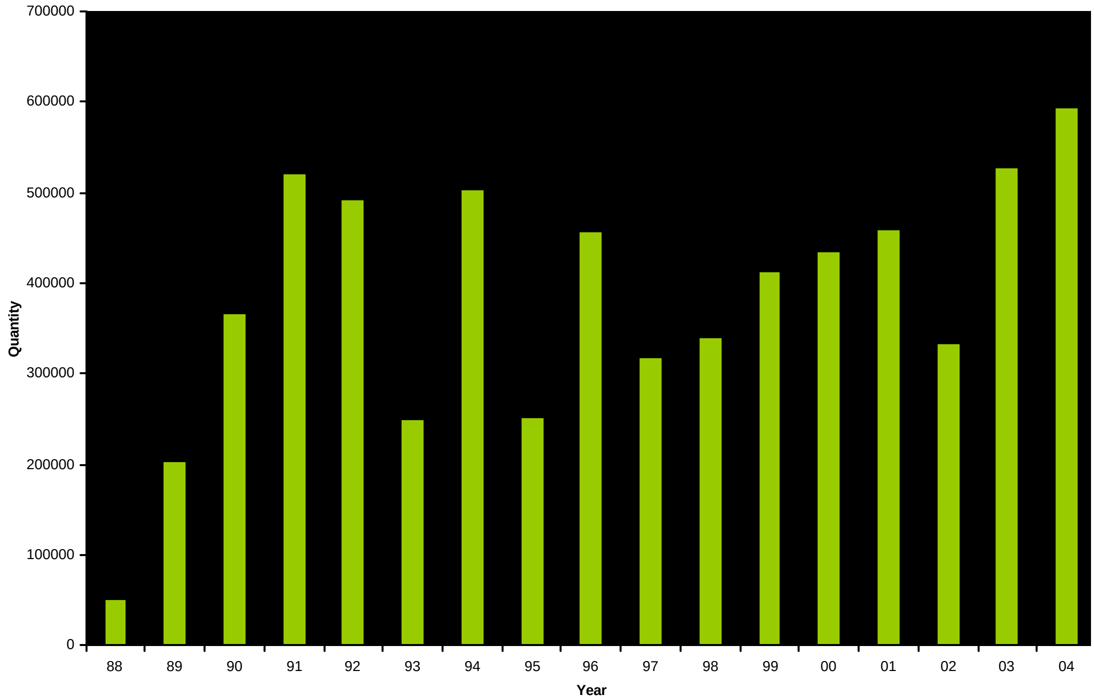
Exporter	1997	1998	1999	2000	2001	2002	2003	2004
Cambodia (direct)	0	0	0	10,000	6272	26,746	0	5000
Cambodia (via Viet Nam)	0	0	0	3000	10,300	8333	640	0
Thailand (direct)	2128	5078	44,622	26,475	12,679	10,148	17,300	30,250
Thailand (via Viet Nam)	0	0	0	0	500	750	0	0
Viet Nam (direct)	0	0	0	0	0	0	300	3100
Total	2128	5078	44,622	39,475	29,751	45,977	18,240	38,350

6. Trade in other by-products

6.1. Meat

Figure 7 shows total world exports as reported in CITES annual reports from 1988 to 2004 and indicates that since 1989 the amount traded globally has averaged almost 400 tonnes yearly and over that period has fluctuated between 250 tonnes in 1989 to 595 tonnes in 2004. Apart from an apparent peak in 1996 and an apparent decrease in 2002, there has been a steady year on year increase since 1995. However, since 1988 there have been major fluctuations in the countries and species involved. Until 1992 the main species in trade was *Alligator mississippiensis* from the United States, particularly to Taiwan, Province of China, Japan, Canada and the United Kingdom. No exports to Taiwan, Province of China, have been reported since 1994 and export levels have fallen since 1995 (see Figure 8) with the main importers currently being Canada, China and Hong Kong. Since 1993, exports of *Crocodylus niloticus* from South Africa, Zambia and Zimbabwe have increased steadily from less than two tonnes in 1992 to a peak of over 380 tonnes in 2004. Initial analysis suggested a decrease to 230 tonnes in 2004, however this was the result of severe under-reporting by Zimbabwe. The figure reported in the Zimbabwe annual report for 2004 was of seven shipments weighing 102 tonnes, while importing countries reported importing 18 shipments weighing 256 tonnes, a figure close to that reported by CFAZ (251 tonnes). The main destinations for the African production are Europe (particularly Belgium, Germany, Netherlands, Switzerland and the United Kingdom), Hong Kong and China, however in 2004 25 tonnes went to Japan. It appears that all of Zambia's production is exported via South Africa. Some imports from Israel and the United Republic of Tanzania have been reported but not since 1996. Figure 8 compares the exports from North America with those of Africa.

Figure 7. Global exports of crocodilian meat 1988 – 2004



Exports from Indonesia of meat of both *Crocodylus novaeguineae* and *C. porosus* appeared to be increasing up to 2000 however since then the only exports appear to have been 666 kg in 2001, 628 kg in 2002, 666 kg in 2003 and none in 2004. All the exports were destined for Hong Kong.

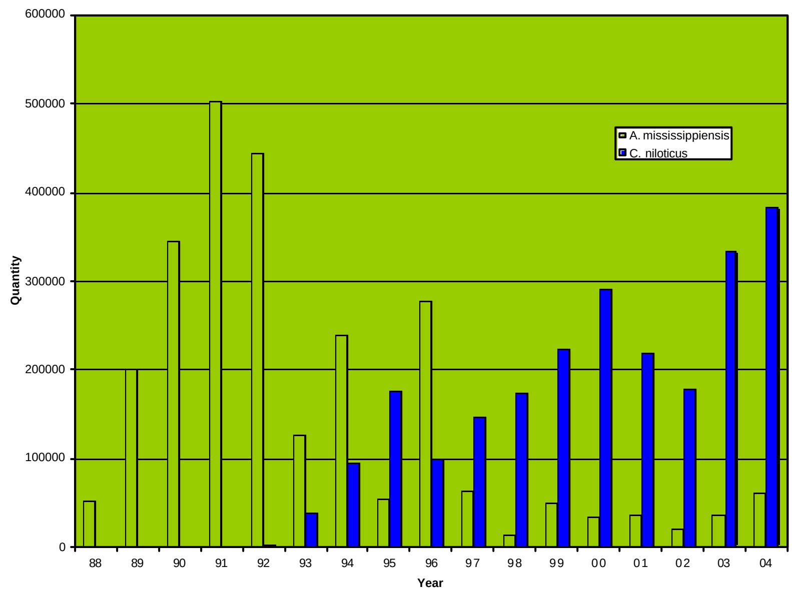
Australia's exports of *Crocodylus porosus* increased from 53 tonnes in 2000 to 57 tonnes in both 2001 and 2002 but then fell slightly to 49 tonnes in 2003 and to just over 13 tonnes in 2004. Although recent problems with the Australian annual reports may suggest that recent data are underestimated, it is possible that the apparent deficit is the result of local consumption. Apart from occasional exports to Europe the main destinations for Australia's production were China, Japan, Malaysia, Hong Kong and Taiwan, Province of China. However no meat was exported to China or Hong Kong in 2004.

Exports of meat from Papua New Guinea are usually of mixed shipments of both *Crocodylus novaeguineae* and *C. porosus*, and have averaged almost 60 tonnes annually between 1996 and 2003. Apart from a few kilograms exported to Belgium in 1996 and Japan in 2002, Australia is the sole importer and reported importing 45 tonnes in 2004.

Thailand is currently the only exporter of *Crocodylus siamensis* and exports have averaged about 35 tonnes annually between 1999 and 2003. In 2004 exports increased to over 68 tonnes. The annual Thailand report describes the product as both 'meat' and 'meat and bone' and the main importing countries are China, Hong Kong, the Republic of Korea and Taiwan, Province of China.

There have been small exports by Mexico of meat of *Crocodylus moreletii* amounting to 432 kg in 2000, 3550 kg in 2002 and 1000 kg in 2003. No trade in meat of this species was reported in 2001 or 2004. Apart from 50 kg reported as an export to Spain in 2002, the sole importer has been Japan.

Figure 8. Comparison of exports of meat of *Alligator mississippiensis* and *Crocodylus niloticus*



6.2. Teeth

Australia is the most important user of crocodile teeth and between 1999 and 2004 imported nearly 285,000. Most of the teeth were *Crocodylus porosus* from the operations in Malaysia, Papua New Guinea and Singapore. In 2003 Australia imported over 3000 teeth of *Alligator mississippiensis* from the United States, and another 8967 in 2004.

7. Declared dollar value

Although CITES annual reports do not usually contain information concerning the value of the trade or of individual shipments, the United States has included this information since 1997. This figure is not necessarily accurate but can used by UNEP-WCMC to identify typographic errors in the report, for example where it is suspected that a decimal point has been omitted. There is great fluctuation amongst the reported values as may be expected and no indication of the size or quality of the skins is provided, indeed for caiman species flanks may have been reported as whole skins to further complicate the issue. Many of the values are nonsensical and may be the result of a typographic error in that field of the report; these have been ignored in the analysis below. Table 10 shows the average declared value per skin (in $US) of exports of *Alligator mississippiensis* and the reported value of re-imports of these skins from Europe, Mexico and Asia after tanning. Although the original value of exports fluctuates from year to year, the value of the re-imports has been considerably higher, as one would expect.

Table 10. Reported US dollar value of *Alligator mississippiensis* skins 1997-2004

	1997	1998	1999	2000	2001	2002	2003	2004
Exports from USA	103.7	77.8	97.6	102.9	100.8	101.4	106.4	112.5
Re-imports by USA	143.0	116.3	140.0	179.4	169.5	108.6	124.6	144.9

Table 11 compares the reported average value per skin of Colombian *Caiman crocodilus fuscus* imported directly from Colombia and via third countries. The source of re-exported skins varies from year to year but the majority are imported directly from Colombia or via Singapore. It is interesting to note that India was first reported as a re-exporter in 2004. The declared value of the direct imports from Colombia increased in both 2001 and 2002 but has dropped back a little since then, while the value of skins from Singapore has fluctuated between $US 48.9 in 1997 and $US 39.9 in 2002.

Table 11. Reported US dollar value of Colombian *Caiman crocodilus fuscus* skins 1997-2004

Exporter/Re-exporter	1997	1998	1999	2000	2001	2002	2003	2004
Colombia	39.3	38.6	39.7	37.4	43.5	50.7	49.9	46.8
European Community	53.2	81.3	25.2	68.5	24.7	63.8	-	-
Mexico	-	-	52.4	43.5	49.1	41.5	38.0	-
Panama	52.0	27.1	-	20.2	59.2	-	54.4	-
Singapore	48.9	48.6	44.7	42.5	43.8	39.9	47.8	43.4
Switzerland	24.3	-	61.4	28.6	29.5	25.0	-	29.5
Thailand	-	48.6	49.4	45.8	52.2	56.5	32.6	54.0

8. Infractions of CITES

Information on seizures are supposed to be recorded in CITES annual reports but is frequently omitted, perhaps because the relevant authorities involved, i.e. the Customs officers making the seizures and the CITES Management Authorities producing the annual reports seldom liaise closely. Furthermore, the data recorded by Customs rarely allows the goods to be identified at the species level. Most of the seizures that are reported are of tourist items such as dried heads, whole stuffed baby crocodiles, etc. and personal imports of manufactured leather goods. It should be noted that most of the data reflect the diligence of Customs officers inspecting tourist luggage and do not indicate problem areas for the crocodilian industry. In addition, many of the items seized on import are subsequently released to the importer when adequate permits have been obtained.

Of the more significant items reported in recent years, the United States reported seizures of 10 back skins of *Crocodylus niloticus* from Zimbabwe and 150 Appendix-I *C. porosus* skins from Singapore in 2000, 2000 skins of *Caiman crocodilus fuscus* from Colombia and a further 399 from Panama in 2001. The United States also reported seizures of two skulls of *Crocodylus rhombifer* from Cuba, four bodies of *C. siamensis* from Cambodia and eight manufactured items of *Osteolaemus tetraspis* from Equatorial Guinea and Nigeria in 2004. Spain reported the seizure of 300 skins of *Caiman crocodilus fuscus* from Colombia in 2002 and Luxembourg reported a seizure of 650 backskins of *Crocodylus* niloticus from Zimbabwe in 2003. In 2002 the United Kingdom seized a shipment of 10 live *Osteolaemus tetraspis* from Niger.

9. Discussion and recommendations

The overall volume of world trade in classic crocodilian skins and caimans from 1996 to 2004 is summarised in Table 12 and based, wherever possible, on country of export data. There are uncertainties regarding the overall total figures because of the lack of annual report data from certain key countries, particularly Kenya, Nicaragua, Uganda and Venezuela. However it is hoped that the estimates made using import country data are sufficient to indicate close approximations to actual exports. Some diversification in the trade began in 2001 with two different species entering the market, captive-bred *Crocodylus acutus* from Colombia and *Caiman latirostris* from Argentina. Trade in these species continued in 2002 and 2003 and the first exports of *C. acutus* from Honduras were reported in 2003. The first exports in recent years of wild *Caiman crocodilus crocodilus* skins from Guyana occurred in 2001 and continued through 2004.

The increase in exports of *Alligator mississippiensis* from the United States of America noticed in 2001 was not sustained the following year and dropped back towards the level seen in the late 1990s. However exports in 2003 and 2004 saw the quantities increase again. The possible reasons for these fluctuations are discussed in the relevant section of this report. Exports of *Crocodylus niloticus* increased steadily up to 2002 with Madagascar, South Africa, Zambia and Zimbabwe being the main suppliers. However, 2003 saw a reduction to the level of 2000,and this trend continued in 2004 with most of the major exporters showing decreased exports.

Crocodylus novaeguineae form Papua New Guinea appeared to increase in 2004 according to both exporters and importers data, and *C. porosus* trade continued to be stable. Thailand's exports of *C. siamensis*, which had ranged between 1679 and 5459 between 1996 and 2002 showed a sharp increase to almost 11,000 in 2003 and to over 20,000 in 2004. Trade in caiman skins peaked in 2000 but fell by 30 per cent between 2001 and 2002. A slight recovery was observed in 2003 and 2004 as a result of increased exports from Bolivia and Colombia. Overall the total number of skins entering international trade in 2004 appears to have been in excess of 1.3 million, higher than in 2002 and 2003 but still less than in three years before that. This figure may be need adjustment when more annual reports are received.

Table 12. Reported trade in crocodilian skins 1996-2004

Species	1996	1997	1998	1999	2000	2001	2002	2003	2004
Alligator mississippiensis	163,936	198,649	206,620	239,944	249,155	343,116	237,840	341,734	368,409
Crocodylus acutus	0	0	0	0	0	100	630	830	197
C. johnsoni	1641	194	309	45	10	0	2	0	0
C. moreletii	20	146	193*	2	1228	3643	1588	1037	609
C. niloticus	>67,528	89,568	79,717	133,339	147,240	150,757	159,953	148,407	140,343
C. novaeguineae	14,234	33,012	25,491	22,191	23,233	30,634	30,749	27,308	39,796
C. porosus	19,651	18,554	24,123	15,971	25,791	28,164	24,278	26,364	30,219
C. rhombifer	40	0	2	0	0	0	0	0	2
C. siamensis	3186	5452	1679	5459	2417	4422	3580	10,982	20,105
subtotal	270,236	345,575	338,134	416,951	423,283	560,836	458,620	556,662	599,680*

Species	1996	1997	1998	1999	2000	2001	2002	2003	2004
Caiman crocodilus crocodilus	26,346	37,084	35,580	32,571	38,155	25,510*	22,709	34,636	55,841*
C. crocodilus fuscus	656,585	475,053	691,348	777,791	840,993	710,113	551,626	572,059	621,691
C. latirostris	0	0	0	0	0	88	90	165	225
C. yacare	1261	21,115	6497	615	15,629	32,128	78,811	60,288	41,882
subtotal	684,192	533,252	733,425	810,977	894,777	767,839	653,236	667,148	719,639
Grand total	954,428	878,827	1,071,559	1,227,928	1,318,060	1,328,675	1,111,856	1,223,810	1,319,319

* = data deficient

Fall Of The Wild? Captive Crocodilian Production And The Shaping Of Conservation Incentives[1]

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1. Background

This presentation reported on the research into the economics of the crocodilian skin industry and its incentives for conservation since 2001.

A lack of systematic economic analysis of the global trade in crocodilian skins has been an obstacle to assessing the full potential for the conservation of crocodilians from a market-driven perspective. The means to address this gap were considered by members of the Crocodile Specialist Group (CSG) of the Species Survival Commission of IUCN, resulting in the commissioning of an initial study into the broad economics issues and linkages between industry and conservation[2], and a subsequent study (reported here) to assess:

- ? the impacts on markets for crocodilians of the shift away from their wild harvest towards captive production; and,
- ? the impacts on conservation of wild crocodilians of this shift.

To inform the study, research focussed on Colombia, the largest supplier of crocodilian skins to the international market; Zimbabwe, also a prime supplier of crocodilian skins; and France, Italy and Japan, as major consumer countries. Interviews with crocodilian skin industry participants in the latter countries were conducted from November 2002 to May 2004 and further information was obtained from literature, international trade data and members of the CSG.

2. Production, conservation, economics and the industry

Many crocodilians were subject to uncontrolled exploitation in the past when sub-adult and adult crocodiles were hooked, speared, shot or otherwise killed, largely for their skins for international trade. Subsequently, species and populations began to be protected and over time several successful commercial crocodilian conservation initiatives have been established.

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[1] The full report that this presentation is taken from can be found on http://www.traffic.org. MacGregor, J (2006). Call of the wild: captive crocodilian production and the shaping of conservation incentives. TRAFFIC On-line report, 57pp. All tables and figures unless stated are taken from this report.

[2] MacGregor, J (2002). International Trade in Crocodilian Skins: Review and Analysis of the Trade and Industry Dynamics for Market-based Conservation. Report for the Crocodile Specialist Group. www.flmnh.ufl.edu/herpetology/CROCS/MacGregorFinalDec2002.doc.

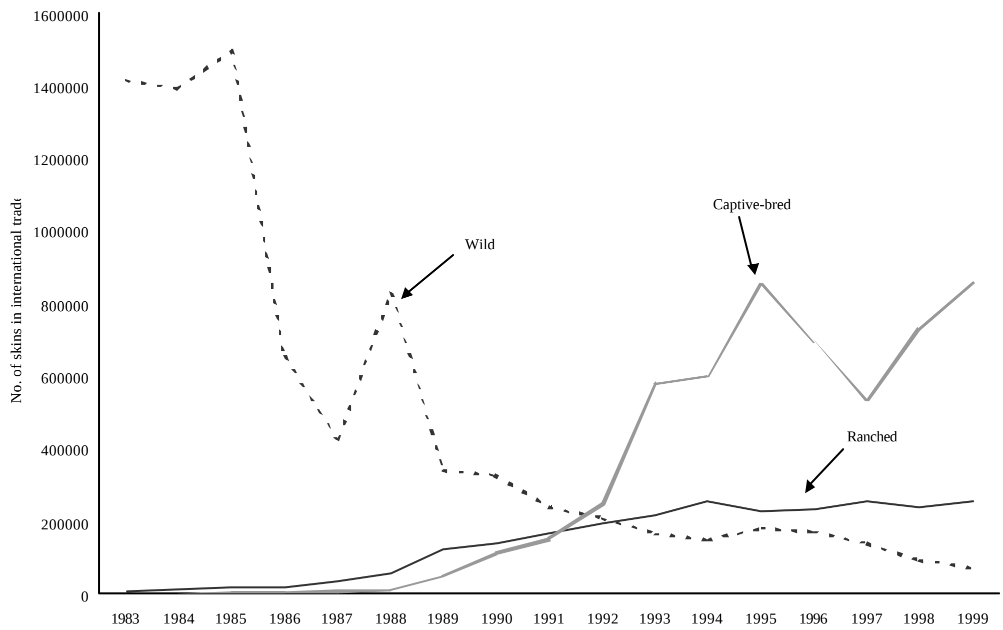
Some of these are still based on the off-take of wild animals, many are based on the off-take of eggs from the wild, but increasingly crocodilians are captive-bred. Current 'best practice' in market-based conservation points to the clearest route for appropriation of conservation values being through wild harvests and ranching. This trend towards captive-bred production of leather is part of the dynamic processes at work in the crocodilian leather industry.

Table 1 presents some of the chief changes to supply characteristics since 1975 and Figure 1 illustrates the global production trends.

Table 1: Changes in supply characteristics of crocodilian skins to international trade since 1975

Factor	Pre-CITES	Current
Source of supply	Wild—virtually 100%	Wild 6%, ranched 22%, captive-bred 72%
No. of skins in international trade	1-2 million (est'd.)	1 million
Producers	Hunters—independent and dispersed	Mainly medium-to-large business interests
Producers of wild skins	Hunters—independent and dispersed	Mix of independent hunters and collectives
Prices per unit (for producer)	Higher than now	Lower than before
Prices per unit (for retailer)	Commensurate	Commensurate
Average quality	Lower than now	Higher than before
Average size of skin	Larger than now	Smaller than before
Leather supply	Higher than now	Lower than before
Supply risk	Less certainty of supply	Far greater certainty of supply
Market segmentation	Species and caiman *versus* classics	Quality, fashion and, to a lesser extent, caiman *versus* classics

Figure 1: Trade trends in crocodilian skin by method of production

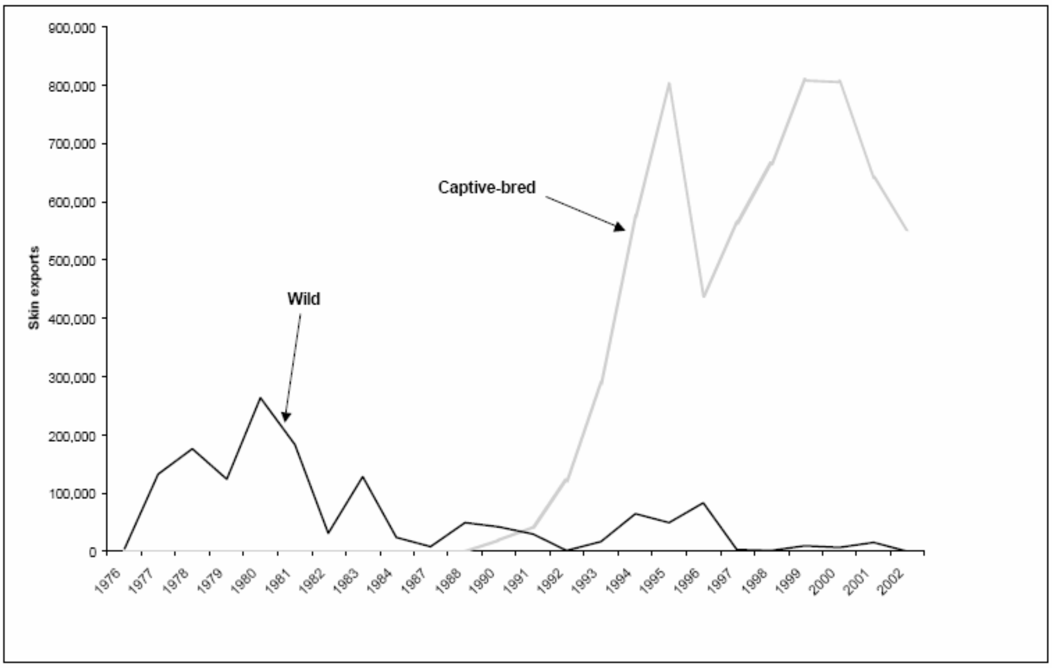


(including caiman production), 1983–99, estimated

Source: MacGregor, 2002

Colombian caiman production illustrates these industry-management linkages. Crocodilian skin production in Colombia today is predominately from captive-bred crocodilians, where the breeding stock is captive. It has an assured place in the market, including in new and growing markets, for example, in Asia. Colombia's crocodilian skin production comprises, almost exclusively, caiman skin. This leather is now prized as high quality, having previously taken second place to the widely favoured 'classic' leather from crocodiles and alligators. See Figure 2.

Figure 2: Reported exports from Colombia of caiman skins by source, 1976-2002



Note: The level of wild-harvested skins may be lower than that reflected here; no legal caiman from Colombia comes from the wild, so presumably these data reflect mistakes in record-keeping. Ranched crocodilians are not recorded here either, although Luxmoore (1992) reported that almost all *Caiman crocodilus* produced by Colombia in 1990 were from ranches.

Source: CITES trade statistics derived from the UNEP-WCMC *CITES Trade Database*, the UNEP-World Conservation Monitoring Centre, Cambridge, UK.

Furthermore, the efficiencies (at farm management level) associated with captive-bred production appear to be substituting for all forms of utilisation of wild crocodilian populations. For example, Zimbabwe's production is based on a mixture of 'ranching', in which eggs are harvested from the wild and raised in captivity, and captive breeding. The proportion from captive breeding is steadily increasing. Table 2 gives a breakdown of the wild harvest of crocodilians for the industry since 1975.

Table 2: Reported exports of wild-harvested crocodilian skins, 1975-2002

	1975	1979	1983	1987	1991	1995	1999	2002
Alligator								
USA	-	-	13 971	41 026	75 991	72 263	56 350	56 414
Rest of world	16	-	3473	-	-	-	-	79
Total	**16**	**-**	**17 444**	**41 026**	**75 991**	**72 263**	**56 350**	**56 493**
Caiman								
Paraguay	-	13 368	348 722	44 769	6	14 852	-	7595
Venezuela	-	-	-	116 344	126 040	60 019	20 319	15 511
Bolivia	-	33 253	67 364	42 480	1384	-	30	33 746
Colombia	-	125 981	210 818	46 670				
Panama	-	-	66 477	100	-	2000	-	49
El Salvador	-	-	30 461	11 975	1587	1	-	-
Guyana	-	-	1130	38 526	8207	30	-	534
Rest of world	1102	187 035	63 815	205 917	25 254	43 608	411	636
Total	**1102**	**359 637**	**788 787**	**506 779**	**162 478**	**120 509**	**20 760**	**58 070**
Crocodile								
Papua New Guinea	-	1150	11 150	40 180	32 896	17 928	10 923	5939
Indonesia	-	-	6899	111	11 518	2845	196	340
Zimbabwe	-	-	785	7723	11 241	3558	183	1572
Zambia	-	4	2	2394	340	5377	1500	3
South Africa	-	-	-	688	254	1	2047	3
Rest of world	4728	19 614	36 887	19 702	9845	2002	1192	1702
Total	**4728**	**20 768**	**55 723**	**70 798**	**66 094**	**31 711**	**16 041**	**9559**
All								
Total	**5846**	**380 405**	**861 954**	**618 603**	**304 563**	**224 483**	**93 151**	**124 122**

Note: Blanks may signify unreported trade as well as zero trade.

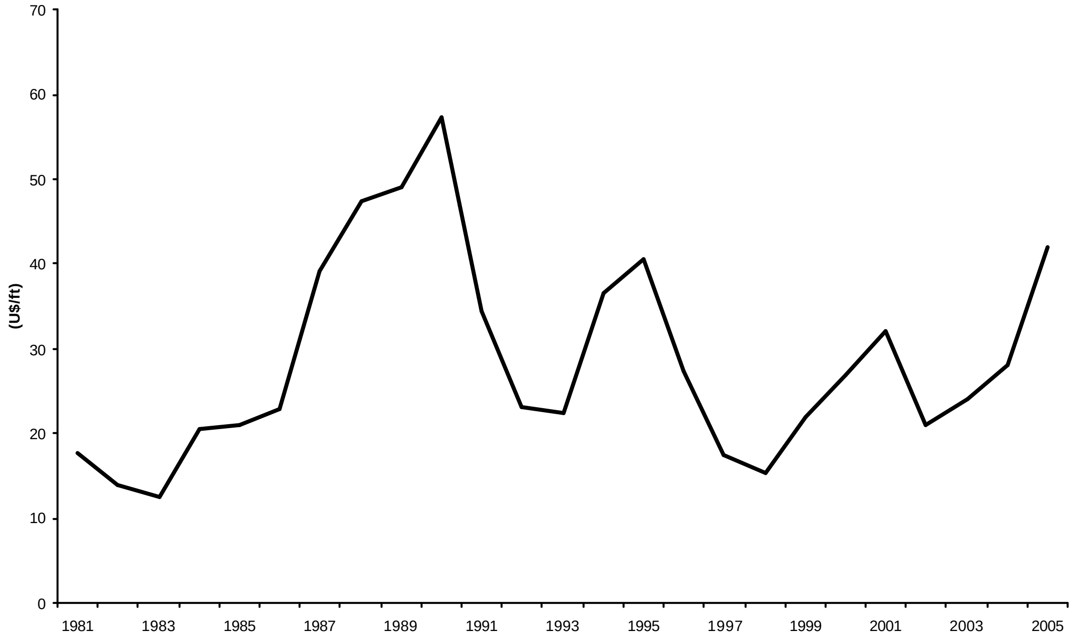
For Zimbabwe, the values given here are known to be wrong—see Methods regarding CITES data. There were no wild-harvested crocodiles from at least 1987 onwards, according to records kept by the crocodile-rearing industry in Zimbabwe—see **Figure 6**.

Source: CITES trade statistics derived from the UNEP-WCMC *CITES Trade Database*, the UNEP-World Conservation Monitoring Centre, Cambridge, UK.

This dynamic industry and its many markets lead to fluctuating prices for producers (see

Figure 3). Pre-export prices for wild skins fluctuate over time in rough concert with the prices for other skins. Conservation, world events, fashion, new and emerging markets, technology, climate, retailer concentration and CITES regulations all play significant roles in defining production volumes and values. However, these data need to be differentiated further by grade and market to discern the full dynamics of the industry, and to associate the inherent conservation values better with industry incentives.

Figure 3: Pre-export values of wild alligator skins, 1981-2005, constant blended (pre-export) values, estimated

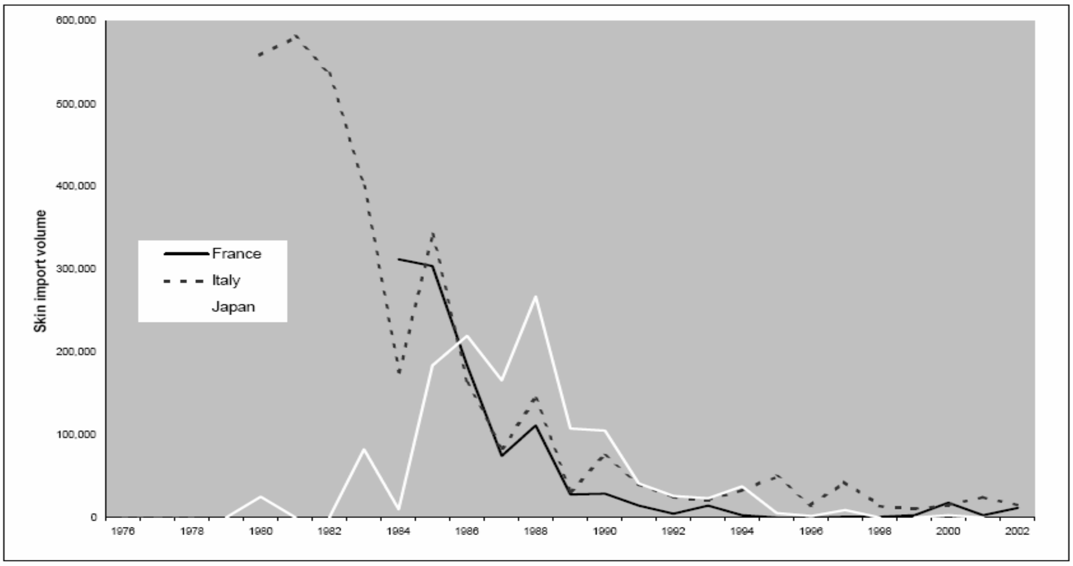


Source: Data from: MacGregor (2002); Don Ashley *pers comm*. 18/6/06.

3. Consumption, conservation, economics and the industry

The falling significance of wild harvested skins in Colombia and Zimbabwe is mirrored by the imports of the major crocodilian skin consumer countries surveyed, which chart a decline in demand for wild-harvested crocodilian skin, to the point of its virtual exclusion from the trade (see Figure 4). Study of the crocodilian skin industry in these countries reflects the upward drift of caiman skin in terms of quality and the consequent blurring of the caiman/classics divide. It also reveals a restructured industry, with a newly-dominant retail sector, partly governed by powerful fashion-brand conglomerates with global reach. Conservation principles are reported to be absent from retailing strategies and consumers' buying decisions. Where conservation is considered, judgements are simplistic and favour captive-reared crocodilians, without any distinction between ranched and captive-bred sources.

Figure 4: Reported imports of wild-harvested caiman skins to France, Italy and Japan, 1975-2002



Source: CITES trade statistics derived from the UNEP-WCMC *CITES Trade Database*, the UNEP-World Conservation Monitoring Centre, Cambridge, UK.

Following some private sector research by the Japan Leather Importers' Association (see **Table 3**), some intriguing new data has emerged about who the Japanese customer of crocodilian handbags is. This shows that the typical consumer of large crocodilian products is over 40, while the 'average consumer' is over 50 and female.

Table 3: Estimated age structure of purchasers of large crocodilian leather products, Japan, 2002 (n=12,274)

Age group	Frequency	Proportion of market (approx. %)
<19	74	1%
20-29	802	7%
30-39	1,594	13%
40-49	2,714	22%
50-59	4,241	35%
60-69	2,175	18%
70>	674	5%

Source: Japan Leather Importers' Association

Initial drivers for the shift away from wild-harvested crocodilian production included conservation motives. The premise on which those motives were based, however, has become outdated by the far-reaching changes the crocodilian skin industry has witnessed since the establishment of the first ranching and captive breeding operations. Largely as a result of the success of these, the industry has come to depend upon the quality and reliability of skins from their captive stock and, indeed, has restructured in parallel and in concert with the development of captive-reared crocodilian production to the point where attributes of captive crocodilian skins coincide with those valued by the crocodilian skin industry and are what the market wants.

4. The future of crocodilian conservation

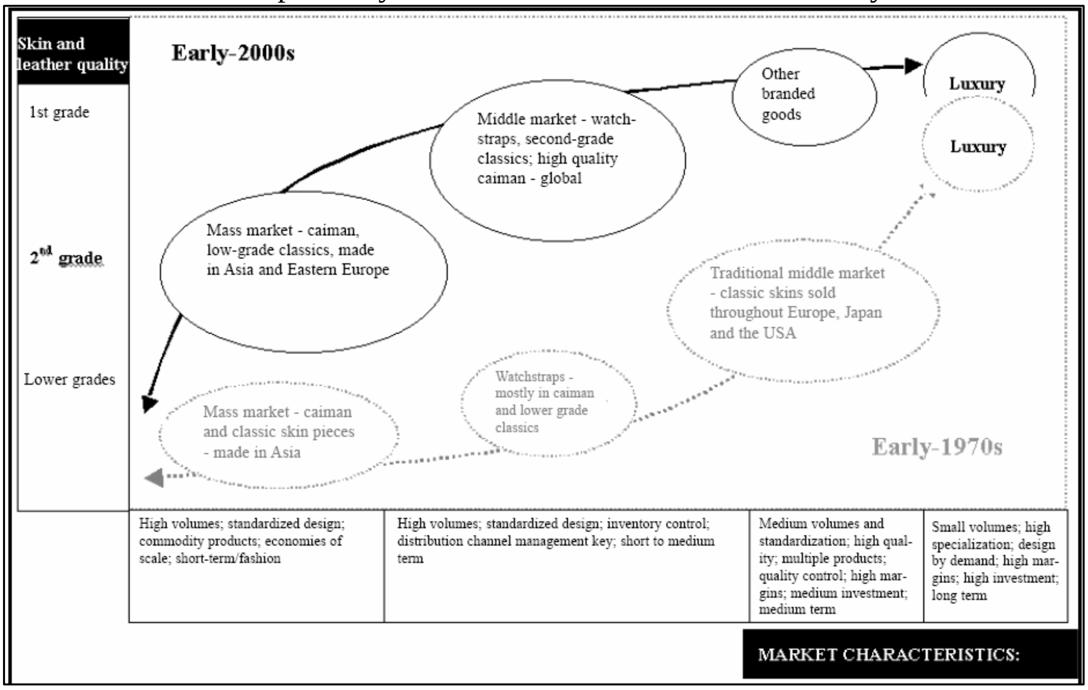
The rationale for market-driven conservation, on which much crocodilian conservation has been founded, is that the financial benefits of commercial exploitation of the species can be harnessed within a management and regulatory framework to provide strong incentives for conservation. This study suggests that the link between commerce and the incentive for conservation is declining since the links between the crocodilian skin industry and wild populations of crocodilians are increasingly tenuous. The conservation motive for re-stimulating trade in wild crocodilian skin was clear. Wild crocodilians could once again be given a trade value and, furthermore, one which outweighed their nuisance factor and the value of other potential uses of their habitat.

The author suggests that wild-harvested crocodilians once again need to be valued by the exotic skin industry, so that sustainable harvesting of wild crocodilians (i.e. hunting or ranching) will increase. What is less clear is how this might be achieved. But satisfaction of both the conservation requirement for a revival of use of wild crocodilians and market criteria could be achieved, and in this regard it is worth considering that:

? the crocodilian skin industry, or any industry founded on wild resources, is unwise to turn its back on the wild supply;
? wild crocodilian skins retain some advantages in today's market—wild classic skins remain at the *vanguard* of the strategy of luxury brands;
? conservation messages are not precluded from the fashion world and, with careful planning and development, conservation and brand messages could be synchronized and complementary; and,
? captive breeding has a role to play in any crocodilian skin industry based on increased use of wild crocodilians and should not be viewed as a production method that needs stamping out.

From an economic viewpoint the restructuring within the industry over the past 30 years is typical of increasingly retailer-driven procurement strategies across all products. Figure 5 illustrates the key changes to the industry since the 1970s (bottom right) to the 2000s (top right). Quality shifts have expanded certain markets (e.g. watchstrap), created new markets (other branded goods) and, importantly, ensured that quality standards are the entry ticket for all industry participants.

Figure 5: Comparing market characteristics and their changes over the past 30 years in the crocodilian leather industry



5. Recommendations for CSG

In the spirit of satisfying conservation and market criteria for crocodilian skins, it is recommended that market potential to favour conservation is harnessed, by the following entities as outlined below:

? Conservation bodies, in co-operation with crocodilian skin industry participants, should:
  - o seek out conservation champions
  - o encourage retailers to realize the potential benefits of the conservation message as a marketing tool.

? Crocodilian range State governments, donor agencies and private companies should work together to 'manage supply', in order to place wild crocodilian populations once again at the heart of the industry. A range of efficient economic solutions exist, including: tied trade; capping captive breeding; quota systems; stimulation of smallholder entry and sustainability along the supply chain; development of a 'conservation brand'; scanning for perverse incentives; conservation tithes.

? Producers of wild crocodilian skins, in order to improve quality and productivity from wild and ranched crocodilians, should:
  - o focus on quality improvements
  - o review enhancement of the value from wild and ranched crocodilian populations
  - o research into the potential role of industry associations in securing advantage for wild and ranched crocodilian skins
  - o learn by example—there is a wealth of experience in sustainable use of wild crocodilians to learn from.

? To maximize potential usefulness of trade data, CITES Parties should improve data, so that it more keenly supports conservation requirements.

Safety Evaluation of Crocodile Blood Diet

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Abstract: The safety for consuming crocodile blood as traditional medicine has not been scientifically reported. To evaluate the effect of crocodile blood consumption on hematological valves, biochemical values and histopathological changes, both sexes of Wistar rats were devided in 5 groups. The crocodile blood, either in fresh or in freeze-dried form, was orally administered for 7 weeks. The blood ingestion had no effect on rat behavior and survival. After taking the crocodile blood 2, 4, 8, 12 and 24 weeks, the rat blood was collected from tail-vein for hematological investigations. The hematological values did not reveal differences between the treated and the control groups. The significantly lower hematocrit values were found in females treated with freeze-dried blood. However, these changes were within normal range. The rat sera were collected before having the blood 12 and 24 weeks after feeding. The biochemical values including alkaline phosphatase (ALP), aspartate transaminase (AST), alanine transaminase (ALT), blood glucose, blood urea nitrogen (BUN) and albumin were not significantly different among experimental groups throughout the study time. These results indicated no adverse effects of crocodile blood on liver and kidney functions. These data suggest the safety of crocodile blood as food supplement in animal.

1. Introduction

Siamese crocodiles, *Crocodylus siamensis*, are one of economic animals of Thailand. They were reared for several purposes including meat marketing, slaughtering, tanning, and making genuine crocodile leather products. People in Asian countries such as in China, Taiwan, Hong Kong, and Korea traditionally believed that crocodile meat is nourishing food. Crocodile blood and organs can served as medicines for curing illness such as allergy, asthma, and may also prolong their life. There are several reports showed that the crocodile blood has ability to inhibit bacterial growth in vitro (Chaeychomsri, *et al*., 2003; Siruntawineti, *et al*., 2003, Siruntawineti, *et al*., 2004 and *HWDO* 0 HUFKDQW However, the safety for crocodile blood consumption has never been reported.

Blood is important tissue that is responsible to carry all metabolic products. As a result hematological alterations can lead to significant immunological effects. The practice of consuming crocodile blood for improving human health is found in the traditions of many Asian cultures (Pichiensuntara and Geeravocks, 2003). To ensure safety in crocodile blood consumption, this experiment was performed to observe hematological, biochemical and histopathological changes in serum of Wistar rats.

2. Material and methods

2.2 Preparation of Crocodile Blood

The blood was collected from Siamese crocodiles (*Crocodylus siamensis*) raised at Sriracha Crocodile Farm and Sriracha Moda Farm, Chonburi, Thailand using sterile technique. Fresh crocodile blood was weekly taken and kept at 4^{o}C in sterile containers. The freeze-dried blood was prepared in sterile conditions, packed under vacuum and stored at 4^{o}C until use.

2.2. Laboratory animals

The Animal Ethics Committee of Kasetsart University, Thailand approved the use of laboratory animals in this study. Wistar rats, twenty-five of each sex, were purchased from The National Laboratory Animal Center, Mahidol University, Salaya, Thailand. They aged 6-8 weeks with weight ranging from 240 to 320 g for male and 180 to 225 g for female. They were housed in animal facility at the Department of Zoology, Kasetsart University. The animals were allowed to have free access to food and clean water under standard conditions of 12:12 h dark-light period, with 30-70 % relative humidity and at temperature of 25-29 ^{o}C. The rats were divided into 5 groups per sex. Group 1 (water control) received treated water (C). Group 2 received 300 ?l of fresh crocodile blood/day (Bd). Group 3 received 300 ?l of fresh crocodile blood/week (Bw). Group 4 received 50 mg of freeze dry crocodile blood/day (FBd). Group 5 received 50 mg of freeze dry crocodile blood/week (FBw). Four groups of treatment (Bd, FBd, Bw and FBw) were fed with crocodile blood as food supplements, either in fresh or in freeze-dried forms, for 45 days. Rats were observed for the sign of abnormalities throughout the study and their body weights were weekly measured.

2.3. Blood Collection and Hematological Study

After supplementing with crocodile blood, rat blood was sampled at 2, 4, 8, 12 and 24 weeks for hematological studies. The blood was withdrawn from tail vein using ethylene diamine tetraacetic acid (EDTA) as anticoagulant. A complete blood count (CBC) with a WBC differential was performed on blood samples. Hematocrit (Hct) was determined according to the standard microcentrifugation method. White blood cell (WBC) was manually counted. The hemoglobin concentration (Hb) was examined by the cyanmethemoglobin method. Thin blood smears were prepared and stained with commercial Dip-Quick® stain (Clinical Diagnostics, Bangkok, Thailand) for WBC differential count. All values were compared to that of untreated control animals and to the standard range for rats.

2.4. Biochemical study
The blood was sampled prior to the experiment 12 and 24-weeks after housing. The blood was taken by drawing from the tail vein and kept in dry centrifuge tubes. The biochemical values of serum, alkaline phosphatase (ALP), aspartate transaminase (AST), alanine transaminase (ALT), blood glucose, blood urea nitrogen (BUN) and albumin were measured by using an automatic biochemistry analyzer (Hitachi model 219).

2.5. Histopathological study
The specimens were taken from intestine, kidney, and liver of rat after 24 weeks of treatment. These organs were then collected, weighted to determine relative organ weights and fixed with Bouin's fixative. Tissues slides were prepared and stained with hematoxylin and eosin. The slides were examined by a pathologist.

2.6. Statistical Analysis The data were analyzed by one-way ANOVA. The significant differences between the experimental groups, at $p<0.05$, were compared by Duncan multiple range test to distinguish significant differences between groups at $p<0.05$. Each value represents mean$\pm$SD.

5 HV ults, discussion and conclusion

Throughout the experiment rats appeared healthy, inquisitive and active. No illness or death occurred. The body weight of male rat received fresh and freeze-dry crocodile in all groups (Bd, FBd, Bw and FBw) were significant higher than control group from first week until the end of the study (Figure 1). In addition, the body weight of only female rat recieved freeze–dried blood groups (FBd and FBw) and fresh crocodile blood per week (Bw) were significant higher than control and fresh crocodile blood per day (Bd). Male rat fed fresh crocodile blood per day (Bd) and freeze-dried crocodile blood per day FBd have significant lower relative weight of kidney than control group, Bw and FBw. Female rat have different relative weight of kidney than male. These results indicated that male rat have higher growth rate after fed crocodile blood in all form than male rat that have normal diet. Although, female rat fed freeze-dried crocodile blood per day and per week and freeze-dried crocodile blood per day have higher growth rate than the rat fed fresh crocodile blood and control, this may in part due to the initial body weight which were significant higher than those of control and FBd from the beginning of the study.

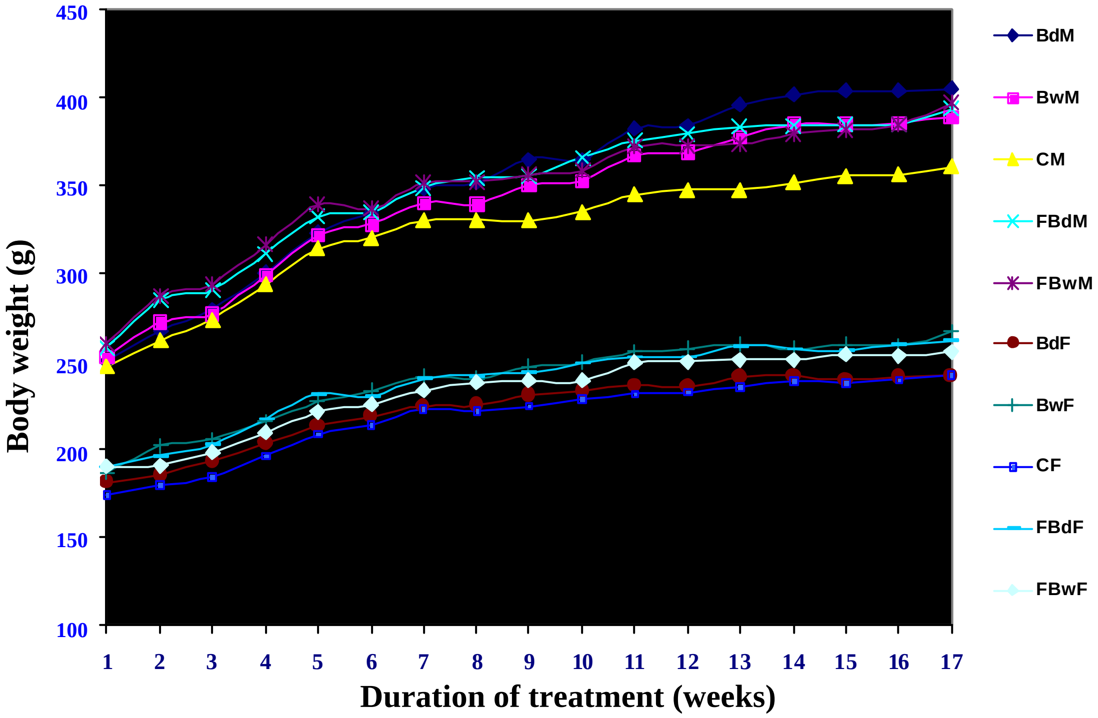


Figure 1 Growth curve of male and female Wistar rat fed fresh and freeze dry crocodile blood for 17 weeks.

The hematological parameters of Bd- and FBd-treated groups did not differ from that of the control in both sexes (Table 1 and Table 2). Basophil was not found during WBC differential counts. The female rats receiving freeze-dried blood had significantly lower hematocrit than those of the control group ($p<0.05$). These were probably due to changes during female reproductive cycle. However, all hematological values were comparable with the normal values reported in literatures (Siruntawineti, *et al*., 2004; Chaeychomsri, *et al*., 2004). This result indicated that administration of the crocodile blood as food supplements, either in fresh or in freeze-dried forms, for 45 days to Wistar rats, did not have any adverse effects on hematological values. Moreover, our previous studies confirmed that the crocodile blood was free from parasites (Flecknell, 1995 and Matsuda, *et al*., 2000.). Therefore crocodile blood should be safe for consumption as food supplement.

Table 1 Hematological examination results of male rat fed crocodile blood before treatment

			0 wk			12 wks			24 wks		
			Control	Bd	FBd	Control	Bd	FBd	Control	Bd	FBd
Male	Hematological Values	Hematocrit (%)	50.80± 2.16	47.87± 1.93	51.00± 1.22	52.90± 2.72	48.50± 2.42	47.90± 2.63	46.16± 1.75	49.66± 0.57	48.66± 0.76
		Hemoglobin (g/dl)	17.37± 0.74	16.60± 0.79	18.24± 0.45	16.88± 1.35	16.24± 1.06	17.92± 2.11	15.54± 1.14	16.60± 0.46	16.50± 0.18
		WBC ($x10^3$/?l)	8.47± 1.59	8.22± 1.25	9.28± 2.26	6.53± 3.44	6.81± 2.24	7.13± 1.81	7.27± 1.31	7.34± 1.39	5.81± 0.72
	Differential count	% Neutrophil	11.60± 4.44	11.60± 4.21	9.50± 4.98	15.80± 8.41	12.60± 2.38	10.37± 3.14	20.66± 3.25	17.33± 2.56	14.16± 4.19
		% Lymphocyte	83.30± 4.32	84.00± 5.55	89.70± 4.82	83.00± 8.28	85.20± 2.70	88.37± 3.90	79.16± 3.51	82.66± 2.56	85.83± 4.19
		% Eosinophil	0.70± 0.27	0.90± 0.82	0.10± 0.22	0.70± 0.57	2.00± 0.79	0.37± 0.47	0	0	0
		% Monocyte	4.40± 0.82	3.5± 1.90	0.70± 0.83	O.50± 0.61	0.20±0. 27	0.87± 0.85	0.16± 0.28	0	0

Significant different from control group (p<0.05)

Table 2 Hematological examination results of female rat fed crocodile blood before treatment.

			0 wk			12 wks			24 wks		
			Control	Bd	FBd	Control	Bd	FBd	Control	Bd	FBd
Female	Hematological Values	Hematocrit (%)	48.66± 0.57	45.25± 2.06	45.62± 1.97*	45.60± 0.96	47.10± 2.32	43.20± 3.05	47.16± 2.56	48.16± 2.71	48.16± 2.02
		Hemoglobin (g/dl)	17.38± 0.54	16.36± 0.47	16.09± 1.08	15.37± 0.81	16.37± 3.51	14.33± 0.77	16.23± 0.58	16.22± 0.90	16.31± 0.21
		WBC ($x10^3$/?l)	7.36± 1.74	5.35± 2.52	8.41± 3.61	5.28± 1.73	4.72± 1.31	3.42± 5.02	5.74± 1.62	6.18± 1.74	6.34± 0.60
	Differential count	% Neutrophil	4.70± 1.98	7.60± 3.94	8.90± 1.91	9.60± 2.70	10.90± 6.50	10.50± 3.06	16.50± 1.50	14.16± 1.75	14.50± 3.27
		% Lymphocyte	92.40± 2.48	90.10± 35.20	89.90± 2.51	88.10± 2.13	87.40± 7.30	87.70± 3.13	83.33± 1.52	85.50± 2.29	83.83± 2.02
		% Eosinophil	0.20± 0.27	0.70±0. 75	0.20±0. 44	1.50± 1.45	0.60± 0.54	1.00± 0.61	0	0.33± 0.57	0.83± 1.44
		% Monocyte	3.10± 2.51	1.6± 1.63	1.00± 1.00	0.80±1. 03	1.10± 0.96	0.80± 0.67	0.16± 0.28	0	0.83± 1.44

***Significant different from control group (p<0.05)**

Biochemical parameters of treated rats, ALP, AST, ALT, BUN, glucose and albumin, were not significantly different from the control (Table 3 and Table 4). However, the blood ALT and ALP of the females, receiving fresh blood crocodile 300 ?l/day, had a tendency to be lower than those in the control group. These results indicated that crocodile blood had no detrimental effect on the liver and kidney function in all treatments.

Table 3 Blood chemistry results of male rats fed crocodile blood for 0, 12 and 24 weeks

Biochemical valve	**Before treatment Wk**					After Treatment (12 wks)					After Treatment (24 wks)				
	Control	Bd)	Bw	FBd	FBw	Control	Bd	Bw	FBd	FBw	Control	Bd	Bw	FBd	FBw
Glucose (mg/dL)	173.00±18.60	168.60±19.16	176.40±20.58	175.20±16.58	171.80±23.05*	129.80±11.98	119.20±13.36	121.60±10.59	112.20±7.72	109.40±5.54	135.66±8.08	129.66±14.36	ND	119.0±7.0	ND
Bun (mg/dL)	24.60±1.51	27.40±3.28	24.00±3.53	26.00±4.47	26.20±1.92	29.95±0.13	29.60±2.60	28.60±2.07	30.40±1.81	31.20±1.64	26.0±2.64	25.33±1.15	ND	24.33±1.15	ND
Alb (g/dL)	4.90±0.24	4.84±0.19	4.90±0.18	5.04±0.16	5.06±0.23	4.84±0.16	4.78±0.19	4.74±0.05	–	–	4.36±0.15	4.3±0.17	ND	4.53±0.15	ND
ALP (U/L)	145.20±15.67	125.80±5.54	139.60±18.92	140.20±17.22	130.20±12.37	83.80±11.32	90.40±10.50	107.60±21.24	–	–	72.0±5.0	64.0±0.57	ND	67.66±12.5	ND
AST (U/L)	161.20±12.31	91.40±5.17*	92.80±10.52*	95.60±19.03*	122.00±10.07*	114.80±5.76	117.20±10.84	117.20±10.84	–	–	132.33±25.5	139.33±16.04	ND	151.66±11.59	ND
ALT (U/L)	40.40±5.72	29.40±5.02	34.80±5.76	36.80±5.02	29.20±4.08	44.20±2.49	39.20±4.60	48.00±12.58	–	–	45.66±6.5	38.66±4.93	ND	39.0±1.73	ND

Significant different from control group ($p<0.05$)

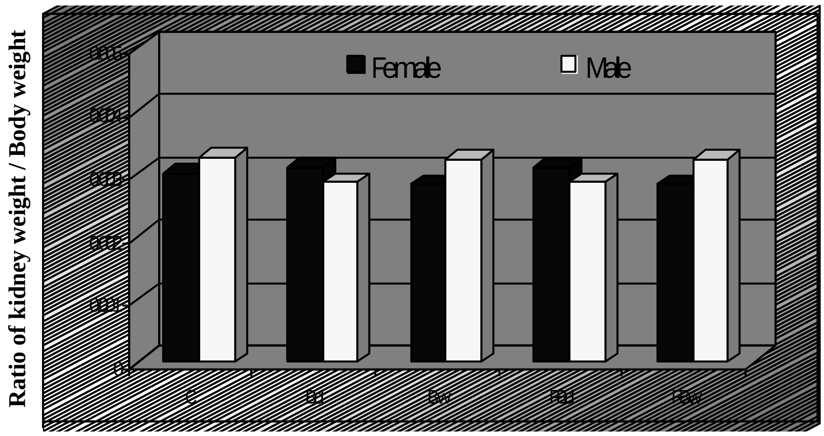
Table 4 Blood chemistry results of female rats fed crocodile blood for 0, 12 and 24 weeks

Biochemical valve	**Before treatment Wk**					After Treatment (12 wks)					After Treatment (24 wks)				
	Control	Bd)	Bw	FBd	FBw	Control	Bd	Bw	FBd	FBw	Control	Bd	Bw	FBd	FBw
Glucose (mg/dL)	100.80±6.61	141.20±21.98	155.60±29.30	152.60±5.02	170.80±23.31	100.60±20.88	127.60±12.54	130.80±7.69	109.20±9.44	122.00±18.46	145.3±4.04	129.66±18.7	ND	142.5±2.12	ND
Bun (mg/dL)	24.40±3.64	24.60±2.40	21.40±2.96	36.80±6.90	32.00±5.70*	25.20±1.78	26.20±2.16	31.60±1.34*	29.00±5.33	28.20±3.19	23.66±4.04	22.0±3.0	ND	22.5±0.70	ND
Alb (g/dL)	–	–	–	–	–	–	–	–	–	–	4.96±0.25	–	ND	–	ND
ALP (U/L)	92.20±12.55	–	–	–	–	–	–	–	–	–	44.33±15.5	–	ND	–	ND
AST (U/L)	181.60±23.56	–	–	–	–	–	–	–	–	–	101.33±1.03	–	ND	–	ND
ALT (U/L)	43.80±5.06	–	–	–	–	–	–	–	–	–	43.66±6.42	–	ND	–	ND

Significant different from control group ($p<0.05$)

Treated rats exhibited no alteration of liver and kidney after 12-week of daily feeding either by fresh or by freeze dry crocodile blood. Similar results were observed in rats that were fed weekly either by fresh or by freeze dry crocodile blood. These results indicated that crocodile blood had no detrimental effect on histological change in intestine kidney and liver in all treatments. However, chronic effects of crocodile blood should be considered from biochemical change after 24 weeks consumption which have no effect on liver function.

Figure 2 Relative of kidney weight of Wistar rat after fed crocodile blood 18 weeks



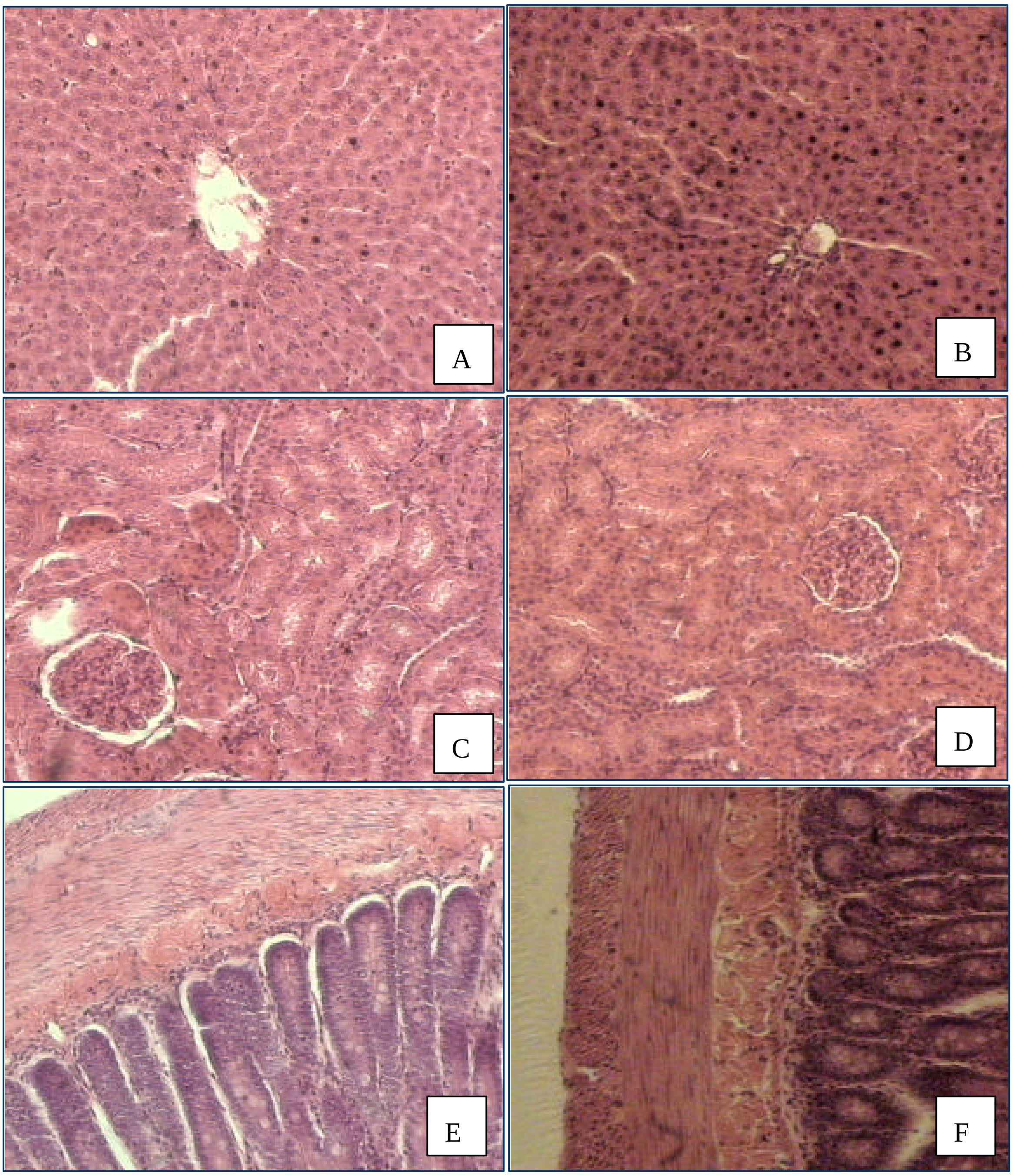


Figure 3 Histopathological examination of liver kidney and intestinal of Wistar rat after 7 weeks of crocodile blood consumtion

(A) Liver cell of control group (B) normal sign of liver cell from fresh crocodile blood consumption.

(C) Kidney cell of control group (D) normal signs of kidney cells from fresh crocodile blood consumption.

(E) Intestinal cell of control group (F) normal signs of intestinal cells from fresh crocodile blood consumption.

4. Acknowledgments

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Development And Evaluation Of Dried Siamese Crocodile Blood Product As Supplemented Food.

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Abstract: Two methods for collecting and drying Siamese crocodile blood were compared. Crocodile blood was either collected by a conventional method or by using apparatus designed by our group. The blood was then processed by either heat drying or by freeze drying. Both heat dried blood (HD-product) and freeze dried blood (FzD-product) products were packed in capsule and kept at three storage conditions for three months. After storage for 0, 1, 2 and 3 months, microbial contamination in dried blood products was determined by the total bacterial plate count. There were no coliform bacteria *Escherichia coli*, and *Samonella* spp. in the products indicating no contamination of gastrointestinal tract and typhoid pathogens. Despite storage conditions and storing times, fewer bacteria were found in FzD-products than in HD-products. The relative suitability for storing FzD-products, in descending order, were at 4? C, at room temperature (26.7? C) with dried condition, and at room temperature with 39.5% r.h. The optimal storage condition for HD-products was at room temperature with dried condition.

1. Introduction

Siamese crocodile, *Crocodylus siamensis*, is the economically important animal of Thailand. It is primarily captive for the leather industry. Other crocodile products including meat, bone, internal organs and blood are also exported. In Thailand, approximately twenty to sixty crocodiles are slaughtered daily in the middle to large scale farms such as Sriracha crocodile farms, Chonburi province (Temsiripong Y., 2005. personal communication). During the crocodile slaughter, crocodile blood is discarded as waste. Recently, it has been collected and processed as heat dried blood for exporting to the Chinese Hong Kong and Taiwan markets.

Crocodile blood have been consumed as supplemented food and used in traditional medicine by Thai and other Asian people (Pichiensuntara and Geeravocks, 2003).

The crocodile blood was traditionally used to treat a variety of locally diagnosed ailments. This belief may derive from the crocodile behavior and its powerful immune system. For instance, the crocodile blood hemoglobin has more effective structure than that of humans (Komiyama *et al.*, 1995). Therefore crocodiles are able to remain under water for more than one hour without surfacing to breathe.

In addition, the components of crocodile blood, involving in immune system, prevent life-threatening infections after savage territorial fights that often leave it with gaping wounds. Although crocodiles live in environment contaminated with microbes, they heal up very rapidly and almost without infection.

Siruntawineti *et al*. (2003; 2004a; 2005) reported the efficacy of Siamese crocodile (*C. siamensis*) serum on bacterial growth inhibition. Merchant *et al.* (2003, 2004, 2005a, 2005b), moreover, found that serum of the American alligator (*Alligator mississippiensis*) demonstrated antibacterial, amoebacidal, and antiviral activities. Recently, these activities follow distinct taxonomical crocodilian lineages were showed (Merchant *et al*., 2006).

To add up the value of crocodile blood, the crude crocodile blood was processed as dried crocodile blood products. In previous studies, we found that there are no blood and intestinal parasites in captive freshwater crocodile, *C. siamensis*, in Thailand (Chaeychomsri *et al*., 2004a; Siruntawineti *et al*., 2004b). Furthermore, food safety tests in animal laboratory scale were performed. It was shown that when the rats consumed either fresh- or dried- forms of crocodile blood as supplemented food, there are no adverse effects of crocodile blood consumption on biochemical and haematological values (Chaeychomsri *et al*., 2004b; Siruntawineti *et al*., 2004c). Besides, the histopathological observation revealed no toxicological changes (Chaeychomsri *et al*., 2005). These data suggest safety of crocodile blood as food supplement in animal.

The objectives of this study were to develop freeze-dried crocodile blood processing and to evaluate microbiological quality of dried crocodile blood products for ensuring the human food safety as edible animal products.

2. Material and methods

2.1. Crocodile blood samples

Crocodile blood was collected at Sriracha Moda Co., Ltd. Chonburi, Thailand. The blood was sampled from Siamese crocodiles (*C. siamensis*), aged 2- to 3-year-old and weighed 25-30 kg.

2.2. Microbiological analyses of fresh crocodile blood

Crocodile blood was collected with sterile technique from the post-occipital venous sinus of Siamese crocodiles. Total plate count or standard plate count, coliforms, *E. coli* and *Salmonella* spp. were evaluated from one milliliter of crocodile blood sample.

2.3. Heat-dried crocodile blood

Crocodile blood was collected into a sterile container, placed on a tray and heat-dried at temperatures in the range from 60 to 80^{o}C for periods of up to 72 hr. Drying was terminated when no further mass changes were observed. Subsequently, the heat-dried blood was powdered and 250 mg of it was put in each capsule. This product was assigned as "HD-product". All processes were conducted at Sriracha Moda Co., Ltd., Chonburi, Thailand.

2.4. Freeze-dried crocodile blood

The large volume of blood was withdrawn from the post-occipital venous sinus of Siamese crocodile with sterile technique using blood collecting apparatus developed by our research group. The blood was collected in close container. The blood was freezed and dried by freeze dryer (Flexi-Dry, FTS System, USA), operating 3 liters per 24 hr at maximum low condenser temperature of -55^{o}C. Dried blood sample was blend and then packed in capsules (FzD-product), 250 mg per capsule, with semi-automatic capsule packaging equipment. Every step was done under sterile condition.

2.5. Dried blood products storage & microbiological tests

Both types of dried blood, HD- and FzD-product, were kept in zip-bags. These products were stored separately in three conditions: (1) at room temperature 26.7^{o}C with general humidity 39.5%r.h., (2) at room temperature 26.7^{o}C with dried condition (using desiccators) and (3) at 4^{o}C refrigerator. The blood capsules were weekly determined for their appearances. After storage for 0, 1, 2 and 3 months, one gram of dried blood was examined for total plate count, coliforms, *E. coli* and *Salmonella* spp.

2.6. Statistical analysis

All statistics presented in this study were mean ? SD. The data were analyzed by one-way ANOVA. Duncan's multiple-range test was applied to distinguish significant differences between groups at $p < 0.05$.

3. Results and discussion

Bacteria were not observed in fresh crocodile blood. This result indicates that crocodile, with closed circulation system, does not have bacterial infection. In addition, there is no bacterial contamination in crocodile blood before being processed as dried crocodile blood product. The conventional blood collection has limitation in volume of blood that depended on size of collected syringe. It is not practical and expensive when used in large volume blood collection from crocodile in industrial scale.

The collection of crocodile blood in large volume has been conducted before slaughter. After being killed, blood is released from crocodile head to the collected container. Then, the large volume of collected blood were kept or processed. By this procedure, blood is easy to be contaminated with bacteria and unexpected agents.

Blood should be collected in hygienic way for food with or without anticoagulants. In this study, the designed apparatus was used with sterile method in closed container for large volume of crocodile blood collection. This blood collection developed process ensures the quality of collected blood before drying process.

In the past, the crocodile blood was placed on a tray and dried under sunlight (solar drying). Blood-drying process was subsequently improved by convection drying using hot-air incubator usually at temperature over 60^{o}C. However, high temperature adversely affects protein structures. Moreover, heat-dried blood is subject to bacterial contamination because it was operated in the open system. By contrast, most protein structures in crocodile blood that has been dried by freeze-drying or lyophilization should be preserved because the permitting dehydration of bioactive peptides from blood proteins at low temperature (Gatlin and Nail, 1994).

After storage, both heat- and freeze-dried blood products were in good appearances at all storage conditions. No incidence of coliforms, *E. coli* and *Salmonella* spp. found in the both products during storages. These results indicate no contamination of enteric and typhoid pathogens that cause the food-borne diseases. The capsules of dried crocodile blood products, in our study, were stored in zip-sealed plastic bags. In order to facilitate consumer and to increase product value, the product packaging should be evolved.

The numbers of aerobic and facultative anaerobic bacteria present in dried blood samples are shown in Table 1. The number of microorganisms in crocodile blood was influenced by drying and storing procedures. One month after storage, significantly fewer bacteria were observed in FzD-products than in HD-products (p< 0.05) at all storage conditions. Similar trend was detected when crocodile blood products were kept for 2 and 3 months. These results suggest that FzD-products are safer to consumer than HD-products because less bacterial contamination was noticed. Storage times did not affect the number of microbes in FzD-products. On the contrary, the number of bacteria in HD-products was significantly altered by the storing times (p< 0.05). For example, the number of bacteria in HD-room temperature significantly decreased as storage times increased (p< 0.05). Conversely, the number of bacteria in HD-4^{o}C temperature significantly increased with storage times (p< 0.05). Effects of longer storage time on quality of dried blood products should be monitored.

Bacterial contamination may occur during the capsule packaging by semi-automatic equipment. These bacteria were endospore-forming bacteria, bacilli, which their spores are resistant to drying and heating (Jay *et al*., 2005) processes. Employing sterilized packaging technique could solve such problem.

In conclusion, freeze-drying method was more applicable than heat-drying procedure for commercially preparing dried crocodile blood products. In three-month period, the optimal condition for storage of FzD-product was at 4^{o}C and for HD- product was at room temperature with dried condition.

Table 1 Microbial population in freeze-dried (FzD) and heat-dried (HD) Siamese crocodile blood products after storage at three conditions and different periods

Drying Process- **Temperature and condition**	**Microbial Population (cfu/ gm)**			
	Storage Period			
	0- month	**1- month**	**2- month**	**3- month**
FzD - RT	10.0 ± 5.4	0^{Aa}	12.0 ± 7.3^{Aa}	0^{Aa}
HD - RT	363.0 ± 16.0	240.0 ± 44.0^{Ba}	61.0 ± 29.0^{Aa}	70.0 ± 30.0^{Aa}
FzD - RT, dry	ND	2.5 ± 2.5^{Aa}	3.3 ± 3.3^{Aa}	2.0 ± 2.0^{Aa}
HD - RT, dry	ND	97.0 ± 2.6^{Aa}	145.0 ± 6.4^{Aab}	4.06 ± 23.0^{Aa}
FzD - 4C	ND	0^{Aa}	0^{Aa}	2.5 ± 2.5^{Aa}
HD - 4C	ND	1646.0 ± 177.0^{Ab}	1425.0 ± 140.0^{ABc}	2278.0 ± 359.0^{Bb}

ND = not determined; RT = room temperature; RT, dry = room temperature at dry condition; 4C = 4°C temperature
Data follow by different capital letter superscripts in horizontal row are significantly different ($p < 0.05$)
Data follow by different letter superscripts in vertical column are significantly different ($p < 0.05$)

4. Acknowledgments

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Feeding Ecology Of The Nile Crocodile (*Crocodylus niloticus*) In The Okavango Delta, Botswana

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Abstract: The stomachs of 286 crocodiles (17 cm to 166 cm snout to vent length) were lavaged over a two year period. *Crocodylus niloticus* has a similar ontogenetic shift in diet to that of other crocodilians. Yearlings primarily predated primarily on aquatic insecta and arachnida, as crocodile size increased (juvenile) the diet became more diverse including crustacea, amphibia and fish. The largest size class (sub-adult) consumed primarily fish. Yearlings fed consistently throughout the year, however a higher proportion of empty stomachs occurred within the juvenile and sub-adult size classes during the winter months. A captive experiment with wild caught crocodiles (0.7 kg – 20 kg) indicated a decrease in satiation rate (maximum mass of food eaten as a percentage of crocodile body mass) from 11.3 % to 6.5 % with an increase in crocodile size. The percentage of stomach stone mass to crocodile body mass increased with crocodile size. Seven species of nematodes were found within the stomachs, four of which represent new geographic records.

Nesting Ecology Of The Nile Crocodile (*Crocodylus niloticus)* In The Okavango Delta, Botswana.

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Abstract: The Nile crocodile (Crocodylus niloticus) population of the Okavango Delta has undergone three major periods of human-induced decline in the past century. Combined, these periods have lead to an estimated 50% reduction in the breeding population of the Okavango Nile crocodile. Although the possibility of population recruitment from two neighboring countries, namely Angola and Namibia, may exist, both countries are currently experiencing a period of major agricultural and economic development. This situation is likely to lead to an increase in crocodile-human conflict and further reduce the likelihood of recruitment into the Okavango Delta from further upstream. Therefore, knowledge concerning the breeding ecology of the Okavango Nile crocodile population and the impact of human disturbance is of critical importance for the long-term survival of this population.

This paper presents data collected over three consecutive nesting seasons in the "panhandle" region of the Okavango Delta, the primary breeding area for this population of crocodiles. Data was collected on nest location, hatching success and other physical nest site parameters. Results indicate that 50-80% of previous nesting sites are no longer in use. Additionally, nest sites are being selected on the basis of minimal human disturbance, rather than on optimal nesting parameters. Through the use of GIS techniques we propose a nesting sanctuary for Nile crocodiles in the Okavango Delta, highlighting the importance of such an area for the long-term survival of the population.

The Reproductive Cycle Of The Nile Crocodile (*Crocodylus niloticus*) In The Okavango Delta, Botswana.

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Abstract: Blood samples were collected from wild Nile crocodile (*Crocodylus niloticus*) between January 2002 and December 2005 in the Okavango Delta, Botswana. Samples were analyzed for seasonal variations in Estradiol (E2), Progesterone (P), vitellogenin (VTG) and testosterone (T) concentrations in females and testosterone concentrations in males. In addition, plasma triacylglycerol (TAG), phospholipids (PL) and cholesterol (CHO) were measured. VTG was detected in females with a total length (TL) = 236 cm.
In males, spermatozoa were detected at the end of June (total length = 196cm) when T starts rising and peaks in Jul-Aug (15.9 ng/ml) coinciding with courting and mating behavior. CHO and PL fluctuation followed the same seasonal pattern as T, but TAG peaked later in Sep-Oct.
In adult females, E concentration was highest in July-August (4.3 ng/ml) as well as VTG concentration (1.5 µg/ml) coinciding with vitellogenesis while testosterone started rising to reach its peak in nov-dec (18 ng/ml). Progesterone would rise steadily until nov-dec were it reached its maximum (45 ng/ml) and then dropped abruptly in January when nests started hatching. The seasonal pattern in TAG concentration mirrored that of estradiol but there was no relations between estradiol patterns and CHO or PL. CHO and PL did not fluctuate significantly throughout the year.

Human-Crocodile Conflict (Nile Crocodile: *Crocodylus niloticus*) In The Okavango Delta, Botswana.

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Abstract: Human-Crocodile Conflict (HCC) is becoming an increasing social and conservation problem in most African countries, as many predator species are under threat due to conflict situations where predation of livestock and humans is occurring. The extent and severity of HCC in the Okavango Delta, Botswana, was investigated through conducting questionnaires with the aid of translators in 35 villages surrounding this unique inland delta (N=483). Perceptions towards crocodiles, the degree of utilization of river resources and traditional beliefs of the local people were also investigated. A high incidence of attacks was expected to occur where human and livestock populations were high, with an increasing number of attacks over recent years. Fifty percent of the people fear crocodiles and remarked that the brain is poisonous when consumed. Most human attacks occurred when people were fishing, swimming and collecting water. Total human attacks (N=125) were positively correlated with human population ($p<0.01$, $r^2=0.40$) and total livestock attacks ($p<0.01$; $r^2=0.32$) [N=3405, average of 3.5 livestock attacked per interviewee]. The rate of attack on humans is increasing linearly over time and therefore mitigation/prevention measures provided will be beneficial in the long term, rather than monetary compensation (currently practiced in Botswana) for the future coexistence between man and crocodile.

Keywords: Human-wildlife conflict and coexistence, socio-ecological questionnaires, traditional beliefs, human and livestock attacks

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Ecology, Conservation And Management Of The Central African Dwarf Crocodile (*Osteolaemus tetraspis*). A Progress Report.

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Abstract: This paper provides an overview and initial results from research on the population ecology and harvest dynamics of the West African dwarf crocodile (Osteolaemus tetraspis tetraspis) in Central Africa. The dwarf crocodile is one of two poorly studied African crocodiles, but is of major importance as an economic and food resource to humans of Central and West Africa. The dwarf crocodile is subject to intensive harvest throughout its range as a source of commercial and subsistence bushmeat.

Found in low energy, closed-canopy swamps and seasonally flooded forests, the dwarf crocodile may be a top aquatic predator in these understudied ecosystems. A lack of information on the ecology and sustainability of this species has prevented appropriate conservation and management strategies. Data collection at Loango National Park on the coast of Gabon is focused on crocodile habitat requirements, population demographics and genetic structure. I use a combination of spotlight surveys, mark-recapture and nesting surveys to collect demographic data; these data are applied to size-structure matrix models to predict population growth and the influence of individual demographic parameters. I am evaluating dwarf crocodile movement patterns at multiple temporal scales through radio-telemetry, mark-recapture and genetic techniques in order to estimate population structure and define the spatial scale of management units. Crocodile harvest dynamics are being documented through biological and socio-economic monitoring programs at the Lac Tele Community Reserve in northern Republic of Congo. These programs evaluate wildlife and fish use within the Reserve; data on crocodile harvest levels, seasonal differences in resource use, hunting techniques and size or sex biases of hunted animals will be incorporated into demographic growth models to evaluate sustainability and develop management guidelines.

1. Introduction

The African dwarf crocodile (*Osteolaemus tetraspis ssp.*) is one of the least studied of the world's crocodiles (Kofron and Steiner 1994), yet it is highly important as an economic and food resource throughout Central and West Africa. Threats to the African crocodiles are primarily hunting and habitat loss. At present, commercial logging and other forms of habitat conversion are less pronounced in Central Africa as compared to West Africa, thus widespread commercial hunting now constitutes the most significant threat to Central African populations. Commercial hunting of Nile crocodile (*Crocodylus niloticus*) and slender-snouted crocodile (*C. cataphractus*), to supply the international leather market, decimated certain populations in Central Africa (Behra 1987). Although the skin trade largely ended with the implementation of CITES regulations in the 1980's, all three African crocodiles are hunted for food in Central and West Africa. Because of its greater relative abundance and small size (i.e. ease of capturing), the African dwarf crocodile is with little doubt the most heavily targeted crocodile in forested Africa today. A combination of high human growth rates, rapid urbanization and expanding transportation infrastructure has led to significant increases in commercial 'bushmeat' hunting and overall increased pressure on natural resources (Wilkie *et al.* 1992). The dwarf crocodile is particularly well suited for the commercial trade - its small size and slow metabolism allows it to be captured and transported live over long distances, without the need for refrigeration. Vendors often store live dwarf crocodiles and sell them only when other game becomes temporarily scarce, elevating the crocodile to the biological equivalent of a savings account.

The objectives of this study are to collect preliminary population ecological data for demographic models of population growth and size-class structure, describe the movement patterns of dwarf crocodiles to define the spatial scale of management or conservation units, and develop biological monitoring programs to collect relevant data on the harvest of crocodiles and other bushmeat.

Demographic models will be used prospectively to evaluate the impact of current and future harvest levels on growth and structure. Population connectivity and movement patterns will be determined across spatial and temporal scales through population genetics, mark-recapture and telemetry. Understanding the scale of movement patterns will aid in the defining conservation or management units and help assess the potential for repopulating over-hunted areas. By quantifying the extent and impact of hunting, and determining the role of crocodiles in local economies, I intend to develop a set of preliminary guidelines for natural resource managers and agencies to use in furthering sustainable use of Central African crocodiles. With appropriate management, other crocodile species have been found to withstand high levels of exploitation (Jenkins 1987).

2. Study Sites

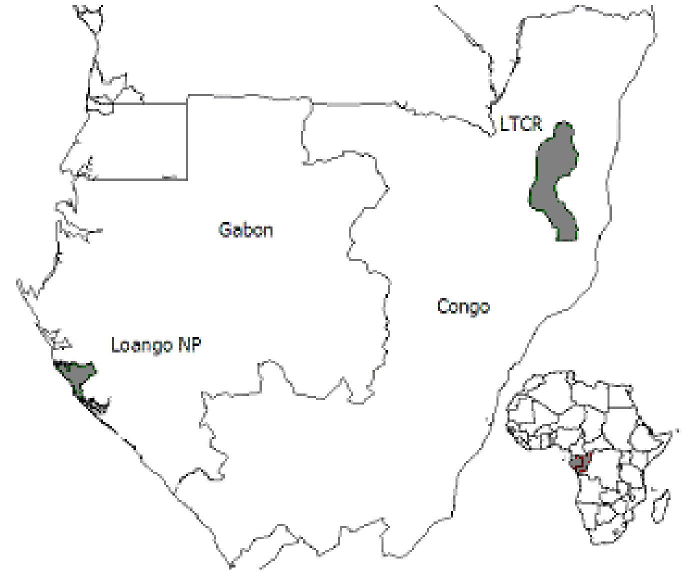

Figure 6: Study sites

Field research for this project is based in Loango National Park, on Gabon's central coast, and in the Lac Tele Community Reserve (LTCR) in the Likouala swamp forests of northern Republic of Congo (Fig. 1). The Loango NP and surrounding landscape contains a diversity of habitats including swamp forest, seasonally inundated river forest, and expansive networks of coastal lagoons and river-ways. The region supports significant populations of *C. niloticus*, *C. cataphractus* and *O. tetraspis tetraspis*. As was true through most of Central and West Africa, Nile and slender-snouted crocodiles were heavily hunted for skins along Gabon's coast until the 1980's, when a CITES ban on international trade in crocodile skins largely ended this harvest. While some poaching of crocodiles and other bushmeat species continues in the south and north-east of Loango NP, most of the crocodile populations within the park's borders have not been hunted for several decades. The Lac Tele Community Reserve is the Republic of Congo's only Ramsar site, with 90% of its 4440 km^2 is comprised of swamp and riparian forests and seasonally flooded forests and grasslands (Poulsen and Clark 2002). The reserve contains low densities of *C. niloticus* and *C. cataphractus*, but potentially large populations of both *O. tetraspis tetraspis* and *O. t. osborni*. The reserve also supports important wildlife habitat for large mammals including elephant, gorilla, buffalo, and chimpanzee. Twenty-six villages, totaling approximately 16,000 inhabitants, are found within or adjacent to the LTCR and are largely dependent upon natural resources for their livelihood. The Reserve was recently linked to the regional capital by paved road and, consequently, to the nation's capital through river and air traffic. Burgeoning human populations and rapid urbanization have resulted in increased extraction of bushmeat for commercial sale outside of the Reserve.

3. Methods

I am collecting data for population demographic analyses using standard crocodile survey, capture and marking techniques (Webb and Smith 1987, Hutton and Woolhouse 1989) and a 'robust' mark-recapture design (Pollock 1982, Kendall 2001). All captured animals are permanently marked prior to release by clipping a unique combination of tail caudal scales. At select sites in Gabon, I tested a technique for temporarily marking animals with uniquely colored reflector strips affixed to the cranial table to estimate within-season re-sighting probabilities. I will use mark-recapture analysis to estimate probabilities of survival, growth, capture and re-sighting. Surveys and captures also provide data on sex ratios, population size structure and relative abundance. Demographic parameters are then applied to size-structured matrix models, which estimate the long-term growth rate (?) and stable age distribution, as well as identify the most influential life history stages and parameters (Nichols 1987, Caswell 2001). Harvest rates and hunter size-selection bias can then be incorporated into the models to assess the effect of hunting on population growth or size-structure.

Using a combination of methods, I will assess population connectivity and movement patterns at multiple spatial and temporal scales. In 2005, I initiated a radio telemetry study to monitor short-term movement patterns and habitat affinities. Within-year movement patterns determined by telemetry are compared to between-year patterns collected by mark-recapture. At the largest geographic and temporal scale, patterns of population connectivity and gene flow within and across study sites will be estimated by genetic analyses. I am collecting a minimum of 25 tissue samples from crocodiles in regions separated by distances of approximately 3, 15, 40, 250, 500 and 1000 km. Using amplified fragment length polymorphisms (AFLPs), mitochondrial sequences and microsatellites techniques, I am evaluating population structure and allele frequencies to estimate large scale dispersal patterns and gene flow across these geographic scales (Salvato *et al.* 2002). I will also use population genetic characters to evaluate phylogenetic patterns, conservation units and to reconstruct evolutionary relationships (Gatesy and Amato 1992, Amato *et al.* 1998, White and Densmore 2001, Gatesy *et al.* 2003).

In 2004 and 2005, I worked with the Wildlife Conservation Society (WCS) and the Republic of Congo's Ministry of Forest Economy to design and implement a village-based biological and socio-economic monitoring program in the LTCR and surrounding region. The research program was designed to complement a fisheries study recently started in the Reserve and to begin systematic monitoring of fish harvest in northern Congo. Fish provide the largest source of protein to Reserve inhabitants (Poulsen and Clark 2002), but no research has quantified fish harvest volume, trends in relative dependence on fish versus wildlife (either seasonally or by habitat type), or the level of commercial trade in fish and wildlife originating from the Reserve. Data on crocodiles harvested in northern Congo will be applied to demographic models to evaluate the impacts of size-specific harvest rates on population growth and structure. Harvest monitoring will also directly contribute to natural resource management efforts in the LTCR.

4. Results

4.1. Abundance, Population Size Class Distribution and Sex Ratios

A total of approximately 420 km of lagoon and stream habitats in Congo and Gabon were surveyed during nearly 100 nighttime surveys. These surveys provide estimates of abundance and habitat affinities of the three crocodile species (Table 1). Across all habitats, dwarf crocodiles were more than four times more abundant than slender-snouted and Nile crocodiles, but were most common in small forest streams of Gabon. In contrast, slender-snouted crocodiles were found most often in medium-sized, freshwater streams and Nile crocodiles in brackish coastal lagoons. In hunted forest streams of Congo, dwarf crocodile abundance was much lower (0.14/km).

Table 4: average crocodile abundance in Congo and Gabon habitats

type	[1]Dist	[2]Ot/km	[2]Cc/km	[2]Cn/km	[3]total/km
Forest streams (Congo)	14.1	0.14	0	0	0.020
Forest streams (Gabon)	64.2	6.78	0	0.53	7.585
Coastal lagoons (Gabon)	65.1	0.80	0	1.73	2.392
Lagoon streams (Gabon)	49.5	2.32	0.41	0.86	3.588
Large stream (Congo)	117	0	0.04	0.04	0.154
Medium streams (Gabon)	106	1.37	1.44	0.11	4.010
Average	[1]420	4.37	1.10	1.00	4.736

[1]total distances surveyed
[2]Ot (dwarf), Cc (slender-snouted), Cn (Nile)
[3]includes unidentified crocodiles (Eyes Only)

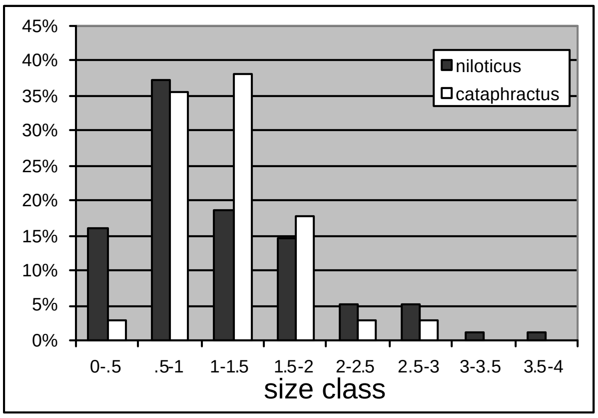

Figure 2: size class distribution of Nile and slender-snouted crocodiles in Loango NP and the LTCR

The size-class distributions of Nile and slender-snouted crocodiles indicate relatively young populations, especially for Nile crocodiles (Fig. 2). These age structures may reflect the long-lasting impacts of intensive hunting for skins, which ended only in the 1970's or 80's. Populations appear to be slowly recovering.

In the region of Loango NP, 299 wild-caught dwarf crocodiles provide an estimate of population size-class structure and sex ratios (Fig. 3). Animals greater than 130 cm total length were almost all males, with the largest recorded female measuring 133.5 cm. The average size of captured males was 86.8 cm, while that for females was 80.4 cm. The small number of animals captured in the 20-30 cm class may represent low survivorship among hatchlings, indicate that research is conducted just before or too long after hatching, or a low capture probability in this size class.

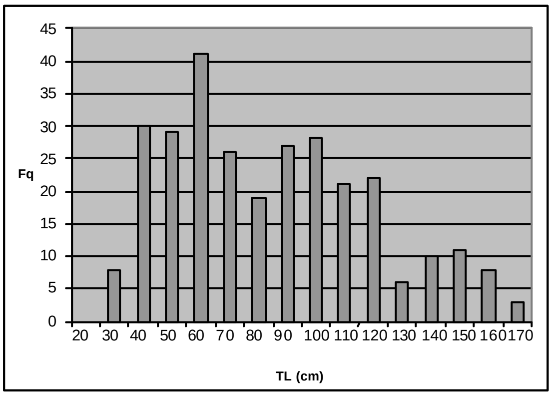

Figure 3: size-class distribution of dwarf crocodiles in the region of Loango NP,

The sex ratio of the captured sample in Gabon is heavily male-biased (2.58:1 M:F). Two small capture samples from elsewhere along Gabon's coast (southern Loango NP and the Rabi Complex, near Gamba) corroborate a male sex bias, with M:F ratios of 3:1 (*n*=8) for Loango and 1.33:1 (*n*=14) for Rabi (Pauwels *et al.* 2006). After excluding all animals over 130cm (to eliminate any effects of harvest size-class bias), a small sample of harvested crocodiles from the Republic of Congo (*n*=25) revealed a sex ratio of 0.92:1 (M:F).

4.2. Growth Rates

I attempted to estimate individual body growth rates using von Bertalnaffy and logistic models (Spencer 2002), but such models were limited due to a small number of recaptures (*n*=11) between the 2004-2005 field seasons (for which all body measurements were taken). Average annual growth rates of dwarf crocodile in coastal Gabon are 7.63 cm in total length and 303 g in mass per year. The average size of recaptures (64.8 cm TL) was less than the estimated population average and thus, because young animals grow more quickly than older crocodiles (Webb *et al.* 1983), these data may overestimate growth rates. Indeed, regressing yearly growth rates (head length and mass) by the last measured size of the animal shows that growth decreases with age [head length: $y = -16.465\ln(x) + 45.463$; mass: $y = -0.0316x + 0.6186$]. The largest animal recaptured (89.5 cm TL, 2.25kg) grew only 1 cm TL and gained no weight. Regression models, however, are not suitable for capturing growth rates - logarithmic models do not asymptote to zero (negative growth is possible, but not likely the rule) and exponential models likely overestimate growth in the smallest size classes. The equations included here will be replaced by von Bertalnaffy or logistic models when sufficient data have been collected.

4.3. Population Demographics

Using data from this study and from the literature, I constructed preliminary deterministic models and sensitivity analyses on population growth and the relative contributions to growth by individual size classes. The models incorporate a 1-year time step and are based on 5 size classes, delineated by shifts in survivorship (Stages 1, 2 & 3) and in reproductive success (Stages 4 & 5). Model parameters include the probability of surviving and remaining in stage *i* (P_i), surviving and transitioning to the next stage (G_i), and fecundity (F_i). Stage transition probabilities are estimated by beginning with a uniform age distribution and an initial growth rate (?$_o$) of 1.0, then allowing the dominant eigenvalue to converge to a constant value as age structure stabilizes. The long-term growth rate (?), size-specific survival rates (s_i), and stage durations are then used to calculate transition probabilities (following Caswell 2001). In addition to growth rate and the stable age distribution, model output includes the lifetime reproductive value of each class. Long-term growth estimates from initial trials ranged from 0.876 to 1.121.

To evaluate demographic elasticities, I successively increased and decreased individual parameters by 10%, while holding all others constant. While the magnitudes of the relative impact on growth varied between trials, the most sensitive parameters were survival probabilities of size-classes 3-5, which is expected for long-lived animals (Lebreton and Clobert 1991), followed by growth in class 3. Class 3 growth and survivorship was most influential on population growth when mortality was highest among reproductive classes, a likely scenario if hunting is biased towards larger animals. The reduced sensitivity to vital rate changes in younger classes suggest that the life history strategy of dwarf crocodiles may depend on high adult survival and, unlike other crocodilians, on early maturation to offset low annual fecundity (avg. clutch size=14.3; Eaton, unpubl. data). Preliminary model manipulations can be used to help guide data collection efforts on the most influential vital rates (e.g. adult survival, growth rates, age-at-maturity, and reproduction) and offer a first approximation of the effects of harvest on population sustainability and where management interventions may be most effective.

4.4. Movement Data

I initiated a radio telemetry study in 2005 in a coastal lagoon and forest stream system of Loango NP. The combination of lagoon, medium-sized freshwater river and small forested streams provides a variety of habitat types to evaluate crocodile movement. Specially designed VHF radio units (Advanced Telemetry Systems, Isanti MN), weighing 100g and fitting crocodiles =105 cm, were attached to the base of the tail using marine epoxy and stitching Kevlar thread through the double caudal whirls. A total of eight male and two female crocodiles (107-158 cm total length) were tagged over the course of the field season. To date, a total of 219 radio-locations (1262 radio-days) have been recorded, with an average of 6.3 days between locations. Two radios were shed after approximately 62 and 130 days, respectively. Radioed crocodiles moved an average of 48.5 linear meters per day, with a small number of longer-distance movements recorded (Figure 4). Radio-tagged animals were most often found under tree roots or in burrows along the banks of small streams (78.8% of locations), but were also found as far as 300 m from water sources. Estimates of home-range sizes and other spatial patterns are currently being analyzed.

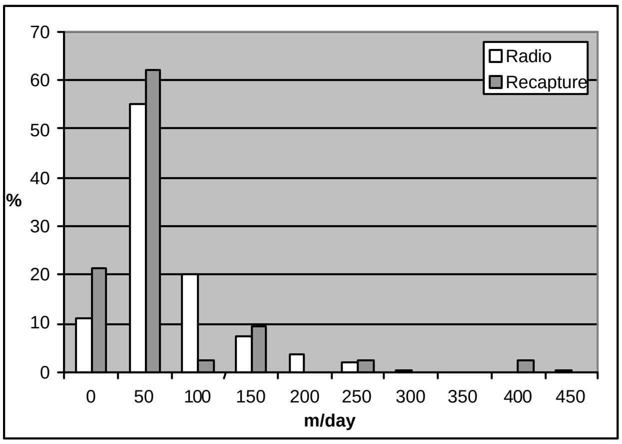

Figure 4: distribution of average daily dwarf crocodile movements based on recaptures and radio-telemetry data from the Louri stream (scaled using percent of frequency)

Relative to short-term movement collected from radio telemetry, 42 re-captures of 28 crocodiles between the 2004-2005 field seasons provide data on somewhat bnger-term movement patterns.

The distribution of estimated daily movement corresponds strongly with the telemetry results, with an averaged daily movement of 30.9 m (Fig. 4). The average number of days between re-captures was 94.9 (max = 414 days) and the range of total distances moved by the 28 animals was 0-420.3 meters (average = 81.5 m).

4.5. Genetic Analysis

Tissue samples have been collected from a total of 330 dwarf crocodiles, 41 Nile crocodiles and 16 slender-snouted crocodiles in Congo and Gabon. The majority of dwarf crocodile samples (93%) were collected from wild captures in which geographic locations were recorded using a handheld GPS. In 2005, I used a sub-sample of 50 dwarf crocodiles from Gabon and Congo to screen genetic markers using amplified fragment length polymorphisms (AFLP), following the methods of Vos (1995) and Mueller (1999). I tested 28 selective primer combinations and identified 6 that produced a total of 233 polymorphic loci. Grouping these samples by their geographic capture locations into 6 putative populations, I compared the average pair-wise genetic differentiation and geographic distance of each population to that of the 5 others (Fig. 5). Nested Mantel tests were used to test the relationship between genetic and geographic distances. Within a spatial scale =22 km there was no relationship found between geographic distance and genetic differentiation, suggesting that the population at this scale is panmictic and movement is unrestricted among these groups (Mantel test: 0.47, p=0.203). Including populations within 50 km of each other, isolation-by-distance was still not detected (Mantel test: 0.96, p=0.065), but this signal may be maintained only by historical gene flow or infrequent migration events. At this geographic scale, population connectivity appears to have largely broken down. This pattern of isolation-by-distance continues nearly linearly up to the largest geographic distances (Congo to Gabon: ~900km), where a Mantel test found significant correlation with genetic differentiation (0.89, p=0.007). Mark-recapture and telemetry data may provide a method to distinguish between recent migration events and historic gene flow in producing such signals. Currently, I am analyzing *Osteolaemus* mitochondrial regions (*cyt*B & D-loop) and working with collaborators at the American Museum of Natural History to develop microsatellite primers with which to continue population genetic analyses. The combination of these methods should improve the resolution of estimating spatial and temporal scales of movement and help define the appropriate size of management units.

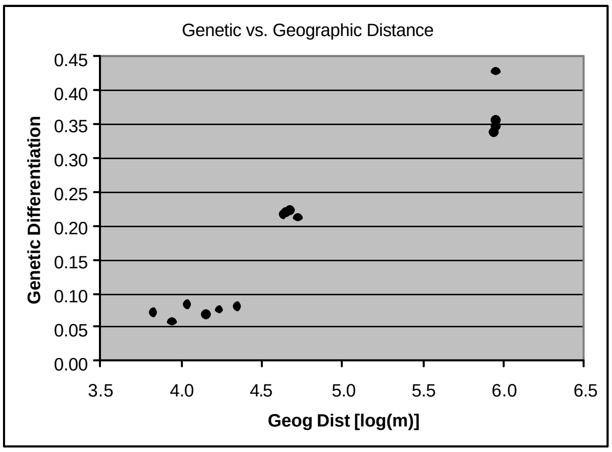

Figure 5: the relationship between geographic distance (straight-line) and average population genetic differentiation for dwarf crocodiles in Gabon and Congo

4.6. Market Monitoring

Beginning in 2003, the crocodile project has conducted *ad hoc* monitoring of villages and markets along the route linking the Lac Tele Community Reserve with the regional capital, Impfondo, with the goal of designing an effective, long-term bushmeat monitoring program for the Reserve. During the 2005 field season, I worked with LTCR staff to formalize a fish and bushmeat harvest monitoring program and implement a sampling design in villages representing the major habitat types found in the Reserve. We convened community meetings to discuss project goals, identified and trained local assistants to begin initial data collection on fish and wildlife harvest, and developed a monitoring database. In addition, we worked with the Director of the Regional Wildlife Office for Congo's Ministry of Forest Economy to design a protocol for monitoring commercial bushmeat trade (and especially trans-border trade between Congo and the Democratic Rep. of Congo) in the provincial capital, Impfondo.

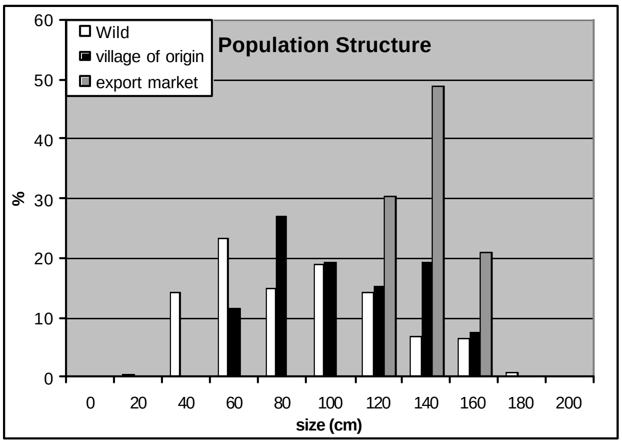

Figure 6: dwarf crocodile size-class distribution comparing wild captures, harvests recorded in local villages (or directly from hunters), and at export markets

While developing the bushmeat monitoring protocol, I collected measurements and other data from 73 dwarf crocodiles from hunters, in Reserve villages, along the LTCR-Impfondo road, and in Impfondo markets. To determine if hunters preferentially target larger, breeding-sized animals I compared the size-class distribution of wild-captures to hunted crocodiles entering local villages; I also compared these distributions to the size classes of crocodiles exported to larger urban markets (Fig. 6). A slight bias is seen in hunter size selection, with a lower representation of animals <60cm TL; generally dwarf crocodiles appear to be hunted in proportion to their abundance in the wild. In contrast, only the largest crocodiles were selected for export to the urban markets where their sale prices increase dramatically (up 50-90%; Eaton, unpub. data). This same trend was found when monitoring dwarf crocodile exports from Impfondo to Brazzaville by riverboat on the Oubangui and Congo Rivers (Efoakondza 1993). Size-specific harvest rate data will be used to adjust survival probabilities in demographic growth models to account for hunting mortality and determine the impact on population structure. Market results suggest that to best characterize the crocodile harvest, monitoring efforts should be focused at the primary village-level rather than in larger urban markets.

In 2005, I accompanied several hunters targeting crocodiles in the Reserve to estimate hunter return rates and document crocodile hunting techniques, Crocodile hunting methods include baited hooks, spotlighting, and spearing crocodiles lured by distress calls.

In a seasonally inundated forest, 42 baited hook-nights captured 4 dwarf crocodiles (capture rate = 0.095) and 1 West African mud turtle (*Pelusios castaneus*). Baited hooks are not a humane technique (the crocodile often swallows the hook and wounds or kills itself during the subsequent struggle), but high mortality rate reduces the likelihood of crocodiles being exported for commercial sale (although there have been cases of live dwarf crocodiles confiscated at London's Gatwick airport with hooks detected in their stomachs by X-ray; C. McLardy, CITES Officer, pers. comm.). Hunting by spotlight and with calls from a pirogue along 10 km of flooded forest resulted in the response of several crocodiles, but the hunter was able to capture only one.

5. Conclusions

Management and conservation of African crocodiles will depend on better understanding of current threats, habitat needs, population demography, and the scale management units defined by population structure, home-range size, dispersal and migration. The goal of this study is to gather baseline data on dwarf crocodile ecology and demographics in order to evaluate the species' potential as a sustainable food and economic resource in Central and West Africa. Management guidelines and recommendations will be produced from synthesizing results from demographic models, analysis of dispersal and movement dynamics and levels of current and predicted harvest. Results and guidelines will be presented to national resource management authorities in Congo and Gabon for inclusion in protected area management planning.

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Conservation et Gestion Communautaire Des Populations de Crocodiles au Mali

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1. Introduction

Située en Afrique de l'Ouest, la République du Mali est un pays totalement enclavé d'une superficie de 1.241.238 km^2 . Il est placé au centre de l'Afrique de l'Ouest avec 7 frontières composées de l'Algérie, le Burkina Faso, la Guinée, la Côte d'Ivoire, la Mauritanie, le Niger et le Sénégal. Le pays s'étend en latitude de 10° à 26° Nord et, en longitude de 4° à 12° Ouest.
La végétation passe du désert extrême au nord à la savane sahélienne et soudanaise, puis à la savane soudano - guinéenne dans l'extrême sud-ouest.
Le climat au nord est aride et devient sous - tropical au sud. Le niveau de précipitations annuelles s'élève à environ 1.350 mm dans le sud-ouest et tombe à des niveaux négligeables dans le nord. Le sud et le centre du pays sont caractérisés par une saison humide distincte de juin à octobre, alors que la période de novembre à février est marquée par un climat doux et sec. La saison sèche de février à juin est aussi la plus chaude de l'année, avec des températures maximales mensuelles pouvant atteindre 46^{o}C.
La population humaine de 11 millions s'accroît rapidement à un taux annuel estimé à 3 %. Près de 45 % de la population a moins de 15 ans. En dépit de quoi, la densité de population humaine du Mali demeure l'une des plus faibles au monde, avec 8,9 habitants au km^2. La majeure partie habite le sud du pays, tandis que le nord est virtuellement inhabité. Les conditions climatiques se traduisent par une productivité primaire élevée au sud, alors que le nord est en grande partie trop sec pour permettre l'existence de populations humaines et mammifères.

Les demandes croissantes de la population humaine ont exacerbé les effets nuisibles du climat de plus en plus sec et la désertification, la déforestation, l'érosion et la pénurie en eau potable sont des préoccupations écologiques majeures (Koné 2001).

Pays à vocation agricole et pastorale, l'exploitation de la faune constitue une des activités les plus pratiquées par les populations maliennes. En milieu rural les populations font toujours recours à la chasse pour assurer leur alimentation en protéines animales. Elle est régulièrement pratiquée partout où le gibier n'a pas totalement disparu. En milieu urbain, les produits de chasse font l'objet d'un commerce intense et porte sur :

- la viande fraîche, séchée ou fumée ;
- les trophées ;
- les animaux vivants.

Les crocodiles dont il sera longuement question lors de ce 18ème congrès est une espèce extrêmement prisée dans ce contexte. Ils occupent une importante place aussi bien dans la nature que dans la société humaine. Certains scientifiques les considèrent d'ailleurs comme les derniers représentant des grands reptiles, qui, durant plus de 150 millions d'années, ont régné sur la terre. Cependant, ces maîtres d'eau sont en voie de disparition au Mali si des mesures draconiennes ne sont pas prises.

Autrefois, on pouvait rencontrer dans les grands fleuves et mangroves de très nombreuses populations de crocodiles en Afrique, en Amérique du Sud et dans diverse régions de l'Asie. De nos jours ils deviennent de plus en plus rares, dans certains endroits ils ont entièrement disparu suite aux pressions des braconniers et la sécheresse.

2. Résumé de la législation malienne en matière de protection et de conservation des populations de crocodiles

Sur le plan écologique, le Mali représente une grande diversité des écosystèmes qui confère au pays une grande richesse en faune dont les effectifs sont mal connus. Cette faune a connu malheureusement une forte régression tant au sein de son effectif que ses habitats due à la longue sécheresse des années 1970 et 1980, la pression agricole (défrichements intenses et anarchiques). A cela il faut ajouter surtout le braconnage favorisé par la longue fermeture de la chasse (1977 – 1995).

En Afrique dans le cadre de l'exportation des peaux de reptiles le Mali vient en seconde position après le Soudan. Durant les vingt cinq dernières années, le Mali était classé au plan international parmi les plus grands exportateur de peaux de Crocodiles. En 1977, la chasse est interdite pour un an sur toute l'étendue du territoire malien . Suite à une demande des exportateurs de peaux de reptiles, le Ministre du Développement Rural dans sa réponse a ainsi écrit :

Messieurs,

J'accuse réception de vos correspondances du 22 octobre 1977 relative à vos demandes d'autorisation d'achat de peaux pour le commerce.

S'agissant de l'importation de peaux, nous n'exigeons de vous que des pièces (certificats d'origine délivré dans le pays où vous acheter vos peaux).

Quant aux peaux du Mali, vous êtes autorisés à acheter et vendre seulement les peaux de serpents, de varans, iguanes compte tenu du fait que ces animaux ne font pas l'objet de chasse au sens classique du mot.

S'agissant des peaux des autres animaux énumérés dans vos demandes, je suis au regret de vous signifier que leur commerce est à présent prohibé avec le nouvelle réglementation interdisant la chasse pour un an.

Je vous prie d'agréer, Messieurs, l'expression de ma considération distinguée.

Le Ministre

Les crocodiles font partis de ces autres animaux énumérés et c'est pourquoi d'ailleurs, compte tenu de la grave crise écologique que le pays traverse et qui ne fait que perdurer. Les principaux cours d'eau qui servaient d'habitats naturels potentiels des crocodiles ont cessé d'être nourris par les eaux des principaux affluents et confluents.

Compte tenu de cette catastrophe écologique en plus des facteurs anthropiques, en 1984, que le Gouvernement du Mali a interdit le commerce des peux de crocodiles, lorsque la CITES a sonné sur le glas en annonçant au plan international la grande menace de disparition de l'espèce. Avant la mesure, le Mali avait comme partenaires les pays européens (France, Belgique, Espagne, Italie, Portugal), américains, d'Afrique et de l'Asie. Force est de reconnaître qu'à l'époque le rythme de l'exploitation des populations de crocodiles et l'importance du flux commercial étaient très élevé au point qu'une grande menace de disparition était constatée sur le stock naturel pour lequel on ne disposait pas d'ailleurs que très peu d'information.

Cependant, malgré l'hécatombe l'artisan malien continuait d'exploiter et exposer aux marchés intérieurs et lors des foires internationales des produits dérivés des crocodiles.

C'est ainsi que sans aucune forme de concertation, ni d'étude préalable, le Gouvernement à l'époque décide sans ambages la fermeture officielle de la chasse par le Décret N° 193 / PG – RM du 1er Novembre 1977 . Un an après par le Décret N° 325 / PG – RM du 06 Novembre 1978, la fermeture totale est prononcée avec comme seul argument de permettre une remontée biologique suite aux effets cumulés de la sécheresse des années 1973 – 1974 et l'impact humain (braconnage, transhumance).

Dix ans après (1986), une étude dirigée par l'UICN et la Direction Nationale des Eaux et Forêts sur l'impact de la fermeture de la chasse au Mali a constaté que les populations de crocodiles étaient sur le point de disparaître si les mesures ne sont prises. C'est justement dans cette optique que l'étude a recommandé la protection totale des crocodiles au Mali.

Jusqu'en 1994, le Mali n'avait pas de statistiques fiables sur l'exploitation des peaux de crocodiles. Les données qui ont existé au niveau de sa banque de données ne pouvaient pas lui permettre de fournir avec précision le volume des exploitations et de l'exportation des peaux..

En 1995, la loi N° 95 – 031 du 20 Mars 1995 est votée, fixant les conditions de gestion de la faune sauvage et de son habitat. Elle est jugée très avancée par les observateurs nationaux et internationaux. Elle s'inspire des différentes législations sous – régionales et des modes de gestion moderne de la faune sauvage. La chasse sera officiellement ouverte en 1995.

La même année et face à la calamité naturelle, les populations de crocodiles sont désormais classées à l'Annexe I (Loi N° 95 – 031 du 20 Mars Fixant les Conditions de la Faune et de son Habitat).

En effet, l'adoption de la Loi N° 95 – 031 / P – RM du 20 Mars s'inscrit effectivement dans la Nouvelle Politique Forestière Nationale élaborée en 1982 renforcée par celle de 1995 qui vise trois options à savoir :

- L'option économique ;
- L'option sociale ;
- L'option écologique.

- L'option sociale vise à responsabiliser les communautés rurales à la gestion durable des ressources forestières, fauniques et halieutiques ;
- L'option sociale vise à favoriser et à garantir l'investissement foncier ;
- L'option écologique quant à elle vise à conserver la diversité biologique.

En 1996, le Mali adhère à la CITES, le commerce international des espèces de faune est alors bien contrôlé.Un organe de gestion a été mis en place et fonctionne bien actuellement .

L'Arrêté N° 97 – 3151 / MDRE –SG réglemente la fabrication d'objets provenant de trophées d'animaux sauvages, le commerce, l'importation, l'exportation, la réexportation et le transit des animaux sauvages vivants ainsi que de leurs dépouilles et trophées. Il est en vigueur depuis le 31 Décembre 1997.

3. Etude statistique des flux commerciaux (Organisation du commerce, volume des exportations, exportateurs et collecteurs)

Depuis le classement de l'espèce à l'Annexe I, l'exportation des peaux de crocodiles est formellement interdite. Aucun document (Certificat d'Origine ou CITES) n'est délivré pour l'exploitation ni pour l'exportation des produits à base de crocodile.

Jusqu'en 1980 où les Sociétés d'Etat étaient opérationnelles au Mali, la Société SONEA (Société Nationale d'Exploitation de la Viande et du Bétail) était la seule autorisée à faire l'exploitation des produits de crocodiles. Un groupe de commerçants et collecteurs de peaux organisés dans le métier exportaient les peaux vers les pays ci-dessous.

Après la fermeture de la SONEA, l'OMBEVI (Office Malien pour le Bétail et la Viande) a pris la relève, mais avec des actions focalisées sur le bétail domestique car la fermeture de la chasse est décrétée en 1983. Malgré les mesures législatives à l'époque très rigoureuses, les artisans maliens très spécialisés dans la confection des articles à base de peaux de reptiles continuaient d'exploiter frauduleusement le capital naturel. Le volume des exportations oscillait entre 120.000 à 150.000 peaux par an.

Dans son étude sur l'importance socio – économique des produits de chasse dans le District de Bamako, la Direction Nationale des Eaux et Forêts (1991) a inventorié dans les hôtels, aéroport et marchés locaux plusieurs expositions d'articles en peaux de crocodiles. Les prix de ces articles vont de :

- 150.000 à 200.000 F CFA pour un cartable;
- 100.000 F CFA pour un sac dame ;
- 75.000 F CFA pour un soulier homme ;
- 55.000 F CFA pour une chaussure dame ;
- 15.000 F CFA pour une ceinture homme ;
- 5.000 F CFA pour un portefeuille homme ;
- 3.500 F CFA pour un portefeuille dame ;
- 2.500 F CFA pour un bracelet montre.

Alors qu'une peau entière brute est cédée entre 3.500 à 5.000 F CFA. Les petits spécimens de quelques centimètres sont les plus recherchés.

En médecine traditionnelle, la peau de crocodile est utilisée pour faire des amulettes (Gris – gris). La peau est vendue en petit morceau suivant la taille recherché par le client, le plus souvent le prix varie entre 250 à 300 F CFA.

4. Les pays de destination

Les grands pays importateurs étaient, la France, l'Italie, la Belgique, l'Espagne, le Portugal, le Japon, le Nigeria, le Sénégal, les Etats –Unis.

5. Etat des populations sauvages

Le Mali est un pays avec plusieurs écosystèmes qui abritent des espèces aquatiques et terrestres. Au plan national, on rencontre les trois variétés de crocodiles à savoir :

- le crocodile du Nil (Crocodylus niloticus) [Laurenti, 1766];
- le crocodiles cuirassé (Osteolaemus tetrapis) [Cope, 1861] ;
- le faux gavial africain (Crocodylus cataphractus) [Cuvier, 1824];

Les études antérieures de B.NIAGATE (1991, 1996, et 2005) sur les populations de reptiles au Mali (Réserve de la Biosphère de la Boucle du Baoulé, Réserve de Faune du Bafing, Réserve de Faune de Niénendougou), le statut des crocodiles reste très préoccupant dans plusieurs localités du Mali. L'espèce bien que classée à l'Annexe I de la Loi 95 – 031 du 20 Mars 1995 est toujours persécutée et braconnée dans les Aires protégées et zones banales du pays. Les causes les plus connues sont surtout :

- le braconnage à outrance pour la collecte des peaux pour la maroquinerie qui devient de plus en plus une activité lucrative de bandes organisées qui sillonnent les grands cours d'eau ;
- la consommation alimentaire d'ailleurs faiblement recherchée ;
- l'utilisation dans la médecine traditionnelle (peau comme amulette, graisse, dents contre les furoncles).

5.1. Les sites de prédilections des Crocodiles.

Au Mali, il y a au total quarante et neuf zones agro – écologiques et six zones agro – climatiques. Les crocodiles existent dans toutes ces zones exceptionnellement les points d'eau (Oueds) dans les régions du Nord et dans les endroits secs, ensablés ou densément peuplés. On les rencontre généralement dans les grandes mares sacrées des villages qui continuent de les vénérer comme au temps des ancêtres. Dans plusieurs régions administratives du pays, les crocodiles sont protégés par les populations par des pratiques traditionnelles ou autres conventions locales de conservation des ressources naturelles.

Actuellement, en plus des mesures législatives nationales, les crocodiles vivent en parfaite harmonie avec les communautés humaines qui en trouvent de véritable ressources touristiques pouvant générer des recettes. Par la fusion des législations nationale et locale, les crocodiles sont actuellement en abondance dans les régions de :

- Kayes (Nioro, Béma, Sandaré, Yélimané, Bafoulabé [fleuves Bafing, Sénégal], Kita [Parc du Baoulé, Réserve de Badinko]);
- Koulikoro (Dioïla [Fleuve Baoulé et Banifing], Koulikoro, Banamba, Kangaba [Fleuve Niger] lac Wégna, Réserve de la Bisophère de la Boucle du Baoulé]) ;
- Sikasso (Bougouni, Koumantou, Manankoro [Réserve de Faune de Niénendougou Fleuve Dégou), Kolondiéba [Commune Rurale de Kadiana , Gonkoro], Koutiala, Yanfolila [Forêts classées de Diankoumérila, Djinètoumanina, Fleuve Baoulé], Yorobougoula) ;
- Ségou (San [Fleuve Bani], Tominian) ;
- Mopti [Koro, Dounapen, Douentza [Boni], Bandiagara) ;
- Kidal : un crocodile introduit dans cette région par un colon blanc vit seul depuis 1948, il est bien protégé par les autorités administratives et locales.

C'est dans les localités de Mopti, Sikasso et Kayes que la dynamique est très importante. On assiste très souvent à un dépassement de capacité de charge au niveau des mares. Dans certaines mares de 50 à 100 mètres nous avons dénombré entre 250 à 500 crocodiles tout âge confondu. Il arrive, ce qui est d'ailleurs un phénomène courant qu'ils ne parviennent pas à trouver à manger d'où surgit le cannibalisme.

Face à la crise de nourriture et la cohabitation légendaire, les populations locales s'organisent souvent en les donnant des cadavres d'animaux ou des sacrifices d'animaux vivants égorgés comme offrandes.

Dans les zones de Sangha (Amani), Koro (Dounapen) et Bandiagara (Pays Dogon) et à Kayes, les populations de crocodiles par manque d'eau font des creux les conduisant jusque dans les habitations. Malgré la crise de ressources vitales, ils ont toujours épargné tous les animaux de leurs hôtes.

5.2. Les sites de collectes des Crocodiles

La collecte des spécimens s'est toujours pratiquée de façon frauduleuse dans les Aires Protégées (forêts classées, les Parcs et Réserve de Faune) et dans les mares isolées. Les opérations de collecte se font le plus généralement et de façon discrète avec la complicité des ressortissants des localités concernées. Les produits sont destinés le plus souvent pour les grandes cités telles que Bamako, Kayes. Actuellement avec la rigueur des mesures de protection et le divorce prononcé par la complicité de certains, les marchés locaux sont moins fournis.

6. La gestion communautaire des populations de crocodiles

L'exploitation de la faune est mal organisée au Mali par contre dans de nombreux pays elle constitue un important moyen de développement économique dans le secteur de l'industrie touristique, du commerce et de l'artisanat.

Une bonne organisation de l'exploitation de la faune au Mali ne peut se faire qu'à travers l'application rigoureuse de la politique nationale en matière de la gestion des ressources naturelles en général et des ressources fauniques en particulier.

Aujourd'hui au Mali, la situation est grave partout, l'exploitation mercantile de la faune a pris le pas sur son aspect socioculturel, ce qui cause aujourd'hui un grand préjudice au capital faunique naturel.

Selon, les résultats de l'étude sur l'impact du braconnage sur la faune dans la Réserve de la Biosphère de la Boucle du Baoulé (B.Niagate, M.Mariko, S.Ouattara 2005) 72% des chasseurs pratiquent la chasse uniquement dans le but de vendre les produits obtenus (viande et trophées) 6% la pratiquent pour le sport, 2% pour des raisons culturelles et 20% pour la médecine traditionnelle.

La protection, le développement et l'utilisation rationnelle des ressources fauniques avec la participation responsable des populations peuvent garantir la sécurité alimentaire et la lutte contre la pauvreté à travers tout le pays (référence à l'option sociale de la Nouvelle Politique Forestière Nationale élaborée en 1982 renforcée par celle de 1995 qui responsabilise les communautés rurales à la gestion durable des ressources forestières, fauniques et halieutiques,). Actuellement, et à travers les constats et les différents rapports techniques des directions régionales, les populations de crocodiles commencent à bien se restaurer. Plusieurs populations de crocodiles qui s'étaient retirés de leurs habitats naturels sont anthropisés dans les mares et rivières des villages maliens.

Nombreuses de ces mares sont aujourd'hui sacrées par des villages maliennes qui donnent des offrandes aux crocodiles venus se réfugier dans leur environnement.

Pour pérenniser la politique et impliquer les populations dans les processus de la décentralisation et développer l'écotourisme autour des sites, le Programme de Petites Subvention du Fonds pour l'Environnement Mondial a financé un montant de 100.000 dollars US plusieurs projets des OCB (Organisation Commune de Base) et ONG à Koumantou (Bougouni) et Dounapen (Koro), pour la protection et la conservation durable des crocodiles. L'intervention du PPS/FEM est soutenue par le département de l'Environnement et de l'Assainissement et s'inscrit dans le cadre partenarial entre le Mali et le PNUD. La stratégie constitue aujourd'hui une bouffée d'oxygène pour les derniers crocodiles des savanes maliennes. Dans les zones encadrées comme à Koumantou, Amani, Dounapen, Kadiana, Gonkoro, les populations à travers le Plan de Développement Communal, ont élaboré en rapport avec les Services de la Conservation de la Nature et certaines ONG un véritable programme d'éducation environnementale et de développement de l'écotourisme.

L'impact de la gestion communautaire des populations de crocodiles :
L'intervention du PPS/FEM est venue dynamiser les politiques de conservation. Un cadre de concertation locale pour la préservation des ressources naturelles est partout opérationnel. Les populations adhèrent et se mobilisent davantage à l'exécution des activités du programme commun de conservation des crocodiles. Des activités de restauration sont exécutées par les Comités Villageois de Gestion des Ressources Naturelles encadrés par la Conservation de la Nature et les responsables des ONGS. Les parties prenantes constituées de la société civile, les autorités locales et administratives, les élus, le service technique et le secteur privé) oeuvrent de concert avec les promoteurs que sont les communautés locales.

Dans les différentes localités on observe les faits suivants :

- la cohésion sociale ;
- l'implication des confréries de chasseurs dans le programme de conservation des ressources fauniques en général et des crocodiles en particulier ;
- la responsabilisation des femmes (GENRE) dans la mise en œuvre du chronogramme d'activités ;
- l'adhésion des structures traditionnelles de décision ;
- l'organisation de la jeunesse autour du programme de conservation de la biodiversité de leur terroir ;
- le renforcement des synergies entre les différents intervenants ;

Les enseignements tirés sur la mise en place des comités et la mise en œuvre des stratégies font que dans les zones appuyées par le PPS/FEM, les populations de crocodiles sont en parfaite augmentation.

Plusieurs personnes ont bénéficié des connaissances supplémentaires en matière de gestion de la diversité biologique de leur terroir. Les populations ont justement compris le sens de la conservation et sont convaincues aujourd'hui de l'importance des politiques nationale et internationale de conservation des crocodiles.

Comme besoin recherche, elles s'appuient toujours sur l'intervention de l'opinion internationale pour effectivement renforcer leurs capacités.

7. Le Central d'élevage de crocodiles de Bakaribougou

La Société Mali – Reptiles est la seule qui a toujours évolué dans l'élevage des crocodiles au Mali. Crée en 1984, elle fait partie des premiers centre d'élevage de reptiles en Afrique de l'Ouest. La société est située dans le quartier périphérique de Bamako. C'est un petit domaine grillagé isolé dans une habitation humaine d'à peu près 120 m de long et 50 m de large. A l'intérieur, il y a un bassin aménagé profond de 2,5m et entouré de sable fin sous une végétation de manguier.

Les buts du centre sont :

- élever, produire des crocodiles ;
- exploiter et commercialiser les peaux provenant du centre pour le commerce international;
- aider le service de la conservation à repeupler les habitats dégradés.

Actuellement avec l'exiguïté du bassin et la proximité des habitations humaines, plusieurs contraintes entravent la valorisation du complexe :

- Nombre pléthorique de crocodiles (250 – 500 individus adultes) ;
- Le manque de capacité d'entretien des crocodiles ;
- Insuffisance alimentaire pour nourrir les bestiaux ;
- Incapacité d'exporter les produits (peaux) ;
- Centre non immatriculé sur le registre de la CITES ;
- Absence de concurrents au plan national.

8. Conclusions et recommandations

Les populations de crocodiles sont de plus en plus rares à observer à l'état naturel. Les quelques reliques qui subsistent malgré le braconnage, les aléas climatiques et la concurrence avec les animaux domestiques arrivent tant bien que mal à vivre avec les communautés humaines.

Au Mali un climat de cohabitation sereine est visible déjà dans plusieurs localités. Les populations humaines et de crocodiles ont effectivement besoin d'un développement. Pour ce faire, il y a lieu de procéder à la restauration des sites naturels à partir d'un aménagement. La démarche fera en sorte qu'il sera possible de développer, promouvoir et valoriser l'écotourisme qui va générer des revenus substantiels, toute chose en retour qui va désorienter les braconniers et leurs complices à poursuivre les prélèvements.

La nouvelle politique de conservation des populations de crocodiles doit aller justement dans le sens de former et aider les populations à la création et la gestion des centres d'élevage.

L'élaboration des conventions locales de gestion durable des populations de crocodiles est un véritable outil accompagnateur de la législation nationale. La cohésion des deux instruments de conservation doit militer pour l'insertion des communautés engagées dans la décentralisation à développer davantage l'écotourisme et l'utiliser comme un des passages obligés de protection des populations de crocodiles (option sociale de la Nouvelle Politique Forestière Nationale et la Loi N°95 – 031 du 20 Mars 1995).

Les Crocodiles Du Nil Du Nord Sahel

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Résumé : Les environnements saharo-sahéliens d'aujourd'hui ont connus une péjoration continue du climat depuis la fin du Néolithique. Végétations, faunes et modes de vie de l'Homme ont connus des mutations profondes. De l'Atlantique à la Mer Rouge, on rencontre cependant des micro milieux qui ont permis le maintient de populations animales malgré des environnements apparemment totalement hostiles. Ainsi diverses petites populations de crocodiles du Nil, totalement déconnectées, survivent-elles dans tous les pays francophones de la limite sud du Sahara.
Après une présentation des sites connus actuellement, nous tenterons de cerner les caractéristiques de ces populations, et de mettre en relief leurs adaptations et stratégies particulières de survie.

Abstract: The extend saharo-sahelians environments have been facing continuous depletion since the end of the Neolithic period. Vegetation, fauna and human life styles have radically changed. However, from the Atlantic to the Red Sea, one meets micro habitats which have made possible animal population to maintain in apparently totally hostile environments. Therefore various small Nile crocodile populations, totally disconnected survive in all francophone countries of the southern limit of the Sahara.
After a presentation of theactual known sites, we will try to comprehend the caracteritics of these populations and to highlight their particular adaptation and strategies to survive.

1. Introduction

Les petites populations isolées de crocodiles du Nil que l'on trouve au Nord Sahel ne sont pas distribuées au hasard ; les facteurs géomorphologiques sont déterminants.
Le Sahara est traversé par des massifs de grès datant de la fin de l'ère primaire et début du secondaire. L'érosion a attaqué ces empilements de grès marins, qui peuvent atteindre 2000 m d'épaisseur, les fracturant, les faisant totalement disparaître par endroits, isolant ainsi des massifs aujourd'hui bien individualisés.

Sur les marges sud du Sahara, ces massifs ont souvent un pendage légèrement nord. Ces reliefs présentent ainsi des lignes de falaises très marquées orientées au Sud, favorisant leur pluviosité, née des remontées du Front Inter Tropical (mousson de fin d'été plus ou moins marquée). L'observation des isohyètes montre que jusque vers 17°N les courbes sont quasi parallèles aux latitudes, puis, toujours en montant vers le Nord, elles adoptent une forme de cloche de plus en plus accentuée dont les sommets se superposent avec ces massifs montagneux.
La géomorphologie favorise donc à la fois les précipitations et leurs concentrations dans des collecteurs, oueds ou cuvettes plus ou moins fermées.
Un autre élément commun est la proximité plus ou moins immédiate d'un grand fleuve, dont le massif n'est d'ailleurs qu'un modeste contributeur. La déconnexion totale de ces populations avec ces grands bassins actifs ne remonte d'ailleurs pas forcément très loin dans le temps, et certaines crues historiques des traditions écrites évoquent des reconnexions temporaires de « nos » crocodiles avec les grands fleuves du Sahel.
Cependant les populations que nous allons évoquer vivent dans des bassins hydrographiques fermés, parfois très restreints. Cet endoréisme, plus ou moins restreint, est une des principales caractéristiques physiques des ces milieux : les échanges génétiques sont *de facto* limités.

Une autre caractéristique est le régime aléatoire des crues alimentant les points d'eau ; suivant les zones ou les années, les régimes peuvent être assez variés. Mais le point commun est que les principaux oueds de ces massifs sont en eau dès 25 mm de précipitation ; l'absence de couche d'humus favorise un ruissellement immédiat et donc la concentration très rapide de ces eaux dans les grands collecteurs. Ces collecteurs peuvent être assez courts quand ils concentrent les eaux de l'amont des falaises, en les évacuant vers le sud ; ces eaux rencontrent alors des barrières sableuses infranchissables. Les populations semblent plus importantes dans l'intérieur des massifs que sur leur bordure, ou les bassins versants sont plus important et les temps d'écoulement plus longs.
Nous distinguons ainsi 3 types de populations : celles de l'intérieur des massifs, vivant essentiellement dans des gueltas, celles des revers de cuesta, dans des gueltas ou des cuvettes de petite taille, à la périphérie des massifs, et celles plus éloignées, occupant des systèmes de dépressions argileuses interdunaires, fermées mais vastes, dont nous ne connaissons l'existence qu'en Mauritanie. Ces deux dernières ont des points communs, en morphologie, fréquentation humaine, etc. On note aussi la présence d'un arbre emblématique de ces types de milieux, de la Mauritanie à l'Ethiopie, l'*Acacia nilotica*, supportant l'inondation sur plus d'un mètre pendant plusieurs mois de l'année. Cet arbre est une ressource très important pour les populations (charbon de bois, nourrissage du petit bétail, sous produits spontanés de la flore arbustive associée, ombre, etc.).

Notons par ailleurs que les crocodiles ne sont pas les seuls animaux à profiter des conditions favorables à leur survie à des latitudes que l'on peut penser au-delà du nord de leur aire de répartition : l'hippopotame, la tortue sillonnée (*Geochelone sulcata*), le varan du Nil (*Varanus niloticus*), les singes Patas (*Cercopithecus patas*) et Babouin (*Papio hamadryas)*, le guépard (*Acinonyx jubatus)*, le galago, le caméléon, etc., peuvent être observés. Sans parler des insectes, batraciens, petits mammifères et plus encore la flore herbacée, arbustive et arborée.

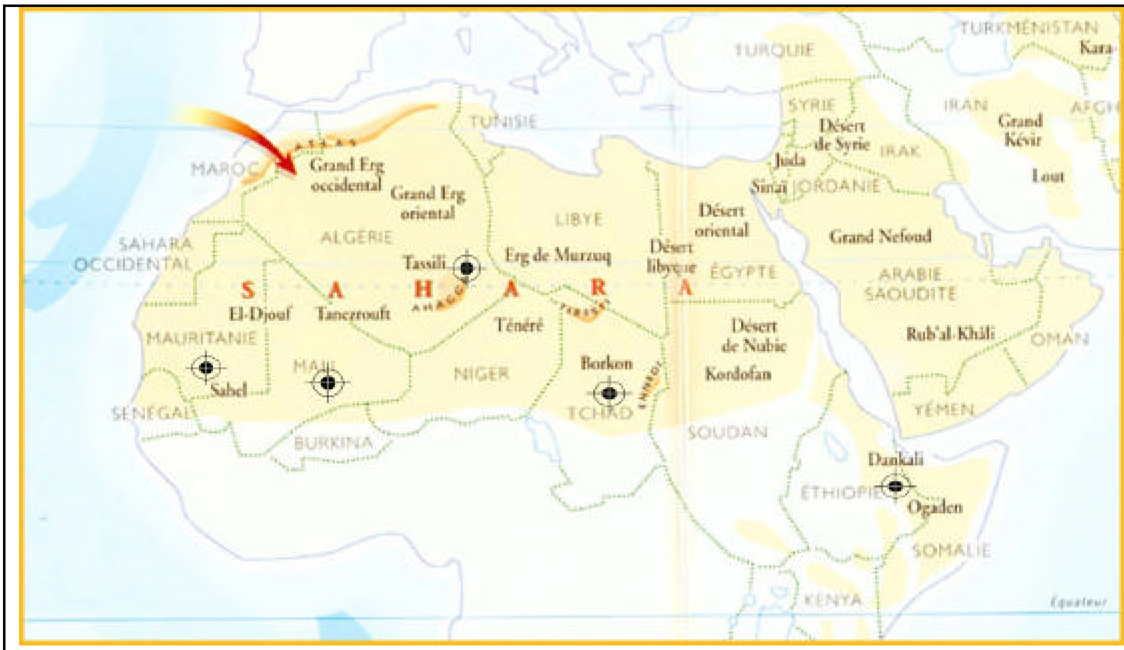

Figure 1 : Les populations présentées se situent en Mauritanie, Mali, Tchad et Ethiopie. Il n'y a pas, à notre connaissance, d'autres populations de crocodiles du Nil, à la même latitude, ni plus au nord que celles présentées.

Les similitudes de ces milieux géomorphologique et bioclimatiques sont probablement à l'origine de similitudes que l'on peut observer chez ces quelques micro populations, réparties sur près de 5000 Km, entre l'Atlantique et la Mer Rouge. L'inventaire de ces similitudes est l'objet de notre présentation, notre manière d'apporter quelques éléments résultants de nos observations sur le terrain, et de poser de nombreuses questions quant à la biologie de ces animaux. Le sujet d'étude est quasi vierge, ce qui demeure pour nous la plus grande énigme…

2. Adaptation comportementale

Adaptation à des périodes, comptées en semaines ou mois, sans eau. Le crocodile fait ainsi face, tout comme le reste de la faune et le couvert végétal (sans parler de l'Homme), à la principale caractéristique du régime des pluies au Sahara et au Sahel : l'irrégularité, c'est à dire la difficulté, voire l'impossibilité de compter à terme sur la disponibilité de l'eau sous forme liquide.

On distingue 3 stratégies principales pour faire face aux saisons sèches :

- Le creusement de galeries dans les talus argilo-sableux, au dessus et/ou au dessous de la ligne d'eau. Il semble que les galeries inondées puissent accéder à des chambres qui peuvent être plus hautes et donc à l'air libre, du moins à certains niveau d'eau, car il faut avoir à l'esprit que les niveaux d'eau sont sans cesse fluctuant. Les observations et enquêtes montrent qu'ils peuvent passer plusieurs semaines, peut-être plusieurs mois en semi léthargie pendant la saison sèche. Il leur arrive alors de quitter temporairement cet abri pour aller dehors, de nuit.

Chasser, uriner, … ? Nous avons observé ces trous de galerie dans tous les types de mares, mais pas systématiquement. Contrairement à ce que disent les nomades (et subséquemment parfois la littérature), ce ne sont pas des lieux de ponte.
- L'utilisation de niches naturelles dans les éboulis de blocs suffisamment gros, pour s'enfoncer assez profondément pour retrouver une hygrométrie importante, et probablement une température régulée (saison sèche = saison chaude).
- L'enfouissement dans l'argile molle encore récemment inondée ; les témoignages d'européens digne de fois sont parfois éloquents et se recoupent parfaitement. Il est possible de creuser sur plus d'un mètre l'argile d'un fond lacustre asséché et trouver un crocodile léthargique. La réelle diapause nous semble biologiquement difficile, et il faudra un jour expliquer complètement ce comportement.

2. Nourriture

Il est commun de lire que les facteurs trophiques sont limitant, voulant ainsi expliquer la petite taille des individus. Il n'est pas besoin de fréquenter longtemps ces points d'eau pour reconnaître que ces crocodiles savent faire feu de tout bois, et que la variété comme la quantité ne manquent pas une bonne partie de l'année tout au moins, quelque soit l'époque de l'année : nos observations et enquêtes ont pu lister poissons, batraciens, coquillages (bulins), crottes de chameaux, oiseaux (plus souvent limicoles ou échassiers migrateurs), petits mammifères, petit bétail (rare), chiens (données très constantes dans le temps et l'espace), …

4. Respect par les populations humaines

Il est évident que ces très rares populations du nord Sahel existent encore parce que l'Homme les tolère, au même titre que les singes et les autres espèces à faible valeur cynégétique. Les autruches, girafes, addax, gazelles, tortues, etc. n'ont pas eu cette chance, car elles pourraient encore exister largement dans ces environnements.
Le crocodile, en plus de ne pas être consommé, occupe un espace non convoité par l'Homme, contrairement aux pâturages qu'il préfèrent réserver à ces chameaux et petit bétail, et que de surcroît la gazelle a un goût exquis après cuisson, fraîche ou séchée.
Entre simple respect et sacralisation, les Hommes semblent accorder aux crocodiles le droit à l'usage de leurs lieux favoris. Cela est très net à l'Est, un eu moins à l'Ouest. Au Tagant (Mauritanie), la sédentarisation croissante, fatalement de préférence autour des points d'eau, rend la cohabitation de plus en plus difficile. Du statut d'étranger, le crocodile est devenu l'intrus. Mais en contrebas du plateau, à Tamchaket (Mauritanie) ou dans les tamourts (Mauritanie), il est respecté.
Au Tchad, dans l'Ennedi, les Hommes sont persuadés que la présence des crocodiles est la condition de la pérennité des deux sources qui alimentent la guelta d'Archeï.
Au Mali, dans la falaise de Bandiagara, le crocodile est le second animal de la cosmogonie dogon ; il est donc protégé par des croyances bien ancrées.

5. Taille des populations

Elles se comptent, par point d'eau ou réseau de points d'eau, en unités ou en dizaines au maximum. L'interconnexion de ces micropopulations serait à prendre en compte mais cela n'a pas été étudié.

On ne sait de quelle manière circulent ces crocodiles à l'intérieur d'un bassin versant, les distances qu'ils peuvent parcourir, et le parti qu'ils tirent des crues, et du potentiel de déplacement qu'elles représentent. On ne sait l'attachement (en années) qu'ils peuvent avoir à un point d'eau particulier. Il est évident que les populations croissent avec la taille des points d'eau plus qu'avec la durée (sur l'année) de la présence de l'eau.
Citons Matmata (Tagant) et Archeï (Ennedi), 2 points d'eau emblématiques et les plus importants de leur massif, jusqu'à preuve du contraire : les observations relèvent au maximum 9 individus pour chacun d'eux ; cependant ces comptages ont toujours été pratiqués de jour, à la saison sèche.
A l'opposé, sur les 244 tamourts recensées dans les Hodhs, en Mauritanie, 39 ont « livré » des crocodiles. Des comptages de nuits ont relevé dans certaines tamourts 30 à 40 individus. Mais aucun comptage systématique n'a été entrepris. Il serait intéressant de savoir quelle distance peut parcourir un crocodile sur du sable, entre deux tamourts. Notons simplement que nous avons pisté sur plus de deux kilomètres un crocodile capturé nous ayant échappé, parti à l'opposé de sa pièce d'eau, dans les dunes.

6. Taille des individus

Si nous partons de l'hypothèse que la petite taille des individus de ces populations est une évolution adaptative, nous devons chercher en quoi il peut être avantageux d'être plus petit que les individus des populations nominales des régions plus au sud, dans les grands bassins hydrauliques actifs.
La petite taille peut être favorable aux déplacements importants, nécessaires à certaines saisons, pour rejoindre des points d'eau éloignés, ou des caches rocheuses en saison sèche.
D'autre parts, ces populations savent utiliser et/ou creuser des galeries que l'on retrouve dans les berges argilo-sableuses (10 à 20 m de profondeur). S'il y avait de grands individus, ceux-ci, une poignée, devraient creuser des galeries à leur taille, et donc travailler pour les autres.
Ces grands individus auraient par ailleurs plus de mal à se faufiler dans les cavités rocheuses, les amas rocheux pour passer la saison sèche, comme le font les populations nord sahéliennes. Certains s'enfouissent dans les argiles de fond de lacs asséchés ; la grande taille pourrait être aussi un inconvénient dans ce cas.

Nous pouvons aussi chercher quels pourraient être les facteurs qui concourent à la petite taille de ces crocodiles, qui ne relèvent ni de la taille de leur territoire (voir la concentration à La Ferme aux Crocodiles !), ni de la faible disponibilité de nourriture, éléments auxquels nous ne croyons pas, ou pas seulement : ces populations vivant en contact étroit avec des Humains, qui habituellement ne font que passer aux poins d'eau, sont souvent dérangés. Ceci peut induire un stress récurrent, lequel pourrait influer sur la croissance des animaux. On peut évoquer que les crocodiles perdurent dans les points d'eau les plus persistants, les plus visités donc par les éleveurs en saison sèche. Les dérangements sont donc plus fréquents à la période chaude, ce qui diminue peut-être le bénéfice en terme de croissance que les crocodiles pourraient tirer de la saison chaude.
Il nous semble par ailleurs que les bilans thermiques quotidiens, saisonniers et annuels puissent avoir une influence, qu'il est difficile d'estimer.

Mais il est assez simple de constater que ces stations sont à la fois plus au nord et plus en altitude que celles des grandes populations plus au sud. Notons que là est peut-être l'explication qu'il n'y ait pas de crocodiles sur le plateau de l'Ennedi (Tchad - 1200 m), mais seulement dans les canyons, alors qu'il y en a sur le plateau du Tagant (Mauritanie – 400 m). Il serait probablement aussi intéressant de disposer pour les différents sites du nord Sahel des statistiques de nébulosité.
Notons encore que sous le tropique du Cancer, par rapport à l'équateur, l'hiver est la saison à la fois fraîche (air et eau), où les journées sont courtes.
L'eau des gueltas des massifs du nord Sahel n'est à notre connaissance jamais supérieure à 25° (18° en hiver), à cause de l'alimentation souterraine en eau froide, de l'évapotranspiration, à la faible circulation de l'eau, et bien sûr à la température de l'air. Alors que le métabolisme requiert une température interne de 35°.
On peut aussi suggérer que la petite taille peut favoriser l'élévation rapide de température interne, les expositions au soleil pouvant être courtes, soit à cause de l'encaissement des sites, soit à cause des dérangements répétés.
Ajoutons encore que nous ne savons rien de l'âge des crocodiles les plus grands de ces sites ; y a-t-il réellement des individus âgés ? Si non, pourquoi ?

On peut donc énoncer que les zones nord sahéliennes ne sont pas favorables au plein développement des crocodiles, pour des raisons à la fois climatiques et de pression humaine sur les points d'eau.
A contrario on peut penser que parmi les populations plus nombreuses du sud du Sahara, il est important pour les males d'être grand pour conquérir les femelles, et capturer des proies de grandes tailles (gnous par exemple), qui n'existent pas (plus) aux points d'eau nord saheliens. Il serait intéressant de savoir où se trouvent les populations qui, à âge égal, ont la taille la plus importante. Pourrait-on chercher une éventuelle corrélation entre la latitude et la taille ? L'inertie thermique (dont la grande taille, la surface augmentant au carré, le volume au cube) est intéressante quand il y a peu d'amplitude thermique jour/nuit.

Encore faudrait-il pouvoir distinguer le ralentissement de la croissance et sa limitation, quelque soit l'âge que peuvent atteindre ces animaux. Savons-nous quels sont les critères qui font la durée de vie d'un crocodile ? Peut-il y avoir en même temps ralentissement de la croissance et limitation de la croissance ? Comment agiraient et se combineraient les différents facteurs ?
Comment interpréter le fait que les femelles soient matures à 1,60 m, qu'elles fassent moins d'œufs, et plus petits ?

7. La permanence de l'eau des différents types de points d'eau

7.1 Gueltas de l'intérieur des massifs

Les plus grandes gueltas sont quasi permanentes, c'est-à-dire que leur assèchement est exceptionnel, et donc possible sans remettre en question la survie des petites populations de crocodiles. Elles bénéficient de l'effet château d'eau des grès aquifères poreux. Les plus petites gueltas, des mêmes bassins que les plus grandes sont des points d'eau de « dispersion », que les animaux quittent s'ils s'assèchent, pour autant qu'une marre plus permanente soit accessible.

7.2. Tamourts
Le régime moyen de l'inondation de ces cuvettes est de 4 à 6 mois par an ; les crocodiles utilisent donc des stratégies d'adaptation répétées chaque année, notamment l'utilisation de chambres souterraines creusées dans l'argile au bout d'un boyau de 10 à 20 mètres. L'environnement des tamourts est le plus souvent uniquement sablo-argileux, les rochers, et leurs abris potentiels faisant défaut. Le volume d'eau ne fait que diminuer entre la mise en eau pendant les pluies de l'hivernage et l'assèchement total, principalement par évaporation.

7.3. Les gueltas ou dépressions des revers de massifs
Ces gueltats sont en général plus durables (voire permanentes) que les tamourts car elles bénéficient d'apport d'eau souterraine de la base des falaises.

8. Quel avenir pour ces populations ?

On ne connaît les circonstances de la disparition récente des crocodiles du Nil qu'en Algérie (1924), alors qu'il semble avéré qu'il était présent, au moins, en Palestine, au Maroc au XVIIIème siècle.
Notons qu'aucune des populations existantes n'a fait l'objet d'étude, biologique, éthologique, etc., sur le cycle complet d'une année. Pas plus que les milieux qu'elles occupent. De même il n'existe aucune protection active des sites ou des populations ; c'est seulement l'usage coutumier des populations humaines de ces sites qui assurent (ou pas) la pérennité de ces reptiles.
La menace la plus importante est celle qui pèse sur la population du Tagant (Mauritanie) : la pression humaine par sédentarisation autour des points d'eau, et l'absence d'une conscience collective de l'importance de la conservation de cette espèce la rend très fragile. Nous avons répertorié un certain nombre de destruction d'animaux.
Nous souhaitons qu'il sera possible dans un avenir proche de procéder à des études de ces populations, aux différentes saisons de l'année, afin de mieux comprendre leur biologie et leur comportement. Il nous apparaît pour le moins évident que ce type d'étude est primordial pour espérer voir vivre encore longtemps ces animaux.

La Situation Et Les Différentes Utilisations Des Crocodiles Du Nil *(Crocodilus niloticus)* Au Niger : Cas De La Région De Niamey

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Résumé : L'utilisation des ressources naturelles renouvelables (faune, flore) de l'environnement est indispensable au développement des pays Africains et plus particulièrement à celui du Niger. Cependant, elle doit être envisagée dans une perspective de durabilité afin de garantir les ressources aux générations futures.

Les problèmes de conservation de la biodiversité ne peuvent se concevoir qu'en relation avec les usages qu'en font les populations humaines et les possibilités de valorisation de la biodiversité. La situation actuelle de la faune nigérienne dérive tout naturellement des causes qui sont à l'origine de l'état de dégradation générale que connaît notre environnement.
Le réseau hydrographique du Niger est constitué essentiellement du Fleuve Niger et de ses 7 affluents, le lac Tchad, et plusieurs mares permanentes. Au regard de l'importance de ce réseau, On dénombre au Niger près de 150 espèces de reptiles et Amphibiens, parmi lesquels, les crocodiliens dont, le crocodile du Nil (*Crocodilus niloticus*) en est son seul représentant. D'où on note la présence d'une population assez importante.
Cependant, compte tenu de la qualité des leurs sous produits (Cuirs, peaux, viande, os…), les crocodiles font aujourd'hui l'objet au Niger, d'exploitation pour le moins désabusée, et ce, malgré les mesures de protection dont ils bénéficient au niveau national et international.
C'est pourquoi, des programmes de sauvegarde de cette espèce doivent être envisagés pour assurer sa pérennité et les différentes utilisations (maroquinerie, pharmacopée traditionnelle, tourisme,…) socio-culturelles, éducatives, scientifiques et touristiques qui en sont faites.

Abstract: the use of the renewable natural resources (Fauna and Flora) is essential for African countries development and particulary for Niger. Meanwhile, it has to be intended in a perspective of sustainability so that the present and future generation can profit. The problems of biodiversity conservation can not be conceived only in relation to the uses that human populations do with it and the possibilities of the biodiversity valorization.
The present situation of wildlife in Niger derived naturally from causes that originated from the general state of degradation of our environment.

The hydrographic network of Niger is consist essentially of the River Niger, and its seven (7) tributaries, Chad Lake and many other permanent rivers (ponds). Regarding to the importance of this network, Niger gets up to 150 species of reptiles and Amphibians amongst which the Crocodilians such as the '' Nil '' Crocodile *(Crocodilus niloticu)* which is the unique representative. The population of this particular species is quiet important.

Meanwhile, considering the quality of their products such as skim, maet, bones etc, the crocodiles are subjected to over exploitation despite the protection measure taken on them at both national and international lavels.
This is why, programmes (projects) of the species safeguard have to be envisaged in assuring its perennity and the various uses (fancy-leather goods, traditional medicine, tourisme etc) socio-cultural, educational, scientific and recreational uses that people carry out.

1. Introduction

L'utilisation des ressources naturelles renouvelables (faune, flore) est indispensable au développement des pays Africains et plus particulièrement à celui du Niger.

Elle doit être envisagée dans une perspective de durabilité afin de garantir les ressources aux générations futures. Les problèmes de conservation de la biodiversité ne peuvent se concevoir qu'en relation avec les usages qu'en font les populations humaines et les possibilités de valorisation de la biodiversité.

L'étagement climatique important et les formations végétales différenciées permettent au Niger d'héberger une faune de vertébrés très diversifiée, comprenant aussi bien des représentants du domaine désertique saharien que du domaine soudano-guinéen (LE BERRE, 1995). On dénombre au Niger près de 150 espèces de reptiles et Amphibiens dont le fleuve Niger et le lac Tchad hébergent de très nombreux représentants.

Le réseau hydrographique du Niger est constitué essentiellement du Fleuve Niger (avec 4200 km de long dont 550 km qui traverse le Niger et de ses 5 affluents), le lac Tchad, et plusieurs mares permanentes. Au regard de l'importance de ce réseau au Niger, on note la présence d'une population importante des crocodiliens marquée par les crocodiles du Nil (*Crocodilus niloticus*).

Ces crocodiles, compte tenu de la qualité de leurs sous produits (Cuirs, peaux, viande, os…) font aujourd'hui l'objet au Niger, d'exploitation pour le moins désabusée, et ce, malgré les mesures de protection dont ils bénéficient au niveau national et international.
Les crocodiles sont en ce moment presque confinés dans les eaux des aires de conservation à l'image du Parc Régional du W du Niger notamment dans les rivières Tapoa et Mékrou où ils constituent aujourd'hui un sanctuaire des crocodiles.

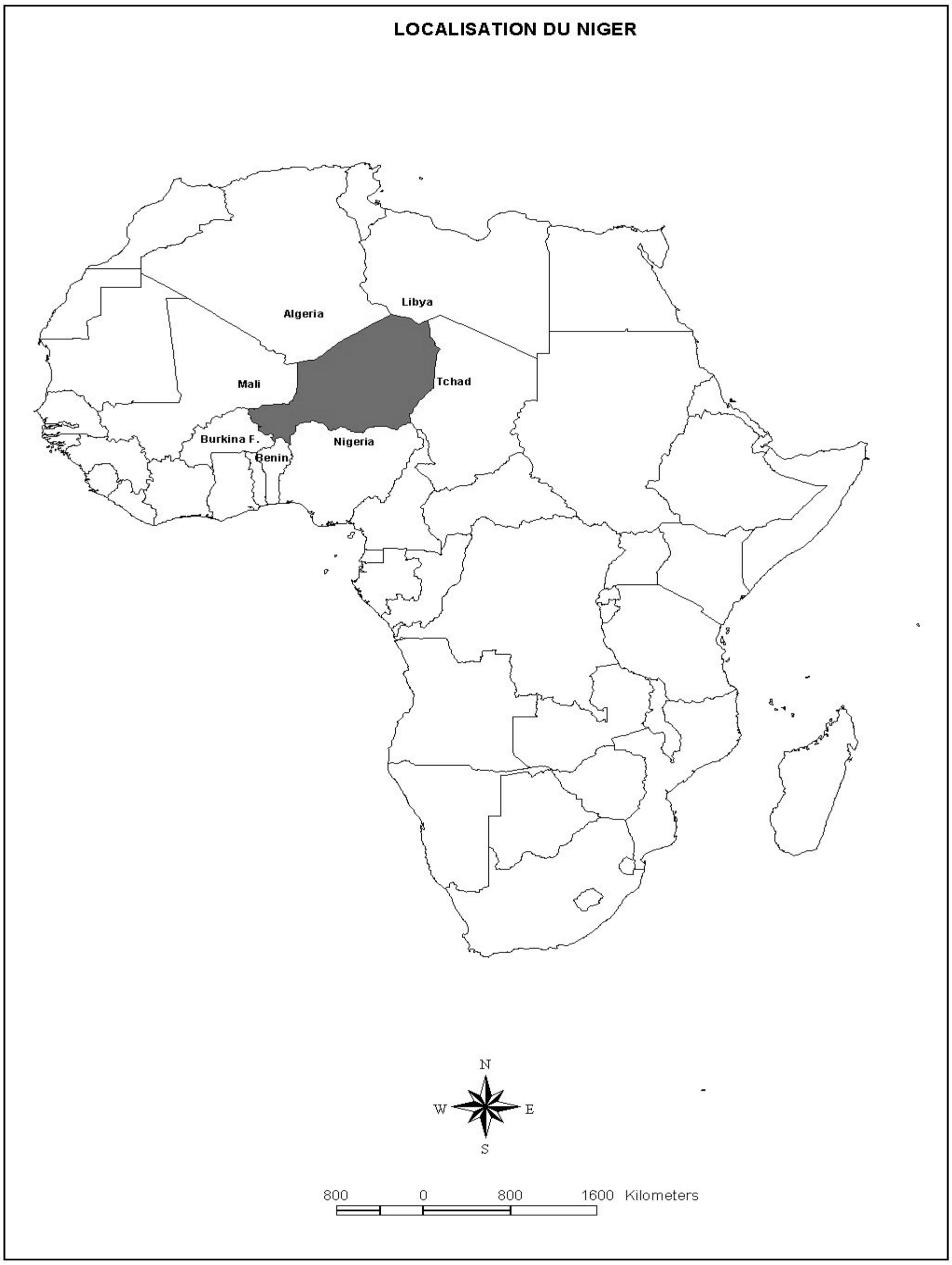
2. Présentation du Niger

La république du Niger est sous un régime démocratique depuis le 9 août 1999. Le pays est subdivisé en huit (8) régions, 36 départements, 256 communes, postes administratifs, cantons et villages, et Niamey est sa capitale.
Le Niger est située en Afrique Occidentale francophone, dans la partie centrale de l'Afrique soudano-sahélienne où elle occupe une superficie de 1 267 000 km². Il est limité au nord par la Libye, au nord -ouest par l'Algérie, à l'est par le Tchad, à l'ouest par le Mali, au sud-ouest par le Burkina Faso et le Bénin, et au sud par le Nigeria. Et est comprise entre les méridiens 0° et 16° de longitude Est et les Latitudes 12°-23°30' Nord.
Le pays se présente comme une vaste pénéplaine ancienne dont l'altitude moyenne est de 350 mètres.
Le climat est du type sahélien avec l'alternance de deux (2) saisons bien distinctes et au cours desquelles on observe une grande variabilité de température:
- Une saison sèche froide de novembre à février, pendant laquelle la température peut descendre au dessous de 10°C la nuit dans le nord du pays.
- Une saison sèche chaude de mars à mai, avec un maximum pouvant atteindre 48°C.
- Une saison pluvieuse pouvant s'étendre de juin à octobre avec une température moyenne qui tourne autour de 25° à 30°C (Kaïllou M. 2002).

Les chutes de pluie étant très limitées dans le temps et dans l'espace, le fonctionnement du réseau hydrographique du Niger est très discontinu. Le Niger est concerné par deux (2) grands bassins versants : celui du fleuve Niger, et celui du lac Tchad. Le fleuve Niger traverse le sud -ouest du pays sur une longueur de 550km. Son débit est permanent, avec une forte saison d'étiage (mars-juin) et des périodes de crue (juin-septembre). Les affluents de la rive droite drainent temporairement les eaux pluviales du Bénin et du Burkina Faso. Ils sont au nombre de sept (7) : Diamangou, Goroubi, Gorouol, Mékrou, Sirba, Tapoa, Dargol. Ceux de la rive gauche (Dallol Bosso, Dallol Maouri) draine les eaux de la région saharienne.

Le bassin du lac Tchad n'est guère concerné que par la rivière peu active, la Komadougou-Yobé.

Cependant, il existe d'autre point d'eau permanent tels que le lac Madarounfa, la mare de Tabalack, la mare de Guidimouni, la mare d'Albakayzé pour ne citer que ceux là.



3.1. Taxonomie

1. Règne …………………………………… Animal
2. sous-règne …………………………………. Des Métazoaires
3. Phylum ……………………………………..Chordata
4. Sous-phylum ………………………………Vertébrés
5. classe ………………………………………des reptiliens
6.sous- classe ……………………………….. des Archosauriens
7.Ordre ……………………………………… des Crocodiliens
8.Sous-ordre ………………………………… des Eusuchiens
9. Familles ……………………………………des Crocodilidae
10. - Sous- famille ……………………………des Aligatorinae
 - Sous-famille…………………………… des Crocodilinae
 - Sous- famille ……………………………des Gavialinae

Donc, comme on le voit, les crocodiliens appartiennent à la classe des reptiliens qui sont des espèces qui rampent et ont des écailles. Ils comprennent (HAMISSOU, 2004) :

- Les Rynchocephales
- Les Chéloniens (Tortues)
- Les Squamates (lézards et Serpents)

Ils appartiennent à la sous-classe des Archosauriens dont ils restent l'unique représentant avec les oiseaux, après la disparition des Dinosaures et des Archosaures.
La famille des crocodiliens est constituée de trois (3) principales sous- familles qui ne sont toujours pas facilement identifiables. Il s'agit des : Alligatorinae, Gavialinae, et Crocodilinae. Parmi ces trois sous-familles, celle qui nous intéresse le plus est la sous - famille des Crocodilinae qui est la seule à avoir certains représentants en Afrique.
Cette sous- famille se compose de 2 genres (Crocodilus, Ostelaemus*)* et de 13 espèces dont trois (3) sont représentées en Afrique. Il s'agit de :

- Crocodile du Nil (*Crocodilus niloticus*)
- Crocodile africain à museau étroit (*Crocodilus cataphractus)*
- Crocodile Nain (*Ostélaemus tetraspis*)

Parmi ces trois (3) espèces présentes en Afrique, seul le crocodile du Nil est représenté au Niger. Mais il est probable que le crocodile nain africain (*Ostélaemus tetraspis*) soit présent dans le fleuve Niger qui s'étend jusqu'au Nigeria, pendant que son aire de répartition couvre la forêt tropicale d'Afrique centrale et occidentale : Sénégal, Liberia, Nigeria. Tandis que le crocodile africain à museau étroit touche les forêts tropicales d'Angola, le sud Mauritanie, Congo, Zambie, et Tanzanie.

3.2. Quelques caractéristiques des crocodiles

La biologie a découvert certaines caractéristiques de leur mode de vie que les anciens n'auraient jamais pu soupçonner.

Les crocodiles mâles sont plus gros que les femelles, leur taille moyenne est de 4 m. Toutefois, elle peut atteindre 9 m de long.

Leurs nasaux, situés à l'extrémité du museau, permet à l'animal de respirer pendant que le reste de son corps est immergé (Hamissou, 2004). Un 2ème palais, est un surplus de peau à la base de la langue qui permet aux crocodiles de fermer hermétiquement leur trachée artère, et d'ouvrir la gueule sous l'eau lorsqu'ils saisissent leur proie. Les crocodiles sont poïkilothermes, mais faussement qualifiés d'animal à sang froid. Ils supportent des températures de 5° C à 38° C, à l'aise de 31° C à 33° C ou de 30° C à 35° C et sont capables de réguler leur température intérieure eux même grâce à leur bouche qu'ils maintiennent longtemps ouverte chez les grands sujets. En outre, les va et vient du crocodile dans l'eau lui permet de conserver sa température constante. Leur déplacement dans l'eau se fait grâce à leur queue améliorée par une crête verticale d'écailles.

L'alimentation des crocodiles se fait de la façon suivante : à son jeune âge, ils se nourrissent d'insectes et de larves (têtards), au moyen âge, d'alevins et de petits poissons, et à l'âge adulte, les crocodiles sont des carnivores nécrophages ou prédateurs. Ils ont besoin de manger au moins une fois par semaine, et n'ont pas de molaires car, ils avalent directement leurs proies et la digère très lentement, ce qui justifie leur faible gourmandise.

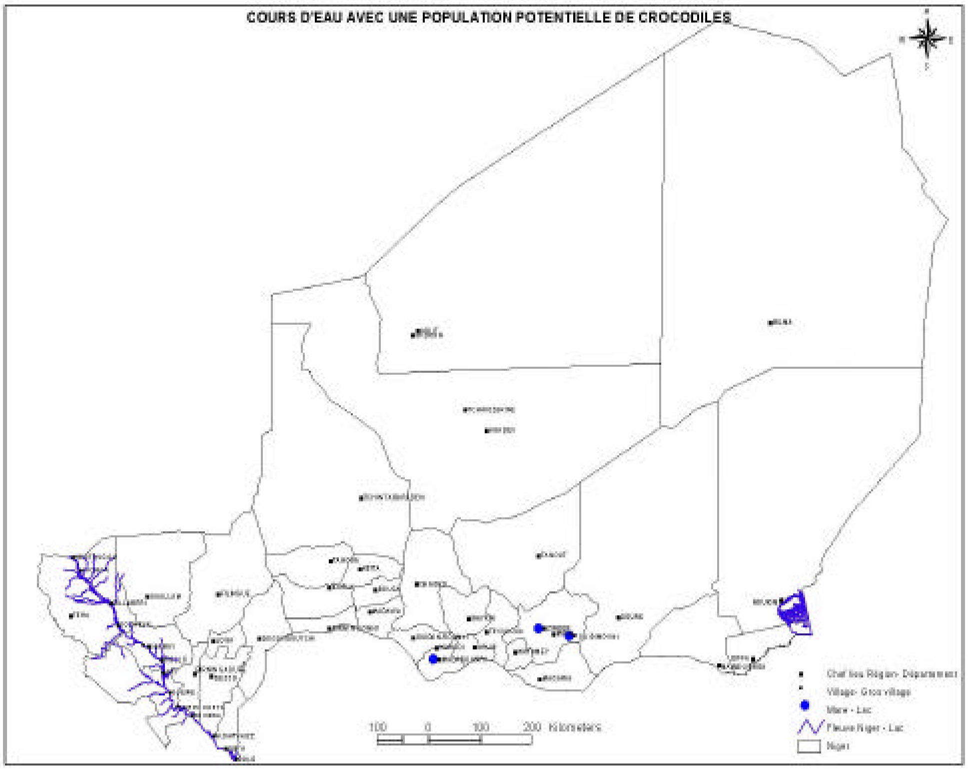
3.3. La reproduction

Les crocodiles sont ovipares, ils pondent en moyenne 7 œufs en 1ère année jusqu'à plus de 60œufs. En général, ils enterrent leurs œufs dans du sable par des cavités creusées à l'ombre, à proximité de l'eau. La femelle surveille les nids pendant 10 à 12 semaines jusqu'à l'éclosion, au cours de laquelle, les petits poussent des coassements qui attirent la mère. Celle-ci dégage alors la terre qui les couvre, pour les porter ou escorter à l'eau.

3.4. Localisation du crocodile du Nil au Niger

Comme indiqué précédemment, l'importance du réseau hydrogaphique du Niger lui permet d'héberger une population importante de crocodiles (cf. carte de répartition de l'espèce).
Ainsi, les plus grands effectifs sont signalés par endroit dans le fleuve Niger et certains de ses affluents notamment la rivière Tapoa et la rivière Mékrou (Document de séminaire DFPP, 1989).
On trouve également, les crocodiles du Nil dans la région de Zinder, notamment dans la commune du même nom (mare de Mella Douwaram) (DDE Zinder, 1998), dans la mare de Goudoumaria.

Dans la région de Maradi, le lac Madarounfa constitue un des derniers refuges du *Crocodilus niloticus*. La région de Tahoua, malgré ses importantes potentialités hydriques est très mal nantie en crocodiles. Quant à la région de Diffa, la présence du lac Tchad lui permet d'héberger quelques spécimens, mais depuis le retrait de celui-ci de la partie nigérienne, cette présence de crocodiles reste improbable (Séminaire DFPP, 1989)



3.5. Statut des Crocodiliens au Niger

Selon la loi 98-07 du 29 avril 1998 fixant le régime de la chasse et de la protection de la faune au Niger, au titre III, Chapitre premier, et à son article 21, elle classait le crocodile du Nil *Crocodilus niloticus)* sur la liste des espèces animales intégralement protégées (Code Rural du Niger, 2004). Mais malgré cette protection, les crocodiles continuent de faire l'objet d'une exploitation locale et même d'un commerce international.

3.6. Etat des lieux des crocodiles au Niger

Les crocodiles étaient très fréquents dans la vallée du fleuve Niger lorsque les conditions de nourriture et d'abri étaient favorables. Aujourd'hui son aire de répartition a été morcelée à tel point que son existence est hypothétique sur des sites où les enfants ramassaient les œufs et les braconniers traquaient les adultes pour leur viande et leurs peaux.
Dans la partie nigérienne du Lac Tchad, l'espèce a totalement disparu suite au retrait total des eaux. En ce temps, on estimait la population des crocodiles à moins de 500 individus (Séminaire sur la faune nigérienne, 1989).

A la date d'aujourd'hui, il n'existe aucune statistique établie au niveau nationale à travers un dénombrement qui donne la situation globale des crocodiles au Niger. Toutefois, des recensements ponctuels avaient donné une indication sur ce qui reste de la population des crocodiles dans certaines mares du Niger. C'est le cas de la mare de Mella Douwaram de Zinder. Située en plein cœur de la commune de Zinder, cette mare est au centre de beaucoup de polémiques quant à son existence, compte tenu des crocodiles qu'elle héberge et des conflits qu'ils créent avec la population locale.

Rappelons que la commune de Zinder renferme une importante population de crocodiles dans des mares et des caniveaux. Ceux-ci ont été introduits par Monsieur AUBERTIN, Agent Voyer de la mairie de la dite commune dans les années 1970, dans le but dissuasif d'enrayer les nombreuses noyades de jeunes enfants enregistrées dans cette mare. La population des crocodiles qui était au départ de deux (2) couples, a été évaluée en 1997 à 80 individus (DDE ZINDER, 1998). Les mares qui abritent ces crocodiles ont un régime semi-permanent (juillet avril), obligeant ainsi ces animaux à se réfugier dans les caniveaux où quelques flaques d'eau stagnant pour le restant de l'année, et ce, jusqu'aux premières pluies pour regagner leur biotope.

Au niveau de la mare de Goudoumaria, selon ALOU M. Directeur adjoint de la Faune, de la Pêche et de la Pisciculture, après un ensemencement de deux (2) couples en 1995, aujourd'hui la population atteint environ 80 individus tout sexe confondu Alou.

Même au niveau du Parc régional du W du Niger qui semble être le creuset de recherches sur la faune, aucun recensement n'est effectué dans sa partie fluviale longue de 65km. Il en est également de même pour les deux (2) affluents du fleuve Niger qui le délimite à savoir la rivière Tapoa sur 70km et la rivière Mékrou sur 130km.
Donc, en l'absence d'une situation très claire sur l'effectif des crocodiles au Niger, toute intervention dans ce domaine passera par le recensement de la population de cette espèce.

Au niveau du fleuve Niger, on retrouve encore les crocodiles sur quelques tronçons notamment dans les localités d'Ayorou, Tillabéry, Gothèye, Boubon, Karma, Say…Mais faute de dénombrement, on ne saurait donner de chiffres.

4. Les différentes formes d'utilisations du Crocodile au Niger

En dépit de son statut d'espèce intégralement protégée, les crocodiles continuent de faire l'objet d'une exploitation pour le moins frauduleuse. Au Niger, cette mesure a quand même ralenti les ardeurs des utilisateurs du crocodile. La plupart des sous produits (cuirs et peaux) du crocodile utilisés sont importés des pays extérieurs. C'est pourquoi, on constate une certaine reconstitution de la population des crocodiles au niveau du fleuve Niger, malgré la dégradation des conditions de son milieu naturel.
Pour savoir les différentes formes d'utilisations qui en sont faites des crocodiles, nous avons mené une enquête sur un échantillon de vingt (20) personnes constituées de professionnels et utilisateurs des crocodiles : Maroquiniers, Tanneurs, Pêcheurs, Chasseurs et Tradipraticiens.
Il ressort de cette enquête les données suivantes :
Plusieurs types d'utilisations des crocodiles sont faites au Niger. Il s'agit des :

- Elevage des crocodiles,
- Usages artisanaux,
- Usages pharmacopiques,
- Usages magico-religieux ou mythiques.

4.1. Elevage des crocodiles

L'élevage des crocodiles est au pratiqué à Niamey, et surtout dans la région de Gaya par des personnes privées. En effet, cette activité bien que réalisée de façon anarchique, prend des dimensions de plus en plus importante dans la vallée du Dendi (Ibrahim, 2005). Deux (2) personnes ont été identifiées à Niamey comme étant des éleveurs de crocodiles tandis qu'à Gaya, l'élevage est essentiellement pratriqué par les pêcheurs professionnels, certains fonctionnaires de la région et les jeunes. Si pour les premiers cet élevage est, pour les seconds, il.

Les éleveurs de Niamey élèvent le crocodile du Nil à titre prestigieux dans de petits bassins pendant un temps relativement court afin de les offrir en guise de cadeaux à de hautes personnalités qui le demandent. Par contre, les producteurs de la région de Gaya élèvent les crocodiles à des fins socio-culturelles et économiques.

Selon Ibrahim (2005), dans la vallée du Dendi qui est aux confins du Niger, du Nigeria et du Bénin, deux (2) espèces, le crocodile du Nil (*Crocodilus niloticus*) et le crocodile nain africain (*Ostélaemus tetraspis*) sont présentes. Toutefois l'élevage ne concerne que le crocodile du Nil à travers le ‘’ Game farming ‘’.

4.2. Usage artisanal

Le Niger est un pays à forte potentialité artisanale. Ces huit (8) régions abritent chacune un ou plusieurs centres artisanaux où différentes variétés de cuirs et peaux sont utilisées dans la maroquinerie et pour la fabrication de divers objets d'arts. Parmi ces cuirs et peaux figure en bonne place la peau du crocodile. Considérée comme ce que représente l'or chez les métaux, la peau du crocodile est la plus appréciée de toutes les peaux de reptiliens (Varan, Boa, Cobra…) en maroquinerie. Ce prestige, elle l'a doit à sa résistance, sa beauté, sa qualité et surtout sa réputation dans le monde occidental.

Dix (10) maroquiniers ont en effet, été enquêtés. Ils affirment tous que la peau des crocodiles qu'ils utilisent, provient en général de l'extérieur du Niger principalement du Nigeria, Tchad, Cameroun, Ghana, et Burkina Faso.

Toutefois quelques cas isolés d'individus provenant des eaux du Niger notamment le fleuve Niger, sont très rarement rencontrés comme en témoignent les tanneurs que nous avions interviewés. Ceux-ci affirment qu'en trente (30) ans d'activités ils n'ont tanné pas plus de 3 pièces de crocodiles.

La principale utilisation du crocodile est surtout basée sur celle de sa peau qui rentre en maroquinerie dans la fabrication d'objets tels que : les sacs et cartables, les chaussures, les ceintures, porte-feuilles…

Cette peau se vendait avant par centimètre (cm) de 600 FCFA à 750 FCFA. Mais aujourd'hui, cette valeur a chuté car la peau se vend par pièce en fonction de leur taille. Elle varie de 20. 000 FCFA à 50. 000 FCFA. Cette dépréciation de la valeur de la peau du crocodile est due aux mesures de protection prises au plan local mais surtout au plan international pour décourager les principaux utilisateurs.

Photo N° 1Un maroquinier entrain de travailler la peau du crocodile du Nil

4.3. Les usages pharmacopiques

L'une des principales utilités du crocodile du Nil au Niger est bien évidemment ses usages pharmacopiques. Selon les personnes enquêtées, toutes les parties du crocodile de la tête à la queue en passant par la peau et même les autres organes, sont utiles en pharmacopée traditionnelle. Mais compte tenu du caractère secret de celle-ci, les détenteurs du remède ne disent jamais les recettes définitives. Le tableau suivant nous résume quelques uns de ces différents usages :

Tableau 1 : Différents usages médicinaux du Crocodile

Parties du crocodile utilisées	Applications	Remèdes
La peau	Couverture des produits et amulettes	Amulette pour l'invulnérabilité contre le fer
Les écailles	- Mises sur des braises en aspirant la fumée - pendues à un fil et accroché au cou en touchant les seins - fumée des écailles	- Lutte contre les cauchemars et chasse les mauvais esprits - Guérit les maux de seins chez les femmes - lutte contre les panaris
Cœur	Mélangé à d'autres produits	Invulnérabilité contre le fer (couteaux, canifs, sabres…)
Poumons	Associé à d'autres produits	Soigne les toux
Les crottes	- mélangé à d'autre produits - mélangé au beurre de karité	- soigne l'asthme - facilite la dentition chez les enfants
Les Os	-	Non défini
La bile	-	Non défini
Les dents	-	Non défini
Les œufs	Associé à d'autres produits	Invulnérabilité contre le fer
Urines		médicaments

Source : résultat d'enquête

4.4. Usages magico-religieux ou mythiques

Pour avoir des informations sur les aspects magico- religieux ou mythiques, nous avons enquêté des Pêcheurs (SORKO) et des Chasseurs qui semblent être les dépositaires de la tradition orale. Les Sorkos sont considérés comme les maîtres des eaux. A ce titre, ils détiennent des pouvoirs magiques pour dompter les crocodiles, les génies de l'eau et toutes les autres forces surnaturelles. Il ressort de nos entretiens que les crocodiles sont des espèces animales très mystérieuses. Pour cela cinq (5) variétés se distinguent les unes des autres selon leur mystère :

- Kareyki ou crocodile blanc
- Ara Goungou (Crocodile nain)
- Bakin Kada (Crocodile noir)
- Maï Soundiya (Crocodile à long museau)
- Talibiya .

De toutes ces variétés de crocodiles c'est la première c'est-à-dire ''Kareyki'' qui la plus mystérieuse mais surtout la plus dangereuse. Tout Sorko initié sait les identifier. Les éventuels pêcheurs de cette variété même par mégarde exposent leurs familles à des malédictions.

Par ailleurs les crocodiles sont considérés par certains Sorkos comme des divinités des eaux. C'est pourquoi ils les vénèrent, les adulent et les protègent contre les braconniers.

Chez d'autres pêcheurs le crocodile est considéré comme marabout. A ce titre il est vénéré comme un guide spirituel.

5. Les perspectives d'avenir

Le réseau hydrographique du Niger regorge d'importantes ressources fauniques qui nécessitent d'être connues afin d'être mieux préservées et valorisées. Pour ce faire, un inventaire de ces ressources, notamment les reptiliens tels que le crocodile dans les eaux où ils sont présents, pourrait nous permettre de savoir précisément les différentes variétés, ou espèces qu'on a Niger. Ce inventaire consistera à une étude détaillée qui fera le point des différentes espèces et leur répartition sur le plan National, ainsi que la situation de leur habitat.
La seconde étape de ce processus serait donc, la conception d'une stratégie et d'un plan d'action du Niger pour la conservation et la gestion durable des crocodiles. Ce plan d'action comportera des axes d'intervention de tous les acteurs au profit de l'espèce en question.
En outre, des programmes de valorisation du crocodile sur le plan touristique, écologique et socio-culturel permettraient aux populations de prendre conscience de la valeur de cette espèce mythique.
Pour accompagner toutes ses actions en faveur de la sauvegarde du crocodile, l'élaboration d'un programme d'information, de formation et de sensibilisation des populations, des professionnels et utilisateurs des crocodiles, ainsi que les agents forestiers chargés de protéger la nature, sur l'importance et la place qu'occupe les crocodiliens dans la chaîne alimentaire.
Enfin, compte tenu du fait qu'il y a une tradition d'élevage de crocodile dans certaines régions du Niger, il serait important d'appuyer ces initiatives locales qui pourraient contribuer sans nul doute à la pérennisation de l'espèce.

6. Conclusion

Le Niger à l'instar de certains états Africain connaissent des difficultés économiques qui lui empêchent de disposer des moyens conséquents pour pouvoir prendre en charge la conservation et la gestion de ses ressources naturelles. C'est pourquoi il se tourne vers des partenaires qui puissent l'accompagner dans ce sens. Au regard de l'importance de place qu'occupent les crocodiles dans la chaîne trophique, et en dépit des menaces qui pèsent sur cette espèce vis-à-vis de l'utilisation dont elle est l'objet, des mesures spéciales de protection doivent être prises pour sa sauvegarde

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Crocodilians As Key Animal Species For Wetland Conservation And Sustainable Development

Challenges And Opportunities For A Community-Based Crocodile Conservation Programme At Lake Sibaya, South Africa.

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Absract: As a result of their dependence on the lake for fishing and fresh water, the amaThonga communities have lived around Lake Sibaya, South Africa's largest natural lake (72,18 km²) for many generations.

During the past three decades a substantial and sustained increase in the amaThonga population has led to increased resource utilisation, disturbance and conflict with crocodiles, causing a decrease in the crocodile population. The crocodiles are estimated to number between 90 and 134 non-hatchlings, and nesting has decreased more than 90 percent over the period. Strict protection strategies are not feasible due to local social and logistical constraints. A programme where the community share in the benefits of a viable crocodile population might be key for co-existence and crocodile survival.

Crocodile population surveys in 2003-2004 indicate that the population is not sufficiently productive to support economically viable ranching. Restocking should be considered, which will require both biological research and political will. Cattle will have to be excluded from current and potential crocodile breeding sites, as their disturbance is depressing recruitment. Safe structures for people should be positioned in frequently used fishing areas. The amaThonga community surrounding the lake consist of three separate tribal councils and their collaboration is needed for success in such a programme. We explore the biological, social and financial information and structures needed to initiate such a program.

A community-based crocodile conservation programme is expected to remain at a small scale and would never be a full solution for unemployment and poverty surrounding Lake Sibaya.

However, a viable crocodile population could be the much-needed catalyst in a community-private sector partnership for the development of ecotourism and the partial alleviation of socio-economic concerns in the area.

1. Introduction

The Greater St Lucia Wetland Park World Heritage Site is situated at the southern end of the Moçambique coastal plain in South Africa, which extends to Kenya in the north. The Park, which covers an area of 2,796 km², includes the last remaining subtropical area containing its original diversity of plants and animals on the south-eastern coast of Africa, and one of the last remaining in the world (Porter and Blackmore 1998). The mandate of Ezemvelo KwaZulu-Natal Wildlife (EKZNW), the provincial conservation organisation, and the Greater St Lucia Wetland Park Authority (GSLWPA) is to manage, protect and restore healthy and viable ecosystems, in line with the Park's Biodiversity Conservation Operational Plan and UNESCO's World Heritage values. Complex socio-ecological challenges include land claims by impoverished neighbouring communities as a result of historical removals, and the conservation management of large, unfenced areas where neighbouring communities utilise valuable resources on a daily basis inside the Park.

The Nile crocodile is the largest predator of the Park's estuarine and freshwater habitats and plays an important ecological role. The Park includes the largest crocodile population in a single water body in South Africa (Lake St Lucia) and hosts one of the three remaining viable populations in the county. Due to the proclamation of a number of protected areas around Lake St Lucia, including one of the oldest in Africa, neighbouring communities have been excluded from large parts of the lake system, resulting in a crocodile population that appears to be stable (Blake 1990; Leslie 1997, Taylor, Conway, Dickson, Ferguson, Gerber & Combrink 2006). In most of the other lakes, rivers, wetlands and swamps of the Park, e.g. Kosi Bay, Lake Sibaya, Muzi Pan, Lake Zilonde etc., crocodile numbers have decreased as a result of conflict with neighbouring communities to levels that are not ecologically viable, and they might be extirpated in the near future. Crocodile breeding throughout the Park, excluding the protected (i.e. fenced) areas of Lake St Lucia has decreased to a few nests each year. This situation is not dissimilar to other part of Africa, where local communities and crocodiles interact and Hutton and Loveridge (1999) conclude that under such conditions it is inevitable that crocodiles will slowly and unavoidably disappear in the face of human expansion.

This paper explores challenges and opportunities in areas where neighbouring communities of the Park, share water resources with crocodiles. Although we will limit our discussion to Lake Sibaya, many of the issues are relevant to other similar areas in the Park.

2. Study area

Lake Sibaya, the largest natural freshwater lake in South Africa (Kyle and Ward 1995), is situated within the Greater St Lucia Wetland Park, approximately half way between Lake St Lucia in the south and Kosi Bay in the north.

The eastern shore of the lake is less than a kilometre from the Indian Ocean, but is separated from the sea by a series of high forested sand dunes. The lake surface is approximately 20 m above mean sea level and the bottom of the lake extends to nearly 20 m below sea level with a mean depth of 10.9 m (Kyle and Ward 1995). With no connection to the sea, the lake level fluctuates in response to the dynamic balance between inflow and outflow (Hill 1979). The main source of inflow consists of surface and subsurface drainage together with direct rainfall, and outflow is regulated by means of seepage to the sea and evaporation (Mountain 1990). The surface area of the lake is rainfall dependent and is 72,18 km² (Porter, Sandwith & Bainbridge 1999) with a shoreline length of 135 km (Combrink, Korrûbel and Ross 2005). The entire lake is unfenced and a public road (only 4x4 vehicles) extends down the eastern shoreline of the Coastal Forest Reserve. An EKZNW checkpoint monitors vehicles through the Coastal Forest Reserve.

Because of its biological diversity and ecological importance, Lake Sibaya was designated a Ramsar Wetland of International Importance in 1991, a nature reserve in terms of the KwaZulu Nature Conservation Act in 1994 (Kyle and Ward 1995) and World Heritage Site as part of the Greater St Lucia Wetland Park in 1999. However, the legal proclamation is only relevant to the physical water body, except the eastern shoreline of the lake, which is officially proclaimed as part of the Coastal Forest Reserve that extends up the coastline to Kosi Bay. Until 1994, the terrestrial component surrounding the lake was under the control of three tribal authorities, i.e. KwaMbila, Mabaso and KwaTembe. However, since 1994 the governance resides with the authority of the KwaZulu-Natal Ingonyama Trust, under the sovereignty of King Goodwill Zwelitini, King of the Zulu Nation. Although the Ingonyama Trust areas are not proclaimed protected areas, all wild animals and most indigenous plants are protected under provincial nature conservation laws, and the use thereof is prohibited or highly regulated with permits. Local communities are allowed to fish with traditional methods on a non-commercial basis in Lake Sibaya and two legal gill-net permits, each for 100 metres of netting have been issued, and catches are monitored.

The Mabaso Community Game Reserve is situated on the southern shoreline of the western arm of the lake. It is leased from the Mabaso tribal council by a private business venture and they have the right to develop certain tourist facilities in the reserve. The area is almost entirely fenced and is currently being restocked with game species that use to occur in the area.

3. State of crocodile population

During 1958 Ken Tinley, an ecologist with Natal Parks Board (now EKZNW), conducted a field survey at Lake Sibaya and reported that "large numbers of crocodiles inhabit the lake, and the surrounding lesser lakes and pans. Some specimens are of an extremely large size, probably up to 20 feet in length" (Tinley 1976:21). Between 1960 and 1970 it seemed like the population decreased at such a rate that by the mid 1970's conservationists began to voice their concern (Pooley 1969; Bruton 1979; Blake 1990; Mountain 1990; Thorbjarnarson 1992). During April 2003, 36 crocodiles were counted during an aerial survey, suggesting a decline of 66% compare to the 1990 population index.

During the same time, 63 non-hatchling crocodiles were counted during spotlight surveys. Nesting has decreased from at least 30 nests in 1970 (Bruton 1979) to three in 2003 and not a single nest was found in 2004. The population is estimated at 112 crocodiles with a variance of 22.49 and standard error of 4.47 (Combrink et al. 2005).

It seems that the population decrease since the late 1950's is a result of a complex and dynamic combination of pressures, some natural e.g. nest predation and flooding, but more importantly due to the increase in the neighbouring communities living close to the lake. Their dependence on natural resources has led to increased disturbance, habitat transformation and conflict with crocodiles.

4. The Amathonga communities

As a result of their affinity for fishing and their dependence on fresh water, the amaThonga people have settled predominantly near the sea, rivers and lakes in Maputaland (northeastern KwaZulu-Natal province) and have lived around Lake Sibaya for many generations, even though the area is known for being low lying, unhealthy, inclement and not well-suited for agriculture or cattle farming (Bruton 1979).

The amaThonga communities surrounding Lake Sibaya are politically grouped into three tribal councils, i.e. KwaMbila, Mabaso and KwaTembe. An iNkosi (Chief) is the traditional leader of each tribal council who falls directly under the traditional authority of the King. A number of Induna's (Headmen) report to each iNkosi, who in turn is head over a number of councillors. Each councillor represents a ward, which consist of a few homesteads (families), each represented by the head of the homestead.

The livelihood of the amaThonga consists mainly of fishing, hunting, snaring, the utilisation of indigenous fruits and vegetables and shifting agriculture. They have planted a variety of crops around the lake and extensive cultivation has occurred in most of the catchments and drainage lines entering the lake system (Kyle and Ward 1995) with the result that many important wetland areas have been transformed into cultivated fields (pers. obs.). This pressure is exacerbated by the general trend of increased population growth in Maputaland, which has more than doubled in the past two decades and is supplemented by large numbers of refugees from countries like Tanzania and Moçambique (Kyle 2004).

At Lake Sibaya, the amaThonga fish throughout the year, using hand lines, rod and line as well as 'umono' valve baskets (Bruton 1979). Sometimes fishermen will walk waist-deep into the water and fish for long periods during the day (pers. obs.). Fishermen seem to be aware of the presence of crocodiles near and even in preferred fishing areas. Although crocodile attacks on dogs, goats and calves (pers. obs.) have been recorded, there is no evidence of attacks on people in recent times.

As a consequence of their way of life, the amaThonga people perceive crocodiles as a threat to their livelihood and livestock. Without any incentive to protect crocodiles or perceived benefits from their presence in the lake, it is not surprising that numerous records of crocodile killings and the destruction of eggs exist (Bruton 1979, Ward 1985; 1986, Ward 1990, Kyle and Ward 1995, pers. obs.) and without intervention, this is unlikely to change in the future. The extensive shoreline (135 km) and shortage of conservation management staff render strict protection strategies and law enforcement unpractical and not a solution for preventing crocodile killings and nest destruction. Child & Chitsike (1987) furthermore reminds us that species can be eliminated through means such as habitat transformation, without even breaking the law.

It is becoming more clear that new, alternative conservation strategies will be required for the successful conservation of the remaining crocodile population. Fundamental to this strategy is the co-management of crocodiles by the neighbouring amaThonga communities who will become the custodians and primary beneficiaries of the crocodile resource through a programme of non-consumptive and consumptive sustainable use.

5. Conservation through incentives

It has been recognised that unless crocodiles are shown to have a commercial value, they face extinction outside the main protected areas (Blake 1990; Jacobsen & Blake 1991). "Sustainable use" as defined by Ross and Godshalk (1994:1) is the "use of a wildlife population for human benefit in a manner that can be continued indefinitely". This can either be consumptive in nature (e.g. hunting or capturing of the animal) or non-consumptive (e.g. photography or eco-tourism). Sustainable use (SU) or "market driven conservation" is often controversial and there is general acceptance that it never will be a universal answer against the loss of biodiversity (Hutton, Ross and Webb 2001). However, with proper management, it can provide the needed economic incentive for communities to maintain crocodiles and their habitat in a natural state thereby increase incentives to conserve them (Ross and Godshalk 1994; Hutton & Loveridge 1999). Benefits will vary according to the specific programme, and will ultimately depend on the socio-economic context and the institutional arrangements in place (Hutton et al. 2001).

6. A crocodile sustainable use programmme

Although crocodile SU programmes have been in existence in Africa for about 30 years, Hutton & Loveridge (1999) mention that it is often difficult to find programmes where direct economic benefits are strongly linked to the communities that experience the negative consequences of their daily existence with crocodiles. This would be the central objective of the SU programme at Lake Sibaya, to create and maintain a strong connection between the local communities utilising the lake and the financial and other benefits incurred from the crocodile resource.

The programme could consist of a combination of consumptive and non-consumptive use of crocodiles. Non-consumptive use mostly includes eco-tourism e.g. guided walks or canoe trips to view basking crocodiles in combination with other rare and interesting birds and mammals.

Private businesses should become more involved in the creation of partnerships with local community eco-tourism guides and linkages to other community initiatives, e.g. traditional bed and breakfast ventures around the lake, should be strengthened.

The consumptive-use component would consist of ranching, i.e. the removal of a certain percentage of crocodile eggs from wild nests around the lake during the breeding season. Ranching could be developed in cooperation with the well developed crocodile farming industry in KwaZulu Natal, as well as in partnership and under the authority of EKZNW. Although ranching has never been part of the conservation management of crocodile populations in KwaZulu-Natal, the principle is supported by the policy of the conservation of the Nile crocodile in KwaZulu-Natal. The policy, approved on 27 March 1992 states that: "The KwaZulu-Natal Nature Conservation Board recognises that KwaZulu-Natal still has large populations which are protected and can be sustainably harvested" and therefore undertakes "to encourage research to expand the existing knowledge on the conservation, and suitable use of wild populations, and sustainable management of commercial operations for the long term survival of the crocodile."

A strategy for the SU of crocodiles at Lake Sibaya will need to take into account biological, social and financial considerations. It will also need to receive extensive inputs during the preparation and implementation phases and be flexible enough to adjust to changing circumstances (Hutton et al. 2001).

7. Biological considerations

The biology of crocodilians is one of the key factors why SU programmes can play an important role in their conservation (Ross and Godshalk 1994). Crocodiles are large ectothermic animals with complex social behaviour (e.g. cannibalism and maternal care), they are multiparous, sexually dimorphic, effectively convert food to energy and behaviourally thermoregulate, enabling them to survive for extensive periods without food. They appear to be particularly resistant to the removal of either very young animals (eggs or hatchlings) or very large mature males (Ross 1999). A number of countries, especially the United States (Florida and Louisiana), Australia, Zimbabwe and Venezuela have based their SU programmes on long term field research (Ross and Godshalk 1994).

As a result of the population decline during the last four decades at Lake Sibaya, only 16 adults (>2.5 m) were counted during the last aerial survey in 2003. No information is available on sex ratios. Although depressed crocodile populations are known to be robust and would recover within a few decades subsequent to the cessation of persecution and disturbance, this is unlikely to be the case at Lake Sibaya in the absence of benefits to the neighbouring communities. In order to fast-track a SU programme, we recommend basic biological research into the population dynamics in order to restock the lake with a breeding component that would be both ecologically and economically viable. The highest number of nests ever recorded at Lake Sibaya was 30, during the first survey in 1970 (Bruton 1979), although no information is available on survey effort or coverage during that survey.

The research findings on the population dynamics will enable management to restore the population structure within an acceptable timeframe to allow more benefits, i.e. eggs, to be harvested for the communities. Wild breeding stock could be sourced from nearby Ndumu Game Reserve, also a freshwater system with a viable population of 700 - 900 adults (Matthews 2006 pers. comm.). Adults released in the lake should be fitted with GPS transmitters to allow the monitoring of movements for the first two years.

One of the most important aspects of the biological component of any SU programme is monitoring the number of crocodiles and identifying all nests subsequent to egg laying. We suggest a combination of aerial surveys with a microlight aircraft and spotlight counts from a boat. During the research phase, all sexually mature females (>2.4 m) would have been fitted with a GPS transmitter in order to assist with the identification of their respective nesting sites. Eggs will be removed as soon as possible after laying and will be transported to St Lucia where they will be hatched in the existing incubator at the St Lucia Crocodile Centre. Hatchlings will be reared until they have reached the required size (e.g. 1.5 m total length) for sale to an abattoir. A certain percentage of hatchlings, yearlings and 1.5 m crocodiles will be released every year back into Lake Sibaya.

The harvesting of eggs (ranching) is preferred over setting up a close circuit captive breeding component, as ranching requires that natural populations and habitats be conserved as the origins of the resource (Ross & Godshalk 1994).

One of the main constraints of crocodile recruitment in the lake is cattle disturbance at nesting sites and during 2003, 63 potential nesting sites, including historical and current, were identified (Combrink et al. 2005). We recommend the protection of these sites from disturbance by excluding cattle and constructing alternative "crocodile-safe" drinking sites. Young cattle-guards from the local communities could play an important role as partners in this component of the programme, ensuring their cattle avoid these sites, so that no physical barrier needs to be constructed.

Key to the success of the biological management of such a programme is the ability to adapt to unforeseen or unexpected circumstances. Quite often, SU programmes will have to be developed despite significant uncertainty as to the exact condition of natural systems and their reaction to human induced changes. In such instances, the most effective way to continue may be through careful trial and error, i.e. adaptive management (Ross and Godshalk 1994) where the effects are monitored so that appropriate action can be taken as soon as required (Hutton et al. 2001).

8. Social considerations

The importance of social factors for the success of a SU programme must be emphasised, and it has been considered as important, if not more important, than the biological factors (Ross and Godshalk 1994; Hutton & Loveridge 1999).

A SU programme, and especially restocking the lake, will have considerable consequences for all users of the lake.

It can only follow extensive negotiations between all the relevant affected and interested parties, including the GSLWPA, EKZNW, private business, the MCGR and the KwaMbila, Mabaso and KwaTembe tribal councils, representing the three local communities. Cooperation between the three tribal councils is crucial to the success of the programme.

Even though the amaThonga communities have lived around the lake for generations, it seems like considerable ignorance regarding the potential danger of crocodiles still persist, e.g. fishermen that believe they are safe from crocodile attacks in certain areas of the lake, or subsequent to specific rituals (Dlamini pers. comm. 2003). We recommend an educational programme, in partnership with EKZNW community conservation section, to create awareness and inform local communities on the social, ecological and economical advantages, as well as the dangers of having a viable crocodile population in the lake. This should be aimed at all users including fishermen, tour guides, schools, adult community members living around the lake as well as tourists.

In order to minimise potential conflict between crocodiles and fishermen, safe structures (e.g. small jetties) will have to be constructed in favourite fishing areas. Where bore holes are not viable and water access points are dangerous, physical exclusion structures will have to be built to allow users to safely obtain water from the lake.

An important social consideration would be the creation of business associations and partnerships between the local communities, the MCGR, private lodges, e.g. Tongaland Beach Lodge, Lake Sibaya Lodge and local businesses based at Sodwana Bay, Mbaswana and Mseleni. The recently proclaimed MCGR borders the lake, is entirely fenced and consists of many potential nesting sites, which could become an immediate sanctuary for crocodile breeding. The MCGR is leased from the community by a private business venture that would benefit in partnership with the community from a SU programme with a unique marketing potential to attract tourists. During 2005, Tonga Beach Lodge, an upmarket lodge was completed within a few kilometres of the lake. Potential exist for diversifying existing tourists activities (e.g. diving and ski boat fishing in the ocean) to incorporate a range of eco-tourism activities at Lake Sibaya.

Finally, a crocodile sustainable use programme should be part of a much larger land use development plan for the lake and surrounding area, which is an urgent requirement as the number of haphazard, illegal and unsustainable activities are increasing in the area.

9. Financial considerations

Hutton et al. (2001) mentions effective partnerships between regulators and all other stakeholders as key to the success of crocodile SU programmes. This is especially true in the South African context where neighbouring communities have historically been denied access to the legal utilisation of natural resources, such as crocodiles, and are still suffering from a lack of formal education or qualifications in areas such as business development and finance.

Given the technical nature of crocodile rearing and the experience and expertise required to produce crocodiles ready for the domestic and international skin and meat market, very strong partnerships are required between crocodile farming organisations, e.g. the Southern African Crocodile Traders and the local communities. These organisations would play a crucial role in capacity building, e.g. training and employment for community members in a SU programme, could provide joint funding with the provisional government and purchase the reared crocodiles from the community.

One of the major drawbacks to the profitability of the programme is the provision of food to the young crocodiles. We propose a partnership between the community and the MCGR where community owned game (e.g. blue wildebeest) would be used as meat. Alternative partnerships and sources of meat could come from the annual buffalo-culling programme in nearby EKZNW Hluhluwe-Imfolozi Game Reserve.

Initially, the most cost effective location for the rearing of the crocodiles would be the EKZNW St Lucia Crocodile Centre, approximately two hours drive from Lake Sibaya. The Centre is equipped with an incubation room and some of the current facilities might be modified to rearing pens within reasonable budgets and approved standards required by the crocodile farming industry. Eventually, as the programme expands, it would be more suitable for the rearing pens and incubation facility to be based at Lake Sibaya. This would facilitate more community involvement and could become a Community Crocodile Centre and a tourism focal point at Lake Sibaya. Community eco-tourism businesses could use this centre as a base for their activities.

Although financial profits are not the only objective, the SU programme will have to be underpinned by an approved business plan, which will be developed in partnership with organisations such as EKZNW, GSLWPA and crocodile farming organisations, e.g. the Southern African Crocodile Traders.

10. Conclusion

There is a growing concern that the wild crocodiles of the Greater St Lucia Wetland Park, especially those in areas bordering neighbouring communities, will disappear from their wetlands and lakes if ways are not found to recognise and utilise their value for the benefit of the communities. This is only possible if such areas are restored to accommodate their once viable and healthy crocodile populations.

Although there are some examples of non-consumptive use of crocodiles (eco-tourism) at Lake Sibaya, we suggest the development of a consumptive sustainable-use component where crocodile eggs will be removed from wild nests around the lake (ranching) and reared at the St Lucia Crocodile Centre until ready for sale to the domestic and international skin and meat market. This would be in line with the policy for the conservation management of the Nile crocodile in KwaZulu-Natal.

The biology of crocodiles is one of the key factors why a SU programme can play an important role in their conservation and their life history appear to be particularly resistant to the removal of eggs or hatchlings.

Such a programme will have important social implications to the neighbouring communities and users of the lake and we suggest the launch of an educational programme combined with safe water access points for people, cattle and especially subsistence fisherman. The forming of partnerships between the community, private businesses is key to sustainability.

Given the expertise required in the rearing of crocodiles for the market, crocodile farmers would be instrumental to this programme and would provide capacity building through funding and training, as well as purchasing stock ready for the market.

However, with high levels of poverty and unemployment, expectations will have to be realistic and it must be clear that the potential monetary benefits from such a programme will be relatively small initially with possibilities for growth in future years. The objective should be the transfer of ownership of the resource, co-management and the responsibility and accountability of this ownership through its conservation.

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The Saltwater Crocodile *Crocodylus porosus* Egg Harvest Program In Papua New Guinea: Linking Conservation, Commerce And Community Development

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Abstract: The saltwater crocodile *Crocodylus porosus* egg harvest in Papua New Guinea is conducted in traditionally owned wetlands of the middle and upper Sepik River region. Substantially higher offtake in recent years integrated with conservation incentives, enhanced involvement of local people, and greater economic benefits for landowners is producing a suite of spinoffs for biodiversity conservation, community welfare and crocodile ranching.

The egg harvest is linked contractually with protection of breeding crocodiles and unharvested nests (including the sympatric New Guinea freshwater crocodile *C. novaeguineae*), and bans on setting of fires in nesting habitat. Systematic aerial nest counts since 1982 indicate a significant increase in the *C. porosus* population, with the highest count recorded in 2006. Results of the most recent *C. novaeguineae* nest counts (conducted in 2003 and 2005) reverse a trend of decline from 1988 to1998, and suggest a synergistic effect from the egg harvest. Degradation of biologically distinct herbaceous wetlands has been curtailed over much of the 1.5 million ha harvest area. Habitat regeneration was, until recently, occurring at key harvest sites, but *C. porosus* nesting habitat throughout the harvest area is now seriously threatened by introduced herbivorous fish species.

Local communities are becoming enabled to sustainably manage wetland resources. The greatest improvement in nesting and habitat is in the upper Sepik, where villages are economically reliant on crocodiles and a measure of rural development is taking hold.

1. Introduction

The biologically distinct and diverse wetlands of the Sepik River region in Papua New Guinea (PNG) (Fig. 1) support more than 50,000 people, the vast majority of whom are dependent on renewable resources of the river system for their hunter-gather livelihood and economic development.

The Middle Sepik was assessed in 1993 as a Very High Priority biodiversity conservation area in PNG (highest category of priority) owing to its range of distinctive land forms and associated biota, in particular a vast mosaic of herbaceous wetlands, and its economic value (Olivieri and Hutchinson 1993, Swartzendruber, 1993).

Two crocodilians occur in the Sepik: the saltwater crocodile *Crocodylus porosus* and the New Guinea freshwater crocodile *C. novaeguineae*. The species are sympatric in wetlands closely associated with the course of the Sepik, which is mainly where current *C. porosus* egg harvests are conducted. *C. porosus* nests circannually in the Sepik exclusively on floating mats of vegetation, with a peak in the November to

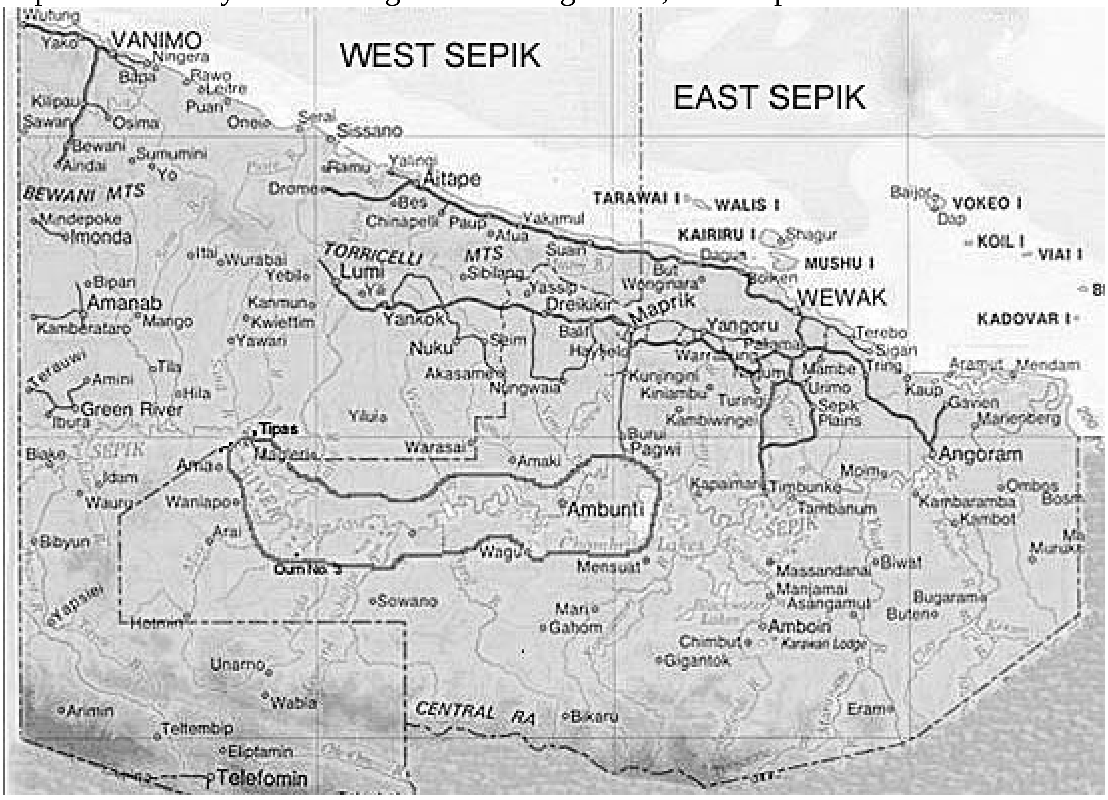

Figure 1. East and West Sepik provinces with outline of egg harvest area.

March wet season and a second, smaller pulse in March and April (Cox 1985; various local informants, *verbally*). *C. novaeguineae* is a pulse nester restricted mostly to the dry season and early wet season (usually August into November), and utilizes floating mat as well as land sites. Late nests built on land are prone to failure by advancing high water (Cox, 1985; local hunter consensus).

Both crocodilians yield commercially valuable skins and by-products, and were exploited extensively for skins and meat in the 1950s and 1960s. Hunting controls in the form of skin size: a bellywidth minimum of 18 cm and maximum of 51 cm were imposed by the PNG Department of Conservation and Environment (DEC) in the 1970s to promote sustainable harvests (Downes 1978).

In the 1980s ranching ventures based on collection of juveniles (mainly yearlings or third year) were developed to capture additional economic value of the renewable crocodile resource, promote end-line production efficiency, and further strengthen conservation of wild populations by economic incentives to protect breeding cohorts.

This mutually beneficial approach was enhanced later in the 1980s by introduction of egg harvests of each species (Cox and Solmu 2002). The relatively more valuable and logistically attractive *C. porosus* egg harvests have since become a powerful incentive to integrate conservation of crocodile populations, nesting habitat and biodiversity with community welfare and rural development (Cox 2005). A holistic management programme has evolved over the past 25 years to ensure that harvests of skins, young and eggs are conducted on a sustained yield basis (Hollands, 1984, Hollands 1986, Genolagani and Wilmot 1988, Genolagani and Wilmot 1990, Genolagani and Cox 1992, Cox *et al*. 1994, Manolis 1995, Cox 1998, Solmu and Kula 2003, Solmu 2004a,b, Cox 2005, Sine and Genolagani 2005, Sine and Kula 2006).

The crocodile resource is important to the local and regional economy, accounting in 2005 for an estimated PNG Kina 35 million (US$ 11 million) in annual exports of skins and meat. Crocodiles were cited in most middle and upper Sepik villages surveyed in 2001 as the most important resource for local livelihood and economic development (Cox 2002). Upscaled recent harvests of *C. porosus* eggs (Figure 8) have generated substantial economic benefits to participating communities, reaching K 154,000 (US$ 48,279) in 2006.

Systematic aerial surveys of *C. porosus* nesting from 1982 through 2006 indicate a significant trend of increase in the nesting population (Fig. 3 and 4). The highest nest count is from the most recent survey (March 2006). Aerial counts of *C. novaeguineae* nesting overlap most *C. porosus* survey areas and yield a more erratic trend, declining sharply from 1988 to 1999, but rebounding in recent years as shown by resumption of surveys in 2003 and 2005 (Fig. 5 and 6). The recovery is considered linked to strengthened conservation measures implemented by local communities for *C. porosus* egg harvests in sympatric areas.

Since September 2001, village communities in main crocodile producing areas of the Sepik have partnered with Sepik Wetlands Management Initiative (SWMI), a community organization based in the district center of Ambunti, East Sepik Province. SWMI is mainly concerned with advancing conservation of crocodile populations and wetlands, sustainable use of wetlands resources, and promotion of rural development.

2. Methods

2.1. Crocodile population monitoring.

Due to dense vegetation and erratic water levels that characterize most crocodile habitat in the middle and upper Sepik, crocodilian populations are monitored primarily by systematic aerial nest counts. These are conducted by DEC during peak season nesting of each species. The current *C. porosus* survey area comprises a sample of 41 nesting sites in approximately 700,000 ha of mixed herbaceous wetlands. These sites represent a cross-section of nesting habitat and crocodile exploitation types, and overlap c. 50% of the egg harvest area.

Counts are considered particularly indicative for *C. porosus*, which prefers to nest in more open and more easily surveyed floating vegetation, and is largely restricted in general distribution to lagoons and lakes in close proximity of the Sepik (Cox 1985).

A helicopter (usually a Bell Jet Ranger) is flown at a height of 60-70 m above nesting habitat and airspeed of 30-40 knots. Speed varies slightly depending on pilot ability to correct for headwind, tailwind or survey course. A constant speed of 30 knots is aimed for when nest spotters scan bands of vegetation, regardless of density and nest visibility. However, to reduce the cost of helicopter hire, 40-50 knots is employed over sections of thin, degraded and largely unsuitable nesting habitat. Bias from varying ability or experience of nest spotters has probably been decreased by employing the same principal spotter (BG) for the past 23 years. Linear regression of count data and direct observation of habitat condition (*e. g.*, incidence of burning/regeneration of vegetation, human activities) are used to discern nesting trends, and if indicated, to consider adjustment of management policy and practices.

Notwithstanding the limitations of standard night count methodology in dense tropical wetlands, a night count regime was introduced in 2005 as part of developing a community-participatory population monitoring program, in particular to gauge the effect of egg harvests on local hatchling cohorts (SWMI 2006). Experimental sites were selected near major egg supplying areas, and controls from non-egg harvest areas. Site habitat is comprised of two types: sections of the main Sepik littoral and oxbow lagoons with substantial areas of open water. Emphasis is given to repeating counts at the same time of year (start and end of dry season), in good weather, and when water levels are at medium-low stage (SWMI 2006).

2.2. Egg harvesting.

Biologically, the egg 'cohort' provides two key utilization advantages: more efficient skin production and minimal risk of adversely impacting the wild population. Crocodilians are K-selected species, laying relatively large numbers of eggs to compensate for high natural mortality of eggs and offspring. Studies of *C. porosus* population dynamics in tidal river systems of Australia suggest that only c. 1% of eggs yield a five year old crocodile, the great majority of eggs (86.5%) do not survive beyond the hatchling cohort, and egg mortality is estimated at 75% (Webb and Manolis 1989).

Egg mortality in non-tidal Sepik C. *porosus* is difficult to gauge. Nest counts from 1982-1984 found 35% of surveyed *C. porosus* and a deduced similar proportion of *C. novaeguineae* nests in the middle Sepik had been foraged for human consumption (Hollands 1986). Of remaining nests, a 1980-1985 nesting ecology study recorded losses to flooding (c. 5%), non-human predation (5-10%) and other causes of embryo mortality (c. 10%); however, these were underestimated (perhaps substantially), because most clutch data were collected in the early and middle parts of nesting seasons. Local informants were often unable or declined to show nests at and shortly after predicted hatching dates (Cox 1985). The study suggests that >60% of eggs of either crocodilian in the Sepik study area fail to produce hatchlings.

Eggs are extracted carefully from nests to avoid physical damage and stress to embryos.

Care is taken not to rotate young eggs, whose embryonic capillaries are connected delicately to the eggshell inner membrane. A crayon or marking pen is used to mark the upright position of each egg in the nest. Viable eggs are packed with the marked side up in layers in a cardboard box filled with nest material and lined with plastic to simulate the clutch cavity environment. Temperature in the top center of the box is monitored regularly; effort is made to maintain an optimal 32° C. Boxes of locally harvested eggs are collected from villages or camps and transferred by motor canoe to a heated room at the staging center in Ambunti. Several days to more than a week may elapse until a chartered aircraft transports eggs c. 500 km to Nadzab (Lae) airport, Morobe province, and after a 37 km drive, transferred to a walk-in incubator at Mainland Holdings, Ltd. (MHL) crocodile farm at Eight Mile, Lae. MHL is the only commercial enterprise in PNG with the capacity to properly incubate crocodile eggs and cost-effectively rear hatchlings.

A contractual tripartite egg harvest agreement between local landowners, SWMI and MHL was introduced in 2005 to enhance sustainability of offtake. Discussions of a draft prepared by SWMI, MHL and JC were held in participating villages, often with line-by-line elaboration, and invariably with requests for local input. Landowners agreed to a harvest limit of about half of known nests at individual nesting areas. Unharvested nests are to be actively protected: clutches are left to hatch, breeding crocodiles are not to be killed, and burning of nesting habitat is prohibited. SWMI is authorized to conduct spot checks of unharvested nests and habitat following the main nesting season. Breech of the provisions may result in eggs not being purchased by MHL in the future. The agreement was refined for the 2006 harvest to include, at the request of some landowners and subsequent consensus, a specific ban on hooking of nesting crocodiles, and a requirement that local harvesters wait for MHL-SWMI teams to announce the start of the harvest at individual village domains (Appendix 1).

2.3. Participatory Rural Appraisal.

The PRA methodology used with crocodile resource management in the Middle Sepik draws heavily from Chambers (1992) and Grant (1996). PRA principles described by these authors and summarized from Cox and Solmu (2002) are:

- **They teach us**. In a reversal of roles, outsiders learn from and with rural people; elicit and use their criteria; discover understanding and appreciate indigenous technical knowledge. Outsiders listen and learn instead of lecturing. Interactions are scheduled for times that are convenient for the community or informants, and happen at a relaxed and informal pace. Note taking is kept to a minimum. Questionnaires are usually avoided. Open-ended questions are asked. Information is probed for, and cross-checked to verify accuracy and reliability.
- **We facilitate**. Local people are empowered and enabled to lead PRA exercises (e. g. mapping, ranking, scoring, planning), and are encouraged to analyze and interpret the results. They own the results and share them with outsiders. *Locally-determined* assistance, whether advisory or material, is the desired output.
- **Critical self-awareness about our attitudes and behavior**. How to deal with doubt; learn by doing; embrace and learn from error. (We often learn more from our mistakes than successes). Build learning and improvement into each activity. Seek diversity and difference. Make rapport more important than methodology; empathy; humor; respect; trust; encouragement; confidence that they can succeed.

- **Outside investigator's direct contact**. Staying in the village. Engaging in face to face contacts. Asking to be taught. Working in small groups. Finding the right questions to ask (We assume we know what to ask; the beginning of wisdom is to realize how often we do not know, and to recognize that we need their help [Chambers, 1992]). Direct observation. Identifying key informants. Seeking a variety of contributors in meetings. Involving women at each and every stage.
- **The power of the open against the closed, the visual against the verbal; group versus individual analysis, and comparing versus measuring**. We are trained to make absolute measurements, although trends, scores or ranking are often all that is required (Chambers 1992). PRA methods are qualitative rather than quantitative.

PRA tools assessed in 2001 as most applicable and subsequently used with local communities are group meetings, interviews, informal discussions, habitat and human interaction mapping, and resource importance matrices (RIMs) (Cox 2002, Solmu 2002).

Villagers drew maps of nesting habitat in the ground , tracing outlines and borders with sharp objects and using locally available symbols (e. g. flowers, leaves, twigs, betel nuts, small stones) to represent important features. Alternatively, other groups preferred school chalkboards (Figure 2), at times including assorted colors of chalk to represent individual features. Questions raised during map making were the principal means to obtain detailed knowledge of specific nesting areas, habitat characteristics (*e. g*., nesting species, vegetation, succession, effects of burning) and issues related to crocodile resource use. The lengthy sessions required to construct maps allowed probing for information to be done in a relaxed and productive manner (Cox and Solmu 2002).

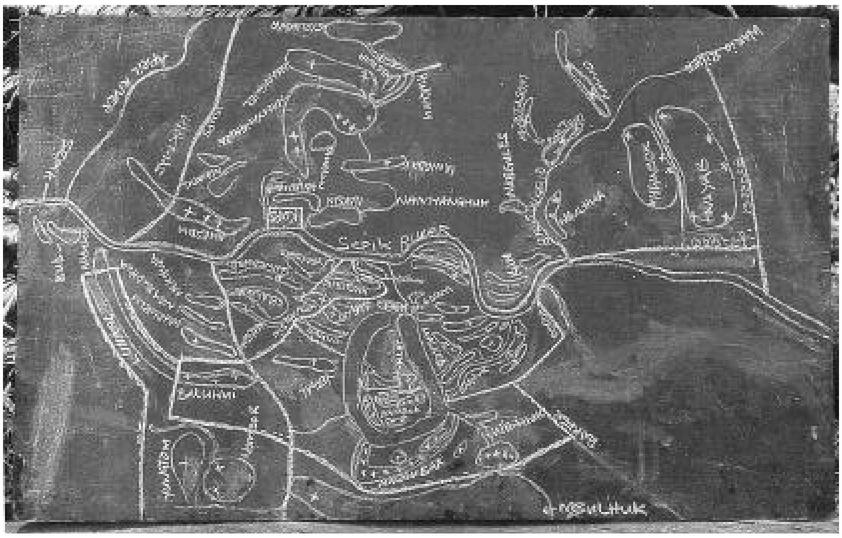

Figure 2. Map of nesting areas in Kubkain village domain.

3. Results

3.1 Population monitoring

Linear regression of replicate nest counts from inception in 1982 to 2006 show that *C. porosus* nesting in the middle and upper Sepik has increased significantly (Fig. 3) at c. 1.6% *per annum* (Sine and Kula 2006). Two data sets of consistently surveyed sites are analyzed owing to a substantial expansion of the survey in 1988. The increase is even more pronounced for sites of undisputed customary landownership versus those under disputed ownership (Fig. 4).

The degree to which nest count results can be extrapolated to infer the status of local populations is unknown, but an indicative relationship is assumed to exist, and local information suggests that *C. porosus* in the upper, and to a lesser extent, the middle Sepik has indeed increased substantially. Hunters in egg harvest areas ubiquitously assert this. The main trader of live crocodiles in the area received 15-25% *C. porosus* in the 1970s, but by the mid-1990s his shipments contained c. 50% (Alan Gallagher, pers. comm.). Daytime sightings of adult *C. porosus* along the Sepik are more common at present than in the 1980s (AM, BG, and JC, pers. obs.).

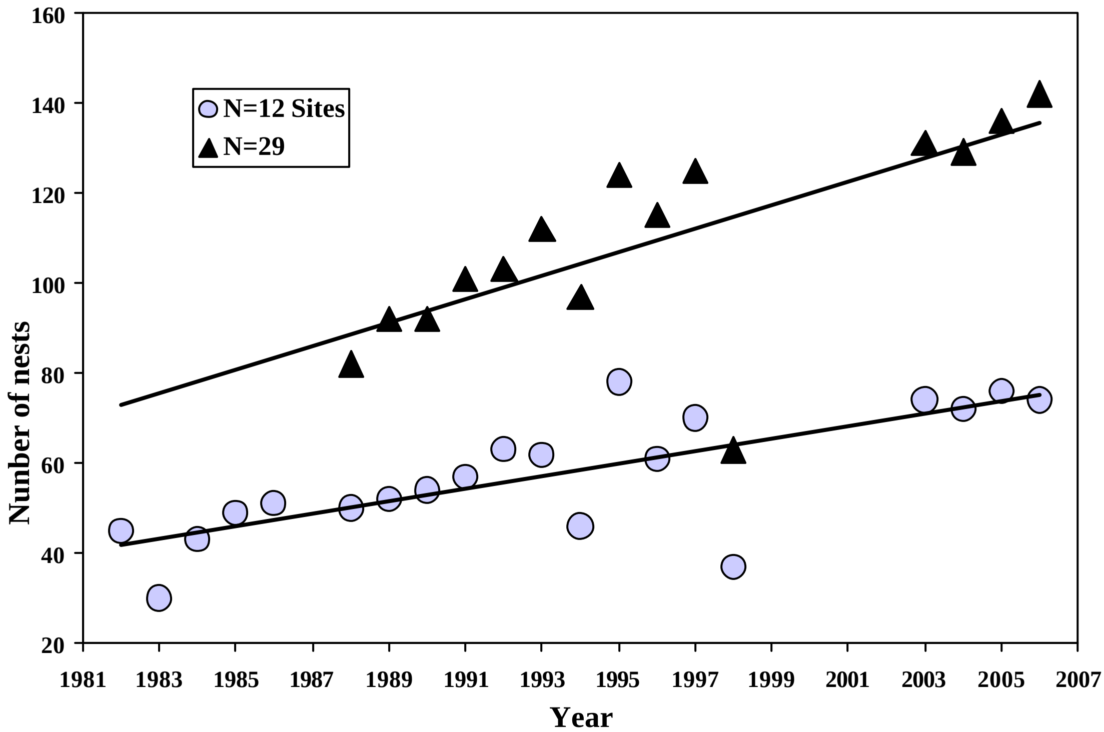

Figure 3. Linear regression of two sets of *C. porosus* nest count data (n=12, n=29) from consistently surveyed sites 1982-2006 and 1988-2006, each showing a trend of significant increase in nesting (p=0.0001 and p=0.003 respectively).

Steep declines in *C. porosus* nesting were recorded in 1994 and 1998, two years that followed moderate-severe El Niño-Southern Oscillation (ENSO) drought events. The steepest decline (51.0%; n=41 sites) occurred in 1998 following the 1997 ENSO episode, reportedly the most severe in 40-50 years (PNG Post Courier, 27 August 1997). Sepik elders interviewed could not recall a harsher dry season since WW II.

Fires were deliberately set and others crept into large areas of primary nesting habitat: sturdy floating mats that had anchored for months. Extensive areas of usually floating pandanus palms, broadleaf saplings, sedge, grass and reed were burnt off. These wetland associations had taken decades to develop, and were summarily degraded to open water and standing 'deadwood' (Kula and Meru 1998; Cox 1998). By contrast, despite the moderately severe ENSO episode in 2004, nest counts in March 2005 increased, particularly at upper Sepik sites (Sine and Genolagani 2005).

The *C. porosus* nesting increase is higher and more significant at sites (n=28) where landownership is undisputed, in contrast to an insignificant decline at landowner-disputed sites (n=13), where user groups from neighboring villages compete for resources and a view of "take it before someone else does" seems to prevail (Fig. 4).

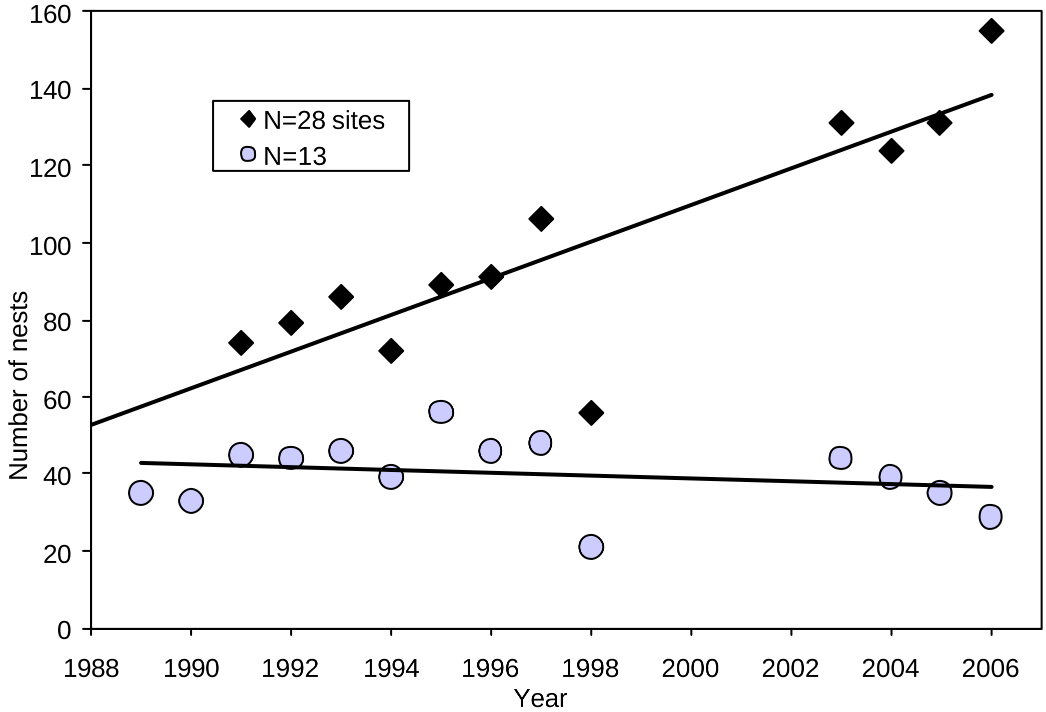

Figure 4: Linear regression of *C. porosus* nest counts at landowner-secure sites (n=28) surveyed consistently 1991-2006 (p=0.000006), and landowner-disputed sites (n=13) surveyed consistently 1989-2006 (p=0.38).

Although poorly quantified and non-uniform, a trend of increasing degradation of nesting habitat was noted on aerial nest counts from the mid-1980s through 1998. The use of fire was gradually destroying extensive floating mats of herbaceous and mixed herbaceous vegetation that function as prime nesting sites, especially for *C. porosus*. March 1998 aerial surveys of nesting showed that since 1987 >60% of 48 survey sites had lost >50% of their floating mat cover. Of special concern was that mats had been reduced by >80% at a third of the sites, a situation assessed to seriously affect the nesting population (Cox 1998).

Nest counts were not conducted 1999-2002 due to financial constraints related to the 1998 Asia-Pacific economic crisis. In 2003 the PNG national government resumed funding of surveys, each of which costs about US$ 25,000. Following the five year hiatus, aerial assessment in 2005 of habitat at most sites in the Ambunti area revealed additional burning of remnant vegetation, but regeneration at many other sites.

Burning at almost all (92.8%; n=28) upriver sites had ceased and regeneration was occurring on a broad scale (Cox 2005, Genolagani and Sine 2005, Sine and Kula 2006).
Aerial assessment in March 2006 showed a similar cessation of burning at almost all (90.2%; n=41) survey sites. But few signs of habitat regeneration and widespread non-fire reduction of herbaceous floating mats were noted, particularly at sites in the middle Sepik, and some as far upriver as Hauna village. Consistent oral reports from local residents attributed habitat degradation to establishment of introduced fish species. Pacu *Piaractus brachypomum* and Java Carp *Puntius gonionotus* (Fig. 5) were cited as the main culprits. The former was said to be a voracious feeder on grass and sedge leaves, the latter a browser of roots.

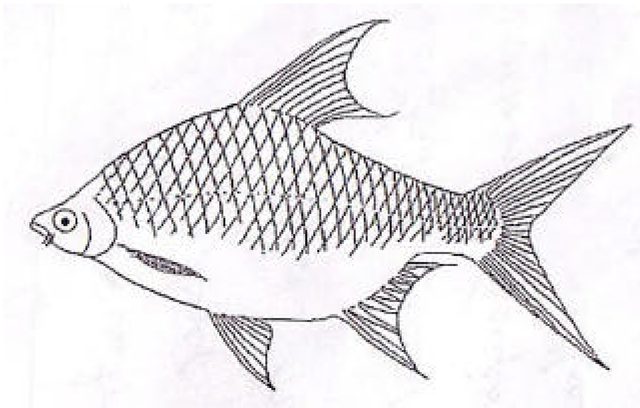

Figure 5. Java carp *Puntius gonionotus*

Linear regression analysis of *C. novaeguineae* nest counts shows no significant trend at sites monitored consistently since 1981 (n=21; p=0.39), or at all sites monitored consistently since 1989 (n=45; p=0.75) (Figure 6). A steep decline in counts occurred from 154 nests in 1989 to 88 in 1999 (although the trend is insignificant: p=0.12; n=45 sites), and was exacerbated by the 1997 ENSO episode. However, strengthening of crocodile nesting and habitat conservation incentives by expansion in 2002 of the largely sympatric *C. porosus* egg harvest were followed by a sharp rebound in nest numbers from the 2003 and 2005 counts (Fig. 6).

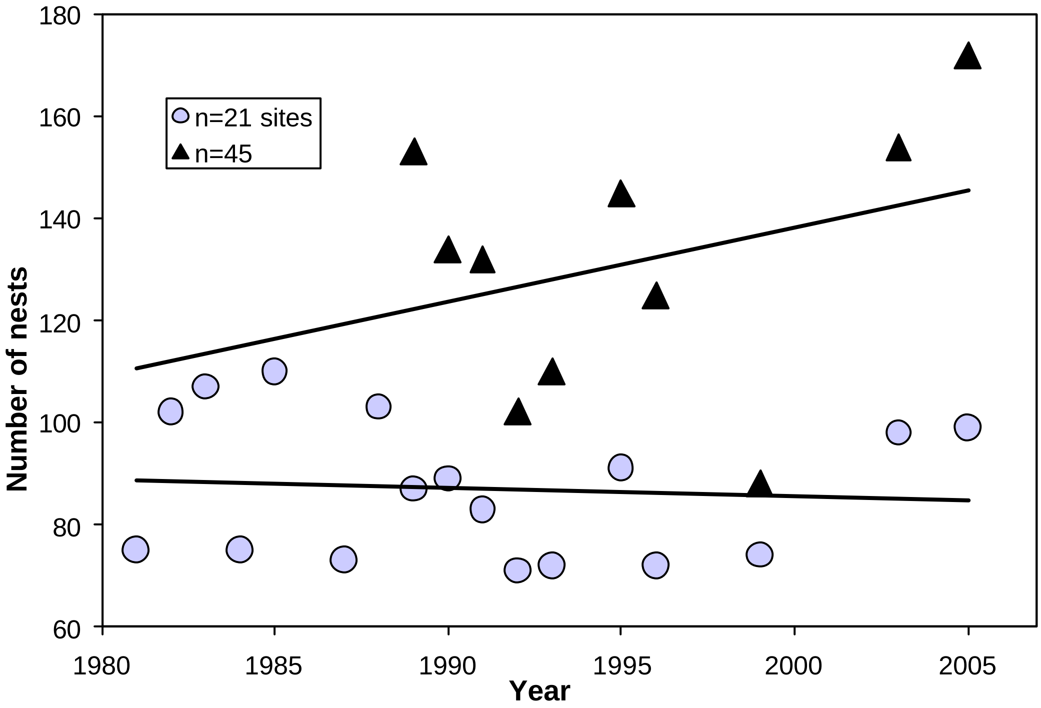

Figure 6. Linear regression of *C. novaeguineae* nest counts at sites surveyed consistently 1981-2005 (n=21) and including additional sites surveyed consistently 1989-2005 (n=45).

Regression of *C. novaeguineae* nest counts at all landowner-secure sites (n=24) surveyed consistently following introduction of the *C. porosus* egg harvest in 1985 shows no significant trend, but a regressed set of sites characterized by disputed ownership (n=9), most of which located in the Ambunti vicinity, yields a significant decline in nesting (p=0.006) (Fig. 7).

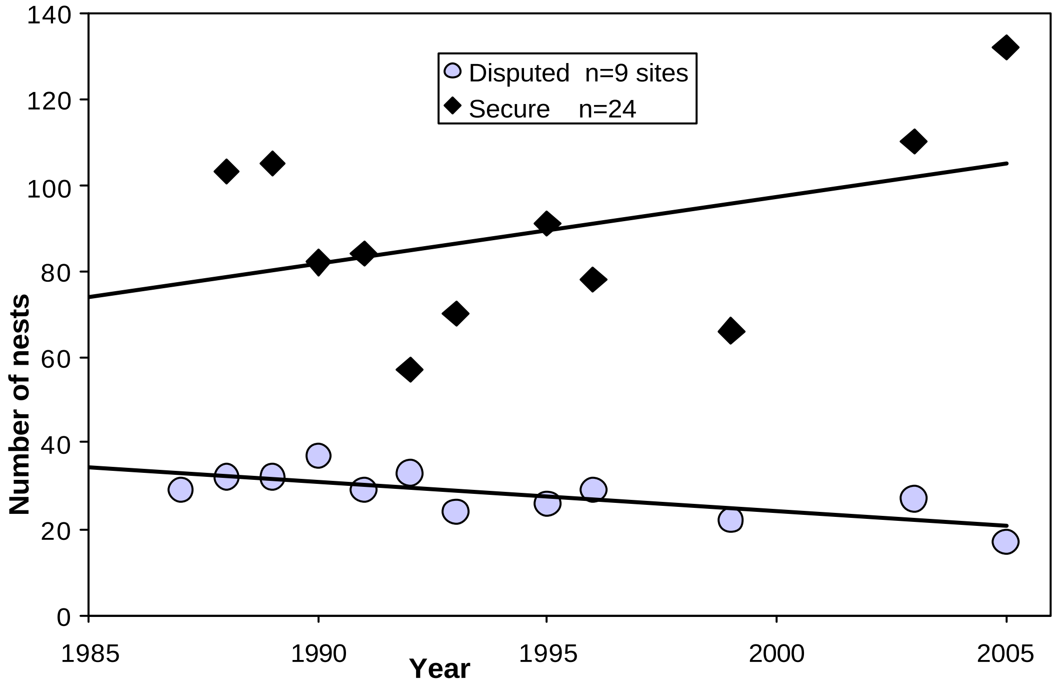

Figure 7. Linear regression of *C. novaeguineae* nest counts at landowner-secure sites (n=24) surveyed consistently 1987-2005 (p=0.23), and landowner-disputed sites (n=9) surveyed consistently 1988-2006 (p=0.006).

3.2. Crocodile night counts

Night counts were introduced in August 2005 as a supplemental population monitoring method, and to enhance local community participation in the scientific approach to crocodile resource management. Landowners or their appointees accompanied the SWMI survey team to lagoons and sections of the Sepik littoral near sites of varying egg harvest intensity (Table 1): light (Wokilan Oxbow, upper Sepik littoral in the Tarakai area), moderate (Swagap Loop, Kebey Lagoon) and intensive (Nebgubag Oxbow). Expansion of SWMI fieldwork in 2006 would allow night counts to be initiated in non-harvest areas such as Walmau Oxbow where nesting females and eggs are evidently protected by the landowning Yau'umbak community.

Table 1. Crocodile night counts in the upper Sepik, 29 August to 15 September 2005. SK=Sepik River littoral; OX=oxbow lagoon littoral; OL=open lagoon; CP=*C. porosus*; CN=*C. novaeguineae*; EO=eyes only; A=adult; J=juvenile; Y=yearling; H=hatchling; H_2O=water level; M=medium; MH=medium-high; NYA=not yet available.

Date	Location	H_2O	Hab. Type	Species			Size Class					Density
				CP	CN	EO	A	J	Y	H	EO	crocs/km
29/9	Sepik W of Tarifai	M	SK	5	12	5	3	8	5	2	4	NYA
30-31/8	Wokilan - Tarifai	M	SK	3	6	1	2	1	3	3	1	0.49
31/8-1/9	Wokilan Oxbow	M	OX	12	19	12	0	0	10	21	12	4.36
3-4/9	Nebgubag Oxbow	M	OX	25	2	8	0	0	7	20	8	2.07
14/9	Swagap Loop	MH	SK	2	0	4	0	0	0	3	3	0.21
15/9	Kebey Lagoon	H	OL	3	1	0	0	0	0	4	0	NYA
	TOTALS			**50**	**40**	**30**	**5**	**9**	**25**	**53**	**28**	

C. porosus comprised most (55%; n=90) crocodile observations where species was determined. Hatchlings and yearlings accounted for 84.8% (n=92) of sightings where size class could be assigned. Surveys west of Tarafai and at Kebey Lagoon were conducted mainly as initial training exercises. All counts were obtained from sub-optimal water levels, owing to an unexpected rise towards the end of the 2005 dry season. Surveys of the Sepik along sections of open and nearly isolated littoral (i. e., the 'Swagap Loop') and Kebey Lagoon were compromised by even higher levels and partial flooding of littoral vegetation. Counts at these two sites are probably depressed by dispersal of crocodiles into adjoining areas of flooded vegetation.

3.3. Spot checks of unharvested nests

They were also introduced in 2005 to monitor protection afforded by landowners and local communities, and to study hatching success in the wild. A fee of K 10 (US$ 3) was paid for each nest visit to compensate landowners for inspection effort and as an additional economic incentive to protect unharvested nests.

At the unavoidably late start of this activity (26 August 2005), the water level of the Sepik and adjacent lagoons had receded to mid-stage. Only nests near open bodies of accessible water could be reached. Local informants reported additional saltwater crocodile nests found following the egg harvest, but like nests known at harvest time, these were said to be inaccessible due to the water level (too dry for canoe travel; too wet for walking), or too remote. Spot checks were therefore conducted opportunistically. Of nine nests inspected, seven (77.8%) were successful hatches as evidenced by presence of eggshell fragments and/or clutch excavation, 1 (11.1%) human-raided, and 1 (11.1%) raided by a small predator (probably a varanid lizard).

3.4. Participatory Rural Appraisal.

PRA exercises led by SWMI in September 2001 ranked crocodiles as the most important economic resource in most (63%; n=11) village communities (Cox 2002). In addition, detailed knowledge of nesting areas was obtained from mapping exercises and subsequent conversations.

Landowners were asked to propose strategies and initiatives on how their wetlands could produce greater economic benefits, simultaneously sustain or increase crocodile populations, and regenerate habitat in degraded areas. Egg harvests emerged as a favored option amongst few alternatives. SWMI, DEC, MHL and JC expressed concerns that the harvests must be sustainable and conservation-based. Such a course, it was maintained, is of mutual long-term benefit to community development, biodiversity conservation and commerce.

The merit and magic of the PRA approach was shown when a landowner from Kubkain proposed that part of his tract of the sawtoothed sedge *Thoracostachyum sumatranum* be converted to open water. He explained that this sedge forms large rooted swaths in the Kubkain area, but some interior facies were perennially floating. This habitat is unavailable to crocodiles (and as noted on aerial surveys widely distributed in the Sepik). If petrol was provided for his outboard motor he could cut a channel during high water and chop most of the sedge mat into pieces, leaving a floating fringe for crocodiles to nest. Receding water would flush out the cut vegetation and a small lake would be left for his clan to fish and eventually benefit economically from recruited crocodiles, their young and eggs.

In addition to facilitating annual egg harvests for Mainland Holdings, SWMI lobbies for greater support of wetlands conservation and basic assistance for locally proposed initiatives to sustainably utilize, and where practicable, restore wetlands for community development. The community-based organization provides technical advice to existing local crocodile ranchers, actively promotes establishment of village crocodile ranches based on stocking of yearlings, and seeks an in-country commercial ranching enterprise to purchase *C. novaeguineae* juveniles and eggs (currently in PNG only *C. porosus* are sought as live purchases or eggs). SWMI also monitors the upriver spread of water hyacinth *Eichhornia crassipes* and has mobilized front-line communities to effectively assist physical and biological control.

An overarching SWMI objective is to promote maximum sustainable use of intact wetlands so that an economic incentive is created for habitat to effectively compete with alternate land use (e. g. conversion to fishing grounds) (see Webb 1991), and to help counter potentially massive degradation from a planned large-scale gold mining scheme in the Frieda River, a tributary of the upper Sepik.

3.5. Egg harvests

They were initiated in 1985 (Fig. 8) in conjunction with a *C. porosus* nesting survey. The harvest was limited to survey sites where concurrent counts showed nests were not ‘human-raided’ for eggs to eat, or hooks placed to hunt nesting females. Usually no more than half (and often only about one third) of active nests at any site were harvested. Priority was assigned to nests assessed as vulnerable to flooding.

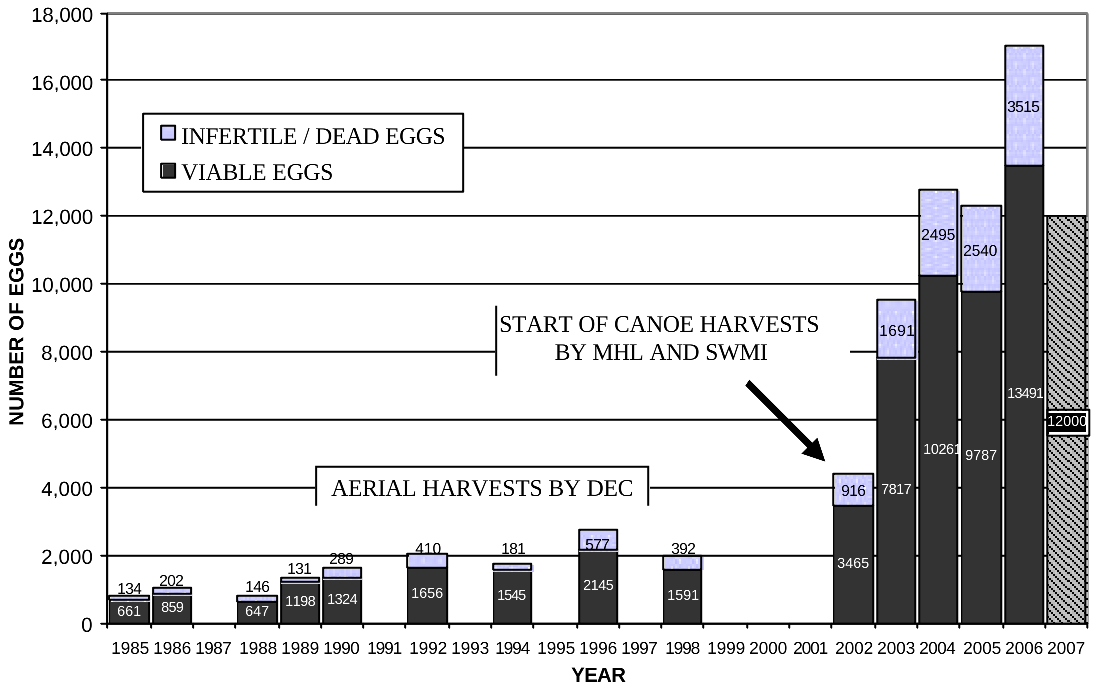

Figure 8. Saltwater crocodile egg harvests in the middle and upper Sepik, 1985-2006.

C. *novaeguineae* egg harvests were conducted in October 1988 and October 1989, producing 4,236 eggs (Solmu 2004b). Due to the drop in value of *C*. *novaeguineae* class skins in the global market in 1990, PNG ranches and farms no longer find it attractive to grow the species, particularly if more valuable *C*. *porosus* eggs or juveniles are readily available.
The *C*. *porosus* egg harvest was suspended in 1987 following unsubstantiated complaints of overharvesting, mostly by individuals and clans from local communities not participating or benefiting economically from harvests, and amplified by local politicians. Annual aerial harvesting resumed in 1988, but changed to alternate year conduct in 1990 due to continuing reservations from non-participating individuals and clans. During the 1990-1998 period of biennial conduct, harvests expanded to additional communities attracted by price increases from PNG Kina 1 to K 2.50 then K 3.50 for viable eggs. Annual collection of viable eggs increased from 1,324 to 2,145 (Cox and Solmu 2002) (Fig. 8).

Harvests were stopped 1999-2001due to non-conduct of surveys and information from local hunters suggesting that nesting crocodiles and habitat had yet to recover from the 1997 drought.

In 2002, SWMI relayed to MHL the consensus of landowners and local communities that nesting crocodiles were well-protected, and had increased substantially in number. Local stakeholders proposed resumption of annual egg harvests. Following this request a more extensive harvest was conducted. This was encouraged by an egg price increase from K 3.50 in 1998 to K 6. Lack of an aerial survey precluded use of a helicopter to reach nests, and required harvest teams to rely on motor and paddle canoes.

Most clutches (53.8%; n=78) were collected by landowners or their appointees. SWMI-MHL personnel and local assistants collected the remainder.

The much larger 2003-2006 harvests saw egg prices increase from K 7 in 2003 to K 9 in 2005 then K 10 in 2006, and featured much greater involvement of local people (Fig. 9). The 7,815-13,491 viable eggs exceeded the ability of SWMI and MHL alone to efficiently collect and transport eggs. By 2005 91.2% of nests (n=205) were harvested by local people, most of whom had participated in previous harvests conducted by SWMI-MHL and were therefore familiar with the techniques of proper egg handing, packing and transport. Hatching success has declined from 89.4% in 2002 to 67.9% in 2006. Community participation increased in the 2005 and even more so in 2006; a decline to 83.9% of nests locally harvested is due to expanded hands-on demonstration of egg management techniques by SWMI-MHL during the harvest.

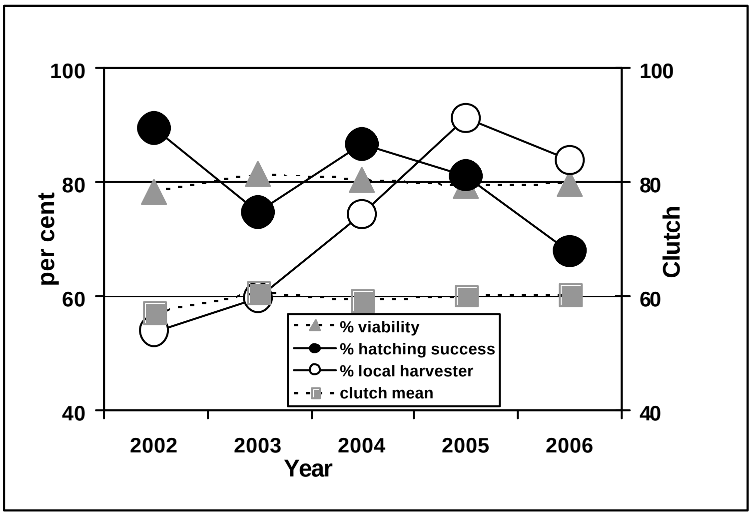

Figure 9. Clutch parameters, hatchability and local participation in recent *C. porosus* egg harvests.

The low hatching success in 2006 is considered attributable mainly to unauthorized premature harvesting of some nests by up to one month, other nests from several days to two weeks, and subsequent maintenance of eggs by villagers inside their unheated houses. The reasons given for this were that nests on unstable mats of vegetation may be flooded by advancing high water, and in some instances, other people may eat the eggs or take them for sale to harvest personnel. Low hatching success of some clutches collected with SWM-MHL teams (e. g. 70.6% at Kubkain, n=9) suggest other causes of mortality related to transport and maintenance.

The bumper 2006 harvest strains MHL capacity to rear hatchlings from wild eggs and its own breeders, prompting notification to landowners that a maximum of 12,000 viable eggs can be purchased in 2007. With growing interest to participate in the programme, and increased availability of eggs, introduction of harvest limits is required. MHL and SWMI consider a quota system most practicable. SWMI has calculated tentative quotas for 2007 based on past patterns of supply and aerial nest counts which reward with larger quotas communities that have more steadfastly supported sustainability safeguards and proper technical conduct of the harvest. Conversely, lower quotas will be applied to communities which have less rigorously abided by the harvest agreement.

Quota assignment is facilitated by a SWMI recommended moratorium on harvests where landownership disputes remain unresolved (*e. g*., Wagu Lakes region south of Ambunti), nest protection appears inadequate (*e. g*., Wangren Baret, Yabgwi Oxbow of Mowi village) or possible overharvesting is indicated by excessive offtake from the number of nests known by local users and results of aerial nest counts (e. g. Prembet scrolls of Swagap village).

In remote upriver communities, which are heavily reliant on the crocodile resource for their economic livelihood, a measure of rural development is taking hold. Egg sales enable villagers to pay high school fees (two clutches = 1 yr), thus guaranteeing continued education of their children. School fees are cited by most local residents as highest priority use of egg harvest income. Other uses are to pay bride prices, start small business enterprises such as trade stores and petrol depots, construct potable water systems, seek medical care, and fund church activities. Alternative economic development potential exists in the Sepik for communities near towns or roads, but in remote areas of the upper Sepik marketing of most agricultural and wetlands products is prohibitively expensive due to high transport costs.

Although remoteness increases egg collection costs, MHL and SWMI have prioritized harvest expansion to these economically neglected communities rather than intensification of harvests from currently participating communities.. Returns to landowners and rural communities from egg sales are amplified and ensured by MHL's policy of delivering payments to the doorsteps of each supplier on post-harvest 'payout' excursions. As a nationally owned diversified company, MHL is keen to assist and benefit from broad-based national development.

4. Discussion

C. porosus egg harvests in the Sepik have evolved over the past two decades from an aerial survey adjunct to a large-scale, mutually beneficial synergy of commerce, conservation and community welfare. While much of the program's success is attributable to its heuristic, socio-economic and environmental approach, an assemblage of dedicated people in each arena closely cooperating for the common good has been crucial. The blend of local expertise, empathy and dedication employed by SWMI members is invaluable. DEC's continuing commitment to regularly monitor crocodile populations and maintain a Wildlife Officer in Ambunti is similarly indispensable. MHL has played a lynchpin role of basing its procurement strategy on the wild resource and demonstrating an affinity to rural welfare. This policy has motivated local communities to become the driving force of the program.

Increased awareness by local landowners and communities of crocodile conservation needs, as promoted by SWMI's extension efforts since 2001, substantially higher prices for eggs, and reinforcement of the tripartite egg harvest contract have led to widespread protection of nesting habitat and nesting crocodiles in the middle and upper Sepik. As a spin-off, biologically distinct wetlands are being effectively conserved over a 1.5 million ha area.

There remains, however, pressing need to better monitor the impact of the egg harvest on the local *C. porosus* population.

Spot checks of unharvested nests need to be conducted in a random, representative manner in May or June when water levels are still high enough to permit canoe travel and nesting outcomes are obvious. Night counts initiated in 2005 need to be repeated at the start of the dry season when levels recede to medium-low stage, and preferably again at the end of the dry season to compare results following further dispersal of hatchlings and dry season hunting. Concurrent discussions with local communities allow conservation-related and socio-economic concerns to be reviewed, and consensus maintained on a holistic management strategy.

C. porosus is widely regarded as the more aggressive species in the middle and upper Sepik, and may be displacing *C. novaeguineae*. The erratic pattern of *C. novaeguineae* nest count results until recent years may also be influenced by droughts, when females may elect not to nest, perhaps cued that conditions are not right. Moreover, hunters gain easier access to nests in periods of drought, when it is easier to place and check hooks for nesting females. Differential protection is afforded by the 51 cm bellywidth limit, which ostensibly includes most *C. porosus* females although numerous reports of 46-51 cm BW and even smaller *C. novaeguineae* nesters have been received (various Sepik hunters, pers. comm.).

There is much scope to expand and update PRA mapping of nesting habitat and integrate the results with aerial survey site histories. These activities would likely yield further insight into local trends of habitat change, nesting and crocodile use.

Pressing need also exists to increase the hatchability of harvested eggs to ensure that the activity is economically viable for MHL. Greater profitability also enables additional increase in egg price, which in turn enhances the economic benefits that accrue to local communities, and when implemented in accordance with the harvest agreement, confers a stronger conservation incentive to crocodiles and habitat.

Premature harvesting and presumed subsequent excessive egg mortality encountered in 2006 should be resolved on the 2007 harvest by MHL's new policy of purchasing eggs only from suppliers who wait for the go-ahead from SWMI. Egg collection can be controlled by distribution of exclusive-use egg cartons to local harvesters at staging locations on advised harvest dates. Higher hatchability can also be promoted by more comprehensive hands-on demonstration of egg extraction, handling, packing and transport, and reductions of time from nest to incubator. These steps should increase hatchability of collected eggs to =80%, the level reached by programs with the American alligator *Alligator mississippiensis* in Louisiana, USA and *C. porosus* in the Northern Territory, Australia (see Elsey and Kinler 2004).

SWMI is ideally positioned to facilitate liaison between MHL and local communities by coordinating and catalyzing fieldwork, and helping realize the ultimate goal of community-led resource management.

Figure 10. Harvesting eggs at Mobowi Oxbow, Mowi village.

This is especially pertinent in the Sepik region where all crocodile nesting habitat is under customary ownership by clans or individuals from local communities. Land use decisions are made by local landowners influenced by considerations of local communities, whose daily needs and economic development depend on making informed decisions in which they have the main vested interest, ultimate control and responsibility. A unique opportunity is thus created for all stakeholders to establish sustainable practices.

SWMI has operated mainly as a Small Grant Programme Project from the Global Environment Facility (GEF) (2001-2003), a small amount of funding from the World Wide Fund for Nature (WWF) - PNG Freshwater Habitat Conservation Programme in 2005, and continuing basic assistance from MHL. Proposals for additional assistance have been submitted to UNDP-GEF and WWF, which present a platform and timely opportunity for such organizations to help fulfill their own mandates, enhance local management capacity and build enduring conservation of biologically distinct wetlands.

Notwithstanding the accomplishments of the egg harvest program, further spread and establishment of introduced fish species in the Sepik castes a pall over future prospects. Development of daughterless gene technology is a distant hope (P. Gehrke, CSIRO, *in litt*.) and other methods of biological or physical control appear inapplicable. If the March 2005 and March 2006 aerial surveys are indicative, much of the prime nesting habitat for *C. porosus* in the middle and upper Sepik could be rendered unsuitable within the next few years. This raises serious implications for viability of the *C. porosus* population (which is reproductively dependent on floating mats of herbaceous vegetation), the welfare of local communities, and the future of crocodile ranching in PNG.

Of similar concern is the potential impact of the Highlands Pacific Ltd. gold and copper mining scheme in the upper Frieda River. This envisaged multi-billion US dollar venture is said to include seven Impact Zones in the middle and upper Sepik (S. Hopkos, Frieda Mining public relations officer, pers. comm.). An MOU between Highlands Pacific and Government of Papua New Guinea was signed by the PNG Prime Minister in 2005.

With greater protection of adult *C. porosus* in the wild and their less wary behaviour, the potential increases for more frequent conflict with the local populace. Nuisance and rogue crocodiles are managed by SWMI. The Chairman (AM) is an expert crocodile hunter and specializes in removal of such animals, most recently a 6.0 m male at Yamanumbu, middle Sepik in January 2006 and the current man-eater being pursued at Biaga in the upper Sepik.
Special attention is needed to rehabilitate the severely degraded Wagu Lakes system south of Ambunti. Competing user groups from area villages have overwhelmed the ability of Yigei-Wagu customary landowners to sustainably manage wetlands resources. The aerial survey in March 2006 confirmed continued use of fire, further reduction of nesting habitat, and a sharp decline in nest counts (16 nests vs. 27 in 2005, n=9 sites).

Ground-based information suggests continued intensive fishing and indiscriminant exploitation of crocodiles. Before a tragedy of the commons takes further shape, SWMI and MHL can use egg harvest returns as leverage to bring stakeholders together for dialogue, consensus-seeking and positive action.

Good potential exists for further expansion of the egg harvest, both upriver and downriver, producing =20,000 viable eggs per year if current capacity of MHL can be expanded, successful liaison with a re-funded SWMI is bolstered, and exotic fish prevented from destroying primary *C. porosus* nesting habitat. New harvest areas include western Chambri Lakes, middle-lower Sepik village domains in the Gauwi Council area, and farther upriver in the Tipas village domain. Such expansion could increase the area under effective wetlands conservation to >2.0 million ha.

5. Acknowledgements

The authors are grateful to the Mainland Holdings Ltd. Board of Directors for endorsing the company's crocodile production programme and Booker-Tate Ltd. (UK) for ongoing management assistance. Dr. Iamo Wari, DEC Secretary, is recognized for his valuable support in obtaining renewed funding for aerial nest counts in the Sepik. Prof. Sakan Teejuntuk, Kasetsart University, Bangkok is warmly acknowledged for his advice and assistance with statistical analyses. Communities in the Sepik which partner with SWMI, DEC and MHL to implement sustainable conduct of egg harvests and conservation of crocodiles and wetlands are greatly appreciated for their vital cooperation

5. Appendix

5.1. Appendix 1. English translation of egg harvest contract.

AGREEMENT
ON THE WAY TO SELL AND LOOK AFTER CROCODILE EGGS

[LANDOWNER'S COPY]

I ______________ of ____________ village as owner of the wetland known as _________ am happy to accept the money to sell crocodile eggs from ___(number) crocodile nests, and I agree to these five (5) points:

1) Follow the good way of Sepik Wetlands Management Initiative (SWMI), at exactly the time SWMI announces to harvest eggs, put the eggs in (the supplied) box with plenty of soft grass, do not rotate the eggs, and look after properly the box of eggs.

2) Look after all unharvested nests on my land so that the eggs can hatch and produce many small crocodiles; I strongly forbid anybody to take those eggs.

3) After selling the eggs I agree that SWMI comes to check the unharvested nests and habitat that I am looking after.

4) It is strictly prohibited to place hooks near or on top of crocodile nests.

5) It is strictly prohibited to set fires anywhere on my land where crocodiles build nests and lay eggs.

If I break this agreement to look after crocodile nests, and look after wetland areas where crocodiles nest, and look after breeding crocodiles, I understand that in the future I can no longer sell my crocodile eggs.

My signature: x ____________________________ Date: _____________

Name & signature of witness: _______________ x ____________ Date: _________

NEST NUMBER	**Number of eggs** (MHL ONLY BUYS GOOD EGGS)			MONEY OWED (Kina)
	TOTAL	GOOD	NO GOOD	
1.				
2.				
3.				
4.				

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Experimental Pilot Project For The Conservation Of C*rocodylus acutus* By Local Communities In The Mangrove Of Cispata Bay, Cordoba, Colombia, South America.

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Abstract: Over the last three years, a group of 18 ex - hunters, known as "caimaneros" at Cispatá Bay, Caribe of Colombia have become conservationists for the critically endangered *Crocodylus acutus.* Actually, there is an approximation of the state of conservation of *Crocodylus acutus* in its natural habitat, with natural distribution and population status at Cispatá Bay.

The project has advance in several lines of development: survey, recovery programs, monitoring of the population, biological studies relevant to sustainable use, communication skills and permanent community training as the final benefactor of the conservation strategy. The project constructed the necessary infrastructure to incubated eggs coming from wild, to raise neonates and to keep juveniles until the animals reach 1mt. to be liberated to wild.

As the project is based on sustainable use of the population, it has been take in consideration a combination of preliminary and secondary studies, monitoring and the formulation of a management plan. It is important to mention that the project is part of the integral management plan of mangroves, which also include about 300 personas who liver hood depends of mangrove wood and about 500 fishermen that also depend on the health of mangrove ecosystem.

1. Introduction

At the Colombian Caribbean geographical area, the Cispata Bay has been study during the last decade and by now the regional environmental authority (CVS) is implemented the first Integral Management Plan for Mangroves at the country and the crocodile program is a important piece of the implementation strategy design.

The crocodile program has annually survey the wild crocodile's populations and takes in account management actions *in situ* and *ex situ.* Through the construction of artificial areas destined it for nesting, the program had reach 47, 67 and 52 nets during the last three years and around 3.000 individuals destined for the wild population recovery program. It has to be in account that it is possible to reach the crocodile's mangrove carrying capacity with these individ uals.
The project has a communitarian focus on 18 crocodiles hunters, knowing as "caimaneros" and its approach are the meeting point of sustainable use to reach ecological, social and economic benefits.

This nature of the project can be consider as a pilot one to be implemented in some others areas and the methological approach can be use for another crocodile's species that has commercial restrictions too. To down list *Crocodylus acutus* population from Cispata Bay specie of CITES list (from Appendix 1 to II), and taken in account the efforts to reach the objectives of the communitarian conservation program, it would be a unique opportunity to achieve the sustainable use and management of the mention population.

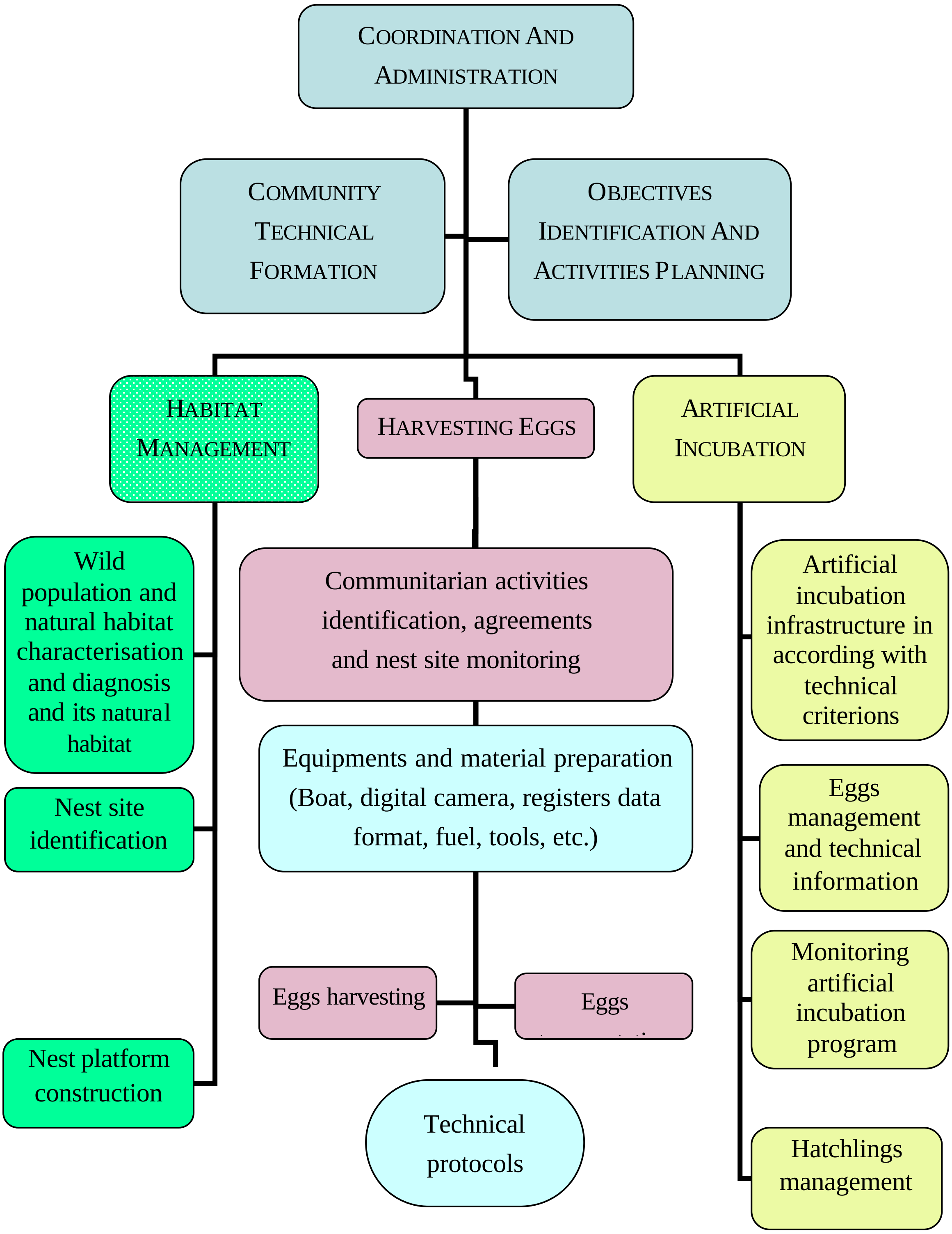
The program is leader by the environmental regional authority –Corporacion Autonoma Regional de los Valles del Sinù y del San Jorge – CVS - and it has been count with the support of Environmental Minister, Alexander von Humboltd Research Institute, Conservation International CI Colombia, Fonade, Nature Foundation, Agrosoledad S.A, ZOBEN CI and GARBE C.I.

2. Methods

After six (6) years, the crocodile communitarian project has development some methodologist models, which has been adjust as well as the activities has been object of replica or monitor. There are several project components that have methologist standardize as: *in - situ* scientific investigation (habitat, wild population and release animals) and *ex – situ* conservation (harvesting eggs, artificial incubation, growth and site release selection).

From 2000 until 2006 the activities project has been done with the community local people (ex - hunters) and professional stuff as well as thesis students.

Methodological Standarization for the Egg Harvesting and Artificial Incubation Program within the *Crocodylus acutus* release program (From Ulloa-Delgado & Sierra-Diaz, 2006).


COORDINATION AND ADMINISTRATION
COMMUNITY TECHNICAL FORMATION
OBJECTIVES IDENTIFICATION AND ACTIVITIES PLANNING
HABITAT MANAGEMENT
HARVESTING EGGS
ARTIFICIAL INCUBATION
Wild population and natural habitat characterisation and diagnosis and its natural habitat
Nest site identification
Nest platform construction
Communitarian activities identification, agreements and nest site monitoring
Equipments and material preparation (Boat, digital camera, registers data format, fuel, tools, etc.)
Eggs harvesting
Eggs
Technical protocols
Artificial incubation infrastructure in according with technical criterions
Eggs management and technical information
Monitoring artificial incubation program
Hatchlings management

3. Results

3.1 Geographical area

The study area corresponds to the mangrove area of the Cispatá Bay in the Caribbean of Colombia and in the Table 1, by way of synthesis, are register all the bodies of waters surveys and some characteristic data of each one of them.

Table 1. Characteristics of the bodies of waters where crocodile survey was done: Cispatá Bay, Córdoba-Colombia. (2001-2002) Ullloa-Delgado & Sierra-Díaz, y (2003-2004) Ulloa-Delgado & Cavanzo-Ulloa,

Bodies of water	Source of the information	Perimeter m	Area has.	Salinity	Mangrove Vegetation	Crocodiles
SECTOR EXTERNAL NORTH (Area of marine influence)						
Marsh Cojo Patos	2001-2	1.051	10,6	Salted	Halohelófila	Crocodylus 1
Marsh Mestizos	2001-2	3.745	79	Salted	Halohelófila	Crocodylus
Salted River	2003-4	18.382	34.5	Brackish	Halohelófila	Crocodylus
River La Rabia	2003-4	400	-	Salted	Halohelófila	Crocodylus
River Navio	2003-4	3.450	6	Salted	Halohelófila	Crocodylus?
HALF SECTOR OR ESTUARINO						
Marsh Navio	2003-4	7.670	121	Brackish	Halohelófila	Crocodylus?
River crosses Navio	2001-2	290	0,3	Brackish	Halohelófila	Crocodylus?
Marsh Manuel Vicente	2003-4	2.483	19	Brackish	Halohelófila	Crocodylus
Marsh Mangones	2003-4	3.837	36	Brackish	Halohelófila	Crocodylus?
Marsh Vertel	2003-4	2.908	20	Brackish	Halohelófila	Crocodylus?
Marsh Ulé	2003-4	345	0,87	Brackish	Halohelófila	Crocodylus?
Marsh The Garzal	2003-4	6.027	76	Brackish	Halohelófila	Crocodylus
River Garzal	2003-4	4.644	9	Brackish	Halohelófila	Crocodylus
Marsh Tapao 1	2003-4	2.807	14	Brackish	Halohelófila	Caiman – Crocodylus
Marsh Tapao 2	2003-4	4.189	31	Brackish	Halohelófila	Caiman
Marsh Tapao or Hidden	2003-4	291	0,58	Brackish	Halohelófila	Caiman
Marsh Remediapobre	2003-4	8.768	63	Brackish	Halohelófila	Crocodylus
River Remedies poor	2003-4	10.858	20	Brackish	Halohelófila	Caiman
River Ostional	2001-2	1.698	1,7	Sweet-brackish	Halohelófila	Caiman2
WESTERN INTERNAL SECTOR (Area of influence of the River Sinú)						
Big River	2003-4	28.279	21	Sweet - brackish	Halohelófila	Caiman-Crocodylus
Marsh Ostional	2003-4	9.655	178	Sweet brackish	Halohelófila	Caiman-Crocodylus
Marsh Ferez	2003-4	1.548	7,7	Sweet	-mixed Helófila	Caiman
Marsh Corozo	2003-4	5.036	38	Sweet	-mixed Helófila	Caiman
Marsh The Bag	2003-4	1.047	5,2	Sweet	-mixed Helófila	Caiman
Marsh Guarumo	2003-4	2.658	13	Sweet-brackish	Halohelófila	Caiman-Crocodylus
Los Cocos	2003-4	4023	22	Sweet-brackish	Halohelófila	Crododylus
Marsh Soledad	2003-4	15.273	469	Sweet-brackish	Halohelófila	Caiman-Crocodylus
SOUTH INTERNAL SECTOR (Area with continental influence)						
River Palermo	2001-2	1.384	3,5	Brackish	Halohelófila	Crocodylus
Marsh Gaul	2003-4	4.787	42	Brackish	Halohelófila	Crocodylus?
River Tijo	2001-2	8.023	15	Brackish	Halohelófila	Crocodylus?
Total		**165.556**	**1.436**			

1 = Crocodylus acutus, 2 = Caiman crocodilus fuscus;

In total they have been at least 30 the bodies of water measured and survey for once, of which 20 correspond at marshes and 10 to rivers. Initially Ulloa-Delgado & Sierra-Díaz (2.002), identified and they characterized 24 bodies of waters (9 rivers and 15 marshes), later on they were added in the characterization 5 marshes and a river, being covered with this form more than 90% of the bodies of waters of this bay.

3.2. Survey routes

Starting from the surveys and the identification and characterization of the bodies of waters, Ulloa-Delgado& Cavanzo-Ulloa (2004) standardized 8 sampling routes that have been the base of the monitoring program. The long distance average is of approximately 37 kilometers for survey/día (registered variability 24-51 km), combining in some cases two routes in oneself night and with a duration average of 4 at 6 hours (Table 2).

Table 2. *Routes standardized for crocodiles wild populations monitoring program at Cispatá Bay, Córdoba,Colombia.*

Routes	**Sites survey**	**Survey longitude (m)**			**Crocodiles Observed**
		Sampling	Access	Total	
1	Caños Salado and Ciénagas Cojopatos and Mestizos (124 ha)	13.986	13.452	27.438	*Crocodylus*
2	Ciénaga Navío, Hulé, Garzal, Mangones and Remediapobres (297 ha)	22.427	23.639	46.066	*Crocodylus*
3	Caño Grande and Ciénaga la Bolsa (26 ha)	4.186	28.780	32.966	*Caiman Crocodilus*
4	Ciénaga Soledad and Caños Cantarillo Remediapobres y Palermo (535 ha)	27.515	12.893	40.400	*Caiman Crocodilus*
5	Ciénagas Tapao1, Tapao 2, and Caño el Garzal. (54 ha)	11.640	12.816	24.456	*Caimán Crocodilus*
6	Ciénagas Feréz, La Balsa and Corozo (51 ha)	6.584	38.292	44.876	*Caiman*
7	Ciénagas Manuel Vicente, Vertel, Galo, El Coco and El Guarumo (116 ha)	16.859	34.524	51.855	*Crocodylus Caimán*
8	Ciénaga Ostional (178 ha)	9.655	24.284	33.939	*Caiman Crocodilus*
Average		**14.106**	**23.585**	**37.691**	
Total		**112.852**	**188.680**	**301532**	

It is appreciated that in most of them it is possible to detect the two species of crocodiles, being the routes one and two exclusive for (*Crocodylus acutus*) and those corresponded to the routes of more influence saline, in opposition with the route 6 that it is exclusive for "babilla" (*Caiman crocodilus fuscus*) and its registered salinity was of 0, because the near influence of River Sinú, of the alluvial plain and the continental drainage that it is increased in season of rains.

4. Wild populations monitoring program

From 1999 up to the 2006 had been registered *Crocodylus acutus:* individuals and postures, in 15 sectors of the Cispatá Bay. The wild population at River Salado is the most abundant, as much in mature animals as in the postures; noticing that this area is very wide, little trafficked and with very far away sectors.

In a sector called “biofiltro”, close by a shrimp farm, that traditionally did have a numerous population concentrated of juvenile, sub-adults and adults, for the 2006 the mature population practically disappeared. During 2003, 2004 and 2005, were gathered 16, 24, and 28 nests respectively but 3 nest were only detected in 2006.

The Figure 1. present the total number of *Crocodylus acutus* observed during the monitories of the last five years, noticing that the methodology has been the same one, but for homogeneity in the intensity and in the standardized routes they are comparable the last three years. That is to say each route was monitoring once in the year. The initial study of 2002 and the following of 2003 were the base for the standardization and in this sense the sampling intensity per year was very high and refers to several monitoring, inclusive areas like River Salado, was survey near 8 times.

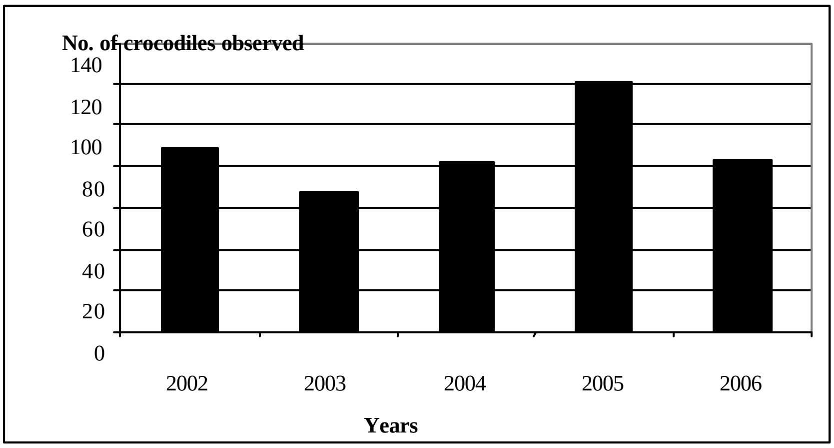


Figure 1. Total number of Crocodylus acutus observed in the Cispatá Bay, during five years. Córdoba -Colombia.

4.1. Populations structures

In the Table 3. it is register the size classes of the Crocodylus population observed in the different monitoring running during five years of evaluation. So far special changes are not detected.

Table 3. Synthesis of the results obtained in the evaluation of the populations of Crocodylus acutus and their natural habitat, during 5 years of sampling. Cispatá Bay, Córdoba, Colombia.

Bodies of water	**2002**	**2003**	**2004**	**2005**	**2006**	**X**
Classes of size cm	**Individuals number**					
(20-60)	3	0	0	0	0	**0,6**
(61-120)	24	3	12	12	6	**11,4**
(121-180)	14	7	10	13	8	**10,4**
(181-240)	23	19	34	49	36	**32,2**
(>241)	25	38	26	48	33	**34**
Total	**89**	**67**	**82**	**122**	**83**	**88,6**

Starting from the results found for Ulloa- Delgado & Sierra-Díaz (2002), and those represent at table 3: by the classes 1 (3 subjuveniles), 2 (24 juvenile), 3 (14 juvenile B), 4 (23 between sub-adults and adults) and 5 (25 adults), it was determined that this structure and dispersion corresponded to a fractional population and in imbalance, characterized by a relative shortage of the classes of neonates size and juvenile.

So far this population condition of imbalance, practically has stayed during the five years of investigation (Figures 3); nevertheless, it is expected that with the liberation of 100 animals bigger than 1 meter that one has foreseen for the month of July and the later liberation of about 500 individuals the structure begins to be balanced and improve the distribution inside the Bay of Cispatá.

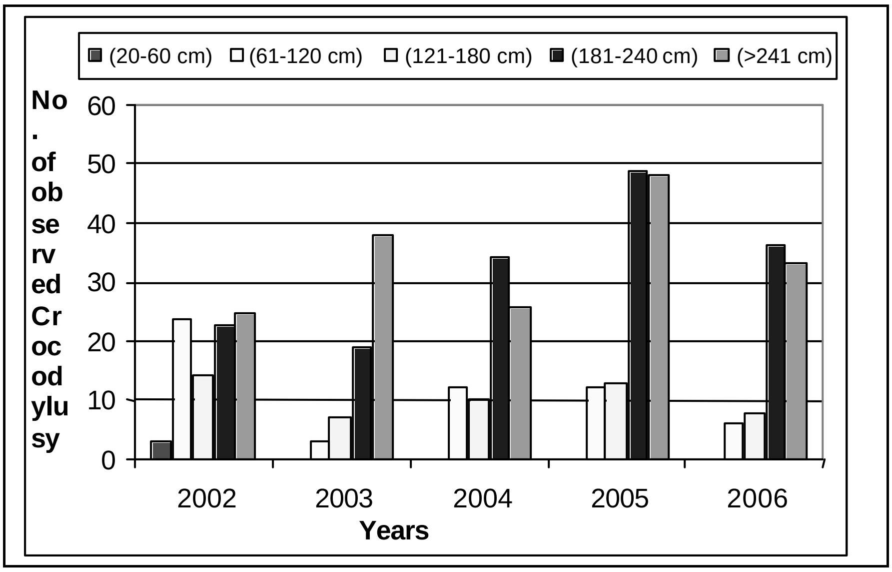


Figure 2. Crocodylus acutus classes frequency distribution observed during 5 years of monitoring program in the Bay of Cispatá, Córdoba, Colombia.

With relationship to other populations parameters and with the purpose of maintaining reference points for the pursuit, in the Table 4 it is register general information of some characteristics of the bodies of waters, like it is the perimeter and that they correspond to total survey. The area in hectares (ha) is the total extension of monitoring bodies of waters.

Table 4. General characteristics of the habitat and some population parameters

Population parameters	2002	2003	2004	2005	2006	X
Perimeter km	71	71.	112	112	112	**95,60**
Area has	864	929	1,436	1,436	1,436	**1220,20**
Distribution Kilometers/animal	0,80	1,06	1,37	0,92	1,35	**1,10**
Density Individuals/kilometer	1,25	0,94	0,73	1,09	0,74	**0,95**
Density Individuals/ha	0,10	0,07	0,06	0,08	0,06	**0,07**

For the time being the information shows the populations homogeneous tendencies, with an evident population imbalance, which is expected that it change with the control and surveillance of the area and the liberation of animals. This would have to show in a better population structure and in different population parameters of distribution and density. That is to say it is expected for the future that the population's tendency is related with a bigger number of crocodiles for kilometer or inspected hectare and with a bigger quantity of animals of classes of size 2 and 3.

4.2. Reproductive parameters

From the results obtained for Ulloa-Delgado & Sierra-Díaz (2002), when registering a good number of mature animals and a population in imbalance, these authors for the year 2003 evaluated the possibility to begin activities of gathering of nests with the encourage of beginning a project of conservation of the species with the participation of members of the community and that it combined the *in-situ* and ex-situ management.

In the Table 5, it is register the summary of the reproductive seasons 2003, 2004, 2005 and 2006. It should be mentioned that the difference as for the intensity of the gathering tasks doesn't allow to compare to each other the reproductive first year with those of 2004, 2005 and 2006, when the gathering of the nests was standardized by the community. The season of postures in general begins at the end of January and it culminates by the middle of March, with annual averages of eggs for nest between 25 and 28

Table 5. Nest registers year's 2003, 2004, 2005 y 2006. Cispatá Bay, Córdoba, Colombia.

Year	Period of postures	No. Eggs	No. Nest	No. ex -hunters
2003	24 February at 21March. (25) days	427 28 e/nest	15	3
2004	10 February at 9March. (27 days)	1176 25e/nest	47	7
2005	29 January at 10 March (40 days)	1715 26e/nest	67	15
2006	30 January to 24 March (53 days)	1.245 25 e/nest	50	15

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Illegal Caiman Hunting In The Sustainable Development Reserve Piagaçu-Purus, Brazilian Amazonia

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Illegal trade of Black (*Melanosuchus niger*) and Spectacled (*Caiman crocodilus*) caimans for meat is widespread in the Piagaçu-Purus Sustainable Development Reserve (SDR-PP), Amazonas state, Brazil. Hunting occurs throughout the Reserve, but is particularly intense in the northern Cuiuanã region and between the Reserve and the Amazonas River. In this area, trade of salted dried meat represents a primary source of income for local fishermen throughout the year. Inhabitants of the Reserve do not eat the meat themselves, but sell it to purchaser coming from Pará state. Most of this meat is sold to farm workers, and the rest is sold in regional markets of small cities near Belém, the capital of Pará. Data from 2004-2006 suggests that more than 50 tons of caiman meat is commercialized annually in the lower Purus region. This represented a total of about 6194 individuals, which about 2851 were *M. niger* and 3343 were *C. crocodilus*. Hunters hunt with harpoons during the dry season, when densities are higher, and use hooks baited with fish, principally during the wet season, when caimans are dispersed into the flooded forest and floating vegetation is abundant. Our data suggested that this exploitation is unsustainable and a ban of at least five years is necessary for a future caiman management program in the Piagaçu-Purus Sustainable Development Reserve.

A Paradigm Shift In Philippine Crocodile Conservation

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Abstract: Following field surveys in the early 1980s that showed that the endemic Philippine crocodile *Crocodylus mindorensis* was on the brink of extinction, the survival of the species has been largely made dependant on a captive breeding program. As long as animals were threatened in the wild by hunting and habitat loss, it was thought wiser to keep animals in controlled circumstances. The breeding of *C. mindorensis* has been successful but so far no crocodiles have been reintroduced into the wild. It is believed that it is not safe to bring crocodiles back to the wild, a situation which is not likely to change as long as no effort is put into mitigating the anthropogenic threats Philippine crocodiles face in the wild. This circular reasoning has effectively stalled conservation efforts for the most severely threatened crocodilian in the world. In 1999, a new conservation program for the Philippine crocodile started in Northeast Luzon after the discovery of a remnant wild population.

Though the threats to these crocodiles (hunting and habitat loss) are similar to other parts of the country, the program has used a different strategy to deal with these problems. A communication and information program was set up to change negative attitudes towards crocodiles. Communities and local governments were involved in decision making processes to design and implement legislation protecting crocodiles and freshwater wetlands. The connection between wetland and crocodile conservation and community well-being provides the necessary incentive for community leaders to be involved and take action: rural communities depend on clean and abundant water supplies for drinking water, washing and agricultural needs, and on healthy fish populations as protein source. The approach has led to the general acceptance of crocodiles by communities in the Northern Sierra Madre and to the protection of crocodile habitat, indicated by a growing population of crocodiles. These *in-situ* conservation efforts provide the experience and example needed to effectively address the threats facing crocodile populations in the wild, which have long halted the reintroduction of the captive population.

1. Introduction

The Philippine crocodile *Crocodylus mindorensis* is a palustrine crocodilian endemic to the Philippines. Previously widely distributed throughout the Philippine archipelago, *C. mindorensis* is now thought to be restricted to a few remote localities on Mindanao and Luzon (Ross and Alcala 1983, Van Weerd and van der Ploeg 2003). The latest national population estimate (Ross 1998) put the total number of surviving non-hatchling Philippine crocodiles at 100. The IUCN Crocodile Specialist Group considers *C. mindorensis* to be the most severely threatened crocodile species in the world and placed the species on the top of the priority list of crocodiles needing conservation action (Ross 1998). *C. mindorensis* is listed on the IUCN Red List (IUCN 2006) as Critically Endangered.

Commercial hunting for the international skin trade decimated Philippine crocodile populations in the archipelago. In 1975 *C. mindorensis* was listed on CITES Appendix 1, banning international trade in the species. Commercial hunting of the species continued for domestic use: skins, specimen, teeth and organs were still widely available on markets in Manila or were smuggled out of the country thru the Sulus in the early 1980s (Ross 1983; WCSP 1997). Crocodiles continue to be killed by rural communities for their meat, and out of fear or for fun (van Weerd and van der Ploeg 2003). The conversion of freshwater wetland habitats for agricultural development fuelled by a rapid growing human population poses another significant threat for the Philippine crocodile, and might prevent a recovery of the species (Ross & Alcala 1983; Thorbjarnarson 1999). Wetlands are among the most threatened habitats in the Philippines (DENR-UNEP 1997; Ong et al. 2002). The widespread use of illegal fishing methods, fishing with dynamite, electricity or chemicals, also poses a heavy toll on remnant crocodile populations.

In theory, the Philippine crocodile is officially protected under Philippine Law: Republic Act 9147 (the Wildlife Act) prohibits the killing of Philippine crocodiles since 2004 (van der Ploeg and van Weerd 2004). Prior to adoption of this act crocodiles only had a protected status in particular areas.

Republic Act 7586, the National Integrated Protected Area System Act of 1992, provided the legal framework for protected areas in the Philippines: it is prohibited to kill wildlife in protected areas except under special conditions (for example for religious purposes of indigenous communities). In practice, the enforcement of environmental laws is generally non-existent; no effective protection exists for the Philippine crocodile in the wild (WCSP 1997, van der Ploeg and van Weerd 2004). Conservation efforts for *C. mindorensis* have been focused nearly exclusively on breeding the species in captivity (Banks 2005). This is based on the idea, widely shared among conservation professionals and policy makers in the Philippines, that negative public attitudes and lack of protection make *in-situ* crocodile conservation impossible (Ross 1983, Messel *et al.* 1992). Based on our experiences in Northeast Luzon, we question these presumptions. In the municipality of San Mariano, rural communities and the Local Government Unit (LGU) have set aside cultural prejudice towards crocodiles and are actively engaged in the protection of a small fragmented Philippine crocodile population in the wild (Miranda *et al.* 2004, see also van Weerd *et al.* this volume).

In this paper, we first review previous Philippine crocodile conservation efforts, particularly the results of the Crocodile Farming Institute (CFI) on Palawan, on which conservation of the species has been made largely dependent of (Banks 2005). In the second part we describe in detail the conservation activities that are currently being undertaken in Northeast Luzon under the framework of the Crocodile Rehabilitation, Observance and Conservation (CROC) project. We discuss three presumptions that have dominated thinking about Philippine crocodile conservation: (1) that crocodiles cannot be protected because of Filipino cultural attitudes towards the species, (2) that crocodiles cannot be protected because of the lack of law enforcement in remote areas, and (3) that crocodiles cannot be protected because it conflicts with socioeconomic development. In the conclusion, we counter these often heard claims and argue that the CROC project offers a model that Philippine crocodiles can, in fact, be protected in the wild with the support of rural communities.

2. The Crocodile Farming Institute

Responding to the alarming decline of crocodiles in the Philippines, a captive breeding program for the species was established in 1987: the Crocodile Farming Institute (CFI). Based in Palawan, CFI had two main objectives: (1) to conserve the two endangered species of crocodiles in the Philippines, and (2) to promote the socioeconomic well-being of local communities through the development and introduction of suitable crocodile farming technology (Ortega 1998). The underlying idea was to develop a crocodile leather industry along the lines of the Papua New Guinean sustainable ranching programs: regulating trade, establishing private commercial crocodile ranches, and improving the processing and marketing of skins (Hollands 1987; CFI 1995; Ortega 1998; Thorbjarnarson 1999). The project was made possible thru a 12 million US$ (1.76 billion Japanese Yen) grant from the Japanese International Cooperation Agency (JICA) (Messel *et al.* 1992).

In principle the rationale of the project was to make a commercial asset from the remaining wild crocodile populations which would provide the needed incentive to conserve them: "*By significantly rehabilitating habitats yet providing local inhabitants within protected areas the opportunity to derive economic returns through regulated harvests, ranching crocodiles is the most effective and sustainable utilization program of conservation*" (Ortega *et al.* 1993: 133). It was argued that the sustainable use of crocodiles would generate benefits for local communities, and provide a counterweight against indiscriminate hunting and habitat conversion (see Figure 1). In practice, however, the attention of CFI has been almost exclusively on captive breeding. Research, for example, has focused mainly on crocodile husbandry and veterinary practices (Regoniel 1997; Ortega 1998; Banks 2005), instead of on field surveys and determining sustainable harvest quota. It was argued that the on-going civil insurgency and negative public attitudes towards crocodiles made an *in-situ* conservation approach impractical in the Philippines, not to say impossible: "*there remain only minor pockets of habitat in which C. mindorensis exists today, and none appears to be protected.* […] *perhaps most important,* [the] *species* [is] *widely regarded as vermin in the Philippines and the probability of* [it] *surviving in the wild is low*" (Messel *et al*. 1992).[3] Thus, because there were so few crocodiles remaining in the wild, the focus of CFI shifted from sustainable use towards captive breeding. In the words of Dr. Gerardo Ortega, who headed the CFI for more than 10 years, such an approach was considered "*the only option left*" (op cit. 1998: 108). The protection of remnant *C. mindorensis* or *C. porosus* populations in the wild, or restocking or reintroducing the species, became a secondary objective for CFI.

Despite initial setbacks, captive breeding has been successful at CFI. From 1987 to 1994 CFI acquired 235 Philippine crocodiles from existing captive populations[4] as well as from the wild. From the very start, concerns were raised that the farm was contributing to the decline of *C. mindorensis* by collecting adult crocodiles from the wild (C.A. Ross op. cit Messel *et al.* 1992: 99). But these concerns were waived: "*Under normal circumstances the removal of breeding adults from depleted wild populations to stock a farm is to be discouraged, because it depresses the reproductive rate of the wild population and slows its recovery. However, it's wrong to leave small nucleus of breeding adults in areas where they are being killed by local people and where their habitat is being alienated to create rice terraces. It would be foolish not to place them in a captive breeding program where their survival is guaranteed and where they can contribute to a conservation program. Such is the situation in the Philippines. Abandoning C. mindorensis in the wild, before real protection can be accorded to them in reserves or sanctuaries would probably have resulted in the final extinction of the species in the Philippines. To save C. mindorensis, they had to be taken from the wild and placed in conditions where they can breed successfully and where the young can survive and flourish until restocking is possible*" (Messel *et al.* 1992: 100). Philippine crocodiles were successfully bred for the first time in 1989. In 1994 CFI had a total of 727 Philippine crocodiles (Ortega 1998).

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[3] Take note that merely demonstrating that a species' population is declining or has fallen below what may be a minimum viable size does not constitute enough analysis to justify captive breeding as a recovery measure (Snyder et al. 1996).

[4] Most crocodiles accordingly came from an existing crocodile farm in Davao.

CFI also made important headway in educating the general public about the ecological and economic importance of crocodiles (Ortega 1998). The farm is open for visitors and attracts around 40,000 visitors per year, making CFI one of Palawan's top tourist attractions. In a visitors guide to Puerto Princesa the farm is enthusiastically promoted: "*the crocodile farm is a showcase of a successful conservation project. The farm breeds two endangered crocodile species found in the country; including the endemic Philippine crocodile. Wanna breed a croc? Ask the caretakers how you can do it right in your own home*" (City Tourism Office). In addition, CFI produced radio plugs, newsletters and posters. It is important to note that these public awareness campaigns focused mainly on Palawan: school children were educated about CFI, and a crocodile conservation week is annually held in Puerto Princesa City (Ortega 1998: 125).

In 1994 the technical support and funding from the Japanese Government was terminated, accordingly due to fundamental differences of opinion between the Japanese and Filipino staff members. The management of CFI was transferred to the Protected Area and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR). The facilities were later renamed Palawan Wildlife Rescue and Conservation Centre (PWRCC). The breeding of *C. mindorensis* continued, and in 1999 CFI successfully produced a second (F2) generation (Rebong and Sumiller 2002). However, budgetary constraints forced PWRCC to temporarily stop the breeding of Philippine crocodiles in 2001. The following year the management of PWRCC was transferred from the PAWB to the Natural Resources Development Corporation (NRDC), a government-controlled corporation, in an attempt to cut the annual operational costs of PWRCC, around US$ 160,000 (8 million peso) (Banks 2005). As it has to sustain its own operations, the focus of PWRCC is now mainly on the commercial production of *C. porosus*. At present PWRCC has around 1,100 *C. mindorensis* , but there remain persistent problems with funding resulting in high mortality rates (Rebong and Sumiller 2002; Thorbjarnarson 2005).

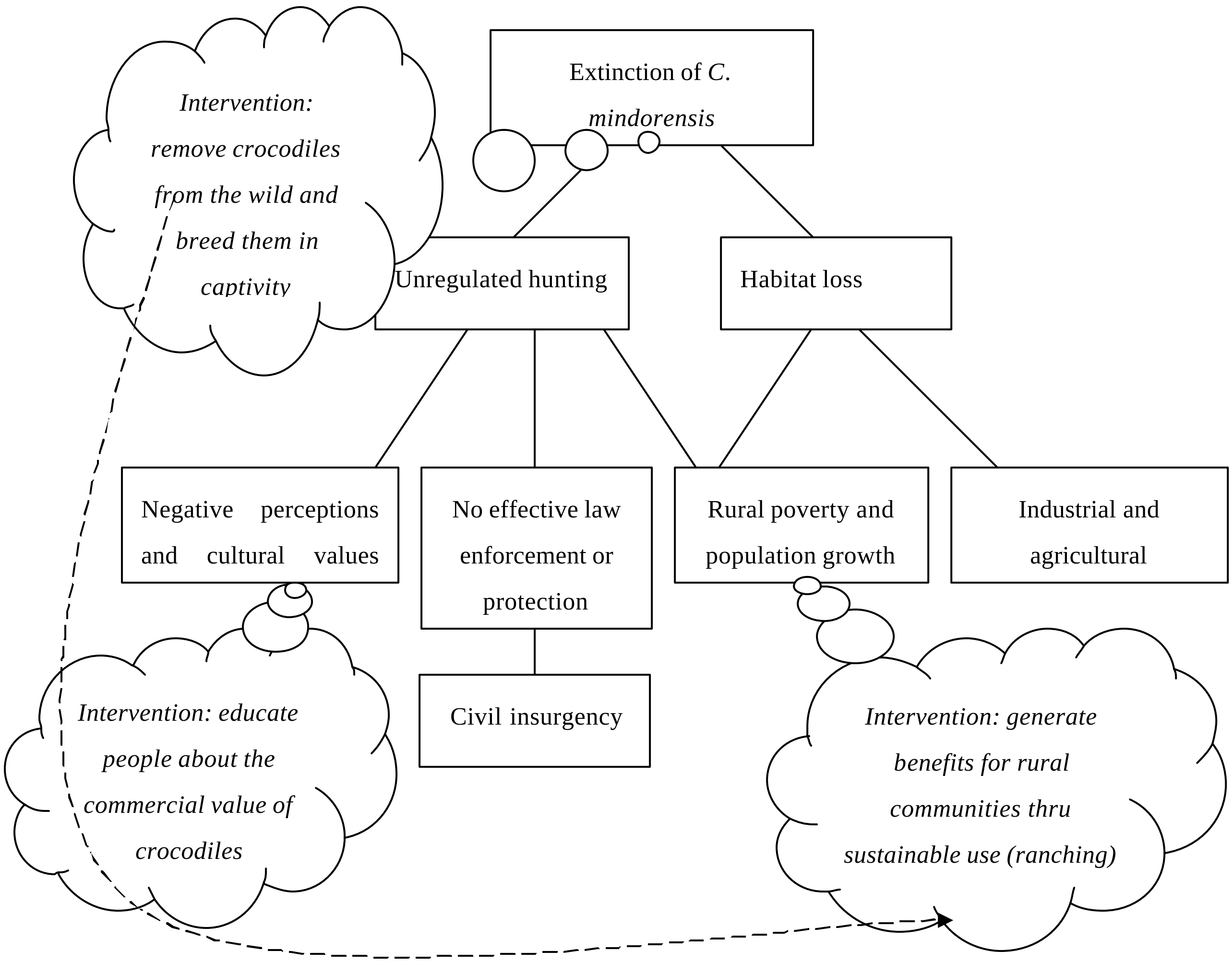
The establishment of crocodile sanctuaries, one of the central aims of CFI, has now been largely abandoned. Several large wetlands were identified by CFI as potential sites where crocodiles could be reintroduced and that could, in the long term, form a base for ranching by local people: the Agusan and Linguasan marshes in Mindanao, and Naujan Lake in Mindoro (Ortega *et al.* 1993). Ortega (1998; 107) reports that no progress has been made in these areas because: "*the [Agusan] marsh is being affected by the growing community of Manobo tribal people residing in the marsh, illegal logging, downstream effects of mining, illegal fishing, wildlife poaching and trading, exotic fish seeding, and slash-and burn farming. […] Linguasan Marsh in Cotabato on the other hand has always been under the control of the Moro Islamic Liberation Front (MILF), a secessionist group. Much of its original area has been converted to agricultural lands and much of this kind of development is still expected to happen.*" CFI has proposed to release *C. mindorensis* in Lake Manguao on Palawan, but local people have strongly opposed these plans.

Nineteen years after the start of the project we can conclude that CFI has failed to meet its central goal: conserving crocodiles in the Philippines.

In practice, CFI now operates as a commercial, closed-cycle *C. porosus* farm, and as such does not generate benefits for communities living in and around crocodile habitat. No sustainable harvesting program or protected areas have been established.

Crocodile populations in the Philippines, *C. mindorensis* as well as *C. porosus*, continue to dwindle in the wild. Interestingly, the failure of CFI is largely being attributed to the inability of the Philippine government to stop hunting and habitat conversion, and to the negative attitudes towards the species; the very reasons the project was established in the very first place! CFI has successfully put crocodile conservation high on the national agenda in the Philippines. Unfortunately this has not led to actual protection of remnant crocodile populations. On the contrary, CFI has reinforced the idea among policy makers and the public that "*these ferocious crocodiles*" (Ortega *et al.* 1993) cannot be protected in the wild in the Philippines. In 1997, the Wildlife Conservation Society of the Philippines concluded that "*there is little future for Philippine crocodiles in the existing (and proposed) wildlife sanctuaries, and that captive breeding is the only hope for the species until public sentiment and awareness of conservation permit effective promotion and implementation of reintroduction programs*" (WCSP 1997: 78-9).

Figure 1: CFI problem analysis and conservation action (Ross 1987; Ortega 1998)

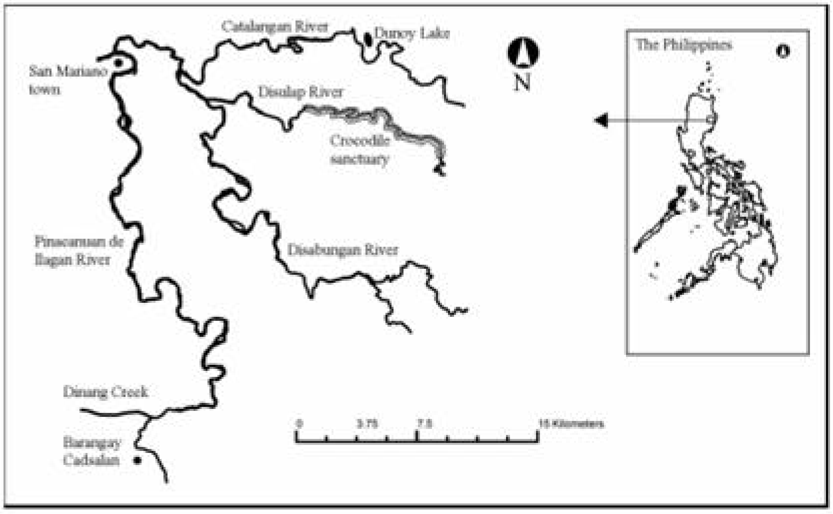


3. The CROC project

The rediscovery of a remnant Philippine crocodile population in 1999 in the foothills of the Northern Sierra Madre led to renewed optimism for the survival of the species in the wild (van Weerd *et al*. 2000). A research and conservation project was established to conserve these crocodiles as a component of the Northern Sierra Madre Natural Park Conservation Project (Van Weerd 2002, van Weerd and General 2003). When this integrated conservation and development project terminated in 2002, crocodile conservation efforts were continued under the acronym CROC: the Crocodile Rehabilitation, Observance and Conservation project (van Weerd and van der Ploeg 2003). A local foundation was established to secure the financial sustainability of crocodile conservation activities: the Mabuwaya Foundation (van Weerd and van der Ploeg 2004). Over the past six years the project has concentrated on the municipality of San Mariano where a small Philippine crocodile population survives in several remote localities (see Tarun *et al.* 2004; van Weerd *et al*. this volume for details on population status).

San Mariano (N 17° E 122°) is one of the 37 municipalities of Isabela Province and covers an area of 1,469 km^2. In 2000 there were over 41,000 people in 36 barangays (villages) in San Mariano. San Mariano is a melting pot of ethnic identities: the vast majority of people are Ilocano immigrant farmers who came to San Mariano in the 1970s looking for land. Today, the indigenous people of the area, the Kalinga and the Agta form a minority with respectively 3.5 and 0.5 percent of the total population. San Mariano ranks among the poorest municipalities of the country: average incomes are around 2 US$ per day (NSCB 2003). Most people in San Mariano are upland peasants. Corn, banana and rice are the most important crops. In general most farmers do not possess any formal land tenure status. Four large rivers transport water runoff from the mountains towards Cagayan River. Numerous smaller creeks feed these four rivers. A number of small natural lakes and newly created water impoundments for irrigation complement the variety in wetlands in this remote upland area. It is in these rivers, creeks and lakes that the Philippine crocodile is still being found. Most villages (barangays) are also situated along streams. People intensively use these wetlands for fishing, transporting goods to the market, washing clothes, fetching drinking water or bathing water buffalos (*carabaos*), and often come in contact with crocodiles.

Figure 2: Map of the municipality of San Mariano.



As in other parts of the Philippines, commercial hunting depleted crocodile populations in San Mariano. In 1970s commercial hunters systematically searched the river system and killed crocodiles for their skin. In many other cases, immigrant farmers purposively killed crocodiles to "clean up" the rivers near their new settlements. These people generally considered crocodiles dangerous for their children and livestock. As a result crocodiles disappeared in most areas in the municipality, and the remnant population remained under permanent threat. The rapid conversion of marshland into irrigated rice fields, for example, led to a significant loss of suitable habitat. Many place-names in San Mariano still remind of the time that crocodiles were widespread: barangay Banag, for example, literally means crocodile in Kalinga. But within thirty years crocodile populations were, as in most other parts in the Philippines, virtually wiped out. A critically small, fragmented crocodile population survived in a few localities near the forest frontier. The Agta and the Kalinga that generally inhabited these remote areas associate crocodiles with the spiritual world and consider it taboo to kill these animals (van der Ploeg & van Weerd 2005).[5] But also in these increasingly human-dominated agricultural landscapes crocodiles face serious risks. Nests are often destroyed and the eggs consumed. Crocodiles are often accidentally killed in gillnets. The widespread use of destructive fishing methods, such as dynamite, electricity or chemicals, also poses a heavy toll on the wetland ecosystems of San Mariano.[6] Some rivers are depleted of fish, not only decreasing the food supply for crocodiles but also seriously affecting local fishermen's livelihoods, especially of poor upland farmers.

[5] The presence of communist rebels in these areas is also an important factor in explaining the survival of crocodiles: the violent insurgency discouraged immigrant farmers to settle in these areas.

[6] Unsustainable land use practices, for example slash-and-burn farming and the intensive use of pesticides, may also have a detrimental effect on the remnant crocodile population. The ongoing erosion of riverbanks caused by logging and slash-and-burn farming is a significant threat for crocodiles and local people: flashfloods often occur in denuded areas, carrying away crocodiles but also houses and farmland. The unrestricted use of farming chemicals is also potentially very harmful to crocodiles and people as river water is used for bathing, washing clothes and as a source of drinking water.

In principle, the destruction of nests and the use of destructive fishing methods are illegal under Philippine law but rural communities are often unaware of national legislation. Very little information is disseminated from the national government agencies to the local level. A good example is that most people in the Philippines, including many senior government officials, simply do not realize that it is illegal to kill crocodiles. With the enactment of the Wildlife Act (R.A. 9147) in 2004 there exists a comprehensive legal framework that would protect the Philippine crocodile in its natural habitat. The use of destructive fishing methods is prohibited under R.A. 8550, the Philippine Fisheries Code. And habitats for critical endangered species should be protected under the Revised Forestry Code of the Philippines (see Miranda *et al.* 2004 for an overview of relevant legislation).[7] But most people remain ignorant about these national policies. In combination with the absence of law enforcement in the uplands of the Philippines this creates a *de facto* lawless situation: violators are never prosecuted.

The Department of Environment and Natural Resources (DENR) is the mandated agency for the implementation of environmental legislation. This responsibility is decentralized to the Community Environment and Natural Resources Offices (CENRO) at the local level. San Mariano falls under the CENRO Naguilian, which has fifty-five staff members. The DENR, however, is plagued by a structural lack of financial resources, technical capacity and credibility. DENR personnel often cite the lack of information dissemination as a reason not to enforce rules and regulations: how does one penalize somebody for clearing his fields in a crocodile habitat, when he is not aware that this is unlawful? Related to this, DENR officials also consider the strict implementation of laws in many cases unethical given the socioeconomic position of the violators, and fear that punishment would fuel the civil insurgency: a widespread practice called "*humanizing the law*." These are indeed very legitimate issues in the Philippine uplands but serve too often as an apology for incompetence and institutional neglect. Political patronage, corruption, a hierarchical bureaucratic culture traditionally focused on resource extraction, and a low esteem for field activities have plagued the DENR and make the national environmental legislation ineffective, and perhaps even irrelevant (van der Ploeg & van Weerd 2004). In the absence of structural administrative reforms, it forces us to consider alternative solutions to protect the Philippine crocodile in the wild.

This grim local reality seems enough justification to remove the remaining Philippine crocodiles from the wild, breed them in controlled conditions, and hope that conditions may improve in the not too distant future. The CROC project chose a radically different strategy to conserve crocodiles in the wild in Northeast Luzon. Extensive fieldwork identified three breeding areas in San Mariano: Dunoy Lake, Disulap River and Dinang Creek (van Weerd 2000; van Weerd *et al.* this volume).

[7] Presidential Decree 705, the Revised Forestry Code of the Philippines prescribes that land owners or claimants should maintain a minimal buffer zone of 20 m around water bodies. In practice this requirement is never enforced.

An in-depth problem analysis was made with all important stakeholders in the region: the LGU of San Mariano, the Protected Area Superintendent of the Northern Sierra Madre Natural Park[8], representatives of the National Philippine Recovery Team, PWRCC, Siliman University, Isabela State University, community representatives, different local and international NGOs, and the national (PAWB), regional (the Protected Areas and Wildlife Service of DENR Region 02), provincial (PENRO) and local (CENRO) offices of the DENR. This led to the design of a long-term *in-situ* conservation action plan for the Philippine crocodile in the Northern Sierra Madre (Lazaro 2002; van Weerd and General 2003) (see Figure 2).

The CROC project is implementing this plan in close coordination with other regional stakeholders, particularly the LGU of San Mariano, the DENR, and the communities in and around crocodile habitat. Three main interventions were identified to tackle the problems facing the Philippine crocodile in San Mariano. First, it was thought essential to mobilize public support for crocodile conservation. A public awareness campaign centered on the theme "*the Philippine crocodile, something to be proud of!*" aims to raise awareness about the Philippine crocodile and challenge negative attitudes towards the species. Five different posters were designed by students of the local Isabela State University and widely distributed in the target communities.

These posters provide information on *C. mindorensis*, the laws protecting the species, and the importance of protecting wetlands. Students of ISU also produced a puppet show and a theater show that are played during barangay *fiestas*, and radio plugs that are aired by the local broadcasting station. In addition, the project produces a quarterly newsletter and a calendar, which are distributed in the remote barangays of San Mariano. Informative bill boards are placed on strategic locations in the municipality. Schoolchildren from San Mariano are supported to visit Dunoy Lake to see the crocodiles in the wild and learn about Philippine crocodile conservation.

Second, the project created crocodile sanctuaries in order to effectively protect the remaining crocodiles in their natural habitat. The LGU of San Mariano enacted four municipal ordinances prohibiting the killing of crocodiles in the municipality (Miranda *et al.* 2004). Community dialogues were organized in the three breeding areas. Here it was proposed to create a buffer zone to minimize crocodile-human interactions, prevent the erosion of river banks, and create suitable nesting conditions. In community dialogues specific management agreements were negotiated upon: in Disulap River, for example, the local inhabitants agreed with creating a 10 meter buffer zone and using sustainable fishing methods only. It was deemed crucial to obtain the consent and cooperation of people because in the absence of permanent guards, the enforcement of rules would largely be based on self imposed control (van der Ploeg & van Weerd 2004). Disulap River became a crocodile sanctuary in 2001 (Miranda et al. 2004). The area was visually delineated with concrete monuments (placed every 50 meter) and informative bill boards. In 2005 the barangay council of Cadsalan passed an ordinance declaring Dinang Creek a Philippine crocodile sanctuary. Dunoy Lake is the only breeding site that is located in the strict protection zone of the Northern Sierra Madre Natural Park.

[8] San Mariano is one of the nine municipalities that are partly covered by the Northern Sierra Madre Natural Park (NSMNP), the largest protected area of the Philippines.

But also here there were intensive contacts with land claimants. An agreement was made not to fish in the lake and to prohibit logging in the near vicinity. A local protection group (the *Bantay Sanktuwaryo*) was trained and deputized by the municipal government to protect the crocodile sanctuaries of the municipality.

Third, improving the quality of life in the remote uplands was identified as an important objective, as it is in all conservation projects in the Philippines. At the start of the project it was aimed to compensate rural communities for their support to the crocodile conservation efforts. Land claimants around the proposed crocodile sanctuaries were assisted in the application for a land tenure instrument.[9] In return the farmers would not cultivate the buffer zone of the sanctuaries. In practice this turned out to be a difficult strategy. Land tenure instruments are issued by DENR and this caused a lot of delays and bureaucratic complications, which frustrated farmers. Linking crocodile conservation to land rights proved also to be tricky in the volatile political atmosphere of the Philippine uplands. There are several instances in which government officials misused these schemes for personal benefits; as a result the NPA (a powerful force in San Mariano) does not support these schemes (see also van der Ploeg and van Weerd 2005).

Therefore the CROC project shifted towards more targeted small-scale interventions to support rural communities. Pump wells were dug to provide clean water. Micro-credits were given to two families in Dunoy and San Jose to start a small shop to sell items to visitors.

In 2004 the CROC project started with a more integrated wetland conservation approach. Based on the realization that it was difficult to generate direct cash-benefits from crocodile conservation for rural communities, it was aimed to make an explicit link between crocodile conservation and sustainable wetland management.[10] People in the uplands of the Northern Sierra Madre depend heavily on wetlands for water, fish and other environmental services. As people are confronted daily with environmental depletion and degradation, there exists broad public support to manage these wetlands in a sustainable way. The CROC project raises awareness about the importance of wetland management and empowers barangay councils to manage their aquatic resources in a way they seem appropriate and in their own interest. In this vision crocodiles become the flagship symbol for community-based wetland management. This becomes especially clear with regard to the use of destructive fishing methods. People in San Mariano are confronted with decreasing fish catches: many fishermen and community leaders would like to prohibit the use of dynamite, electricity and chemicals but are not aware of the legal possibilities and feel powerless when facing outsiders.

[9] Most upland areas in the Philippines are classified as forest zones and are formally public land. Under Philippine law, upland farmers can obtain a 25-year lease contract for the land they are cultivating. There is a variety of schemes for this purpose: the Certificates of Stewardship Contract (CSC), the Social Integrated Farming Management Agreement (SIFMA) and the Community-Based Forest Management Agreement (CBFM).

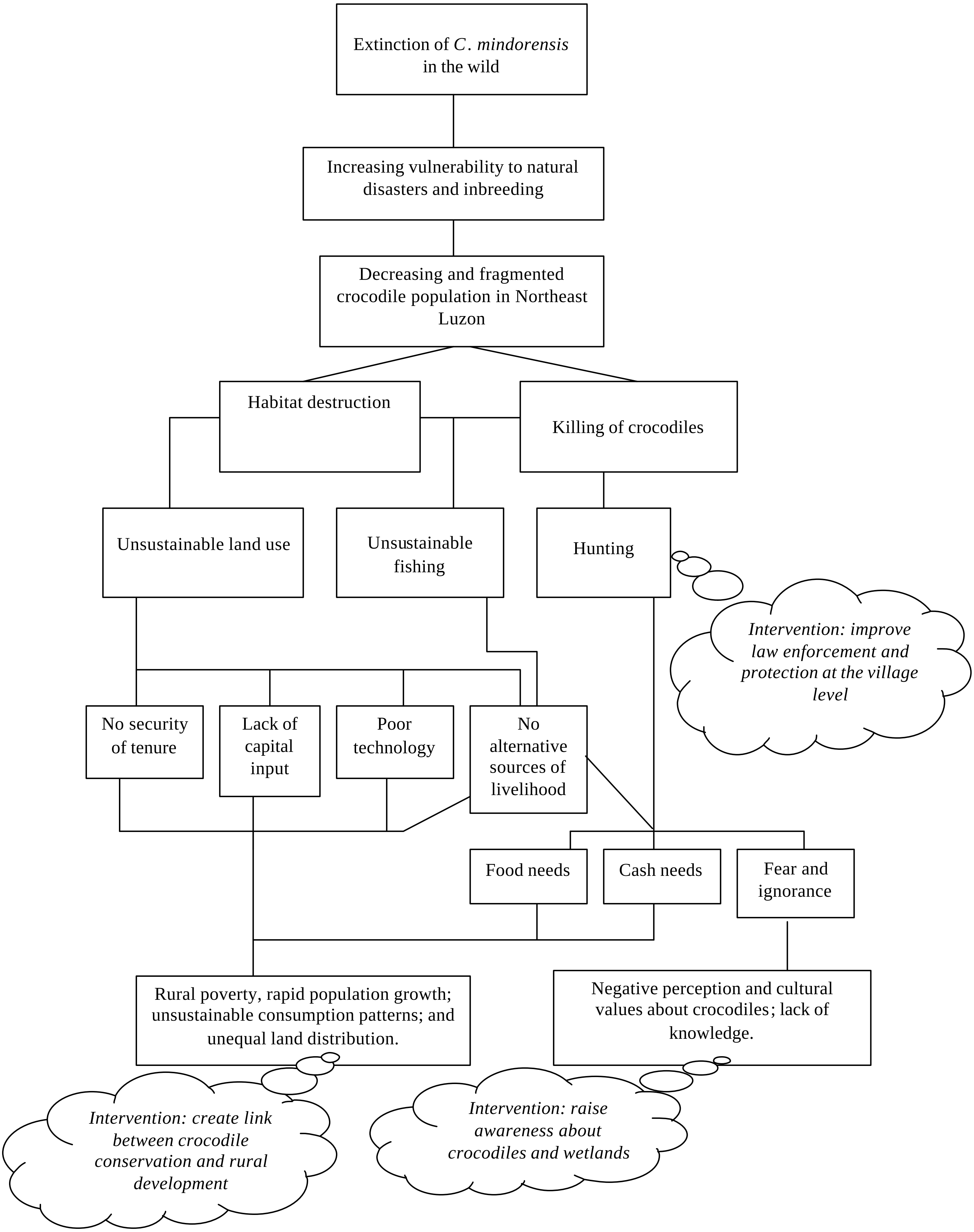
[10] Direct cash benefits can, for example, be generated through ecotourism. However, this is, at present, not a viable option because of the remote location, the absence of facilities and the peace and order concerns. Sustainable use, which generates income for local communities in other countries, is obviously not an issue with this critically endangered species.

The result is a classic tragedy of the commons: everybody is using these methods to maximize their fish catch, which leads to depleted fish-stocks and severe threats to crocodiles. The CROC project assist the *Sangguniang Barangay* (the village council) in designing barangay ordinances to regulate fishing. The village officials are informed about national legislations that can support their local efforts and are trained in law enforcement techniques (Cureg *et al.* 2005). This will enable them to implement and enforce local rules that directly benefits communities and crocodiles.

Six years after the start of crocodile conservation activities in the municipality of San Mariano, the crocodile population is still very low but increasing. Most importantly, reproductive success has substantially improved (van Weerd *et al.* this volume). Hunting of crocodiles has largely stopped in San Mariano (van Weerd and van der Ploeg 2004). Everybody in the municipality now knows that crocodiles are protected by law. The use of destructive fishing methods has significantly decreased: there is broad social basis to ban dynamite, electricity and chemical fishing. The three breeding sites are relatively well protected: people generally respect the buffer zones and crocodile nests are permanently guarded by the *Bantay Sanktuwaryo*. The LGU remains firmly committed to *in-situ* crocodile conservation in the municipality despite changes in political leadership, and considers the Philippine crocodile the symbol of sustainable development in the municipality. The majority of the people in San Mariano is supportive of *in-situ* Philippine crocodile conservation, and is proud crocodiles survive in their hometown (Van Weerd *et al.* 2004).[11]

[11] The Mabuwaya Foundation has established itself as the core agency for crocodile conservation in Northeast Luzon. It has six permanent staff members from the region who are well trained in handling

Figure 3: CROC project problem analysis and conservation action (based on Lazaro 2002) crocodiles, monitoring crocodile populations, and community-organizing.



4. Discussion: challenging the premises of Philippine crocodile conservation

The dominant paradigm in the conservation of the Philippine crocodile has been that it is impossible to conserve the species in the wild, and that captive breeding is the only possibility to safeguard the species from extinction. Three interrelated arguments are forwarded to justify the breeding of the species in captivity. First, it is argued that negative public attitudes towards crocodiles make *in-situ* conservation impossible. Second, the failure of the Philippine government to effectively control rural areas is a prohibitive objection for the preservation of the species in the wild. And third, it is thought that there is a fundamental conflict between Philippine crocodile conservation and socioeconomic development. These ideas have dominated thinking about Philippine crocodile conservation since the 1980s. The CROC project has challenged these assumptions in Northeast Luzon on the ground. In this paragraph we will analyze these premises in detail and look at their implications for Philippine crocodile conservation.

How to mobilize public support for crocodile conservation when people detest crocodiles?

The fact that crocodiles in the Philippines are often considered as dangerous pests has been identified as a major obstruction for Philippine crocodile conservation (Banks 2005). Ross (1983: 27), for example writes that "*Filipinos (with the exception of the Alcala family, Mr. Soldana and other directly involved with this project) do not like crocodiles and the concept of crocodile conservation is foreign to them.*" Many Filipinos indeed consider crocodiles as vermin; especially in coastal areas where *C. porosus* poses a significant threat crocodiles are feared. Where Estuarine crocodiles no longer occur, stories are retold. Immigrants bring these stories inland and project them on the Philippine crocodile, as is the case in San Mariano. In popular culture corrupt government officials, policemen, and selfish athletes are often called *buwaya* (Banks 2005). Hollywood movies reinforce the image of crocodiles as dangerous man-eaters. Crocodiles are often associated with bad spirits (Banks 2005), which reflects perhaps more the Catholic influence of the Spanish colonizer who used crocodiles as symbol for the devil than a unique Filipino trait.[12] Obviously, these negative community attitudes towards crocodiles are not a typical Filipino condition but a worldwide problem for crocodile conservation. Forty years ago public attitudes in Australia and the United States towards crocodiles were also outright hostile (Hines and Abercrombie 1987; Webb and Manolis 1989). The experiences in these countries also show that an effective communication, education and public awareness program can change these negative perceptions quickly: people in the Northern Territory and Florida now consider their crocodile population an important part of their regional identity. These examples bring us to the core of our argument: also in the Philippines it is possible to change negative perceptions towards crocodiles.

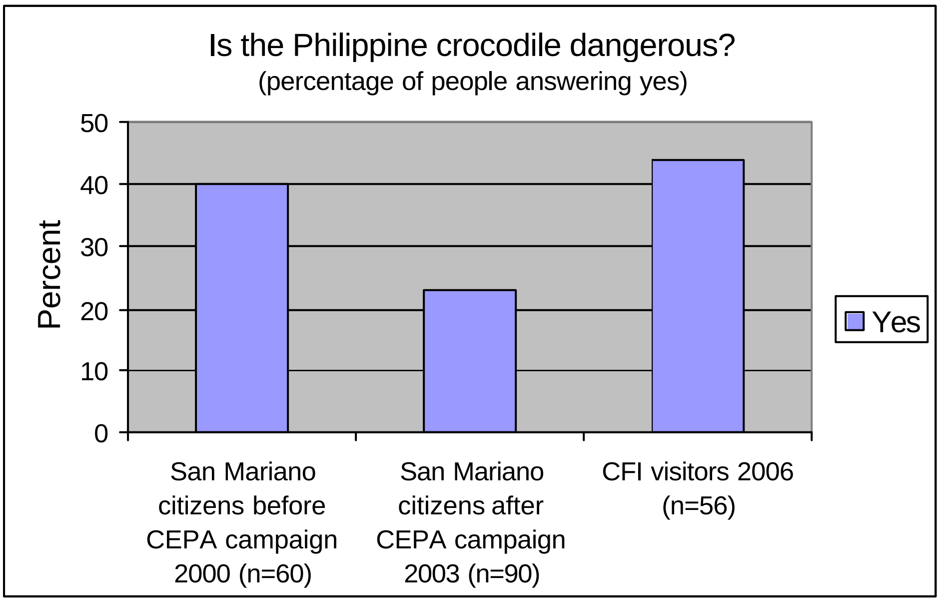
[12] Among the indigenous people of the Philippines crocodiles are often revered and are often considered a symbol of power or male virility.

Figure 4 shows the impact of the public awareness campaigns of the CROC project in San Mariano. Community attitudes towards the species have changed significantly in San Mariano: 90 percent of the people now think that crocodiles have the right to live (Van Weerd *et al.* 2004). The CROC project has specifically targeted people living in and directly adjacent to crocodile habitats. This requires a lot of investments (translating education materials in the local language and distributing these in remote barangays) but has a direct conservation impact. Small-scale public awareness campaigns targeted at people living in close contact with crocodiles will prove instrumental to create the necessary conditions for the recovery of the species. The principle of these campaigns has to be that crocodiles have to be protected in their natural habitat by local communities. This is a fundamental shift from earlier efforts: in many instances the captive breeding program has reinforced stereotypes of crocodiles as dangerous man-eaters that are incompatible with rural development (see also figure 4). Here, the responsibility to solve the "crocodile problem" is primarily placed in the hands of the expert system; not the rural communities. People are informed about the captive breeding program, not on how to protect crocodiles in the wild. For example, when asked what to do in case a crocodile was observed, 80 percent of the visitors of CFI mentioned they would inform the authorities to capture the animal.

Public education has been an important component of the CFI (see above). The target audience largely consists of visitors to the farm and urban dwellers in Manila; people who are seldom in areas where crocodiles still occur.[13] Of course it is of crucial importance to educate the urban middle class, but these people are not necessarily the problem or the priority. CFI also did a lot of work in the rural areas of Palawan to educate people about the importance of Philippine crocodile conservation. Especially around Lake Manguao, a potential release site for the captive Philippine crocodiles, it was tried to mobilize local support to introduce *C. mindorensis*. It did not work out (Ortega 1998). Interestingly it seems that in areas where crocodiles no longer occur, people are less inclined to support crocodile conservation (van Weerd 2002). In rural areas where crocodiles are an integral part of daily life, in San Mariano for example, people do not consider the crocodiles very dangerous. Local fishermen, who sometimes encounter the animal underwater during spear fishing, are not afraid of crocodiles and do not consider the presence of crocodiles problematic. This paradox (people who have actual experience with crocodiles are less afraid of the species and more supportive of its conservation than people in areas without crocodiles) has important implications for crocodile conservation in the Philippines. It reinforces the importance of *in-situ* conservation of remnant crocodile populations: once the crocodiles are gone it will be even harder to win local support for crocodile conservation (Banks 2005: 21). Just waiting until conditions improve might, in fact, lead to a worsening of chances to protect the Philippine crocodile in the wild, even with an effective education program.

[13] Establishing a small-scale crocodile zoo in Manila, as an annex of CFI, in order to educate the public about crocodile conservation was an explicit recommendation of the IUCN Crocodile Specialist Group (Messel *et al*. 1992: recommendation no. 10).

Figure 4: Changing attitudes towards the Philippine crocodile



How to protect a critically endangered species in a context of weak governance and civil insurgence?

A second argument that is often used to justify an exclusive focus on captive breeding is that the Philippine Government can not effectively protect crocodiles in the wild. It is argued that the on-going communist and Islamic rebellions make law enforcement in the Philippine uplands very weak, even in protected areas. This view had important implications: '*We see little future for crocodiles in sanctuary areas, either in the existing ones or proposed ones. Some sanctuaries now exist, but the absence of or low law enforcement leave the crocodiles unprotected. We know of no area in the Philippines […] where crocodiles occur that does not have peace and order problems […]. If sanctuary areas are relied upon for the conservation of the crocodiles in the Philippines […] C. mindorensis will become extinct throughout its range. For this reason, we feel that it is critical to gather remaining C. mindorensis in captivity and hold and propagate them until public sentiment allows them to be reintroduced in the wild with a chance of survival. […] If C. mindorensis is to survive over the next decade it will be through captive populations, not sanctuaries*" (Ross 1983: 26-7).

Weak law enforcement is still a major problem in the Philippine uplands. The DENR lacks the capacity to effectively implement national legislation protecting crocodiles and wetlands. However, the devolution process that is now transforming the Philippine political landscape creates opportunities for localized environmental conservation activities (van der Ploeg and van Weerd 2004). Legally, the Local Government Code of 1991 devolves authority over and responsibilities on natural resource management to local governments units. The *Sanguniang Bayan* (municipal council) can enact and enforce ordinances to protect natural resources within the jurisdiction of the municipality. The *Sanguniang Barangays* can do the same on the village (barangay) level. The problem is that local government officials are often not aware of their new responsibilities. Local governments also often lack sufficient technical skills and knowledge to design, implement and monitor successful environmental programs.

Especially at the barangay level, law enforcement is still weak as a result of a lack of knowledge on legal matters, and a general fear of taking action against possibly politically powerful outsiders.

In San Mariano, the CROC project has assisted barangay officials to design and implement local institutions that protect the Philippine crocodile. In fifteen barangays in San Mariano local ordinances were formulated that prohibit destructive fishing methods or create a local sanctuary (Cureg et al. 2005). As was mentioned above, there is growing awareness at the local level about the consequences of the depletion of fish stocks and the destruction of wetlands, especially about the direct impact this has on the livelihoods of rural farmers. Barangay and municipal officials are eager to act upon it. Capacitating local officials at the barangay and municipal level will lead to specific local conservation action plans and local legislation that is supported and considered legitimate by the vast majority of the people in the barangays, and will thus be respected by local people (van der Ploeg and van Weerd 2004). Providing legal support to barangay officials and strengthening the executive powers of the *barangay tanods* (the barangay police) will make sure there will be an adequate response if these local institutions are not respected. In February 2005, for example, a farmer was fined PhP. 500 (10 US$) for burning a part of the buffer zone of the Disulap River municipal Philippine crocodile sanctuary. And in April 2006, three teenagers were fined PhP. 1500 for using pesticides to catch fish in Diwagden Creek. These fines may not seem very prohibitive, yet they are substantial for local farmers and are considered a fair and just punishment for these particular crimes.[14] And the fact alone that breaking the rules of the barangay will be punished sends out a clear signal to other possible violators.

The Philippine uplands are still largely outside the direct influence of the Philippine Government. The absence of effective law enforcement is still a major drawback for the conservation of wildlife in the Philippines (UNEP and DENR 1997). But this is not, and should never have been, an argument for abandoning the Philippine crocodile in the wild. A centralist approach focused on the DENR might not result in protection of crocodiles and their natural habitat. But localized efforts to empower local governments to protect their wetland resources and crocodiles might form an alternative solution; one that has showed promising first results in San Mariano. Such an approach circumvents the impasse at the national level which has characterized Philippine crocodile conservation for so long.

How to create tangible benefits from crocodile conservation for rural communities?

[14] Sanctions on violations of local ordinances are mostly graduated (increasing sanctions with repetition of violations) and are often more realistic than sanctions in national laws. For example, the national Wildlife Act puts a fine of PhP. 100,000 (US$ 2,000) on killing crocodiles whereas average annual incomes in San Mariano are PhP 50,000 (ca. US$ 1,000) per year (NSBC 2003). The local ordinance of San Mariano penalizes the same offence with 500 Pesos (US$ 10); an amount that is seen as a just and fair punishment by local farmers (van der Ploeg and van Weerd 2004). The devolution of authority makes these local penalties legal, and do not necessarily create problems of macro-coherency. The barangay council and the violator can opt to settle the issue at the local level, without involving the municipal trial court.

Underlying the problems with public awareness and law enforcement is the fundamental belief that crocodile conservation conflicts with rural development. Ross (1983) for example argues that *"it must be realized that when conservation of natural areas or preserves, or […] a wildlife species, interferes or has the potential to conflict with high priority government goals dealing with human settlements and livelihood programs, the socioeconomic improvement of the local human population will have priority."* This pragmatic view is emblematic for how the expert system has viewed the integration of crocodile conservation in Philippine society: crocodiles will only survive if their presence benefits rural communities. This belief also forms the basis for the envisioned sustainable use program of CFI.

In San Mariano too it was argued that a link should be made between crocodile conservation and poverty alleviation. This was done by supporting communities with land tenure instruments and by donating water pumps (see above). But in practice it proved difficult to make an explicit connection between crocodile conservation and these interventions. It succeeded in mobilizing support of selected farmers but did not tackle the underlying threats facing crocodiles such as the use of destructive fishing methods. Questions also remain over the long term sustainability of these interventions: will people remember that the water pumps were donated because of the presence of crocodiles? In order to create tangible benefits from crocodile conservation, the CROC project adopted a wetland ecosystem approach. Here, a link is made between the sustainable management of wetlands and fisheries and the well-being of rural communities. In this approach the Philippine crocodile becomes a flagship species of local environmental management: a living symbol for a better future. This is basically a reversal of the paradigm that crocodile conservation is incompatible with rural development. In San Mariano the conservation of the Philippine crocodile does not yield direct cash benefits for rural communities. But the sustainable management of wetlands provides several indirect benefits to the people in San Mariano (increased fish catches for example).

Summarizing: in areas where people earn less that 2 US$ per day it is obviously very important to create benefits from crocodile conservation. However, these benefits do not necessarily have to come from sustainable use or in the form of cash. Providing alternative livelihoods should not be viewed as a *conditio sine qua non* for crocodile conservation in the Philippines. In San Mariano people were (perhaps surprising) primarily motivated to support crocodile conservation because they consider the sustainable management of wetlands to be in their own interest. In addition, pride, interest and fun proved to be as important as a monetary contribution to the household incomes. Apparently immaterial benefits can be significant incentives for local communities, also in developing countries.

5. Conclusion: a future for the Philippine crocodile

During a workshop organized by the CROC project in November 2004, DENR officials stressed that crocodiles can only be effectively protected in captivity. The barangay representatives were advised to turn over the crocodiles to the DENR or to zoos or tourist resorts that are interested in taking care of the animals (Cureg et al. 2005: 22).

This created some confusion and discussion in which the CROC team desperately tried to convince the DENR officials that the national policy as defined by PAWB is to conserve the Philippine crocodile in the wild. The DENR officials reasoned that if the goal was to conserve crocodiles, it could be best done in captivity as this would be much safer for the crocodiles. Then the CROC project got support from an unexpected side. The barangay captain of Disulap strongly protested the idea of the DENR to remove the crocodiles in his barangay. He argued that this would indeed protect crocodiles but not its habitat or the fish stock (Cureg et al. 2005: 23). What was supposed to become of his barangay without the crocodiles? For the barangay captain crocodiles were an integral element of the sustainable development of his village. In the views of this rural community there was a clear synergy between the conservation of crocodiles and human well-being. This small anecdote from the Northern Sierra Madre captures the essence of the problems with Philippine crocodile conservation.

Over the past twenty years, Philippine crocodile conservation has been almost exclusively focused on *ex-situ* conservation at CFI. In itself captive breeding is an effective (though very costly and technocratic) way of saving a species from extinction but it has to be integrated in a comprehensive *in-situ* conservation strategy (IUCN 2002; Snyder et al. 1996): this was never done in the case of the Philippine crocodile. The goal to set up a sustainable use program was soon abandoned in lieu of a narrow focus on crocodile farming. In fact, captive breeding efforts displaced effective habitat and ecosystem protection; it shifted the attention of crocodilian managers away from the real problems (Snyder et al. 1996, Thorbjarnarson 1999). Indeed very little has been done over the past twenty years to conserve the critically endangered species in the wild. It is argued that negative community attitudes towards the species and the inability of government to enforce environmental legislation make *in-situ* conservation impossible. Underlying this approach is a fundamental belief that crocodiles and man can not coexist. In the absence of large wilderness areas without human disturbance this view implies that there is no future for the Philippine crocodile in the wild.[15]

The CROC project has challenged these premises in practice in Northeast Luzon. In the municipality of San Mariano, community attitudes towards crocodiles have changed. Most people in the municipality take pride in the occurrence of the Philippine crocodile. Rural communities and the local government are actively engaged in the protection of the species in its natural habitat: the use of illegal fishing methods is prohibited and sanctuaries are effectively protected. Crocodile conservation is regarded as an integral part of sustainable rural development. Even though there are no direct cash benefits from crocodile conservation, local communities are motivated to act. Indirect and immaterial benefits seem to be equally effective incentives for communities to support crocodile conservation. Cohabitation is the key word in San Mariano: people tolerate crocodiles.[16]

[15] It is interesting to note here that a recent proposal by a group of crocodile farmers to conserve the Philippine crocodile has focused on reintroducing a number of crocodiles on large private haciendas and keep them there in semi-wild conditions (Ross 2006 pers. comm.). The problem with this approach, characteristically, is that efforts are focused on keeping crocodiles under controlled conditions, while nothing is done about the threats facing existing crocodile populations.

[16] An important factor to explain the success in San Mariano is that no vested interests are at stake.

The coming years will prove whether this community-based strategy will be successful in supporting a recovery of the species in the Northern Sierra Madre.

The attention of the national and international crocodile expert system, however, continues to be captured by the farm. Up to this day discussions about the future of the Philippine crocodile revert back to the crocodiles in CFI. In this paper we plea to refocus on the remaining Philippine crocodiles in the wild. The experiences in the Northern Sierra Madre have generated important lessons about conserving Philippine crocodiles in the wild: it is possible to protect remnant crocodile populations in the Philippines with the support of local communities. The challenge is now to scale-up these initiatives and replicate them in other areas, most particular in Mindanao. The challenge is to listen to the views of the barangay captain of Disulap and many other people in the uplands of the Philippines who believe in a better future for people and crocodiles.

6. Acknowledgements

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Community-Based Conservation Of Siamese Crocodiles In Cambodia

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Abstract: Cambodia's critically endangered Siamese crocodile (*Crocodylus siamensis*) population is highly fragmented and declining. Although most remaining wild stocks are in wildlife sanctuaries, national parks and protected forests, they remain severely threatened by collection for crocodile farms, destruction of wetlands and gallery forests, drowning in fishing nets and electrofishing. With too few government rangers to provide round-the-clock protection, the help of local people is crucial. Fortunately, Siamese crocodiles are generally not considered dangerous, and some communities have strict taboos against harming them.

Since 2001, six villages have become actively involved in protecting and co-managing the largest known colonies, all in the Central Cardamoms Protected Forest. By means of a modified form of participatory land use planning, the people have elected management committees, created sanctuaries, established rules to protect wildlife, rivers and forests, and deployed community wardens to monitor the crocodiles, provide extension, and detect illegal activities. Villagers are rarely paid directly for their efforts, but have instead been assisted to sustainably improve their food security and generate income, e.g., through the sale of forest products. The target communities have developed a strong pride in the crocodiles and successfully rallied to prevent poaching and habitat destruction. This strategy could be usefully extended to other key sites.

The Phylogenetic Differentiation In African Dwarf Crocodile (*Osteolaemus tetraspis*) Based On Molecular Analyses

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Abstract: As the smallest species in the family of Crocodylidae, the Africa dwarf crocodile (*Osteolaemus tetraspis*, Cope 1861) is often kept in zoological gardens. The genus *Osteolaemus* includes one species: *Osteolaemus tetraspis* which is devided into two different subspecies: the western african subspecies *Osteolaemus tetraspis tetraspis* (Cope 1861) and the central african subspecies *Osteolaemus teraspis osborni* (Schmidt 1919). As this species is endangered European zoos are planning to start an European Breeding Program. The longtime aim of this project is to breed *Osteolaemus* in zoos and to reintroduce new populations in the wild. For an adequate breeding program it is necessary to verify the subspecies level of these species. To reach this goal, we analysed mitochondrial DNA features (e.g. COI) of individuals kept in zoological gardens which will be involed in a future conservation project. The subspecies assignment of these individuals is unsure. The obtained molecular data were compared with molecular data of voucher material from different national and international museums to confirm the subspecies level within *Osteolaemus* and to investigate the subspecies differentiation of the zoo individuals. The phylogenetic analysis of the molecular data could not confirm the separation of *Osteolaemus tetraspis* into two subspecies *Osteolaemus tetraspis tetraspis* and *Osteolaemus tetraspis osborni*. Our results will support future management decisions for the conservation of this threatened species.

Crocodilian Osteoderms And Critical Thinking: A Student Approach To Discovery

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Abstract: This presentation is designed to help teachers and presenters facilitate the learning of both subject matter and a critical thinking process. Using crocodilians as the subject matter under investigation, the student is taught by example and practice how to use ten intellectual strategies. These strategies, ranging from physical context to logical sequence, underlie much of all rational thought. As such, teaching these strategies becomes part of the task of educators.

When presenters of environmental education are asked to visit classrooms, they should be prepared to reinforce these ten strategies. Consequently, the goals of environmental organizations and schools merge in the teaching of critical thinking skills.

In terms of actual practical application of this approach, the ten strategies are integrated into a heuristic. This heuristic can be defined as a set or questions or operations that speeds up the process of inquiry and, more specifically, aids the student:

1) in retrieving relevant information already known about the subject,

2) in drawing attention to information not possessed but available by observation and research, and,

3) in discovering ordering principles appropriate to the task at hand. One of the strengths of this heuristic approach to critical thinking is its high degree of transferability to different subjects and disciplines.

The PowerPoint presentation will introduce the intellectual strategies as contained in the heuristic followed by application of each of the ten strategies to the subject of crocodilians, specifically osteoderms. A number of summary handouts and bibliographies will be available after the presentation as well as at the Poster Sessions.

Gharial Conservation In Nepal: Results Of A Population Reinforcement Program

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Abstract: Two species of the family Crocodylidae are found in Nepal: The marsh Mugger, *Crocodylus palustris*, and the freshwater Gharial, *Gavialis gangeticus* Gmelin, 1789. The gharial has a large extremely slender-snout. Adult male has a conspicious narial excrescence commonly called *ghara*. It is listed as endangered Protected animal in the National Parks and Wildlife Conservation Act 1973 of Nepal and on Appendix I of CITES. Gharials are specialised fish-eaters. At present, individuals are distributed in isolated remnant populations in the Karnali, Babai, Narayani and Sapta Kosi river systems. Just recently a new population of more than 20 animals is re-established in the Rapti River of Nepal. All of them are in or adjacent to protected areas. The population of Gharial in the Sapta Kosi River is very low.

Since 1981, the "Gharial Conservation Project" at Kasara in Royal Chitwan National Park began a program for crocodile conservation. More than 500 gharials have been released since then. However, captive breeding at the Gharial Conservation Project is successful but survival of the released animals is very low. The recent observation of the gharial in the Narayani and Rapti rivers indicated that the population of the adult gharial is declining but it is compensated by the regular release of the captive reared animals though the survival is very low. In order to manage this animal efficiently, a program was launched by the Department of National Parks and Wildlife Conservation, in collaboration with the La Ferme aux Crocodiles (Pierrelatte, France) and WWF Nepal Program. The programs include the construction of scientifically improved hatchling pools and regular monitoring of the released gharials in the Narayani River.

1. Introduction

Two species of the family Crocodylidae are found in Nepal: The Marsh Mugger, *Crocodylus palustris* belongs to the subfamily crocodilinae and the Gharial *Gavialis gangeticus* Gmelin 1789, belongs to the subfamily gavilianae is only survivor of the Gavialidae family (Maskey and Percival 1994). The gharial is the most aquatic of all the crocodiles, and its hydrodynamic body allows it to be an excellent swimmer. The peculiarity of the gharial morphology is striking. It has a large extremely slender-snout and adult males grow around their nostrils a bulbous nasal appendages called "ghara", which is absent among other crocodilians. It is listed as endangered Protected animals in the National Parks and Wildlife Conservation Act 1973 of Nepal and on Appendix I of CITES. Gharials are specialized fish-eaters.

In the past, the gharial was commonly found in all the major rivers of the Indian sub-continent, including rivers of Pakistan, Burma, North India, Nepal and Bhutan and in the south to the Mahanadi of India. But today this population has virtually disappeared. In spite of its wide distribution and abundance in the past, it is the least known of the 23 species in the world (Whitaker and Basu 1983). Gharial is one of the seven of the most threatened crocodiles in the world. The main cause of decline of the gharial population: human steal their eggs for food and medicine; killing the gharials for the skin and the superstitious value of the ghara of male gharial; overharvesting and poisoning of the fish in the rivers; caught in carelessly placed fishing nets which result death of the animal; industries pollution in the river; encroachment of the habitat by the extended agricultural practices and finally by the construction of reservoirs and dams in its suitable habitat.

2. Present Status

In the middle of the 1970's, its population was estimated at about 300 specimens in the world. Near from extinction, the species was saved from the brink of extinction, thanks to captive rearing and restocking programs led in India and Nepal. In India after re-introduction program, the population of gharial was counted more than three thousands animals but today it is again decline to a estimated wild population of about 585 individuals among which 450 in Chambal River, 50 in Girwa River, 25 in Son River, 10 in Ken River and less than 50 in other rivers (Poster Session, 18th CSG Meeting, Montelimar, 2006). In Nepal, the remnant population of gharial is found in Koshi, Narayani, Rapti, Babai and Karnali rivers. The estimated number of gharial in Nepal is given in Table 1. In Pakistan, Bangladesh, Bhutan and Myanmar, there is no record of wild gharial in the present situation. They are either rare or been wiped out from the river systems.

Table 1. Estimated gharial population in Nepal

Years	Rivers					
	Narayani	Rapti	Koshi	Karnali	Babai	
2004	31	30	10*	10*	12*	93
2005	27	23	10*	10*	12*	82
2006	22**	25**	10*	10*	12*	79

* Just estimation (Actual population is not known)

** Confirmed population in wild – not more than 47

3. Conservation Initiatives

In 1978, The Government of Nepal with the support of Frankfurt Zoological Society launched a Gharial Conservation Project in Royal Chitwan National Park, thanks to the Government of Nepal. It aims to protect the natural sites where gharials lay their eggs; to collect the wild eggs and hatch the eggs in artificial conditions; rear the young until they reach two meters (length at which they are not subjected to predation anymore) and to release them into the rivers in order to support the wild populations. Since 1981, about 477 young gharials from the rearing centre at the Gharial Conservation Project have been released into the Rapti and Narayani rivers of Chitwan. Some were released into the Koshi, Babai and Karnali rivers (Table 2). These combined programs restored the population of gharial in the wild.

4. Collaboration in Gharial Conservation

Expanding the conservation measure led by the Nepalese Government for more than 20 years, a collaboration between the Department of National Parks and Wildlife Conservation, La Ferme aux Crocodiles and WWF Nepal Program was initiated in 2002, aiming to establish a gharial interpretation centre, initiate a monitor program of the released gharials in the Narayani and Rapti rivers and improve the rearing facilities established at the park headquarter (Cadi *et al.* 2002, Cadi *et al.* 2005).

4.1. Establishment of Gharial Interpretation Center

A gharial interpretation center was established in the premises of Gharial Conservation Project in Chitwan National Park. It includes the information on the historical background and conservation of gharial in Nepal, its distribution and nesting biology, food habits and threat to the survival of gharial in the wild. The interpretation center is very helpful to disseminate the information of gharial conservation to the local communities and the visitors to the park.

4.2. Monitoring of released gharial

From March 2002 to date, 76 gharials have been released at different location in the park. Before each released, each individual were attached with the numbered cattle tag for identification during monitoring. In addition, 20 individuals were equipped with radio transmitter, 10 in March 2002 release and 10 in November 2003 release. The monitoring result shows a homogenous distribution of gharial in Rapti and Narayani rivers (J.M. Ballouard *et al.* 2005) There is a higher concentration of gharial in the Bhawanipur – Kasara sector of Rapti River and Amaltari – Tribeni sector of Narayani River. In comparison with the 76 km of Narayani River, the Rapti River with with only 36 km shows the highest concentration of gharial. This is probably because of the more human disturbances like heavy movement and fishing in the Narayani River and pollution created by dozens of industries established along the Narayani banks.

4.3. Reinforcement of Captive Breeding Facility

Despite the scrupulous care of the hatchlings in captivity, the growth of the hatchlings are recorded very slow and more than 50% of them died within the six month period of their hatching. In the current context of extinction of the species, it is essential to improve the existing condition of the hatchling pools that provide them more heat and a clean pool to reduce the early stage mortality. After discussion with many experts particularly with Dr. F. Huchzermeyer, Chairman of the Veterinarian Committee of the CSG), Gharial Conservation Center and La Ferme aux Crocodiles has designed a improved type of hatchling pool and constructed in the premises of the Gharial Conservation Project, Chitwan National Park (A. Cadi 2005). This new facility will allow overall a suitable environment to reduce the mortality of hatchlings during its early stage contributing more anima survival in the captivity.

5. Recommendations

Participatory Conservation Program: The role of local community to the gharial conservation is very important. They help to collect wild eggs, supply fish for food and take care of the gharial conservation center.

Reintroduction: The re-introduction of the gharial into its suitable habitat is the only solution to built up the gharial population in the wild. In future re-introduce more gharials in the Karnali and Babai rivers of Bardia National Park and Koshi River of Koshitappu Wildlife Reserve.

Pollution Control: Rivers and wetlands are vulnerable to pollution from human activities and increasing industrialization. The water quality should be improved especially in the Narayani River where a high number of gharial is present. Effluents from industrial waste must be treated before it enters into natural water to preserve critical habitat of endangered aquatic species.

Strict enforcement of existing laws: Human activities like heavy movement and over fishing are directly or indirectly responsible for the disappearance of gharial from its habitat. The large scale fishing activities and human movement should be restricted in the Narayani River.

Community Development Initiatives: There is a provision of revenue sharing of Chitwan National Park in the existing National Parks and Wildlife Conservation Act 1973. Some portion of these revenue sharing resources should be canalized to support the local communities such as income generation activities, fish pond/ fishing farm construction for their livelihood and awareness program.

6. Acknowledgement

I would like to take this opportunity to thanks L. Fougeirol (La Ferme aux Crocodiles) for his support to participate the 18th meeting of CSG and his continue support to the Gharial Conservation Project in Nepal. I would also like to thanks Dr. Antoine Cadi, Noé Conservation / SOS Crocodiles, J. M. Ballouard, J. Oison, P. Priol, A Ciliberti and of course Dr. Samuel Martin for their hard work in the field to collect data on the survival of gharial in the Narayani and Rapti Rivers. Last but not least, I would like to thanks Karim Daoues, La Ferme Tropicale for his help from Paris Airport to Paris Airport.

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Danish Crocodile Zoo

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Abstract: There are only a handful of zoos around the world that feature crocodilians as their main focus for displays. The Danish Crocodile Zoo presently has the largest number of crocodilians species on display in Europe, and only 2 or 3 others in the world exceed this number.
Originally opened to the public in 2000, the Crocodile Zoo has seen a very busy few years, leading to plans for expansion. In June 2006, construction will commence on a new facility. This facility has been designed and planned to cater for all 23 species of crocodilians, as well as other large reptiles, including Komodo dragons, and some of the more prominent bird and primate species.
Set for completion in 2007, the new facility will not only feature naturalistic displays of all croc species, but will also feature some unique display techniques, breeding and research areas, accomodation rooms for visiting researchers, as well as all the public facilities such as shop, café, restaurant etc.
With a decade of breeding successes behind us, the new Zoo building will enable us to contribute to the worldwide knowledge of crocodilians, as well as embarking on new breeding programs. As we have been doing all along, we will continue to contribute a portion of every entry fee toward CSG conservation programs.

A Short Presentation Of A Planned Project Concerning The Monitoring And Management Of *False Gharial* Populations In European Zoos

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Abstract: A possible method is being described to assess the general state of health of False Gharials by means of blood samples. Special attention is turned to the correlations between stress and sex hormones, based on the working hypothesis that a rising stress hormone level results in a decrease of the ability to reproduce as well as a reduced immunocompetence.

In combination with clinical blood parameters and the analysis of the keeping conditions reasons for reproduction disorders are to be acquired and, if applicable, removed.

1. Introduction

The False Gharial, *Tomistoma schlegelii*, is a very shy animal and highly susceptible to stress. Only few European zoos keep *Tomistoma*, unfortunately without breeding success, if the animals survive at all. It does happen, that individual animals suddenly die for no apparent reason. Reproduction does not take place. If eggs are laid, they are either unfertilised, or the females deposit them into the water. Obviously – as the situation of *Tomistoma* in nature is now highly precarious, their survival being doubtful - it is important to find out the reasons for this. Keeping the animals' high susceptibility to stress in mind, this trait might prove a decided disadvantage to the health of the animals in captivity. Boisterous visitors, few or lack of hiding places, cohabitation with other (crocodile) species, wrong feeding or keeping often result in chronic stress.

The general state of health of an individual animal must be a central topic in any captively kept crocodile species, because the protection and breeding of these animals in human care is counterproductive or impossible with animals lacking in health. Analysing blood is a straightforward and effective method to assess this state of health. Important parameters are blood ions, products of metabolism, enzymes, and stress and sex hormones. The lab parameters should always be interpreted together with clinical findings, thus merging the information in the diagnosis.

In order to yield useful results multiple blood samples ought to be taken from each animal over a longer period of time. In this way it is possible to monitor a potential breeding stock successfully over a long period of time. The advantage of taking several blood samples from each animal over a certain period of time lies in the possibilities to compare the result, thus discovering trends, improvements, aggravations, and observe hormone variations, which means being able to reveal not only the state of health, but also the cyclic status of the animals. Furthermore it is to be expected - as the authors could observe in other crocodile species – that the animals will become accustomed to being handled for gaining blood samples, which in turn will reduce their acute stress in this situation.

Further important information that can be gained from blood is of the genetic kind. Dr. Jens Poschadel from the University of Hamburg is already analysing blood genetically in order to find out if there are any subspecies of *Tomistoma*. The area of origin of most of the European zoo-*Tomistoma* is not known. Before breeding with these animals can be considered, this question has to be settled, as it would be of no use to anyone to produce genetic bastards. DNA profiling is also necessary to see if the potential offspring can be reintroduced into the wild for natural population reinforcement.

Taking blood samples can be considered as micro-invasive. Usually the animals do not have to be sedated or even anaesthetised. Normally, the taking of samples is a fast and harmless act for the animal.

In small crocodiles blood is taken from the ventral coccygeal vein. If the animal is big, one can take blood from the sinus occipitalis at the nuchal region of the neck.

It has to be pointed out, however, that we do not know how well *Tomistoma* copes with being thus handled. The immobilisation has to be carefully considered in order to prevent injuries in the animal as well as its handler.

Since general physiological reference blood values of *Tomistoma* are not known, blood samples from healthy, regularly reproducing animals should be taken. The analysed blood could then be used to serve as reference blood values for comparison with those blood samples of animals in European zoos. Suitable reference-animals can be found on the farms of Mr. Uthen Youngprapakorn in Thailand, as these animals live in semi-natural conditions and reproduce regularly. Mr Youngprapakorn has already kindly agreed to cooperate.

In case these tests supported the thesis that *Tomistoma* in European zoos are indeed suffering from chronic stress, it would be imperative to pin-point the cause and eliminate it subsequently.

Causes of stress are numerous, but as mentioned before, keeping conditions are predominantly responsible for stress-associated disorders. It is well known that stress hormones (corticosteroids) suppress the production of sex hormones (estrogenes and testosterone). This decrease in sex hormone production can lead to behavioural disorders and/or malfunction of the gonads, resulting in a decrease of fertility and thus the ability to reproduce in the animals. Males become infertile, or do not show mating behaviour, while in females nesting and egg deposition are being disturbed.

It is therefore necessary to collect and analyse data concerning keeping parameters in European zoos and subsequently compare them with similarly collected data from the farms of Mr. Uthen Youngprapakorn, with the aim of not only improving the conditions for the crocodiles in European zoos, but also of creating a manual for improved keeping of *Tomistoma schlegelii* in cooperation with Mr. Ralf Sommerlad. Keeping parameters include the so-called "social infrastructure", i.e. interaction with visitors, keepers, or animals of either the same or different species, and the possibility to evade such contact, population density, sex-ratio, further parameters are space, lighting (quality and amount), temperature, humidity, quality of and availability to food, water, and basking places, possibilities for oviposition (e. g. available nesting material), presence or absence of hiding places, and the "constructional infrastructure", where the main parameters are the depth of the water, the size of the water tanks, present or absent vegetation, semi-natural or "sterile" conditions, ground material.

To elucidate the pathogenesis of the above-mentioned behavioural disorders, namely infertility and lack of mating or nesting behaviour, the amount of stress and sex hormones in the blood should be analysed.

All these parameters, i.e. blood values plus keeping parameters, properly evaluated, would serve to establish optimized keeping conditions and proper medical care for *Tomistoma* in zoos.

2. Blood parameters

- **Calcium**: bone metabolism, feeding/UV-B, state of female cycle, kidney function
- **Phosphate:** bone metabolism, feeding, kidney
- **Uric acid:** kidney, feeding, gout
- **Ammoniac:** liver, feeding, kidney
- **Bun** (urea)**:** kidney, feeding, kidney failure
- **AST** (aspartate aminotransferase), **ALT** (alanine aminotransferase): indication of cell degeneration ✍ liver, skeletal muscle, heart
- **LDH** (lactate dehydrogenase): cell degeneration ✍ liver, heart, skeletal muscle
- **Albumin:** generation in liver, so malfunction of liver detectable
- **Total protein:** malfunction of protein metabolism (liver) and malabsorption (gut)
- **Glucose:** blood sugar ✍ good stress indicator ✍ hypoglycaemic shock often lethal in crocodiles.
- **Triglycerides**: In crocodiles naturally higher (milky white plasma), metabolised in the liver, in females dependent on sexual cycle (vitellogenesis), parameter for undernourishment
- **Haematocrit**: degree of hydration, anaemia
- **Leukocytes**: processes of inflammation
- **Differential blood count**: exact percentage differentiation of the leucocytes, viral, bacterial or parasitic infections, evaluation of other blood components, assessment of morphological features of blood cells

3. Important Hormones in Stress Management and Reproduction

- **CRH** (Corticotropin releasing hormone): Produced in the hypothalamus, stimulates the pituitary gland ✍ secretion of ACTH
- **ACTH** (Adrenocorticotropic hormone): Originates from the anterior lobe of the pituitary gland ✍ stimulates the adrenal gland ✍ secretion of corticosteroids
- **Corticosteroids:** Androgens, gluco- and mineralocorticoids; made in the adrenal gland; effects on sexual behaviour, water balance, metabolism, circulation, immune and nervous system. Chronic stress augments negatively these effects, giving rise to e. g. sexual malfunctions and immunosuppression.
- **Glucocorticoids** (i. e. cortisol): Important role in regulation of the intermediate metabolism and the immune response. Higher concentrations over a longer period of time can result in malfunction of the gonads, immunosuppression, osteoporosis, obesity, diabetes, muscle weakness/degeneration.
- **Catecholamines** (adrenaline, noradrenaline): Stress of all sorts causes release from the adrenal medulla; among others effects include fast energy supply, increase of heart rate and blood pressure, stimulation of ACTH- secretion in the pituitary gland.
- **GnRH** (Gonadotropin-releasing-hormone): produced in the hypothalamus ✍ stimulates adenohypophysis to release FSH and LH.
- **FSH** (Follicle-stimulating hormone), **LH** (Luteinizing hormone): built in the anterior lobe of the hypophysis (adenohypophysis) ✍ stimulates gonads to produce the sex hormones: estrogens (ovaries) and testosterone (testicles).
- **Testosterone:** Primarily male sex hormone; induces differentiation and growth of genitals and male attributes, regulates sex drive and reproduction.

- **Estrogens** (i.e. Estradiol): Primarily female sex hormone; induces differentiation and growth of sex organs and female attributes, regulates sex drive and reproduction ✍ maturation of eggs in ovaries

4. Stress

Stress is the answer of the body to internal or external stimuli (stressor), which endangers the internal balance of the organism when becoming chronical. The capacity of the body to adapt to continuous stressors is limited and often this causes severe damage up to a lethal effect.
Many factors can cause stress. To stressful circumstances, the body reacts primarily with a hormonal answer. The centre of the stress regulation is the hypothalamus, which is controlled by the sensory regions of the brain. Especially during short-term stress reactions the adrenal medulla is activated through Releasing Hormones from the hypothalamus, which mediates a release of catecholamines (adrenaline and noradrenaline), those hormones responsible for controlling mostly short-term stress reactions.
In stress situations the hypothalamus releases more CRH (corticotropin releasing hormone). CRH stimulates the adenohypophysis which secretes ACTH (adrenocorticotropic hormone). The function of ACTH is to provoke the adrenal cortex to release corticosteroids, which are those parameters that are to be measured in the blood. Normally, the adrenal cortex sets free a certain amount of cortisol. This is part of a negative feedback-loop, inhibiting the hypothalamus in its production of ACTH, thus controlling its own cortisol concentration in the blood, so that the level of circulating hormone is not too high. Yet, with continuous stress, this negative feedback-loop is by-passed, because the “normal” level of cortisol in the blood is raised. This causes many disadvantageous effects, e. g. on the production of sex hormones and on the immune system.
It has to be pointed out that in reptiles the adrenal gland is composed differently to mammals. This, however, does not affect the underlying principle or the way the hormones work.
In the natural sexual cycle with the adequate stimulus, the hypothalamus releases GnRH (gonadotropin-releasing hormone). This leads to production of Follicle-Stimulating-Hormone (FSH) and Luteinizing Hormone (LH) in the adenohypophysis. These stimulate the gonads to produce more sex hormones. An increasing concentration of sex hormones normally is the elicitor for mating behaviour.
A negative correlation between corticosteroids and sex hormones could be shown in several animals. On the one hand, the hypothalamus is inhibited in his production of GnRH through an increased level of corticosteroid, due to stress. Owing to that, the adenohypophysis is producing less FSH and LH with the result that the gonads are releasing less sexual hormones. Behavioural disorders and reproduction disturbances become evident.
On the other hand, raised stress hormone levels inhibit the receptors for estrogen and oxytocin at the oviduct, resulting in turn in the inhibition of the labour-pains and in dystocia. Veterinary treatment is therefore often necessary in captive animals.

5. Conclusion

The evaluation of blood parameters as well as the collection of data concerning keeping conditions provide an insight into the states of health and the ability to reproduce, which may enable us to take corrective action resulting in breeding success and a healthy breeding stock.

Furthermore it would be possible to prove or to confute the thesis that stress is responsible for the absence of breeding success.

Zoos have long since monitored their mammals in this manner, and are hugely successful in their mammals' breeding efforts. So these methods are field-tested, and they are highly overdue for *Tomistoma*, especially considering its endangered status.

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Study & Conservation of crocodilians in Latine America

Impacts of tourism motorized boating and recreational capture on caimans

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Abstract: Many protected areas in the world are facing growing tourism pressure and some uncertainties on the impacts of associated disturbances. In French Guyana, the Kaw-Roura Nature Reserve combines rivers, wet savannas and mangroves. The Kaw River hosts some emblematic species, including one of the last viable populations of Black Caiman (*Melanosuchus niger*).

We assessed the impacts of motorized tourism trips by boat on the river and recreational capture on the Common Caiman (*Caiman crocodilus*), as part of an environmental impact assessment of tourism ordered by the manager of the nature reserve. Disturbance of caimans by motorised boats was assessed by comparing the diving distance of caimans approached by boat, in straight line by night, either with engine switched on or paddling with engine switched off. The diving distance is 2.4 times higher when the engine is on than when paddling. Thus, using engines generates a higher disturbance than paddling. In addition, recreational capture of caimans for tourist exhibition is a common practice inside the reserve. Such a practice is known to induce a physiological stress, which may be associated with lowered survivorship. Growing visitation and motorised tourist activities, with frequent recreational captures, may have a significant impact on caimans, either by lowering their survival or reproduction due to repeated stress events, or by inducing emigration out off the area. We thus recommend (i) to stop engines while approaching caimans, (ii) to implement an ecotourism charter to persuade tourism operators to ban recreational capture, and (iii) to develop the use of electric boats.

Keywords: Caiman, tourism, frequentation, French Guyana, stress, capture, impact, protected areas

Résumé: Beaucoup d'aires protégées dans le monde sont confrontées à une fréquentation touristique croissante et à une incertitude sur les impacts de cette fréquentation. La Réserve naturelle des marais de Kaw-Roura, en Guyane française, associe rivières, savanes inondables et mangroves. La rivière de Kaw abrite des espèces emblématiques, et notamment une des dernières populations viables de Caïman noir (*Melanosuchus niger*). Nous avons évalué les impacts de la circulation des embarcations motorisées et de la capture recréative (avec relâché) sur le caïman à lunettes (*Caiman crocodilus*), dans le cadre d'une étude d'impact des activités touristiques commanditée par le gestionnaire de la réserve (Association ARATAÏ). La perturbation induite par les embarcations motorisée sur les caïmans a été quantifiée en comparant la distance de plongée de nuit, entre deux modes d'approche en ligne droite: embarcation avec moteur allumé ou moteur éteint. Il résulte que la distance de plongée est 2,4 fois plus élevée lors d'une approche moteur allumé que moteur éteint. L'utilisation d'embarcations à moteur génère donc un dérangement plus important que l'approche à la rame. Par ailleurs, la capture récréative des caïmans pour les montrer aux visiteurs est une pratique courante dans la réserve. Or un telle pratique est connue pour induire un stress physiologique important, se traduisant éventuellement pas une baisse de survie. Une fréquentation touristique motorisée importante et les captures récréatives répétées pourrait donc avoir un impact négatif sur les populations de caïmans, soit en diminuant leur survie ou leur reproduction du fait des stress répétés, soit en les faisant fuir hors de la zone fréquentée. Nous recommandons donc (i) d'approcher les caïmans en éteignant le moteur pour minimiser la perturbation, (ii) de mettre en place une charte d'écotourisme encourageant les prestataires touristiques à arrêter la capture récréative des caïmans, et (iii) de développer l'usage d'embarcations électriques.

Mots clés : Caïman, tourisme, fréquentation, Guyane française, stress, capture, impact, aires protégées

1. Introduction

Many protected areas in the world are facing growing tourism pressure. Quantification of the impacts of visitation is difficult. One of the main reasons for that difficulty is the absence of data that allow a comparison of visited and unvisited areas. Another reason is the difficulty to distinguish whether the impact is purely created by tourism or by other human activities such as hunting, external pollution, etc. However, measurement of the impact of tourist activities can be very useful to managers in order to justify any policy on visitor flow regulation.

The Kaw-Roura Marshes Natural Reserve (KRMNR) in French Guiana is a *Ramsar* site (wetlands playing an international role for some targeted species conservation), including rivers, flooded savannas, and mangroves. The Kaw River shelters emblematic species like the Black Caiman (*Melanosuchus niger*). Creation of the reserve in 1998 was followed by a spectacular recovery of caiman populations. The cessation of hunting is the principal factor explaining this trend.

However, the river is easily navigable, and for the last 10 years, tourism has strongly developed there. As uncontrolled eco-tourism activities may have a negative impact on local animal populations (e.g. De Groot, 1983. Klein *et al.*, 1995; Bookbinder *et al.*, 1998), the NGO ARATAI, which runs the KRMNR, together with the Regional Environment Management Administration, has asked for an assessment of the effects of lodging visitors within the KRMNR, as well as the effect of using different observation methods on fauna (birds and caimans). Also, we have evaluated the effect of different motorized boat types used for tourism, and the impact of capturing caimans for tourists entertainment.

As black caimans are vulnerable animals (the conservation of this particular species is one of the main goals of the KRMNR) and their population density is low, we chose to carry out the experiments on the Spectacled Caiman (*Caiman crocodilus*). This species is common in the reserve and sympatric with the Black Caiman.

2. Caimans of the Kaw-Roura Marshes Natural Reserve (KRMNR)

Of the 103 reptile species recorded within the KRMNR boundaries, four species of caimans are represented: Spectacled Caiman (*C. crocodilus*), Black Caiman (*M. niger*), Dwarf Caiman (*Paleosuchus palpebrosus*) and Smooth-fronted Caiman (*P. trigonatus*).

During last century black caimans were extensively hunted for their meat and valuable hides. The species is now classified as “Lower Risk” in the IUCN-World Conservation Union’s Red List of Threatened Species (IUCN, 2006). Formerly present throughout the Amazon basin, populations now only remain in Brazil, Ecuador, Peru, Guyana, Bolivia, Suriname, Colombia and French Guiana (Thorbjarnarson 1998; Republic of Brazil, 2006). The black caimans of the Kaw marshes are supposed to be one of the last viable populations for this species (see Document N°1), in addition to Brazilian (Rebêlo & Lugli, 2001; Da Silveira, 2002; Republic of Brazil, 2006; Von Mühlen *et al.*, 2006), Ecuadorian (Asanza, 1999) and Bolivian populations (Cisneros *et al.*, 2006).

Contrary to the three other caiman species, which are legally hunted French Guiana but are not marketable, the Black Caiman has been officially completely protected since 1986 by a Ministerial Decree. In the natural reserve, hunting of these four species is totally prohibited. Populations of these species have been monitored for several years in the reserve (see Document N°1).

Document 1: Principal results of the study of the populations of caimans of the Kaw-Roura Natural Reserve (Thoisy & White, 2000; Thoisy, 2001)

- Black caimans are definitely less represented in the accessible zones of the Reserve and in particular because of the few adults (size more than 2 m) and newborn hatchlings. This suggests a strongly disturbed population. Reasons for this imbalance could be the pressure of former hunting, increasing tourist visitation, and poaching.
- On the Kaw River, observed densities strongly fluctuate throughout the year. The lower the water levels, the more black caimans can be observed in savannah. During the high water season, the most important densities are observed where forests surround the river. The capture-mark-recapture study, which begun in 2002, will allow determining if individuals recorded on the river are resident or if they are migrant individuals coming from ponds of the core of the marsh. So far, only two zones of nesting were identified: within the marsh, and in the Approuague.
- The Spectacled Caiman is more abundant in savannahs bordering the Kaw River. Its distribution seems to be related to water levels.
- Evolution of the population size of the Red Caiman (*Caiman yacare*) is difficult to forecast, and determinants of fluctuations remain to be identified.
- The follow-up by capture-mark-recapture is supplemented by a genetic study which, by quantifying genetic variability among individuals, will allow identifying major reproductive subunits and estimating effective population size. First results indicate that individuals from the central marsh and those of the Kaw River come from the same population, and are genetically differentiated from individuals of the Approuague.

2. Materials and Methods

2.1. Selected indicator of sensitivity

The distance to which an animal can be approached before it escapes is an indicator of response to disturbance caused by man, often referred to as approach distance, and is widely used for many vertebrates, particularly birds (e.g. Klein *et al.*, 1995; Carney & Sideman, 1999; Triplet *et al.*, 2003), and also crocodiles (e.g. Webb & Messel, 1979; Ron *et al.* 1998; also see 'proportion of eyes only', e.g. Webb & Messel, 1979, Rebêlo & Lugli, 2001). For caimans, the distance to which an individual could be approached before it dived was used as indicator of effective disturbance due to approach by boat. Our goal was to measure the disturbance induced by motorized boats used for observing caimans. Induced disturbance was compared between two modes of approach: (1) engine on, (2) engine off (approach with paddles). In both cases, the speed of approach was slow (*c.* 5-7 $km.h^{-1}$), corresponding to local policies.

2.2. Measurement conditions
Distance measurements were taken at night (18:00-20:00 h; nights without moon) using an infrared rangefinder. Approach distances were measured in two sectors of the nature reserve: upstream (until Maripa) and downstream of the village of Kaw (to the Roy channel for the downstream). The search was divided into two periods: one hour of approach with the engine on, and one hour of approach with the engine off.

The mode of approach used first or second was alternated from one evening to another. The boat used for approaches was a 5 m long boat from the reserve, equipped with a 5 HP engine.

2.3. Data analysis
Differences in approach distance between modes of approach were tested by analysis of variance (ANOVA). Distances were Ln-transformed (i.e. Ln(distance+1)), so that the variable followed a Normal distribution, a necessary condition for ANOVA to be reliable. The addition of a constant (i.e. 1) was required because some diving distances in the dataset equalled '0'. The effect of mode of approach was tested in presence of the effect of study zone in the ANOVA model. Potential difference in the effect of mode of approach among study zones was tested by including an interaction term in the model, i.e. interaction approach mode x study zone.

3. Results

Only spectacled caimans were recorded during experiments. Surveys provided 82 measurements of approach distance: 51 with engine turned on (22 upstream, 29 downstream), 31 with engine turned off (8 upstream, 23 downstream). Two observations of creches were not taken into account.

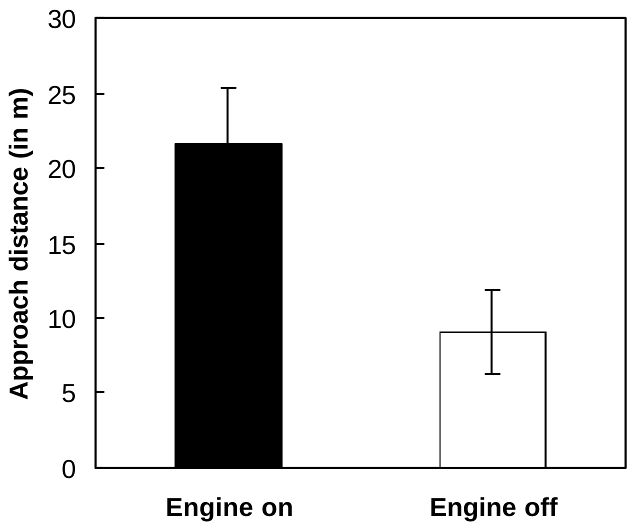

Figure 7: Approach distances (mean ± standard error from raw data) of spectacled caimans according to approach mode: engine on and paddling with engine off.

Approach distance significantly differed among modes of approach (dependent variable was Ln(distance+1) in all tests; $F_{1,77} = 5,33$, P = 0,024; Fig. 1), with a longer approach distance with engine on (mean ± standard error from raw data; 21.6 ± 3.8 m) than when paddling with engine off (9.0 ± 2.8 m).

Impact of mode of approach did not differ between study zones ($F_{1,76} = 1.22$, P = 0.272), although average approach distances differed between study zones ($F_{1,77} = 14.67$, P = 0.0003): 28.7 ± 4.7 m upstream, and 10.2 ± 2.8 m downstream.

4. Discussion

4.1 Impact of the mode of approach

Should the approach be with or without engine, the distance before escape/diving by caimans significantly differed from 0 (null), i.e. whatever the mode of approach, approach of caimans induces disturbance (see also Webb & Messel, 1979). This disturbance could be minimized while remaining at a distance greater or equal to 15 m from caimans (upper limit of 95% confidence interval, 0.05 a-level, with engine off).
Induced disturbance differed among modes of approach. Escape distance for motorized boats was 2,4 times longer than when paddling with engine off. Entertaining observation with motorized boats thus stresses caimans more than with non-motorized boats. Frequent tourist visitation with motorized boats may thus have detrimental impacts on physiological conditions and demography, and in the long-term on caimans population size inside the reserve (but see Rebêlo & Lugli, 2001, where caimans wariness did not vary between human-disturbed and not disturbed areas). A study on the physiological response to stress generated by the approach may allow evaluating precisely to what extent caimans are disturbed by those practices.

4.2. Difference in sensitivity to disturbance between zones of study

The important difference in diving distance between upstream and downstream study zones (three times higher) is not interpretable with currently available information. An explanation could be that sensitivity to disturbance is increased due to higher frequency and/or intensity of man disturbances (such as capturing for entertainment, hunting, former fishing, poaching) upstream than downstream. Indeed, repeated approach and capture of caimans is known to increase their diving distance (Ron *et al.*, 1998; Rebêlo & Lugli, 2001). Another explanation could come from size/age-dependent wariness. Large crocodiles are more prone to diving in response to approach than smaller ones (Webb & Messel, 1979). If upstream individuals were on average larger/older than downstream ones i.e. age-structure of the population would be younger), then it would explain that they were inclined to dive sooner when approached. These explanations deserve to be appropriately tested.

4.3. Impact of mode of lighting

It has not been possible to test the effect of various sources of light on diving distances of caimans. A complement to our study would be to test if the diving distance differs between approaches with lamps with weak (e.g. flashlights, frontal) or strong intensity (e.g. halogen lamp). Indeed, emitted light can be very different among these light sources. Light outputs were very different between two types of head lights, i.e. with traditional incandescent lamp and with diodes (Fig. 2).

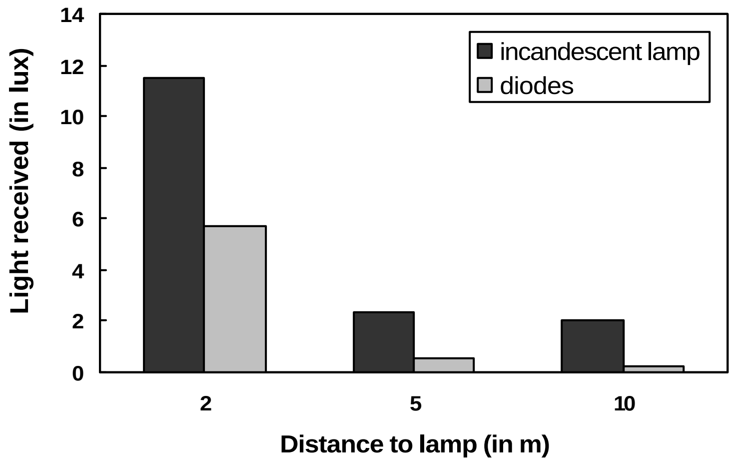

Figure 8: Light emitted by headlights with incandescent lamp or with diodes, and received at different distances.

4.4. Limits of the method

Approach experiments could not be performed in zones with low human frequentation because the whole Kaw River is subjected to an important river traffic by fishermen, hunters and tourists (but see Rebêlo and Lugli, 2001, suggesting that such a test may not reveal differences in wariness).

4.5. Impact of entertainment capture

Estimating the impact of entertainment captures carried out during tourist outing on caimans could not be quantified. To understand and qualify the impact of capture and handling for tourist entertainment, we took part to a night excursion organised by a local tour operator.

Document 2: A typical caiman night excursion

"We were very grateful to the tour operator who invited us along to take part in his organised tourist expedition. The outing started at around 19:00 h, departing from the village of Kaw after a meal. Tourists embarked on a large aluminium hull without any specific briefing and directly started searching for caimans. A specialist in capture of caimans was standing in front of the boat, guiding the pilot. This search began from the canal, in Kaw village, and we could already perceive the bright eyes of caimans, but without any successful capture attempt. Then we went upstream above the village on the Kaw River. After about 20 minutes and two or three unsuccessful attempts, the specialist ended up capturing a Spectacled Caiman of *c*. 80-cm length. The animal was used for show with the aim of teaching basics of anatomy and biology of the species. While handling the animal in different positions, the specialist pointed out the number of toes of the front and rear feet, sex, and the nictitating eyelid by sticking his finger in the eye… Then the animal was passed on to adults willing to handle it or to take picture souvenirs. The animal was then released and the search continued. Later on, a second individual, definitely smaller, was captured, and this time, it could be handled by children tourists (see above pictures). Without worrying at all about the expectations of tourists taking part to the outing, the tour leader sets out again and tried in vain to capture other individuals in vain for more than one hour. Successive approaches, turns, decelerations, accelerations, reverse gears, were exhausting and bored passengers. The tour leader was probably afraid that capturing of two caimans only would not be satisfying enough for tourist passengers to estimate the trip worth their money. No information was given on conservation of the species, neither any information on the Reserve nor its activities for the conservation of caimans. Although tourists commented the astonishing sight of the fireflies flying all over the Kaw savannahs, they did not receive any comment on other topics than caimans capture…

This experiment highlights that night outings are exclusively regarded as "caiman" trips on behalf of tour operators of the Reserve of Kaw-Roura. During the described visit, absolutely no other topics was tackled, and in particular not caimans conservation.

Note that caimans capture is practiced by most tour operators in the area. However, some operators do not capture caimans during their outings, contributing to create a more appropriate atmosphere, likely more pleasant than basic tracking of caimans.

The described trip allowed observation of obvious behavioural signs of stress, such as repeated intimidation blows. It is difficult to believe that sexing, stacking fingers in the eyes, and handling by tourists did not induce stress. Even handling by trained biologists, taking care of the individuals, induces a subsequent behavioural response of disturbance avoidance (Ron *et al.*, 1998; Rebêlo & Lugli, 2001).

Generated stress could have a quantitative, important impact since each evening, each tour operator, is likely to capture several individuals (two or more), which, multiplied by the number of colleagues (sometimes five simultaneously), could represent an important proportion of the caimans population inhabiting the few kilometres of river to be regularly handled and disturbed.

For all individuals, or maybe only more susceptible life stages as hatchlings and young individuals, stress due to regular disturbance and capture may decrease their survival (e.g. Romero and Wikelski, 2001). The potential impact of capture for entertainment purposes may thus not be neglected. A follow-up over 20 years showed that the population of a North American terrestrial tortoise (*Clemmys insculpta*) drastically declined in a few years because of the opening to tourism to the geographical area occupied by the species (Garber and Burger, 1995).

Given obvious signs of local animal population recovery in the Kaw-Roura Reserve (e.g. increase of some bird species, young age-structure of caimans), it would be unfortunate that tourism reverses these positive trends.

4.6. Hormonal measurement of stress in caimans

In complement to behavioural indicators of disturbance-induced stress (e.g., approach distance, but also bradycardia, ventilation; e.g. Gaunt and Gans, 1969), endocrinological measures would allow quantifying actual physiological stress. A common practice is to quantify concentrations of circulating 'stress' hormones such as corticosterones and adrenalins. Several studies highlighted the stress generated by capture in crocodilians. Lance and Elsey (1999) showed with captive-bred alligators that capture causes a severe stress, detected by a progressive increase in plasma concentration of circulating corticosterone. Jessop *et al.* (2003) showed that capture induced an increase in energy expenditure (i.e., increased glycaemia with emission of corticosterone subsequently to handling).

Whereas interpretation of behavioural indicators of stress in crocodilians could be arguable, information from hormonal concentration is irrefutable evidence of physiological stress due to capture. Various studies linked chronic stress of animals with a fall of their survival (e.g. in birds, Müllner *et al.*, 2004; in iguanas, Romero & Wikelski, 2001). Therefore, it is possible that repeated capture for tourist entertainment have a negative impact on caimans population dynamics. Investigations to be implemented subsequently to our study would be to evaluate the physiological impact caused by entertainment capturing on spectacled caimans by endocrinology measurements of stress under various modes and frequencies of capture, and between zones with or without entertainment capturing.

4.7. Regarding safety measures

In addition to the problems of the impact of capture on caimans welfare, this practice presents considerable risks in terms of safety of tourists. This is all the more true as there are children who start handling the smallest captured individuals. Tourists are therefore not safe from a bite, which can be severe. It could eventually also result in tour operators being bitten.

5. Recommendation guidelines

A regulation and the setting of more respectful tourist practices are recommended to reduce the potential negative effects of tourism on the fauna of the Kaw-Roura Reserve.

5.1. Additional studies to measure the impact of capturing

The natural reserve certainly needs a precise and sure evaluation of the impact of capturing caimans, based on eco-physiological and demographical approaches (Wikelski & Cooke, 2006). Information from similar studies is available (Lance & Elsey, 1999; Jessop *et al.*, 2003).

To refine these results and define alert indicators, the natural reserve could get engaged in a deeper ecological monitoring of caimans populations:

- by focusing the study on the recovery of a caiman population after setting up strictly protected areas in sectors with the lowest human frequentation.
- by adopting a more comparative approach, between hunted sectors (out of the reserve) and not hunted ones, and inside the reserve, between sectors subjected to human activities and those free from it

5.2. Nocturnal tourist activities to be regulated

Regarding the management of nocturnal tourist activities, it may be asked to turn off the engine when approaching to a distance shorter than 50 m from an area potentially occupied by caimans. It would minimize disturbance to caimans, facilitate their observation without capture, and would also increase the excursion's quality by being quieter.

To counteract the cessation of capturing caimans for tourists, one could propose to develop the interpretation of the nocturnal environment on the Kaw River by diversifying the presented aspects. The nocturnal excursion would then not only be a 'caiman tracking excursion', but oriented more toward nature interpretation and conservation needs awareness.

To shift toward night excursions without caimans capture, the Reserve could lead tour operators to move forward to single capture excursions and then, after two or three years of time, to the ban of capture.

These two points could be included in a future "charter for ecotourism" in the Kwa-Roura Reserve signed by volunteer tour operators. Due to cessation of caiman poaching within the Reserve, populations are now recovering. One can expect, as seen in some other South American countries (Brazil, Venezuela), to end up with a situation where the visitor can approach the caimans without difficulties and observe them very easily, even in some case during the daytime.

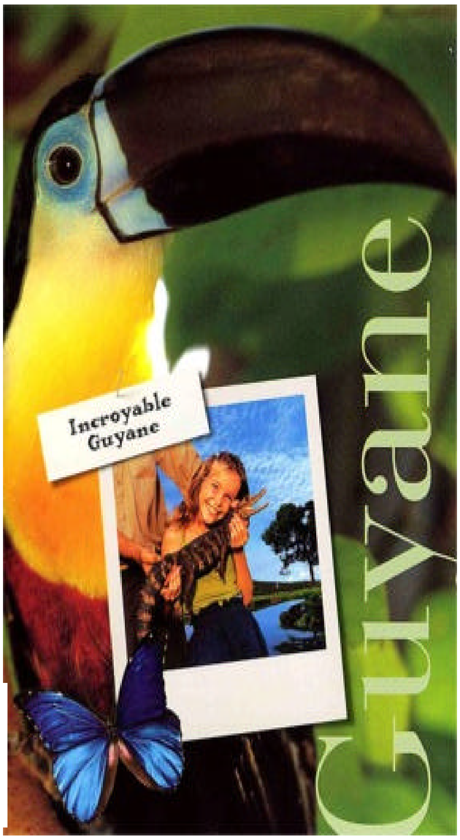

Figure 3:
Leaflet for the promotion of tourism in French Guyana
(Source: Guyana'sTourism Committee)

An image of eco-tourism for French Guyana and the Kaw-Roura Reserve
If one wants to promote an image of eco-tourism in French Guyana, based on the richness of its natural resources, its biodiversity, its forests, its rare and significant species, it is important to respect the resources which one makes promotion with. With increasing awareness of tourist professionals, promotional campaigns based on the capture of caiman in French Guyana may come to disappear (3: the "small girl with the caiman" on the promotional documents of the Committee of Tourism of French Guyana). The offer and the promotional campaigns giving that kind of image inevitably contribute to create the demand, which in turn contributes to maintain the offer. It would be welcome to break this vicious circle. To limit the offer of caimans capture should, in the long-term, reduce tourist demand for this kind of product. This must of course be compensated by richer tourist activities in their educational contexts and discovery of a natural legacy.

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A Collaborative Ecological Study Of The Black Caiman (*Melanosuchus niger)* In The Rupununi Savannah Region Guyana: A First Year Report

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Abstract: An ecological study of the black caiman (*Melanosuchus niger*) is underway in Yupukari Village, Guyana, where we have constructed a field station and built educational facilities to benefit local Macushi Amerindians. The study involves training and hire of local Amerindians, 11 of which have participated in the project thus far. In the 2005/06 dry season, 146 non-hatchling black caiman were marked and 11 recaptured. Early trends show a skewed ratio of males to females (107.39) = (73.3% males; 26.7% females) Total length ranges have been .567 meters to 3.62 meters; 25 caiman (17.1%) have been males over 3 meters; 8 (5.5%) females ranging from 2.5 to 2.73 meters in total length. Data collected and treatment on each specimen include GPS capture points, caudal clippings, and PIT tagging. Morphometric, behavioral, and ecological data are recorded. 25 nests were examined. Data from 511 eggs from 15 undisturbed nests were obtained showing an egg clutch range of 26 to 39; mean 34. Additionally, 69 hatchling caiman from six clutches were studied. This project is planned to run at least two more full seasons, adding dietary analysis, genetic, and radio telemetry components. The local human/black caiman interface is being quantified as well, and caiman-based ecotourism is developing as a non-sacrificial economic benefit.

Problem and Significance

The Rupununi region of Guyana currently hosts a rare, largely recovered population of *Melanosuchus niger*. A village-based long-term study in the Rupununi is an opportunity to gain an understanding of the black caiman's ecological role and its physical and cultural context with local Amerindians and wildlife managers. Through this knowledge it may be possible to build a new consensus for its management from the local level on up. Beyond its inherent value as a prime component of its ecosystem, an intact population may also serve as a sustainable resource for the indigenous peoples, whether for hides, meat or ecotourism.

Basic goals of the study

1. Conduct a detailed ecological study of the black caiman within its Rupununi environment and for comparison with populations elsewhere.
2. Recommend management protocols to resolve human/caiman conflicts.
3. Develop a cadre of indigenous naturalists to provide the basis for the continued study of crocodilian species, to educate local people on conservation and management issues, and to assist in the implementation of sound conservation practices.
4. Promote active discussion of black caiman issues at village and regional levels.
5. Enhance our knowledge of the natural history and biology of black caiman through scientific publications and other media.

1. Introduction

Surveys conducted in 1983 by Dr. Federico Medem found black caiman to be close to extinction in Guyana. While that statement may have been a harsh verdict, those surveys did follow a period of intensive hide-hunting beginning in about 1955 that may have continued until the 1970's, despite the government's five-year ban on caiman hunting initiated in1968 (Gorzula and Woolford, 1990). Surveys in 1990 by Gorzula and Woolford found *Melanosuchus* populations making a recovery in the North Rupununi, where they were locally abundant. Those surveys showed an uncorrected population density of 3.7 per shoreline km in local river systems (41.2 kms surveyed), with an overall non-hatchling population estimate of 2000-4000. At that time this was the largest quantified *Melanosuchus* population anywhere.

My own dry season surveys (March/April 2001) in a more circumscribed area of the region encompassed critical areas of habitat over 17kms of rivers, lakes and creeks, showed densities surpassing those appraisals. Mean river densities of non-hatchlings were 4.5 per shoreline km and in three principal lakes; 164 non-hatchling caiman were observed for a 16.9 per shoreline km rate during peak dry season. A nursery area containing five creches of offspring was located in a forming oxbow off the Rupununi River, indicating strong reproductive activity in the area. Furthermore an overall healthy balance of size classes were represented, including evidence of individual caiman over 4 meters in length, estimated at close range and confirmed by track measurements. During these surveys, efforts have been made to eliminate census misrepresentation from inadvertent incorporation of spectacled caiman, (*Caiman c. crocodylus*) which occurs in the area in populations of 10% or less than that of black caiman.

That same year (2001) a team from Iwokrama guided by Dr. Graham Watkins performed wide-ranging surveys (unpublished) in four river systems and associated water bodies within the Rupununi wetlands area. While their overall density findings were slightly lower but similar to mine (to 4.18 per shoreline km in rivers), they defined the broad distribution of *Melanosuchus* in the region. The total numbers of 2443 actual counted caiman overall, and 1695 non-hatchlings, represents a quantified magnitude of black caiman matched only by the Northwest Brazil population at Mamiraua. The discovery of that thriving population of crocodilians was overlooked by scientists until 1993 and has since been intensively studied, chiefly by Dr. Ronis Da Silveira of the University of Amazonas, but also by Dr. John Thorbjarnarson of the Wildlife Conservation Society and others. (Thorbjarnarson and Da Silveira 2000)

2. First season goals and activities

2.1. Develop a learning system

Human capacity-building in the form of training interested locals to serve as members of the research team has been a critical point of development for the project this year. In conjunction with the identification and incorporation of a key local counterpart (Ashley Holland) to assist the primary researcher, 11 men and 2 youths (age 14) from Yupukari Village have made themselves available to the project.

They have demonstrated dedicated work habits under often challenging conditions, and have learned rapidly the field skills needed to make the project work. Indeed the researcher has benefited greatly from the ingenuity, attention to detail, and local knowledge possessed by Macushi men. The exchange of knowledge that continues to fuel the project goes hand in hand with its progress. Explanations of all aspects of the work are disseminated at village meetings to maximize awareness of what is happening in the study.

The biggest obstacle we have faced has been human interference on the part of young male villagers with the HOBO data loggers we have placed in caiman nests. The apparently ingrained habit of destroying caiman nests and eggs and setting savannah fires has disrupted data collection and destroyed at least three (of eight) HOBO units, some burned to a crisp in fires that completely consumed nests. Our response has been to go back into the classrooms and educate children, especially boys, about what we are doing, what the study is all about, and why it is important not to interfere with nests. Live juvenile caiman, snakes, turtles, and various natural artifacts are regularly brought into the classroom, and several computer slide show presentations have been presented.

Beyond the outright tearing up of nests or destruction by capriciously lit fires, there is a level of direct human persecution of larger specimens of black caiman and spectacled caiman) that we have been attempting to quantify. In the past year, at least 6 specimens of black caiman ranging from 2.2 to 3.3 meters have been killed in local ponds or in the river. Another black caiman, a large male, was intentionally shot after it was observed closely approaching villagers on several occasions as they bathed, washed clothes, or otherwise used the river. Usually the cause of death has been attributable to the discovery of tri-pronged, barbed arrow points buried within the carcasses of caiman. An equal or greater number of caiman have been found alive with these objects lodged in their bodies some apparently having been there for months. There is a historical basis for some of this behavior, although much can be explained under the heading of “juvenile mischief” and does not fit into anything like a "well cogitated" local management plan.

There have been several fatalities and a larger number of bite incidents attributed to this species over the past half century under various circumstances. Along the portion of the Rupununi system south of the Kanuku Mountains, a fatality was recorded in March of 2001 at Katoka Village, and another 1 May 2006, approximately 160 kilometers downriver at Apoteri Village. Both victims were young boys. In both situations it was reckoned that the presence of dogs may have first cued the caiman to approach the victims so closely. There is a growing perception within the region that the caiman situation as it affects humans is worsening. While outright black caiman attacks on humans may still be very rare, the presence of greater numbers of larger caiman and an increasing human population could combine to generate more incidents. I am attempting to establish a baseline for behavior and attitudes towards this species, and to gain a more accurate historical record of attacks and deaths from black caiman in the region. This will help to determine courses of action and educational plans aimed at improving the co-existence between this large predator and the people using the same environment.

2.2. Explore ecotourism

Already in the first year of the project it appears that ecotourism may hold significant potential as a non-sacrificial role for black caiman. Visitors to our field station ("Caiman House") and paying guests at nearby Karanambu Eco-Lodge have followed our capture team in a second boat (from a safe distance) and been able to observe catching operations and participate in data collection once the caiman are properly restrained. Representatives from professional tour companies are formally pursuing this option as an exciting new component in their wildlife-viewing businesses, creating an economic incentive for preserving black caiman. People are willing to pay to see them in a way they have not been able to in the past, and to have skilled interpreters on hand to explain exactly what they are seeing.

2.3. Census

We have continued to do local censusing of black caiman and spectacled caiman in our mark-recapture sites, and in some peripheral areas beyond. Within our study area we are seeing black caiman densities to match or exceed 5.0 per river kilometer under good dry season conditions. Higher densities of above 15.0 per shore kilometer are seen in lake and pond situations. However we plan to extend our censusing to include wider areas of the habitat, the total range of black caiman and the sympatric spectacled caiman. We have also identified populations, and examined individuals of the two other crocodilian species in the country: the dwarf caiman (*Paleosuchus palpebrosus*), and smooth-fronted caiman (*Paleosuchus trigonatus*). In at least one river/creek section of the Eastern Kanaku Mountains three of the four species (excepting *P. palpebrosus*) can be found within the same river kilometer.

2.4. Identify critical areas of habitat use

We are locating and quantifying areas of reproductive activity and nesting sites and collecting detailed information, so far greatly lacking in studies of *Melanosuchus*, on nest construction, clutch size, clutch mass, incubation temperatures, and of special interest, maternal/paternal behavior associated with nest maintenance, nest defense, and parental care of young. Information gathered on the reproductive aspects of black caiman biology in this first year have surpassed expectations and provided a strong guide for expanding that part of the investigation. Looking at nesting situations, chiefly in savannah lakes and ponds puts us in contact with black caiman habitat that does not overlap capture sites. The active collection sites, one riverine, the other a lake and creek site permanently connected to the Rupununi River, extends further our view of habitats utilized by black caiman.

Eight HOBO data logger units have been implemented thus far in the study for the collection of temperature data inside flagged black caiman nests. The use of these in this first year has been mostly experimental. It was important to see how the HOBOS would perform under these field conditions and how they should be adapted for use. The best data has been obtained by HOBOS placed inside of plastic Ziploc bags which are in turn placed inside rigid polystyrene containers. While some of the containers were scored or damaged by adult females releasing their young, the units inside were not destroyed. Another unit was not recovered at a nest which was completely predated by a tegu lizard. Out of eight initial units, data was obtainable only from three.

2.5. Investigate diet

Thus far we have only made spot observations of this part of the ecological investigation but intend to obtain some stomach contexts during this year's wet season as well as next dry season. One impression we gained while handling caiman early in the dry season was the observation that many of the animals were looking heavily fed. This included male caiman, whose condition could not be confused with gravid females, adults of which could appear heavy with eggs at this time of year. It made sense that the caiman were experiencing greater feeding opportunities as lower water levels led to concentrations of aquatic organisms being available for food.

2.6. Determine home ranges and patterns

We have collected useful information on the general distribution of black caiman in the defined study section of the Rupununi River this year and during previous surveys. GPS points accompanying each capture extend our picture of distribution patterns and how they relate to age, gender and size class. However this data needs further analysis, and the important data that can be gained from affixing telemetry equipment on individual black caiman during the dry season is yet to be collected; this will commence in the 2006-7 dry season.

2.7. Collect for future genetic, toxic metal and toxic compound contamination studies

We are saving tissue in the form of tail scute clippings for this analysis but may use blood samples as well in future. Academic contacts such as Dr. Izeni Farias at the University of Amazonas in Manaus (This year at the U. of Puerto Rico) are committed to teaming up for this phase of the work.

2.8. Consider the question of sustainable use, direct or indirect, of black caiman and products derived from it.

Ecotourism as an indirect product is being tested as a profitable outlet in which black caiman have a valued role. There are continuing discussions within Guyanese agencies concerning the potential harvesting or prescribed culling of black caiman in selected areas within the population. We continue to hope that the present study will produce quality information that will guide policy decisions to be made about this species should exploitative utilization become a viable option.

2.9. Collect field data

2.9.1. Mark-Recapture

As of this report is given we have resided one year at Yupukari Village. Efforts during this year have necessarily concentrated on developing familiarity with the local geography and specific habitats used by black caiman. During these explorations we have not only identified areas containing all size classes and both genders, but have also located, captured, and examined multiple individuals of the other three species of crocodilian found within the country. (*Caiman c. crocodylus, Paleosuchus trigonatus, and Paleosuchus palpebrosus)* As an ecological component relating to black caiman, the spectacled caiman (*Caiman c. crocodylus*), is the most important of the three species, having the greatest ecological contact with *Melanosuchus.*

The active mark-recapture portion of the project, from 24 September 2005 until 4 May 2006, has consumed 146 man days and 1232 man hours, chiefly working with four-man crews and a single boat. A key condition for doing this work, especially with the larger specimens, is the exposure via dropping water levels of large sandbanks on which to work. These naturally-provided work spaces make it far easier to handle caiman over two meters in length on a regular basis. Other challenging elements of doing the work in this environment are working in the current of a river, finding sufficiently deep water in which to handle large specimens and coping with numerous exposed or submerged snags.

The first study area is the Rupununi River within a 10 kilometer radius of the Yupukari Village landing. The second location is "Simoni Lakes," entered by traveling a one-kilometer creek 25 kilometers downriver from Yupukari. This site is seasonally more isolated and closed from the main river system, although flooding wet season waters can connect it with adjacent savannahs as well as through the permanent creek. We collect the following data and execute the following protocols for each caiman:

1) Date and time of capture, and capture methods.
2) GPS position of capture and specific habitat description.
3) Behavior of caiman at the time of approach and capture.
4) Gender determination.
5) Caudal scutes are clipped for future field identification.
6) PIT tags are injected into tail.
7) Nuchals, dorsal scale rows, double caudal scale rows and verticals are counted.
8) Four head/skull measurements.
9) Snout-vent length, vent, tail, and foot measurements.
10) Girth or mid-body maximum, and general condition assessments.
11) All caiman are weighed (Pesola scales or dynamometer).
12) A full inspection of the caiman is made to describe anomalies, pitting, injuries, or distinguishing characteristics of any kind. (e.g. rake marks etc.)
13) Condition of chin spots: strongly marked, fading etc.
14) Weather conditions, moon phase and visibility, and air and water temperatures are recorded.
15) Crew description, starting and finish time of mission.
16) Comments on "other wildlife" including, on selected nights, a one-way censusing of black caiman and spectacled caiman.

While certain collecting biases are inevitable, many dictated by the caiman themselves, we have attempted to capture caiman as opportunistically and indiscriminately as possible to present a true picture of the population. From our growing sample of 146 non-hatchling individuals, we are seeing what appears to be a healthy population of *Melanosuchus* showing a balanced age and size structure. We are at the same time seeing a preponderance of males in the population (107.39 =73.3% males vs. 26.7 % females). There have been 11 recaptures of marked specimens in the study so far, 6 within the first site and 5 within the other, suggesting that we are at least beginning to penetrate the population.

Regarding size structure based on measured total length our sampled population of non-hatchlings, or young-of-the-year breaks down as follows:

1) .557 to 1.0 meters……9 specimens (6.2%)
2) 1.01 to 2.0 meters…...48 specimens (32.9%)
3) 2.01 to 3.00 meters… 64 specimens (43.8%)
4) 3.01 to 3.62 meters….25 (all males, 17.1%)

We believe we are observing a nicely balanced size class distribution of black caiman, indicative of a healthy population. We have not yet collected “top end” males, which exceed 4.5 meters in this population.

2.9.2. Eggs and Hatchlings

Day work has consisted of exploring habitat, observing various diurnal patterns of activity (basking behavior, maternal care of nests and young). From 04 November 06 through 13 December 06, approximately 25 days were spent in the field locating nests and collecting data on a full range of black caiman nesting behavior.

69 hatchlings from six different nests were collected shortly after the hatching season ended in February 2006. Based on egg data collected in 2005, hatchling *Melanosuchus* are predictably large. A total of 15 of 25 black caiman nests examined were discovered in time to yield complete nest/egg(s) data sets. This part of the work took place between 04 Nov. and 13 Dec 05. Most nesting took place from the last week of October 05 through the third week of Nov. 05. Some of the earliest nests and eggs deposited were subject to flooding damage in early Oct. 05.

80 % of nests (12/15) are shade dominated nests (mean assignment = 87.4% shade) composed chiefly of leaves, twigs, and other available ground debris. The 3 sun dominated nests (mean assignment 93.3%) are composed chiefly of savannah grass species.

Counter-intuitively but confirmed by field measures, sun dominated nests are significantly cooler internally at 28.1 degrees C./86.4 F. as compared to 30.1 degrees C./90.2 F. It is theorized that generally high ambient temperatures, nest composition, material density in nests, and, for sun dominated nests, coloration and reflectivity of nest materials (light-toned grass types), are some of the factors directing these thermal dynamics. Temperatures were typically taken in mid afternoon.

Mean number of eggs per clutch = 34.0 (N =15); mean clutch mass = 4776 grams (4.776 kilos) (N = 15). The mean of “clutch means” (N = 15) for egg mass = 141.8 grams (range = 128.0 – 157.6 grams as nest egg mass averages). Of the other 10 nests examined 5 were partially or completed predated, 2 showed hatching activity, 2 were damaged by flooding, and 1 was destroyed by burning (human lit fires)

For all 25 nests, as many as 9 (36%) were visited by tegu lizards (*Tupanambis teguxin*). Of these, 7 (28%) seemed to have been completely predated.
Of the 15 nests for which full data was obtained, eight had some degree of hatching occur, four were destroyed, burned or otherwise tampered with by humans, three received destructive visits by predating tegu lizards.

Nests that have been visited or actually raided typically show the marks of a surgical strike or what I am calling a "salipenta" bore. "Salipenta" is the local name for tegu, the bore describes a hole or tunnel that runs laterally into the middle of the nest and terminates at the egg chamber. Eggs seem to be removed entire and then taken some meters away to be consumed. Only a few, perhaps two or three eggs at a time, are removed, so that it may take weeks before a nest of over 30 eggs is depleted if the female black caiman is unable to intervene. Tegus do very little damage to nest structure, whereas other potential predators, such as crab-eating raccoon (*Procyon cancrivorous*) crab-eating fox (*Cerdocyon thous*), and jaguar (*Panthera onca)* are likely to be more destructive during their incursions on a nest. We have seen marginal evidence to suggest the activity of these mammalian predators in this area thus far.

Between 3 February and 28 February 68 hatchlings from six different nests were discovered in pods or creches in ponds or along the Rupununi River itself.

Table 1: Size of hatchlings

Group N°	**Number in group**	**Estimated age** (days)	**Mean mass** (g)	**Mean total length** (mm)
1	6	1-2	89.5	339.2
2	24	7-10	101.7	347.6
3	24	5-7	91.3	329.4
4	9	21-24	102.3	355.1

While judgments and facts presented about this population of black caiman resonate within the scope of merely a year, trends concerning certain aspects of Rupununi black caiman are emerging. The strongly skewed gender distribution in the population, nesting and clutch dynamics, hatchling qualities, natural predation, or destructive human behavior, may very well hold up as information is compiled, but diet, information about individual home ranges, and genetic qualities of the population still must be investigated. Updated censusing within all important sections of this species' Guyanese range still needs to be done. With these aims in mind, another two full years or more can easily be devoted to this project.

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Monitoring The Distribution, Abundance And Breeding Areas Of Black (*Melanosuchus niger*) And Spectacled Caiman (*Caiman crocodilus*) In The Sustainable Development Reserve Piagaçu-Purus, Central Amazonia, Brazil.

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Information on distribution and abundance of Black and Spectacled caimans were collected in the Piagaçu-Purus Sustainable Development Reserve (SDR-Piagaçu), Amazonas state, between September and October 2005. We undertook 17 standardized night surveys in 22 different water bodies, for a total of 279,5 km of shoreline. Both species were found in almost all the water bodies that were surveyed. During the study period, 4729 caimans were counted, and 18,3% of these individuals had their species identified. *C. crocodilus* was the most abundant species, representing 62.7% of caimans with the species identified. Caiman average density in all the water bodies was 15.3 ($\pm$ 10.5) individuals/km of shoreline. Caiman's nests were surveyed in 15 water bodies during the reproduction period. We found 28 nests of *M. niger* and 28 of *C. crocodilus* in 11 localities. Female *C. crocodilus* were observed near ten nests, and no *M. niger* female was seen. Local people poached eggs in 15 nests (10 *M. niger* and 5 *C. crocodilus*). This indicates that also the nests could be under a moderate hunting pressure in the region.

Distribution And Abundance Of Black Caimans (*Melanosuchus nger*) In The Brazilian Amazon

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Abstract: The Brazilian Amazon accounts for approximately 80% of black caiman distribution range. This study shows that the species has abundant and widespread populations within Brazil. Confirmed sighting of black caimans in the Brazilian states reveals that the species occurs throughout its historic range and is more abundant in white water rivers of the Amazon Basin, although throughout its extensive distribution, the species occupies a wide diversity of humid habitats, including large rivers and streams, oxbow lakes, floodplains and seasonally flooded savannas. Natural black caiman populations can also be found in black and clear water types, and in manmade dams. In 2004 and 2005, spotlight surveys were conducted in 85 sites in five Brazilian Amazonian states (Amazonas, Amapá, Rondônia, Tocantins and Goiás). Surveys covered 767.3 km of shoreline, and 38,711 black caimans were detected. Black caiman were found in 94% of the surveyed sites. Density indices estimates varied from 2.4 to 740.5 ind.km^{-1}. The high densities consistently recorded indicate that the species is one of the world's most abundant crocodilian species. As part of the monitoring program, population size structure and sex ratio were obtained in four Brazilian Amazon states. The population is currently composed mostly of large individuals, although hatchlings were also detected. The average sex ratio was biased towards males (82%), because most of the animals were captured in open waters, where males are more commonly found, whereas females are found in areas covered by aquatic vegetation. The size structure, with an abundance of large animals is typical of populations close to carrying capacity, with a relatively low level of exploitation. Assuming that the populations were extensively harvested from 1950 to 1970 and, because of over hunting the population was severely depleted, the actual densities confirm that black caiman populations have increased steadily. The Center for Conservation and Management of Reptiles and Amphibians (RAN/IBAMA), with the support of Amazonian States Environmental Agencies, has a nation wide monitoring program (Program for Biology, Conservation and Management of Brazilian Crocodilians) that considers the ecosystem as the management unit and implements monitoring by systematic surveys, applying a set of standard methodologies which includes i) habitat description based on satellite image interpretation, ii) water level, temperature and rainfall recording, iii) standard geo-referenced spotlight surveys estimating population size, structure and sex ratio, iv) nesting ecology, and v) in sites with sustainable use potential, mark-recapture techniques. In order to apply such methodology and to ensure a sustained program, local personnel have been trained and equipped for the job. Based on biological data and with an efficient system to monitor the natural populations and their habitats in place, Brazil is proposing the downlist of black caiman populations from CITES Appendices I to II. This will not harm or result in risk to wild populations and will ensure that conservation goals through sustainable use can be achieved.

Legal Hunting Patterns And Conservation Of *Caiman yacare* And *Melanosuchus niger* In The Bolivian Amazon

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Abstract: *Caiman yacare* has recovered in Bolivia after having been hunted illegally during several decades (1950-1970), whereas black caiman *Melanosuchus niger* is still restricted to remote habitats, generally within protected areas. Bolivia initiated in 1997 a national cropping program for *C. yacare*, allowing the annual extraction of between 30 000 and 45 000 *C. yacare* for the leather industry. The present paper discusses the legal hunting patterns within the protected area TIPNIS (National Park Isiboro Sécure). The indigenous tribes living in this area received in 2005 a harvest quota of 524 *C. yacare*, after having elaborated a species management plan that was approved by national authorities. 99.2% of all caiman hunted were *C. yacare*, which showed that hunters can distinguish between the two species. It was also shown that hunters can select efficiently adult *C. yacare*, thus avoiding the killing of juveniles and subadults. The impact of legal cropping of *C. yacare* on *M. niger* was estimated through a detailed analysis of hunting behaviour and the measurement of caimans hunted. The data are used to provide recommendations on caiman management and conservation in TIPNIS and in other parts of the Bolivian Amazon.

Resumen: *Caiman yacare* se recuperó después de un período de caza indiscriminada en los años 50 y 60. Por otra parte, el caimán negro *Melanosuchus niger*, sigue restringido a zonas remotas, generalmente en parques nacionales. El año 1997, Bolivia inició el programa nacional para la conservación y aprovechamiento sostenible del *C. yacare.* Discutimos aquí los patrones de caza legal dentro del marco del plan de manejo del *C. yacare* del territorio indígena parque nacional Isiboro Sécure (TIPNIS). El año 2005, los indígenas yuracare y trinitario que viven en esta área recibieron un cupo de cosecha de 524 *C. yacare* por parte del gobierno. 99.2% de los caimanes cazados eran *C. yacare*, lo cual muestra que los cazadores saben discriminar entre las dos especies. Además, aparentemente los cazadores saben discriminar adultos de subadultos de *C. yacare*. Los datos recolectados nos permiten dar recomendaciones para la conservación y el manejo de ambas especies.

1. Introduction

The history book of wildlife trade contains some black pages on South American crocodilian species (Ojasti 1996). In Bolivia, both *Caiman yacare* and *Melanosuchus niger* were virtually exterminated during the 60s and 70s (Medem 1983; Ruiz, 1988).

As a late response to save these and other species from extinction, the Bolivian government imposed (in 1987, ratified in 1990) a strict control upon illegal hunting, promulgated a law that banned wildlife hunting and signed the CITES international agreement. Through these initiatives, the economical incentive to hunt and commercialize *C. yacare* and *M. niger* was removed.

National and international conservation efforts contributed to the gradual recovery of the natural populations of *C. yacare*. By the 90s, healthy populations were again encountered in the Amazon lowlands and in the Bolivian pantanal (Ergueta & Pacheco, 1990; King, 1995; Llobet and Goitia, 1997; Llobet and Aparicio, 1999; Rios, 2003; Aguilera, 2002; Rios, 2003; Llobet et al. 2004; Cisneros 2005). In 1997, under pressure of cattle farmers and indigenous tribes, the National Program for Conservation and Sustainable Use of *Caiman yacare* (PNCASL) was inaugurated, backed by a specific law that introduced management regulations. At present, PNCASL is implemented in the Amazon lowlands of the state departments of Beni and Santa Cruz (Llobet and Aparicio, 1999). *C. yacare* cropping is only allowed in indigenous territories (TCOs) and cattle ranches. In 2005, 562 cattle farmers and 15 indigenous territories requested and received hunting quota from the State.

Though extraction of adult caiman individuals is difficult to regulate and contains a high risk factor (Ross and Godshalk, 1999; Ojasti, 2000; Cisneros & Van Damme, 2005), so far there are only few reports describing the positive and negative lessons learnt implementing these cropping programs. An exception is Velasco et al. (2003), who described that the Venezuelan *C. crocodilus* cropping program resulted in higher adult caiman densities in cropping areas than in reference areas. There is also virtually nothing known of the effects *C. yacare* hunting on its sympatric species *M. niger*. The specific law that regulates *C. yacare* cropping does not even mention *M. niger*.

The broad aims of the present study were (a) to evaluate the sustainability of the *C. yacare* cropping program in the study area; and (b) to evaluate the impact of the *C. yacare* program on *Melanosuchus niger*. The study took place in the framework of the implementation of the *C. yacare* managament plan in the TCO TIPNIS in 2005.

2. Methods

The study was conducted in the central zone of the TCO TIPNIS, coinciding with the Ichoa river basin. This area belongs to the white water floodplain of the Mamore river, which is characterized by prolonged inundations. The indigenous people inhabiting this inhospitable area elaborated a *C. yacare* management plan in 2005, and the implementation started in 2006. We accompanied hunters during legal cropping activities.

In the hunting area, three hunting groups were established by consensus during an assembly in which participated indigenous authorities and community members. During the same assembly, the hunting strategy was planned in detail. Each hunting group consisted of three hunters, which were accompanied by a park ranger, an indigenous technician and a biologist. A specific hunting area was assigned to each of the hunting groups.

Each person within the groups adopted a different role adapted to its abilities: the hunter (who uses a torch and shoots the animals), the assistant (who pulls the shot animals to the boat and decapitates the caimans) and a pilot (the person who navigates the canoe). A subquota, deduced from the total 2005 harvest quota of 524 assigned by PNCASL to TCO TIPNIS, was assigned to each hunting group.

Hunters were well informed that only caimans of at least 180 cm total length would be accepted by the tanneries. This total length corresponds with a head length of 27 cm (Cisneros and Van Damme, 2005). A normal hunting day consisted in the following activities. A water body (lake or river) was selected using local knowledge and taking into account accessibility. After arriving at the water body, the darkest hours during night time were chosen to hunt, and preparations were taken for hunting. Generally, from the banks of the water body the presence of adult individuals was verified with a torch before embarking in the canoe. Once adult individuals (>180 cm) were localized, they were blinded using torch light and then shot with a gun, pointing at the cerebral region. The animals were pulled in the canoe and decapitated. The dead animals were then taken to the river bank, where they were skinned the morning after.

During hunting the habitat where caimans were hunted was registered. We distinguished four different habitat types: rivers, streams, tectonic lakes and oxbow lakes. We registered the total number of *C. yacare* hunted, the number of *M. niger* accidentally hunted, and the number of *C. yacare* rejected for one of the following reasons:

(a) caimans of too small size (< 180 cm) to be commercialized;
(b) caimans that drowned after being shot and that could not be recuperated
(c) caimans whose skins were damaged during fighting activities and that could not be commercialized

Table 1: Size clases of ***Caiman yacare*** and ***Melanosuchus niger***

Species	**Size class IV (cm)**	**Size class V (cm)**
Caiman yacare	180 – 250	-
Melanosuchus niger	180 – 250	= 251

Adult caimans were classified using the criteria established in the law that regulates the *C. yacare* cropping program. For *M. niger*, the classification was based on Pacheco (1990) (Table 1). Generally, *C. yacare* size class IV contains mainly adult males, whereas adult females mostly belong to size class III (Cisneros and Van Damme 2005). Similarly, most of the adult *M. niger* males belong to size class V, whereas females belong mostly to size class IV.

3. Results

99.2% (N=587) of the total number of caimans hunted were *C. yacare* and 0.8% (N= 5) were *M. niger*. The total number of *C. yacare* effectively commercialized was 524 (88.5% of the total of caimans hunted), whereas 15 of the *C. yacare* hunted were rejected due to their small size (2.5% of the total), 19 *C. yacare* were lost due to drowning (3.2% of the total) and 29 (4.9% of the total) were rejected because their skins was damaged (Table 2).

Of the 592 caimans caught, 41.7% was hunted in tectonic lakes, 29.7% in streams, 14.7% in oxbow lakes and 13.9% in rivers. Black caiman were not encountered in rivers, whereas in streams and oxbow lakes 2 individuals were hunted, and in tectonic lakes only 1. The highest percentage of rejected animals was registered in streams and in tectonic lakes (Table 2; Fig. 1).

Table 2: Number of *C. yacare* and *M. niger* hunted in rivers, streams, oxbow lakes and tectonic lakes. Percentages for provided for each habitat type.

Habitat types	Total number of caimans hunted	Total number of *C. yacare* commercialized	Total number of *C. yacare* discarded	Total number of *M. niger* accidentally hunted and discarded
River	82	78 (95.0%)	4 (5.0%)	0 (0.0%)
Streams	176	151 (85.8%)	23 (13.1%)	2 (1.1%)
Oxbow lakes	87	81 (93.1%)	4 (4.6%)	2 (2.3%)
Tectonic lakes	247	214 (86.6%)	32 (13.0%)	1 (0.4%)
TOTAL	592	524 (88.2%)	63 (11.0%)	5 (0.8%)

In Figure 2, the size frequency distributions of hunted caimans are presented. The size interval 200-210 contained more *C. yacare* than any other interval. The mean length of rejected *C. yacare* was similar to the mean for *C. yacare* that were commercialized. All animals that were smaller than 180 cm were rejected and disposed of by hunters. The size of four *M. niger* accidentally hunted and finally rejected overlapped in size with the largest *C. yacare* encountered. One black caiman had a slightly larger size than any of the *C. yacare* (255 cm).

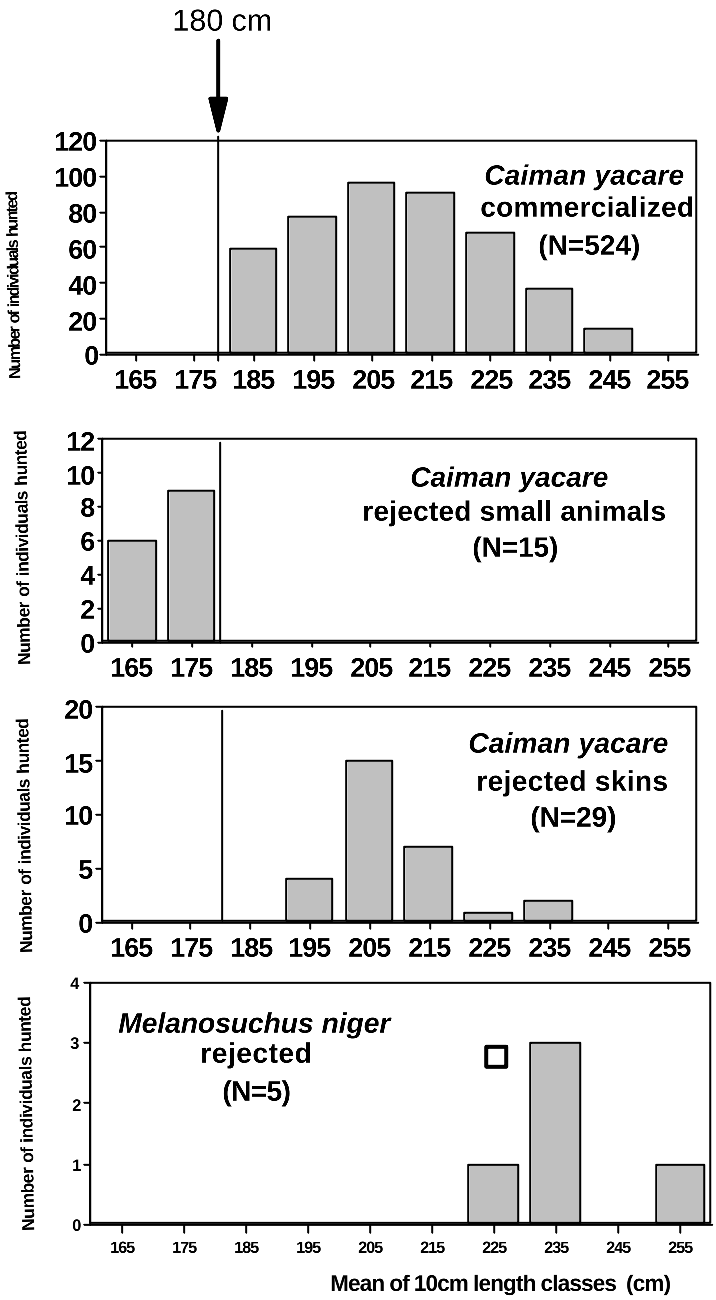

Figure 2. Length frequency distribution of hunted caiman (*C. yacare* and *M. niger*) in the Ichoa river floodplain. The vertical line shows the *C. yacare* size limit established

4. Discussion

The present data show that hunters have a high ability to distinguish between caimans of different size groups. On a total of 524 *C. yacare*, only 15 size mistakes were made. Implicitly, the specific law that regulates *C. yacare* cropping acknowledges this error made by local hunters, accepting not more than 10% of skins of individuals between 160 and 180 cm.

However, commercial tanneries generally do not accept these small individuals, which is the reason why they are generally disposed of by local hunters. The existence of this type of discards, added to the rejections that are the consequence of the high quality standards used by tanneries, implicates that hunters generally hunt 20% more than their official harvest quota.

Mendez (2006), who conducted nocturnal counting of caimans in the same habitat types in the floodplain area of the Ichoa river, found that of 465 adult (> 180 cm) individuals counted 85.4% were IV class *C. yacare*, 11.4% were class IV *M. niger* and 3.2% were class V *M. niger*. On the other hand, the present data show that only 0.8% of the caimans hunted were black caimans. These data show that hunters during hunting can distinguish reasonably well between both caiman species. Of each of 20 of the black caimans encountered, approximately one (5%) was mistaken for *C. yacare* and killed.

Cropping can only reach sustainability when strict control and regulations are imposed. The imposture of these management regulations generally is responsibility of the central government. In the case of the *C. yacare* cropping program in Bolivia, some of the strategies used are the assignment of local harvest quota on the basis of GIS analysis and counting (Rumiz and Cochrane 2005), the registration and inspection of tanneries, and the regulation of hunting sizes. In the present local context, however, the success of the harvesting program depends to a large extent on local regulation systems and active participation of the local indigenous communities. It is argued by Van Damme et al. (2006) that the strengthening of local communities is the best strategy towards sustainability of the management program.

Various authors indicated that hunting should be limited to only a small percentage of reproductive adults (Webb et al. 1992; Hines and Abercrombie 1987; Velasco and Ayarzaguena 1992). This strategy aims at keeping enough adult individuals that reproduce successfully. Alternatively, loss can be compensated by increased growth or immigration (Ross and Godshalk, 1999; Ojasti, 2000; Velasco et al., 2003). In the PNCASL it was established that only 25% of individuals larger than 180 cm should be hunted, under the hypothesis that all these are males, that enough males will remain in the area to reproduce successfully and that compensation growth, and consequently mayor recruitment, will occur among juveniles and subadults. However, the present study shows that hunters kill all the adult individuals encountered in a specific area. The hunters also do not apply a rotation system and do not give the chance to local population to recuperate. If immigration fails or recruitment can not compensate for the constant loss of adult animals, this situation might put the *C. yacare* population in danger.

The effect of the *C. yacare* cropping program on *Melanosuchus niger* might be smaller than was expected at the start of the study. Hunters seem to be able to distinguish well between the two species. However, illegal hunting in the area might affect black caiman more significantly. Cisneros and Van Damme (2005), for example, found that 3.4% of a small sample of 29 skins that were confiscated in TIPNIS belonged to black caiman. This is one argument more to strengthen legal cropping in the area.

Table 3 summarizes the impacts of different types of caiman hunting on natural *C. yacare* and *M. niger* populations in TIPNIS. We distinguish in this table between legal cropping of *C. yacare*, “illegal” cropping of *C. yacare* (which is cropping to satisfy harvest quota of other regions), selective hunting of adult male *M. niger* and the local use of both species. The table suggests that *C. yacare* cropping might have an important impact on black caiman populations. The latter species may benefit from the emptying of niches previously occupied by adult *C. yacare*. The occasional removal of dominant adult black caiman by local people may also contribute to the recovery of populations of this species. However, it will be necessary to design national and local management strategies in order to guide the recovery process of this ecologically and economically important species.

Table 3: Probable and possible impacts of caiman hunting on natural *C. yacare* and *M. niger* populations

Hunting Activities	Characteristics	Impact on *C. yacare* populations	Impact on *M. niger* populations
Legal cropping of *C. yacare*	* Focused on male *C. yacare* > 180 cm * During low water season	* Probably compensatory growth of juveniles and subadults * Possibly immigration of individuals from source areas * Probably does not affect reproduction success, however, recruitment of male adults might be affected	* *M niger* can possibly occupy emptied niches and might re-establish in historically occupied habitats
Illegal cropping of *C. yacare*	* Mostly focused on male *C. yacare* > 180 cm (historically and/or occasionally also focused on smaller individuals for illegal local markets) * Throughout the year	* Probably compensatory growth of juveniles and subadults * Possibly immigration of individuals from source areas * Probably does not affect reproduction success, however, recruitment of male adults might be affected	* Possibly occupies emptied niches and might re-establish in historically occupied habitats
Selective hunting of adult male *M. niger* (> 250 cm)	* Occasional killing to reduce or avoid human-caiman conflicts	* Could possibly occupy empty niches	* Probably compensatory growth of juveniles and subadults
Local use of *Caiman yacare* and *M. niger*	* Occasional hunting for extraction of caiman oil or meat	Probably a very low impact	Probably a very low impqct

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Plan De Acción Para La Conservación De La Especie Babilla (*Caiman crocodilus fuscus*) En Jurisdicción De La Corporación Autónoma Regional Del Sur De Bolívar – C.S.B. Colombia

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Resumen: El Ministerio de Ambiente de Colombia mediante la resolución 1660 del 2005, obliga a las Corporaciones Autónomas Regionales a proponer Planes de Acción para desarrollar programas de conservación con la especie Babilla (Caiman crocodilus fuscus).

En jurisdicción de la C.S.B. se encuentra quizá el más importante complejo cenagoso del país, conocido como “Depresión Momposina” representado por 6.036 km2, de humedales originados por las cuencas bajas de los ríos Magdalena, Cauca, San Jorge y Sinú. Área natural de gran variedad biológica, donde se destaca la babilla.

El plan de acción contempla la ejecución de dos programas; que se desarrollarán en 10 años. El primero tendrá en cuenta la Evaluación, Recuperación, Protección de poblaciones, hábitat, y Manejo para lograr el uso sostenible, de acuerdo a la evaluación de poblaciones y teniendo en cuenta las cuotas de repoblación y reposición generadas por la actividad de zoocría industrial de la especie babilla en la región, para de esta manera comenzar con programas estables de esas cuotas. El segundo se ejecutará de forma paralela y se apoyará mediante programas de Educación ambiental, Gestión y Fortalecimiento Institucional. En donde se pretende gestionar, organizar, concientizar y sensibilizar a las comunidades asociadas para generar cambios de actitud.

Abstract: The Colombian Ministry of Environment, through Resolution 1660 of 2005, obligates the Autonomous Regional Corporations (Corporaciones Autónomas Regionales) to propose action plans for the development of conservation programs for the babilla (*Caiman crocodilus fuscus*).
In the jurisdiction of the CSB is perhaps the most important swamp complex in the country, the Momposina Depression, which comprises 6036 km^2 of wetlands originating in the lowland river basins of the Magdalena, Cauca, San Jorge and Sinú Rivers. It is a natural area of great biological diversity, where the babilla is very evident.
The action plan considers the implementation of two programs, to be developed over 10 years. The first involves the evaluation, recovery and protection of populations, habitat, and management to achieve sustainable use based on the evaluation of populations, and by taking into account restocking quotas and activities by the commercial caiman farms in the region. The second will be implemented at the same time, and will assist through programs on environmental education, management and institutional strengthening. The aim will be to try and manage, organize and sensitize communities involved and change attitudes.

1. Introducción

Los humedales del sur del departamento de Bolívar, conforman tal vez el más importante complejo cenagoso de Colombia, conocido como la Depresión Momposina, área que en un alto porcentaje pertenece al área de jurisdicción de la Corporación Autónoma Regional del Sur de Bolívar (C.S.B.). Esta subregión es área de distribución natural de una rica variedad biológica de especies tanto de flora como de fauna, dentro de las cuales se destaca la babilla (*Caiman crocodilus fuscus*).

Sobre las poblaciones naturales de esta especie actualmente no conocemos su estado, por lo tanto es menester hacer una evaluación las mismas, junto con los hábitat, para luego implementar acciones de repoblamiento con una proyección de estabilidad de las poblaciones y de manejo sostenible en conjunto con las comunidades.

Ahora bien, desde 1984, año en que comenzó el uso de la fauna mediante la figura de Zoocriaderos en ciclo cerrado, para los cuales dentro de su conformación fueron concebidos entre otros, como centros de conservación, puesto que al extraer del medio natural individuos adultos para comenzar la actividad productiva, estos deberían devolverse al medio, de donde fueron extraídos, entendiéndose este concepto como cuota de reposición; De igual manera se creó la obligación por parte de los zoocriaderos de la devolución al medio natural del 5% de la producción obtenida por cada año de producción, entendiéndose esta como cuota de repoblación. Cuotas sobre las cuales, hasta la actualidad no se ha desarrollado de manera significativa, programas de conservación que conlleven a la sostenibilidad de la especie babilla, habiéndose llevado a cabo tan solo algunos ensayos a nivel experimental en jurisdicciones diferentes a la de la C.S.B. y sobre los cuales hasta el momento no se ha podido establecer el grado de efectividad. De tal forma que la propuesta de este programa de conservación se encuentra enfocada dentro del marco de lo exigido en el artículo primero de la resolución 1660 de noviembre 4 de 2005 (M.A.V.D.T.) y demás normatividad vigente.

2. Antecedentes

La subregión de la Depresión Momposina es considerada el área cenagosa más grande de Colombia, estos ecosistemas son estratégicos para el país puesto que actúan como reguladores de los ríos Cauca, Magdalena, San Jorge y Sinú, son generadores de una gran productividad biológica especialmente de recursos hidrobiológicos y además se constituyen en la principal fuente de ingresos de las comunidades locales, quienes derivan en gran parte su sustento mediante el aprovechamiento de los recursos que allí se encuentran.

3. Problemática

En cuanto al aspecto social, para el año 2002 se identificó que la ocupación en actividades productivas en general por parte de los habitantes que viven en inmediaciones de los complejos cenagosos de la región y que derivan su sustento de la oferta que brindan los humedales, se distribuye así: pesca en un 36%, en segundo orden se encuentran los cultivos de *pancoger* en un 30%, ganadería 17% y la caza en un 17%. Sin embargo la estimación sobre la actividad de caza no es muy confiable y por tratarse de una actividad ilegal no puede ser claramente cuantificada y ostensiblemente puede ser mayor.

Por lo tanto, durante la ejecución del presente programa se pretende implementar acciones que permitan ofrecer una proyección de estabilidad de la especie babilla, con el concurso de las comunidades, sobre la cuales se desarrollará el respectivo proceso de educación ambiental que conlleve al manejo sostenible de la babilla, teniendo presente los derroteros del marco normativo de la política nacional de manejo de humedales y de la fauna silvestre.

4. Area de estudio

El universo de estudio, para la implementación del programa de conservación de la especie babilla, comprendería un área total de humedales correspondiente a 6036.29 km2, área que incluye las cuencas bajas de los ríos magdalena, Cauca, San Jorge (Depresión Momposina) y el río Sinú (subregión Sinú), esto sin tener en cuenta otra serie los complejos cenagosos, los cuales no han sido categorizados.

En cuanto al aspecto social, se ha identificó que para el año 2002 la ocupación en actividades productivas en general por parte de los habitantes que viven en los complejos cenagosos de la región y que derivan su sustento de la oferta que brinda los humedales y permanecen en ellos a lo largo del ciclo hidrológico, independientemente de aguas altas o bajas se distribuye así: pesca en un 36%, en segundo orden se encuentran los cultivos de pancoger en un 30%, ganadería 17% y la caza en un 17%. Sin embargo la estimación sobre la actividad de caza no es muy confiable y por tratarse de una actividad ilegal no puede ser claramente cuantificada.

5. Plan de acción

5.1. Objetivo general
Implementar el plan de conservación y manejo sostenible de las poblaciones silvestres de la especie Babilla *(C. c. f.)* y su hábitat natural en jurisdicción de la Corporación Autónoma Regional del sur de Bolívar.

5.2. Objetivos específicos

1. Caracterizar y diagnosticar el estado de poblaciones silvestres de la especie Babilla *(C. c. f.)*, en jurisdicción de la Corporación Autónoma Regional del sur de Bolívar.
2. Caracterizar y diagnosticar el hábitat de las poblaciones silvestres de la especie Babilla *(C. c. f.)*. en jurisdicción de la Corporación Autónoma Regional del sur de Bolívar.

3. Identificar los hábitat para la implementación de programas de liberación que correspondan al área natural de distribución de la especie Babilla *(C. c. f.)*. en jurisdicción de la Corporación Autónoma Regional del sur de Bolívar.

4. Establecer los criterios técnicos para la selección de especimenes de la especie Babilla *(C. c. f.)*. destinados a liberar dentro del marco de los programas de conservación en los hábitat naturales evaluados en jurisdicción de la Corporación Autónoma Regional del sur de Bolívar.

5. Diseñar e implementar un sistema de seguimiento y monitoreo al estado de las poblaciones naturales de la especie Babilla *(C. c. f.)*. y su hábitat.

6. Diseñar e implementar estrategias de participación comunitaria y de educación para la conservación de la especie de la especie Babilla *(C. c. f.)*. y su hábitat.

7. Vincular a los institutos de investigación y academia, en los programas de conservación de especies de la fauna silvestre.

6. Ejecución

El plan de acción se ejecutará, teniendo como base la problemática identificada *"in situ"* y los aportes de las comunidades asociadas a los humedales en el desarrollo del plan.

Con base a la cantidad de ciénagas y los 10 complejos cenagosos identificados en la jurisdicción de la C.S.B. Se ha proyectado un término de diez (10) años, para la ejecución de los diferentes programas correspondientes al plan de acción, siempre y cuando exista apoyo económico por parte de otras entidades, dado que la C.S.B. no cuenta con recursos propios para la implementación del mencionado programa.

De tal manera que para tal fin se propone la ejecución de Programas que cumplan con los objetivos propuestos, por complejo cenagoso, teniendo en cuenta que el primer programa se desarrollaría en la zona B15 con una duración de tres años, sobre este primer programa se iría ajustando la metodología y los tiempos para el desarrollo de los 9 complejos cenagosos restantes así como el monitoreo de los mismos.

Los recursos de los cuales dispone la C.S.B. para la ejecución del primer programa equivalen a $10.000.000 (Diez millones de pesos), como recursos propios, además se contaría con $74.950.000 (Setenta y cuatro millones novecientos cincuenta mil pesos) como aportes correspondientes al pago de las cuotas de repoblación del zoocriadero Colombian Croco Ltda. Hasta el año 2.005. Adicionalmente el mismo zoocriadero haría un aporte en especie que es el aporte de las incubadoras y todo lo que conlleva el proceso de incubación de la especie babilla (*C. c. f.*) el cual se ha valorado en $5.994.000 (Cinco millones novecientos noventa y cuatro mil pesos.

De tal forma que para la implementación del primer programa se implementara el respectivo proyecto, teniendo en cuenta que prácticamente para los otros nueve complejos cenagosos no habría que adquirir equipos y seguramente los costos podrían ser un poco menores que los propuestos para el primer programa.

6.1 Duración del Proyecto Primera fase.

La primera fase tendrá una duración de tres años, el tiempo esta condicionado a las diferentes actividades que se van a desarrollar en marco del programa de conservación de la especie babilla.

6.2 Alcance

6.2.1 Área de influencia

El programa de conservación de la especie babilla (*C. c. f.*) se adelantará en jurisdicción de la C.S.B., es decir en la parte sur del departamento de Bolívar; teniendo como punto de referencia el complejo cenagoso B15, el cual comprende los municipios de Barranco de Loba, San Martín de Loba, Tiquisio, Pinillos, Altos del Rosario y Achí, ocupando una extensión de 610.336 Ha, de las cuales 1.490,7 Km^2 Corresponden a cuerpos de agua.

6.2.2 Población beneficiada

La población beneficiada con el programa de conservación de la especie babilla en estos municipios, estará constituida por los habitantes que conforman las comunidades que viven en inmediaciones de los complejos cenagosos de la región y que derivan su sustento de la oferta que brindan los humedales que allí se encuentran, por esta razón y en primera instancia se verán beneficiados los cazadores que se identifiquen en el desarrollo de las actividades propuestas durante la ejecución del presente programa, tales como censos, monitoreos, y demás actividades que conlleven al uso sostenible de la especie babilla (*C. c. f.*).

6.2.3. Sostenibilidad del proyecto.
Dentro del esquema propuesto y como resultado de las acciones en este programa propuestas se espera que las poblaciones naturales de la especie babilla se mantengan estables dentro del ecosistema y que se pueda generar un aprovechamiento de este tipo de productos provenientes de la fauna silvestre, por parte de la comunidad; bien ya sean huevos, neonatos, juveniles o adultos. Situación que conoceremos como resultado de la implementación del presente programa. Por lo tanto se espera que ese aprovechamiento se pueda hacer mediante la aplicación de la normatividad legal vigente que para el caso esta dispuesta en el decreto ley 1608 de 1978, la ley 611 del 2000, resoluciones y actos administrativos complementarios; en donde se establecen otras maneras de ese aprovechamiento de la fauna, diferente al ciclo cerrado en donde se tienen en cuenta esquemas tales como el Ciclo Abierto y el Ciclo Mixto. Económicamente se contará con un dinero proveniente del pago de las cuotas de repoblación del zoocriadero que se encuentra en nuestra jurisdicción, el cual se seguiría empleando ya sea bien para los monitoreos de las poblaciones naturales de la especie babilla y otras especies que sean promisorias.

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A Family Tradition Since 1917;
Caimanes Y Cocodrilos De Chiapas (CAICROCHIS).
A Successful *Crocodylia* Conservation Program.

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Abstract: A worldwide demand for personal and clothing articles made with crocodiles hides, encourage at the beginning of the past century and subsequent decades, the extraction and commercialization of big amounts of crocodilians and hides from Mexico's coasts. Because of its tropical coastal ecosystems richens, the state of Chiapas was part of this extractions; and knowledge of this, it's known, conserved and transmitted by the only family who has subsist nearly a century of use of caimans and crocodiles, the LÓPEZ VÁZQUEZ family.

With 5 generations working in the conservation, education, capturing, reproduction, management, transformation and commercialization of the Crocodylia and their products, they are a living example of the correct sustainable use of a wild species with a consions for the conservation of the natural resources.

From Doña Hermicenda Marina, forerunner of this tradition since 1917, all the Lopez family passing through Don Fidel Lopez Marina, Don Rafael Lopez and Doña Maria Cristina Vazquez till Maria de la Paz Lopez and her son Luis Julian Lopez have been part of this evolution.

Beginning with wild harvest and now they have a conservation, investigation, reproduction, management, education, sustainable use and cultural exhibition CENTER, beginning with a rustic system for curing hides and now with artisan and industrial process for the transformation of hides.

The experience and knowledge of 5 generations, unique in Mexico, are a big pile of information for the development and evaluation of successful programs for the conservation of Crocodylia in our country.

Key words: Family López, 5 generations, conservation, knowledge, evolution, tradition, *Crocodylia*, Tapachula, Chiapas.

Resumen: Una demanda mundial por artículos personales y de vestir en piel de cocodrilo fomentó a principios del siglo pasado y décadas subsecuentes la extracción y comercialización de grandes cantidades de ejemplares y pieles de cocodrilianos en las costas de México.

Por su riqueza en sus ecosistemas tropicales costeros, el Estado de Chiapas fue parte de esta extracción; y conocimiento de ello, lo conservan, transmiten y se conocen por la únicamente familia que subsiste a casi un siglo de aprovechamiento de los caimanes y cocodrilos, la Familia LÓPEZ VÁZQUEZ.

Con ya 5 generaciones trabajando en la conservación, educación, captura, reproducción, manejo, transformación y comercialización de los Crocodylia y sus productos son un ejemplo viviente del correcto uso sustentable de especies silvestres con una conciencia de conservación de los recursos naturales.
Desde Doña Hermicenda Marina, precursora e iniciadora de esta tradición desde 1917, toda la familia López pasando por Don Fidel López Marina, Don Rafael López, Doña María Cristina Vázquez hasta María de la Paz López y su hijo Luis Julián López, han sido parte de la evolución. Iniciando con la cosecha directa del medio silvestre, y ahora con un criadero que es un CENTRO de conservación, investigación, reproducción, manejo, educación, aprovechamiento, y exhibición cultural; iniciando con un sistema rústico de curtido y ahora con procesos artesanales e industriales para la transformación de la piel.
La experiencia y conocimiento de 5 generaciones, única en México, son un gran acervo de información para desarrollo y evaluación de programas exitosos para la conservación de los Crocodylia en nuestro país.

Palabras clave: Familia López, 5 generaciones, conservación, conocimiento, evolución, tradición, *Crocodylia*, Tapachula, Chiapas.

1. Introducción

Historia: "Relato de los acontecimientos y los hechos dignos de memoria" (Larousse Universal) o… sucesos, hechos o manifestaciones de la actividad humana… (Diccionario Enciclopédico Salvat).

Todo acontecimiento, suceso, hecho o manifiesto de la actividad humana, o de los seres orgánicos o inorgánicos de la vida natural digna de conocerse, es reflejo del modo del vivir de los animales, y de vivir y pensar de los seres humanos en un período y un territorio determinado, constituyen fuentes de un valor decisivo para el conocimiento y desarrollo de un grupo, pueblo, nación o persona, siendo la TRADICIÓN la transmisión anónima de los hechos.

En México la tradición oral es una de las principales formas de transmisión anónima familiar de los sucesos, hechos y conocimientos adquiridos entre las generaciones de un grupo familiar. La tradición oral se altera continuamente y sucesivamente, deformándose a cada transmisión lo que da origen a las leyendas, por lo que, los documentos escritos permiten tener conocimientos encaminados a facilitar el análisis e interpretación de los hechos, y son una transmisión fiel que permiten evaluar y evitar errores del pasado por un futuro mejor.

A lo largo de la "Historia" del planeta los saurios se han manifestado y dejado vestigios materiales por más de 200 millones de años, han influido cultural, espiritual y económicamente en muchas culturas a lo largo de la historia de los pueblos, siendo, entre otros, los caimanes y cocodrilos incorporados a sus creencias y costumbre.

En México hay pintados, esculpidos y grabados en vestigios materiales y descripciones escritas en documentos, sobre la gran influencia que los caimanes y cocodrilos tuvieron a lo largo de la historia en nuestro antepasados. Deidades como Cipactonal (Cultura Mexica) e Itzamná (Cultura Maya) (Cupul et al 2004), son reflejo de las atribuciones relacionadas con los cocodrilianos. Atribuciones de poder para hacer el bien o el mal, relación entre el agua y la tierra, la fertilidad, el creador y la personificación de la tierra y el inframundo.

Fuentes materiales y descripciones escritas de la historia sobre esta influencia que los caimanes y cocodrilos tuvieron en las culturas de México se pueden encontrar en vasijas, collares y estelas del período preclásico Maya, en la región del Soconusco en el período preclásico temprano (200 – 1200 a.c.) se puede encontrar vestigios de alfarería con motivos relacionados con los cocodrilos y caimanes (Comp. Personales López 2004) y para el período preclásico medio y tardío se encuentran vestigios de importantes centros de comercio en Obregón donde se comercializaba principalmente el cacao y la gran zona de culto de Izapa, fechado que alcanza su esplendor entre 300 y 50 a.c., centro sagrado donde las escenas esculpidas en las grandes piedras, llamadas "Estelas" tienen motivos que ver con la fertilidad y la abundancia (caracterizados generalmente con forma zoomorfas de cocodrilos), las relaciones entre hombre y mujer, la creación y la procreación. (Ramos R. 1996).
En el Códice Laud aparece un dibujo con rasgos característicos de *Cipactli* – cocodrilo, en el manuscritos "Relación de las cosas de Yucatán" (1563 – 1572) de Fray Diego de Landa relata la vida silvestre de la península describiendo al cocodrilo como *"muy fiero lagarto, los cuales aunque andan e el agua, salen y están mucho en tierra………, ponen huevos y para ponerlos hacen grandes hoyos en la arena, muy cerca del agua, ponen trescientos o más………,salen del huevo tan grandes como un palmo"* y la captura de un cocodrilo por haber matado a un *"indio"* cerca de un monasterio (Cupul et al 2004). Para los Mexicas Cipactli es el primer signo de los días de su calendario, sin embargo los indígenas temían a éste ser, ya que se creía que atraía a la gente con su aliento para matarlos (Martínez 1997)

En épocas recientes, contamos con gran cantidad de documentos escritos que naturalistas como Linnaeus (1758), Blumenbach (1779) y Bocourt (1876) describen y clasifican al caimán (*Caiman sclerop chiapasius*); Cuvier (1807), Preudhomme (1868), Duméril y Bocourt (1870) entre otros describen y clasifican al cocodrilo de río, *Crocodylus acutus* y Duméril, Bibron y Duméril (1851) y Bocourt (1870) entre otros describen y clasifican al lagarto negro, *Crocodylus moreletii* (Álvarez del Toro 1974).

Y para las últimas tres décadas del siglo pasado contamos con conservacionistas, zoólogos y naturalistas como el Profesor Miguel Álvarez del Toro (1917 – 1996) y Federico Medem, investigadores como el Dr. Gustavo Casas Abreu y el Dr. Gonzalo Pérez Higareda, entre muchos otros han aportado un legajo escrito muy importante para el conocimiento de los cocodrilianos en México.

Con múltiples publicaciones nacionales e internacionales por gran cantidad de autores nacionales e internacionales se puede observar el vestigio sobre el conocimiento de las tres especies de cocodrilianos en México, pero sobre la tradición oral (transmisión verbal del conocimiento) no se tienen trabajos que nos permitan garantizar que estas tradiciones continúen, no se pierdan y no se alternen con el tiempo.

Trabajos enfocados al conocimiento de las tradiciones con caimanes y cocodrilos de México, no hay, se cuentan con artículos que recopilan las interacciones entre hombre y cocodrilianos, como el trabajo de Jorge Martínez et al 1997, "*Relación existente entre los cocodrilianos y los pescadores de la Reserva de la Biosfera La Encrucijada, Chiapas, México*" por ello y reconociendo la importancia de este tipo de vestigios históricos, este trabajo preliminar pretende recopilar la tradición del único grupo familiar en México que por cinco (5) generaciones ha trabajado con Caimanes y Cocodrilos en la costa de Chiapas, descendentes de pobladores Mayas, la Familia Marina, López, Salazar, Vázquez, Leal, han continuado con una tradición anterior a 1917, y son un ejemplo vivo de posibles programas exitosos de conservación a través del aprovechamiento sustentable de los caimanes y cocodrilos.

2. Objetivos

2.1. Objetivo General

El objetivo general de este trabajo es dar a conocer la importancia de la tradición y el legado de la familia "López – Vázquez" a favor del conocimiento y conservación de los Crocodylia en México. Siendo un antecedente de conocimientos y ejemplo que permita a investigadores y autoridades establecer lineamientos para programas exitosos de aprovechamiento sustentable con las comunidades y productores.

2.2. Objetivos Particulares

- Conocer la importancia de la tradición familiar "López – Vázquez" en la conservación de los Crocodylia en México.
- Conocer la información generada a través de "El Arte Mexicano", durante cinco generaciones en, la taxidermia, el curtido y transformación de pieles de cocodrilianos y otras especies.
- Conocer la información general, generada en la UMA Caimanes y Cocodrilos de Chiapas.
- Conocer las aportaciones a la sociedad por la UMA Caimanes y Cocodrilos de Chiapas.

3. Justificación

Casi 100 años de trabajo y contacto con el mundo de los Crocodylia, han llevado a la familia "López – Vázquez" a tener amplio conocimiento y experiencia, desde su manejo y crianza en *in-situ* y *ex situ*, hasta el aprovechamiento comercial de todos los productos y subproductos elaborados, además de las aportaciones a la sociedad en su conservación y compresión como especies dominantes.
Por ello no podemos permitir que esta tradición oral y acervo de conocimientos se pierda con el paso del tiempo, y la forma de preservar una historia es documentarla.

4. Antecedentes

Para poder entender la importancia de la Familia "López – Vázquez" en la historia del aprovechamiento de los cocodrilianos en México, el tener la lista biográfica y la participación de cada uno de los miembros ayuda a identificar las diferentes generaciones.

5. Lista Biográfica

5.1. Hermicenda Marina Flores (1876 – 1952).

Nace en Chiapa de Corzo, Chiapas; por la Revolución se muda a Tapachula donde inicia con Fidel López, su hijo adoptivo, la tradición en el manejo de pieles. Primera Generación.

5.2. Raúl Marina Flores (¿??? - ¿???)

Hermano de Hermicenda Marina F. quien ayudó a su hermana durante la revolución y dejó al cuidado de está a Fidel López M.

5.3. Fidel López Marina (1909? – 1969).

Nace en el poblado de la Hierbabuena en la región Lacandona, Chiapas, adoptado por Hermicenda Marina Flores cuando era muy pequeño. Y juntos, ya establecidos en Tapachula, Chiapas, inician la curtiduría y talabartería. Le da nombre al negocio denominándolo "El Arte Mexicano"; obtiene el primer premiso para captura de cocodrilianos en aguas nacionales, y es quien realiza las primeras exportaciones de ejemplares vivos y de pieles de cocodrilianos, a los Estados Unidos de Norte América. Segunda Generación.

5.4. María Salazar Jimenez (1910 – 1990)

Nace en Tuxtla Gutiérrez, Chiapas, esposa de Fidel López Marina, tienen 5 hijos, Rafael, Evagelina, Guadalupe, Flor de María y Martha Luz. María cuando fallece de Fidel toma la dirección de la comercialización del negocio El Arte Mexicano hasta 1981, dejando al frente de ésta a su hijo Rafael López Salazar.

5.5. Rafael López Salazar (1939 – ----)

Primogénito de la unión de Fidel López M. y María Salazar J., nace en Tapachula, Chiapas, desde muy pequeño trabajó directamente en la curtiduría y talabartería, siendo el primero en ir a la selva a capturar ejemplares de Lagarto Real (*Crocodylus acutus*). Toda su vida se ha dedicado al manejo de los cocodrilianos tanto en vida silvestre como en cautiverio, transmitiendo la importancia de estos a sus hijos. Al fallecer su padre Fidel López M., queda al frente del negocio El Arte Mexicano, dando continuidad a los trabajos y actividades que se realizaban. Obtuvo permisos para la captura de ejemplares de pululo (*Caiman crocodilus fuscus*). En 1989, deja al frente de éste a su esposa María Cristina Vázquez V. Es iniciador y fundador del criadero de cocodrilianos actualmente denominado Caimanes y Cocodrilos de Chiapas, dirigiéndolo hasta el año de 1994. Actualmente se dedica a la taxidermia, curtido de pieles y la maquila de productos de cocodrilianos entre otras especies.

Realiza el manejo de los ejemplares de cocodrilianos en *in situ* y *ex situ.* Asimismo continúa con la tradición oral al enseñar y transmitir sus conocimientos a sus hijos, nietos e interesados en este arte. Tercera Generación

5.6. Maria Cristina Vázquez Vázquez (1950 – ----)
Nace en Ocozocuautla, Chiapas, esposa de Rafael López S., tienen 6 hijos, Luis Enrique, María de la Paz, Iliana, Rafael, Julián y María Cristina. Desde que contrae matrimonio con Rafael se involucra en todas las actividades del manejo de los Crocodylia, la taxidermia, la talabartería y la curtiduría, además de la preparación de platillos especiales con carne de cocodrilianos, entre otras especies. En 1988 queda completamente al frente del negocio El ArteMexicano, y actualmente dirige la comercialización de productos.

5.7. Evangelina López Salazar (1941 – ----).
Nace en Tapachula, Chiapas, primera hija del matrimonio entre Fidel López M. y María Salazar J. De niña, ayudaba a su hermano y papá a preparar las pieles en la curtiduría; eventualmente participaba en las actividades de caza. Se casó con Eduardo Cansino Argüello. Tercera Generación

5.8. Guadalupe López Salazar (1943 – ----)
Nace en Tapachula, Chiapas, segunda hija del matrimonio entre Fidel López y María Salazar. De niña, ayudaba a su hermano y papá a preparar las pieles en la curtiduría. Se casó con Fernando Flores Cervantes. Tercera Generación.

5.9. Flor De María López Salazar (1949 – ---)
Nace en Tapachula, Chiapas, tercera hija del matrimonio entre Fidel López y María Salazar. De niña, ayudaba a su hermano y papá a preparar las pieles en la curtiduría. Se casó con Rubén Recinos. Tercera Generación.

5.10. Martha Luz López Salazar (1951 – ----)
Nace en Tapachula, Chiapas, cuarta hija del matrimonio entre Fidel López y María Salazar. De niña, ayudaba a su hermano y papá a preparar las pieles en la curtiduría. Se casó con Estanislao Viveros Pérez. Tercera Generación.

5.11. José Antonio López Aguilar (1960 – ----)
Nace en Tapachula, Chiapas, hijo de Rafael López Salazar. Aprende el arte de la curtiduría y talabartería por parte de padre. Actualmente se dedica a la comercialización.

5.12. Luis Enrique López Vázquez I (1968 – 1989)
Primogénito del matrimonio entre Rafael López S. y María Cristina Vázquez V., nace en Tapachula, Chiapas. Desde muy pequeño ayudó a su padre y madre en las labores de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Desde que cumplió los 6 años acompañaba a su papá en los viajes que realizaba para capturar ejemplares de Pululo (*Caiman crocodilus fuscus)* y para el suministro de materia prima. Trabajó en el criadero y aprendió el arte de la taxidermia, curtiduría y la talabartería. Junto con su padre comercializaban los artículos terminados con clientes en el país. Cuarta Generación.

5.13. María De La Paz López Vázquez (1970 – ----)
Primera hija del matrimonio entre Rafael López S. y María Cristina Vázquez V., nace en Tapachula, Chiapas. Desde muy pequeña ayudó a su padre y madre en las labores de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Estudio la carrera de Médico Veterinario Zootecnista. Al termino de sus estudios se involucra en las labores del criadero, denominado "Criadero de Caimanes El Palomo", y es quién tramita y obtiene el permiso para su operar, así como su tecnificación. En el 2000 recibe como herencia el criadero que actualmente se denomina como UMA Caimanes y Cocodrilos de Chiapas y funge como responsable técnica y administradora. Realiza el manejo de los ejemplares de cocodrilianos en *in situ* y *ex situ.* Colabora con María Cristina Vázquez en la comercialización de los productos y subproductos. Madre de Luis Julián López Vázquez. Cuarta Generación.

5.14. Rafael López Vázquez (1970 – ----)
Segundo hijo varón del matrimonio entre Rafael López S. y María Cristina Vázquez V. Nace en Tapachula, Chiapas. Desde muy pequeño ayudó a su padre y madre en las labores de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Actualmente es quien transforma las pieles en productos (Maquilación) y realiza el manejo de los ejemplares de cocodrilianos en *in situ* y *ex situ.* Casado con Beatriz Leal Morales padres de Fryda Karolina y Paola Montserrat. Cuarta Generación.

5.15. Iliana López Vázquez (1971 – ---)
Segunda hija del matrimonio entre Rafael López S. y María Cristina Vázquez V. nace en Tapachula, Chiapas. Desde muy pequeña ayudó a su padre y madre en las labores de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Ya mayor estuvo encargada por una temporada de la comercialización de productos. Madre de Luis Enrique López Vázquez II. Cuarta Generación.

5.16. Julián López Vázquez (1973 – ---)
Tercer hijo varón del matrimonio entre Rafael López S. y María Cristina Vázquez V. nace en Tapachula, Chiapas. Desde muy pequeño ayudó a su padre y madre en las labores de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Participó en el manejo de los Crocodylia en el criadero Caimanes y Cocodrilos de Chiapas. Casado con Martha Patricia Armenta Caraza madre de Estefanía Armenta Caraza. Actualmente radicando en Canadá, en busca de nuevas oportunidades personales y de mercado. Cuarta Generación.

5.17. María Cristina López Vázquez (1975 – ---)
Tercera hija del matrimonio entre Rafael López S. y María Cristina Vázquez V. nace en Tapachula, Chiapas. Desde muy pequeña participó en las actividades de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia. Actualmente ha participado en talleres, pláticas y cursos de conservación, así como en las actividades del Criadero de CAICROCHIS.

5.18. Manuel I. Muñiz Canales (1966 – ---)
Arquitecto de profesión, inicia en 1989 a involucrarse con los cocodrilianos y en 1990 establece el Criadero Cocodrilos de Chiapas. Coordinador, promotor y desarrollador de la SECOCM y la COMACROM. Representante de Centroamérica y México ante el Grupo Especialista en Cocodrilos de la UICN. Actualmente socio y responsable técnico de la UMA Caimanes y Cocodrilos de Chiapas. María de la Paz López Vázquez.

5.19. Beatriz Leal Morales (1975 – ---)
Esposa de Rafael López Vázquez, nace en Tapachula, Chiapas, madre de Fryda K. y Paola M. Ha participado en las actividades del criadero y de las ventas a menudeo de los artículos terminados.

5.20. Martha Patricia Armenta Caraza (1976? – ---)
Esposa de Julián López Vázquez., nace en Xalapa, Veracruz. Madre de Estefanía. Actualmente radica en Canadá.

5.21. Luis Enrique López Vázquez Ii (1990 – ----)
Primogénito de Iliana López Vázquez, nace en Tapachula, Chiapas. Actualmente cursa la preparatoria. Desde pequeño participó en las actividades de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia y ha estado involucrado en las actividades del criadero. Quinta Generación.

5.22. Luis Julián López Vázquez (1993 – ----)
Primogénito de María de la Paz López Vázquez, nace en Tapachula, Chiapas. Desde muy pequeño participó en las actividades de la taxidermia, curtiduría, talabartería y se le enseño a convivir con los cocodrilianos y su importancia, ha acompañado y participado con su madre en reuniones, cursos, taller y actividades relacionadas con los Crocodylia. Actualmente cursa la secundaria. Dentro de las actividades del criadero es guía de turistas, diseña y elabora letreros para el público, da pláticas a grupos de jóvenes y adultos y colabora en el manejo de los cocodrilianos y las otras especies. Quinta Generación

5.23. Estefanía Armenta Caraza (1994 – ---)
Hija de Patricia Armenta C., nace en Xalapa, Veracruz. Radica en Canadá cursando la secundaria. Actualmente esta en platicas para el diseño de artículos con piel de cocodrilo.

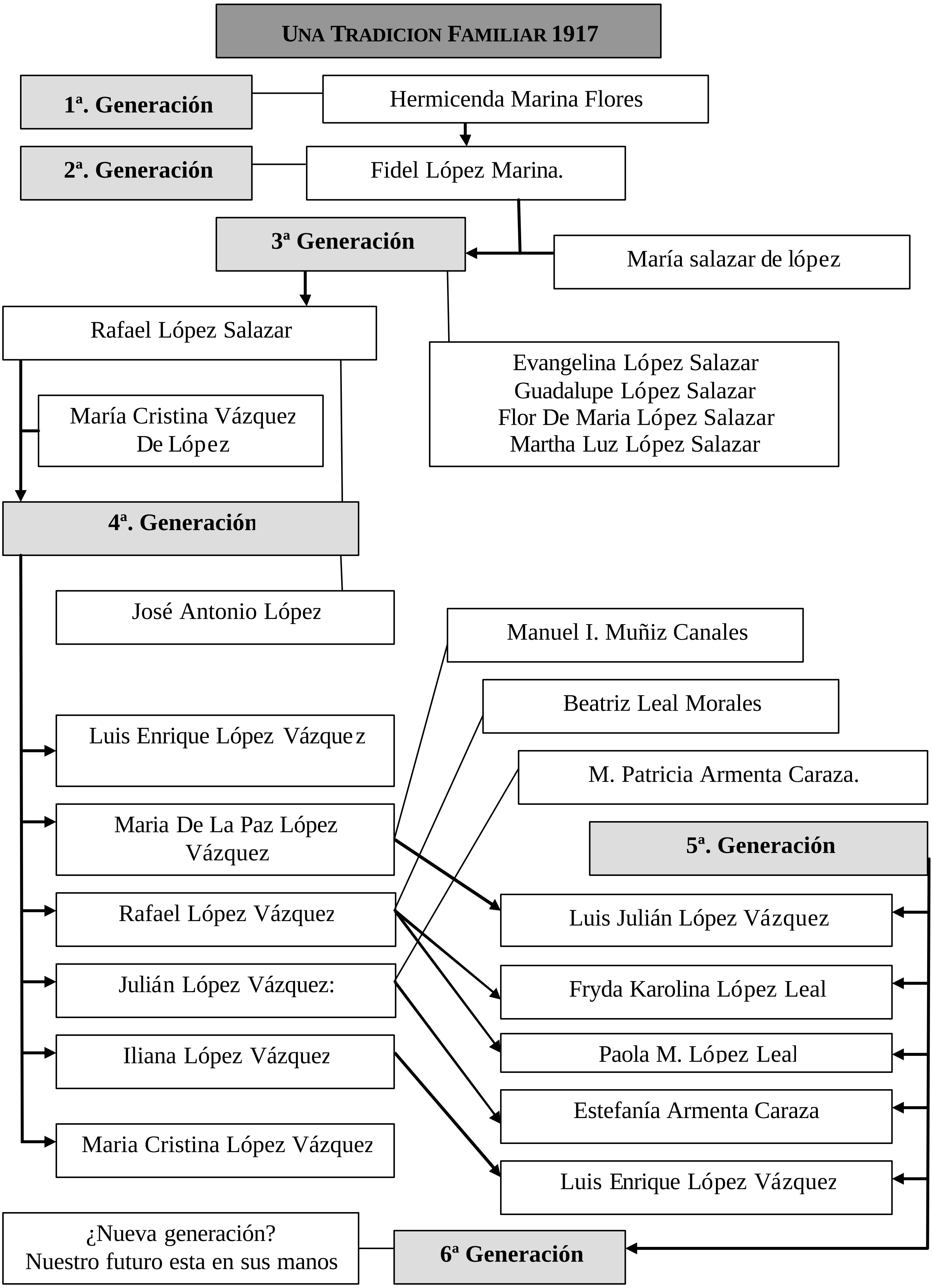
5.24. Fryda Karolina López Leal (2000 – ---)
Primogénita del matrimonio de Rafael López Vázquez. y Beatriz Leal Morales, nace en Tapachula, Chiapas. Desde muy pequeña se le enseño a convivir con los cocodrilianos y su importancia y participa en las actividades del criadero, ayuda como guía de turistas, hace demostraciones en el manejo de crías de cocodrilianos y ha dado entrevistas para televisoras. Actualmente cursa el Kinder. Quinta Generación.

5.25. Paola Montserrat López Leal (2005 – ---)
Segunda hija del matrimonio de Rafael López Vázquez. y Beatriz Leal M., nace en Tapachula, Chiapas. Con poco más de un año de edad, ya interactúa con crías de caimanes y se le transmite la tradición de la familia por la conservación de los Crocodylia.

6. Fechas Relevantes

1876: Nacimiento de Hermicenda Marina Flores.
1914: Huida de Chiapa de Corzo y establecimiento en Tapachula, Chiapas.
1937: Matrimonio de Fidel López Marina con María Salazar.
1939: Nacimiento de Rafael López Salazar, tercera generación.
1945 Primera salida de Rafael López Salazar como lagartero.
1952: Fallecimiento de Hermicenda Marina Flores.
1953: Se establece el negocio como "El Arte Mexicano" Talabartería y Curtiduría.
1954: Primer permiso por la Secretaría de Marina para la pesca local a corta escala de Crocodylia.
1955: Primer permiso para la comercialización de pieles al extranjero.
1960: Se obtiene el Registro Federal de Contribuyentes.
1966: Rafael López Salazar contrae matrimonio con Cristina Vázquez Vázquez.
1967: Renovación del permiso para la pesca local a gran escala de Crocodylia.
1968: Nacimiento de Luis Enrique López Vázquez Cuarta Generación.
1969: Fallecimiento de Fidel López Marina. María Salazar hereda "El Arte Mexicano", su esposa.
1970: Nacimiento de María de la Paz López Vázquez, Cuarta Generación.
1970: Año en que se declara la Veda total de los cocodrilianos de México.
1970: Permiso para Rafael López S. de la Secretaria de Marina para la captura de caimán.
1971: Inclusión del Lagarto real (*Crocodylus acutus*) y el Cocodrilo de pantano (*Crocodylus moreletii*) en el acta de especies en riesgo de los Estados Unidos de Norteamérica.
1973: Nacimiento de Rafael López Vázquez, Cuarta Generación.
1979: Rafael López Salazar establece el criadero de caimanes.
1985: Rafael López S. recibe la administración del negocio "El Arte Mexicano"
1989: Inclusión de México en CITES
1989: Cristina Vázquez Vázquez, queda al frente del "Arte Mexicano".
1990: Fallecimiento de María Salazar.
1993: Nacimiento de Luis Julián López Vázquez (5ª Generación)
1994: Registro ante las autoridades del Criadero de caimanes "El Palomo". Propiedad de María de la Paz López Vázquez.
1997: Renovación del permiso de criadero.
2000: Nacimiento de Frida K. López Leal (5ª Generación).
2003: Refrendo de la autorización y cambio de nombre a UMA "Caimanes y Cocodrilos de Chiapas" (CAICROCHIS).
2005: Primera exportación a El Salvador de ejemplares adultos vivos de caimanes (*Caiman crocodilus fuscus*)

7. Árbol Genealógico



8. El criadero Caimanes y Cocodrilos de Chiapas.

En la actualidad, **CAICROCHIS,** que significa **Caimanes y Cocodrilos de Chiapas**, es una Unidad de Manejo para la Conservación, y Aprovechamiento Sustentable de Vida Silvestre (UMA). Resultado de cinco generaciones de trabajo con los Crocodylia.

La UMA tiene la autorización para las siguientes finalidades: **Conservación, Investigación, Reproducción, Exhibición, y Aprovechamiento Comercial**, y con permiso de operación ante la Dirección General de Vida Silvestre de SGA, SEMARNAT, con clave de registro: **INE/CITES/DFYFS-CR-IN-0054-CHIS/03**; ubicado en la **Calle Josefa Ortiz de Domínguez #57-61, Colonia San Antonio Cahoacán, Tapachula, Chiapas, México.**

Caimanes y Cocodrilos de Chiapas se encuentra edificado en tres predios con una superficie total de 1,500 m2. Dividido en tres secciones:

- Sección A:

La sección A cuenta con:
Museo de los Crocodylia "CROCOMUSEO"
Dos casetas de ambiente controlado
Encierro para exhibición de *Crocodylus acutus*
Encierro para exhibición de *Crocodylus moreletii*
Encierro de tortugas de agua dulce.
Encierro para ejemplares en observación
Oficina
Tienda de recuerdos y taquilla.
Bodega, Rastro y Cocina
Casa.

- Sección B

Encierros para subadultos *Caiman crocodilus fuscus*
Encierros para juveniles *Caiman crocodilus fuscus*
Encierros para *Crocodylus acutus*
Encierros para *Crocodylus moreletii*
Encierro para tortugas africanas.
Incubadora
Fosa Séptica

- Sección C

Encierros para reproductores *Caiman crocodilus fuscus*

9. Método

Para garantizar la correcta transmisión de la Tradición debe estar involucrado un miembro familiar receptor y transmisor de esta.

Por lo que el método consiste que la Dra. María de la Paz López Vázquez (Maripaz) funja como receptor y transmisor de la tradición. Conociendo a todos los miembros de la familiar y estando involucrada directa o indirectamente en cada uno de los acontecimientos nos permite mediante pláticas, entrevistas, fotografías, documentos, viajes y vestigios familiares recuperar la tradición que en este trabajo se denomina “López – Vázquez”.

Maripaz desde que inició este proyecto a recopilado decenas de fotografías, artículos personales y ha tenido múltiples entrevistas con bisabuelas, abuelas, tíos, tías, primos, tanto en primer orden como en segundo orden, con conocidos de la familia que participaron con ellos y principalmente con sus hermanos, su mamá y papá.

Esta recopilación a llevado a realizar múltiples viajes a los municipios donde Don Rafael, su papá, compartía con los habitantes de poblados remotos y rancherías sus aventuras de caza y captura de cocodrilos. Así como viajes a las ciudades y poblados en el estado donde viven parientes lejanos, y viajes donde los hermanos están o estuvieron trabajando al norte del país.

Las entrevistas permitieron acceder a una gran cantidad de información que fue corroborada, corregida, discutida y enriquecida entre los miembros de la familia López – Vázquez lo que ha permitido tener mayor veracidad en la tradición oral y evitar al máximo la distorsión de los acontecimientos y obtener resultados que nos permita implementar acciones a favor de la conservación de los Crocodylia en la tierra sin limites del Soconusco, Chiapas y México.

10. Historia Familiar

Los vestigios de la familia (1914) nos llevan hasta La Hierbabuena, Chiapas; región aislada rodeada de la selva, donde se encuentran los últimos descendientes del Gran Imperio Maya. Enfermedades (63%), accidentes y/o premeditación (37%) fueron y son las principales causas de mortandad entre la población, aunada a esto las presiones de otros pueblos indígenas como los Tzetzales Tzotziles y Tojolabales así como los mestizos de habla castellana rodean a los poblados de Lacandones y constituyen las principales amenazas y motivos por la cual familiares prefieren la migración y/o transformación de sus costumbres y tradiciones (Möller 1992).

Los Lacandones vivieron o viven (quienes sobreviven a sus tradiciones) en armonía con la naturaleza, aunque no siempre fueron pacífico pero tampoco fueron invasor, se les comparó con el Jaguar (*Felis onca*), felino que no tolera a nadie en su territorio. A lo largo de su historia han sido considerados fugitivos por el Imperio Español, siendo en 1790 el último intento registrado fallido por parte de los españoles de cristianizar a los Lacandones, frecuentemente engañados, despojados y vejados por casi todos los forasteros sin distinción de origen: indígenas, mestizos o blancos, siendo actualmente son considerados como reliquias vivientes objetos de especulación y estudio (Möller 1992).

A principios del siglo pasado (1905) el estado de Chiapas se encontraba inmerso con los grandes terratenientes que poseían gigantescas extensiones de selva y montaña chiapanecas, y se dedicaban a la explotación del oro verde maderero de la época, época de esclavitud por las montanerías y explotación de los recursos naturales, la venta de pieles de nutria, de jaguar y de cocodrilo, algunos monos y aves de plumajes llamativos significó y significa para ellos su único ingreso económico que por cierto bastante magro (Möller 1992).

Toda esta actividad maderera y explotación de los recursos naturales implicó inmigración y migración y con ello dispersiones de nuevas o viejas enfermedades que se volvían epidemias, así pues (termino chiapaneco), a principios de la segunda década del siglo pasado, se extiende una epidemia, la viruela negra, que prácticamente acaba con toda la población de Hierbabuena y alrededores , el abuelo Fidel López de tan solo 6 años, junto con su hermano al perder a sus padres por la enfermedad y lo poco que poseían deciden migrar sin rumbo a otras tierras, llevando con ellos la tradición de un imperio maya.

Después de un tiempo desconocido de deambulando llegan a un poblado donde reciben cobijo, a pesar de su corta edad como en la mayoría de los poblados de la época, son inducidos a tomar algún tipo de aguardiente, asustando Fidel y viendo al hermano mayor inconsciente posiblemente para él muerto, huye, huye a una realidad incierta y sin conocimientos de rumbo u otros familiares se encuentra con Don Raúl Marina, quién se apiada de él y lo lleva a Chiapas de Corzo con su hermana, Doña Hermicenda Marina. Doña Hermicenda lo acoge y protege como a su propio hijo y a su vez Fidel López Marina, quien recibe el apellido de ella, protege y cuida a su madre de corazón.

Doña Hermicenda y Fidel tuvieron pocos años con estabilidad juntos, ya que la Revolución había iniciado en 1910, con las nuevas leyes, los precios bajos y la gradual escasez, el futuro de las familias pudientes se destiñó y los grandes hacendados y terratenientes tuvieron que dispersarse para sobrevivir.

La inestabilidad e inseguridad se extiende hasta el estado de Chiapas y en 1914, Don Raúl Marina, tuvo junto con su familia buscar refugio en Pitiquito, Sonora al norte del país, dejando atrás a padres, hermanos y en particular a Hermicenda y Fidel.

Sin muchas alternativas de prosperidad para 1917, Doña Hermicenda Marina, jefa de su familia y persona de gran corazón, tuvo junto con su familia que buscar refugio al sur del estado en Tapachula la Perla del Soconusco, y junto con Fidel dan inició a la tradición “López Vázquez”.

Un exilio duro y de mucho trabajo, la forma de vida de las familias hacendadas se transformo prácticamente de la noche a la mañana, y así como inició se termino la revolución dejando un país transformado y con muchas deficiencias.

Doña Hermicenda no satisfecha con su destino post-revolucionario y persona trabajadora y visionaria opta por buscar nuevas alternativas de trabajo y una mejor vida, es ahí cuando decide establecerse junto con su único hijo de crianza, Fidel, una talabartería.

Cerca de la estación del ferrocarril en el Municipio de Tapachula, en una casa donde vivían es el lugar donde inician de manera informal a trabajar la talabartería con pieles de bovino y ovino, mismas que le surtían desde Comitán; pero en poco tiempo se mudan de domicilio a Av. Central Norte esquina con la 1ª. Poniente, en la ciudad de Tapachula donde continúan con esta actividad.

Posteriormente y por esa visión que caracterizaba a Hermicenda Marina se mudarían al lado Oriente (Cruzando La Calle Frente A La Anterior Dirección), lugar más grande y con posibilidades de crecimiento, es donde conocen al Sr. Benjamín Colmenares, un vendedor de pieles, originario de Salina Cruz, Oaxaca, quien les proveía de la materia prima para la talabartería, primero pieles de bovino y caprino y posteriormente de cocodrilo y otros reptiles. En ese entonces, Don Benjamín los empezó a interesar en que aprendieran y quien les enseñó este nuevo arte, el de la curtiduría, además en ese año la familia empezaba a tener conocimiento y contacto con los cocodrilianos, 1917.

Años mas tarde Fidel López Marina se casa con María Salazar Jiménez, quienes tienen a su primer hijo Rafael López Salazar nacido el 21 de septiembre de 1939, quien sería su primogénito y heredero de ésta tradición familiar. La familia nuevamente se muda a otro domicilio (Central Norte entre Central Oriente y Primera Oriente), aquí solamente se tenía la talabartería y venta al público, y en la Central Oriente entre Primera y Central Norte tenían la curtiduría, predio que le pertenecía a la Sra. Doña Micaela gran amiga de Hermicenda Marina. Aquí es donde empiezan a curtir ellos mismos las pieles, para después trabajarlas en la talabartería.

La piel del Lagarto Real *Crocodylus acutus*, empezó hacer la más cotizada, y al saber que había esta especie en la región, inician ellos con la compra de pieles saladas, y es cuando conocen al "lagartero" el Sr. Tiburcio quien les vendía estas, y quién enseñó a Don Fidel y posteriormente a Rafael a capturar a los cocodrilos; el tamaño de las pieles era impresionante, ya que median entre 14 y 18 pies las mas grandes, y desde dos a 3 pies las mas pequeñas, las más comunes en trabajar eran las que median entre 4 y 6 pies de longitud total, sin cabeza, mismas que las transformaban en maletas, baúles, bolsos, cinturones, etc.; estas pieles eran de cocodrilos que habitaban en la zona de manglares de Puerto Madero, municipio de Tapachula. El comercio de estos productos originalmente era local, y al paso de los años se volvía regional.

Hasta este momento alrededor del año de 1944, Hermicenda Marina Flores, se encargaba de la comercialización y producción, y Fidel López Marina era quien se encargaba de trabajar directamente en la talabartería y curtiduría, mientras que Rafael López Salazar empezaba a interesarse por interactuar con los cocodrilos, desde muy pequeño empezó a involucrarse con la actividad que tenía su abuela y padres, siendo a la edad de los cinco años donde recuerda Rafael, que empezó a agarrar a los primeros cocodrilos vivos, que ocasionalmente tenían en cautiverio.

Tres años después la familia tendría nuevamente un cambio más de domicilio, pero este sería el más importante, se mudan a la Carretera Internacional Tapachula-Talismán (Actualmente es la Central Oriente) en ese entonces era en las afueras de la ciudad de Tapachula; sitio donde vivirían y pasarían toda una vida, aquí ya es donde se tendría de manera definitiva el taller de talabartería, curtiduría y taxidermia, mismo lugar donde se comercializarían los productos elaborados en piel de cocodrilo, como de especies de granja. El taller contaba con un área para la talabartería (ENRRAMADA), y con un área para la curtiduría que constaba de tres estanques grandes para el curtimiento de pieles, principalmente de bovinos y cocodrilos de gran tamaño, la casa de Hermicenda Marina, y la casa de Fidel López con su familia, era un predio rústico, con mucha vegetación natural, y árboles frutales (Mango, plátano, aguacate). En el año de 1952, de 76 años de edad Hermicenda Marina muere a causa de una enfermedad, dejando así como único heredero de la actividad que desarrollaban a su único hijo de crianza, Don Fidel López Marina. Todo el tiempo transcurrido desde 1914 a 1952 período en que Hermicenda llevaba las riendas de la familia y el negocio, no existió la preocupación por llevar acabo tramites para las autorizaciones o permisos con las autoridades competentes en ese tiempo por las actividades que desarrollaban. Causa por la que al tomar Fidel López Marina el mando, y en esa época iniciaba para la familia el poder comercializar los productos especialmente los trabajados con piel de cocodrilo al extranjero, se ven obligados a dar inicio con los trámites correspondientes; es en ese entonces donde se le da la denominación social a la empresa familiar: "El Arte Mexicano".

El 17 de noviembre del año de 1954, la Secretaría de de Marina, a través de la Dirección General de Pesca e Industrias conexas, otorgan el primer permiso número B 74972 para pesca local a corta escala, emitido a favor de Fidel López Marina, con domicilio en Puerto Madero, Chiapas, para efectuar la pesca local a corta escala, en las aguas nacionales del Océano Pacífico, con una duración máxima de un año a partir de la fecha antes mencionada; pagando por los derechos de la expedición de este permiso, según fracción________ de la tarifa de pesca vigente la cantidad de $7.00, según recibo de entero número 113300 expedido por la oficina Federal de Hacienda, con fecha del 17 de noviembre de 1954, en Tapachula, Chiapas, firmando el Inspector J. Oficina de Pesca Felipe Casahonda Castillo (C-a-18931).

El 01 de julio de 1960, se da de alta en la Secretaría de Hacienda y Crédito Público para el Registro Federal de Causantes (CEDULA PERSONAL).

El 24 de febrero del año de 1967, la Secretaría de Industria y Comercio, a través de la Dirección General de Pesca e Industrias conexas, otorgan el Precario.- Renovación del permiso número 97756 para pesca local a gran escala, emitido a favor de Fidel López Marina, con domicilio en Calle Central Oriente #93, Tapachula, Chiapas, para efectuar la pesca captura de caimán (Huesudo), en las aguas nacionales del Estado de Chiapas, con una duración máxima de un año a partir del 17 de marzo de 1967; pagando por los derechos de la expedición de este permiso, según fracción 24 de la tarifa de pesca vigente la cantidad de $100.00 moneda nacional, según recibo de entero número 785754 expedido por la oficina Federal de Hacienda, con fecha del 07 de febrero de 1967, en Tapachula, Chiapas. Firmando el Director General Lic. Jorge Echaniz R. el 24 de febrero de 1967 en México, D.F.

El 23 de febrero del año de 1968, la Secretaría de Industria y Comercio, a través de la Dirección General de Pesca e Industrias conexas, otorgan el Precario.- Renovación del permiso número 97778 para pesca local a grande escala, emitido a favor de Fidel López Marina, con domicilio en Calle Central Oriente #93, Tapachula, Chiapas, para efectuar la pesca captura de caimán (Huesudo) "PULULO O HUIZIZIL", en las aguas nacionales del Estado de Chiapas, con una duración máxima de un año a partir del 17 de marzo de1968; pagando por los derechos de la expedición de este permiso, según fracción___de la tarifa de pesca vigente la cantidad de___, según recibo de entero número 45210 expedido por la oficina Federal de Hacienda en Tapachula , Chiapas, con fecha del 01 de febrero de 1968. Firmando el Sub Director de Asuntos Económicos Pesqueros Lic. Alejandro Cervantes D. el 23 de febrero de 1968 en México, D.F.

Siendo este el último permiso expedido a nombre de Fidel López Marina, ya que el … de febrero de 1969, muere a consecuencia de la diabetes. Momento en que la Sra. María Salazar Jiménez (ESPOSA) se queda a la cabeza de la familia, junto con su hijo Rafael López Salazar….

El 01 de marzo de 1969, se da de alta en la Secretaría de Hacienda y Crédito Público para el Registro Federal de Causantes (CEDULA PERSONAL).

El 27 de mayo de 1970, la Secretaría Marina, a través de la Dirección General de Pesca e Industrias conexas, otorgan la Tarjeta Credencial "B" número 126898, valedera por un año civil a favor de Tranquilino Simón Espinosa, con domicilio en Villa Coomaltitlán, Chiapas, expedida al amparo del permiso número: A-73725, Fracción 24/A a nombre de Rafael López Salazar para capturar caimán; pagando por los derechos de la expedición de este la cantidad de $1.00, según recibo oficial número 176970 otorgado por la oficina Federal Receptora de Hacienda, fechado el 18 de mayo de 1970, expedida en Tapachula el día 27 de mayo de 1970. Firmando el Jefe de Pesca Alvaro Tello Vivar.

11. Análisis

Pareciera que los seres humanos nos hemos apuntado como los guardianes del planeta, cuando somos los más ignorantes de sus recursos naturales y en especial del funcionamiento de sus ecosistemas. Los seres humanos somos nada más una parte de este proceso de evolución y que derecho nos da para determinar la existencia de algún otro ser. Pero como ser humano contamos con la inteligencia y los métodos para garantizar la permanencia de las especies en este planeta.

Fueron objeto de un aprovechamiento desmedido *in-situ*, el Caimanes *Caiman crocodilus fuscus*, el Lagarto Real (*Crocodylus acutus*) y el Cocodrilo de pantano (*Crocodylus moreletii*), como otras tantas especies, las que presentaron una disminución en sus poblaciones. A 35 años de las declaraciones de veda y prohibición de su comercialización, podemos ver una recuperación de las tres especies de cocodrilianos (COMACROM), lo que nos lleva, como seres inteligentes y con conciencia, a establecer reglas, normas y lineamientos que nos permitan hacer un correcto uso de los recursos naturales.

Incitamos a las autoridades mexicanas a que aceleren el proceso para establecer estos métodos de aprovechamiento sustentable que permitan dar el valor correcto a las especies para su conservación y permanencia en su hábitat natural.

12. Resultados Y Conclusiones

Con casi 100 años de información y trabajo, concluimos que este trabajo de ser objeto de una publicación mucho más amplia por si solo, el plasmar en un libro la importancia de la tradición familiar, incluyendo anécdotas, comentarios, referencias, reseñas, aprendizajes y descripciones entre otros permitirá realmente conservar el legado histórico dignos de conservar en la memoria.

Son tantos acontecimientos, sucesos, hechos y manifiestos a favor de la conservación de los Crocodylia en México como reflejo del modo de vivir y de pensar de los seres humanos de la época, que la preservación y análisis de cada uno de ellos nos permite identificar errores y aciertos, para establecer directrices favorables para la permanencia de las especies en nuestro país.

Los Crocodylia en México, pueden ser sujetos a un aprovechamiento sustentable, aunque actualmente las Unidades de Manejo no tienen una interacción *in-situ* de extracción se cuenta con tradición que demuestra, que con un correcto uso las especies se ven protegidas y su población aumenta.

13. Agradecimientos

Este trabajo esta dedicado a la memoria de Luis Enrique López Vázquez, quién ama la naturaleza y sigue ayuda a la preservación de todos los cocodrilianos. Con su amor, cariño, cuidado, asesoría y conocimiento sigue ayudando a la familia en muchas ocasiones. Muchas gracias.

Deseamos agradecer a toda la familia y amigos quienes ayudaron y dieron sus consejos, sus recuerdos y sus memorias para escribir este documento.

Pero especialmente a Maria de la Paz López Vázquez y Luis Julián López Vázquez por haber iniciado este viaje, a María Cristina Vázquez Vázquez por su gran memoria, frases y dichos muy especiales, a Rafael López Salazar por ser quién nos transmite la tradición oral a toda la familia y amigos interesados, a Evangelina López Salazar quien nos ayudo mucho a contactar a otros miembros de la familia.

Y este viaje no fuera posible sin la ayuda y apoyo de Caimanes y Cocodrilos de Chiapas, CAICROCHIS y María de la Paz López Vázquez.

Nuestro Futuro Esta En Sus Manos
Our Future Is In Their Hands

Conservation Challenges For The Cuban Crocodile

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Abstract: In January 2000 a workshop on the Population and Hábitat Viability (PHVA) for the Cuban crocodile *(Crocodylus. rhombifer)* was held in Cuba. At this event the main impacts and threats to the survival of the Cuban crocodile were identified for the two remaining areas where wild populations still occur: the Zapata Swamp in Matanzas province and the Lanier Swamp on the Isle of Youth. The participants agreed that the three greatest threats are habitat loss and fragmentation, illegal hunting and the ongoing hybridization of Cuban and American crocodiles. This paper will present information on work that has been done since 2000, and the results of a recent workshop held in Cuba (May 2006) to reassess the nature and degree of these and other threats. The main result of this workshop was the decision to develop a National Action Plan for the conservation of this endangered species, and these recommendations will be discussed.

PROGRAMS FOR THE CONSERVATION OF THE AMERICAN CROCODILE IN CUBA.

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Abstract: The American crocodile (*Crocodylus acutus*) is widely distributed throughout the Cuban Archipelago, which contains some of the largest known and best conserved populations. The conservation of this species, classified as Vulnerable (IUCN) and its habitat is the responsibility of the Cuban government, through the Ministry of Science, Technology and the Environment (CITMA- which is charged with the coordination of environmental issues) as well as three other ministries that manage the conservation and use of natural resources in specific regions: the Ministry of Fisheries (MIP), the Ministry of Tourism, and the Ministry of Agriculture.

Within the Ministry of Agricultura, the National Flora and Fauna office (Empresa Nacional para la Proteccion de la Flora y la Fauna; ENPFF) administers a large number of Cuba's protected areas. CITMA, MIP, and the Ministry of the Interior (MININT) are primarily responsible for the juridical aspects of protection of these areas, through their offices of Inspection and Environmental Licenses (in CITMA), Fisheries Inspection (MIP), and the Environmental Police (MININT). The ENPFF runs the National Crocodile Program, which is the main program for crocodile research, conservation, and managed use of American crocodiles in Cuba. This overall program is comprised of several sub-programs: research and management of wild populations, captive management, and environmental education. Research on wild crocodile populations has been carried out at sites within the national system of protected areas which contain the largest populations, in particular the Delta del Cauto and Rio Maximo Wildlife Refuges and the Peninsula de Zapata and Peninsula de Guanahacabibes National Parks.

Conservation Status Of The Morelet's Crocodile (*Crocodylus moreletii*) In Mexico: A Proposal For Its Reclassification In The U.S. Endangered Species Act (ESA)

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Abstract: Based on a field study (2002-2004), developed by a group of experts (COPAN Project), CONABIO concluded the first national evaluation of the status of wild populations of *Crocodylus moreletii* in Mexico. It gathered information on presence, abundance and habitat from 10 States (63 localities). Forty new localities were recorded, for a total of 105; the species was recorded in 21.9% of historic localities visited. A general index of abundance (total individuals/Km surveyed) gave a figure of 3.16 ind/Km. Based on these data and geographic projections of available habitat an estimation of *ca*. 15,000 adults in the wild was obtained (nearly 80,000 individuals of all ages). Adding available data from Guatemala and Belize, the estimation reached about 19,000 adults in the whole species' range (or slightly over 100,000 individuals of all ages). Furthermore, a dynamic population simulation using Vortex 9.42, with only about $^{1}/_{3}$ of the total estimated population, due to the upper limit of the software (30,000 individuals) showed a very low probability of extinction (0.1380 ± 0.015). These results indicate an effective comeback of a resilient taxon, after nearly critical depletion of natural populations by 1970. On the basis of this, and other evidence, a proposal for removal (or downlisting) the species in the U. S. ESA was submitted by Mexico.

The proposal places an emphasis on the need for status congruence with the IUCN Red List and the Mexican NOM-059-SEMARNAT-2001, which rank it as of Lower Risk conservation dependent (***LRcd***), and Under Special Protection (***Pr***), respectively. A tri-national workshop held in Mexico fostered the development of a regional strategy to ensure cooperation for the conservation of the species in the long term, along its whole distribution range.

1. Introduction

After a field survey (2002-2004) developed by a group of Mexican experts (COPAN Project) a first national evaluation of wild populations status for *Crocodylus moreletii* in Mexico was developed. In December 2004, the COPAN report was reviewed during a specialized workshop convened by Mexico's National Commission for the Knowledge and Use of Biodiversity (CONABIO) to reassess the species status in the IUCN Red List, NOM-059 (national red list) and the U.S. Endangered Species Act (ESA), including the newly collected data. The field survey gathered information on the presence, abundance, and habitat for *Crocodylus moreletii* from 10 states, summing up information for 63 localities. The COPAN Project, for a current total of 145, recorded 40 new localities for the species in Mexico; the species was recorded in all of 21.9% of historic localities visited. Based on these recent field data virtually covering all the species' range in Mexico, a general index of abundance (total individuals/total Km surveyed) was calculated for Mexico. Estimations for Guatemala and Belize's wild populations sizes were carried out, based on published information, in order to produce a total estimation for the species throughout its range. Furthermore, a dynamic population simulation was carried out to evaluate its probability of extinction.

2. Background

Morelet's crocodile (*Crocodylus moreletii*) lives in low-elevation water bodies (usually <900m), from northeastern Mexico to northern Guatemala, and Belize (see Figure 1).

Figure 1. *Crocodylus moreletii* world distribution

The species was abundant in the past, despite the extensive alteration of natural areas since the XVII Century, but was heavily exploited in the late XIX Century and in the XX Century, to 1970.

These levels of exploitation seriously imperilled wild populations along its whole range. Consequently, Mexico imposed a ban to commercial hunting of wild individuals in 1970, which is in place up to date. Also in response to that situation, the species was included in the ESA as *Endangered* in 1970. At that time, this measure reinforced Mexico's policy for the recovery of the species. In order to complement these actions, the Mexican government, in conjunction with NGOs and national institutions, promoted the installation of captive rearing programs, meant to serve as reservoirs for potential reintroduction or restocking programs. In addition, many Natural Protected Areas have been decreed in Mexico in the last two decades, and this has significantly increased the species area and habitat under protection. These continuing actions sowed the seed for the recovery of this crocodile that recent field evidence is demonstrating.

3. Field study results

Field surveys included ten States of Mexico, summing up 63 localities. So far, 40 new localities have been recorded, for a total of 105 (IUCN had cited only 40 of those previously reported). From the total known (historic) localities, the COPAN Project visited a sample of 21.9% of these, and persistence of the species in all of them was recorded. In addition, 24 localities were surveyed for habitat quality for the species, and from these 57% were evaluated by the COPAN field team as with habitat apt for *C. moreletii*. According to reports of these surveys, self-consumption fishing and cattle raising appear to mildly affect the species, while urban development and industry are the least compatible activities. Agricultural areas have historically altered crocodile habitat in Mexico, and this factor was taken into account as will be explained later.

4. Abundance and population structure

Abundance indices obtained by COPAN were moderate in most areas, with a single surprising case of 38 ind./Km, which was not taken into account for further analyses as it represents an obviously outlying value (see Figure 2). Averaging of abundance indices reported resulted in 5.76 ind./Km and a wide interval of confidence (0.31 to 10.16 ind./Km). But as data did not show a statistically normal distribution, the average and SD were discarded for further work. Besides, as arithmetical averaging does not reflect actual frequencies of values, from the same database the Mode was then calculated, and resulted in 3 ind./Km. Also, a general index of abundance could be calculated as total individuals seen / total Km surveyed in the more than 60 localities in Mexico. This exercise gave a figure of 3.16 ind./Km. As this overall index for Mexico was very close to the Mode, and much lower than the average, it was used for further calculations, in order to keep a precautionary approach. Based on COPAN results, a working estimation of wild population size for *C. moreletii* in Mexico was conducted, though it is recognized that periodic updating may improve the analyses we report here.

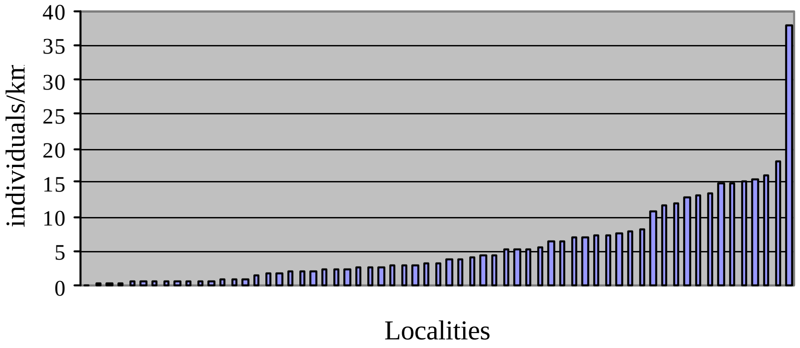


Figure 2: Abundance indices for *C. moreletii* as registered for 63 localities in Mexico

The 3.16 ind./Km abundance index obtained for *C. moreletii* in Mexico is comparable to those known for other crocodile species considered as of lesser concern, in terms of potential extinction, within the IUCN context (see Table 1.).

Species	Country	Index	Year
C. porosus	Malaysia	1 – 3 ind./Km	1998
C. palustris	India	2.8 ind./Km	2002
C.acutus	Honduras	2 ind./Km	2002
C. novaeguineae	Indonesia	2 – 2.1 ind./Km	2003
A.mississipiensis	USA	0.3 – 4.7 ind./Km	2003
C. moreletii	Mexico	3.16 ind./Km	2004

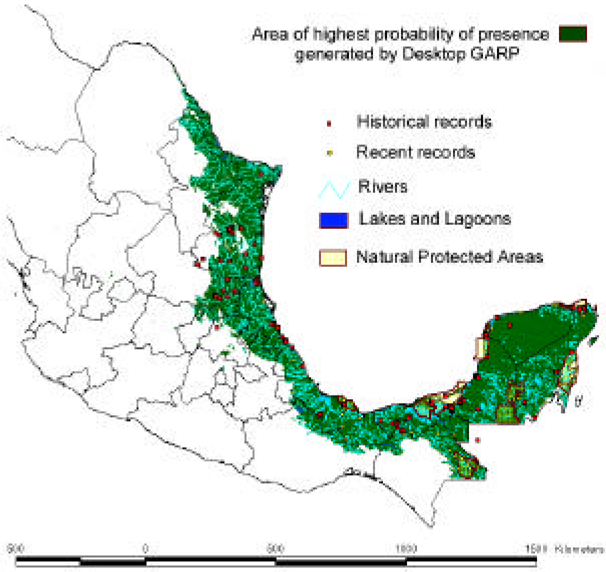
Table 1. Relative abundance indices for several crocodilian species not considered as endangered

Sources of data for Table 1: *C. porosus* (Ross, 1998); *C. palustris* (Vyas and Vyas, 2002); *C. acutus* (Cerrato, 2002); *C. novaeguineae* (Kurniati y Manolis, 2003); *A. mississipiensis* (Mazzotti *et al.*, 2003); *C. moreletii* (COPAN, 2004).

Regarding population structure, the analyses relied on the composite sample for all the area surveyed. It was found that adults represented 19% of the total sample reported by the COPAN from Mexican territory. Also, a 1.55:1 male:female sex proportion, was found. A high proportion of Class I (<1 year) and Class II (juveniles, assignable to ages 2-3 years) makes for a sum of 62% young *C. moreletii*. Based on this information, we can assume reasonably good nesting, hatching, and recruiting success in the composite sample from the species' range in Mexico.

5. Geographic area

A total of 396,455 Km^2 were indicated by a GARP algorithm as having a greater probability of presence of *C. moreletii* in Mexico. That initial projection was based on the geographic attributes of the actual records of the species. Within these, a total of 106,707 Km of river and lake shoreline were computed as present within the area, with the aid of GIS (see Figure 3). Even excluding intermittent bodies of water, a total of 49,465 Km appeared as potentially available for crocodiles.



Total potential distribution area = 396,455 Km

Total length of permanent rivers and water bodies = 49,465 Km

Figure 3. Potential distribution of Morelet's Crocodile in Mexico

6. Potential distribution: available habitat

As 49% of the GARP area was found to be currently altered (see Figure 4), it was discarded, thus leaving a 51% in comparatively good condition for *C. moreletii*. Assuming an analogous proportion of shoreline length still in good shape, the cut yielded a more realistic, precautionary 25,227 Km of available habitat length, and this figure was then used for subsequent estimates. Nevertheless, it is important to mention that COPAN informed having recorded Morelet's crocodiles also in altered areas; thus, habitat might be somewhat underestimated by our calculations.

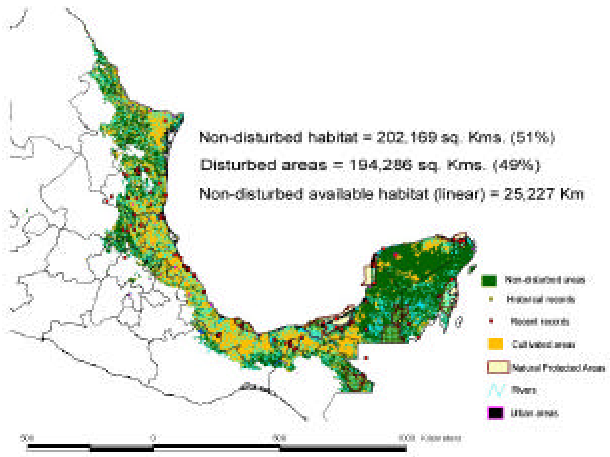


Figure 4. Potential distribution of Morelet's Crocodile in Mexico, minus areas with agricultural and urban disturbance.

7. Population estimates for each country in the species' range

Based on the previous calculations, the value of 3.16 ind./Km, was considered as an overall index for Mexico (very close to the Mode and much lower than the average). It was used to estimate total population size in Mexico as shown below:

7.1. Mexico
Abundance index used = 3.16 ind./Km (near Mode, from field data by COPAN).
Suitable habitat length, precautionary estimation by GARP-GIS = 25,227 Km.
Total animals estimated in the wild: 79,718 individuals.
Total of adults estimated in the wild (19% of total, proportion from COPAN Project): 15,146 individuals.

Similarly, with available published data, calculations were done for Guatemala and Belize, as follows:

7.2. Guatemala
Abundance index used = 2.078 ind./Km (average of values cited by Lara, 1990).
Suitable habitat length inferred from literature data = 6,994.5 Km (from data on extension and degradation of the Peten; Castañeda-Moya, 1998).
Total animals estimated in the wild: 13,911 individuals.
Total of adults estimated in the wild (19% of total, using proportion from Mexico as a surrogate): 2,643 individuals.

7.3. Belize
Abundance index used = 2.63 ind./Km (from Platt, 1998).
Suitable habitat length inferred from geography = 3,347 Km.
Total animals estimated in the wild: 8,803 individuals.
Total of adults estimated in the wild (19% of total, proportion in Mexico as a surrogate: 1,673 individuals.

8. A total wild population estimate

From data and calculations explained above, a tentative global figure of 102,432 (for a downward rounding of *ca*. 100,000) individuals of all ages in the wild was estimated for the whole range of the species. From this value, an estimated total of 19,462 (downward rounding of *ca*. 19,000) adult individuals were calculated. The latter figure lends support to earlier considerations by experts made in the 1995 workshop and to subsequent work summarized by Ross (1998) departing from consultations with experts, both indicating that in excess of 10,000 free adults were thought to exist within the species' range (see IUCN Red List, 2005, online).

9. Prospective dynamic modelling of potential population trajectory

Current data on natural history and fresh field information from COPAN on wild populations, and from literature in the case of Guatemala and Belize, were input into the Vortex 9.42 program (Lacy *et al.*, 2003) to generate and initial exploratory population trajectory model for *C. moreletii*.

Software limits allowed for simulating only an initial population of 30,000 individuals of all ages (*i.e.* as if only 1/3 of the total estimated individuals of *C. moreletii* were thought to exist). Extinction was arbitrarily defined as only 500 individuals left (deliberately ignoring the fact that even such a small population might well constitute a founding basis for an eventually needed recovery program).

The chosen scenario simulated high stress, including a steady progressive reduction of carrying capacity (this is very improbable in reality, but of great help for getting insight on population reactions to extreme pressure). Reduction of carrying capacity was simulated as up to 75% in the 500-year lapse defined for the simulation of population trajectory. With these parameters, five hundred iterations were run.

Potential catastrophes simulated included: a) transcendent habitat deterioration (p = 0.10 for the lapse), and b) transcendent reduction of prey base (p = 0.15 for the lapse). Parameters considered: no inbreeding depression assumed to occur, on the basis of current evidence. First age of reproduction for males and females, 8 years; maximum breeding age (senescence), 30 years; sex ratio at birth (slightly biased towards males, based on COPAN findings), 60%; polygynous mating; 41.3% of adult males assumed successful in having descendence *(more field data are needed)*; 80% percent adult females assumed as breeding *(more field data needed)*. Of those females producing progeny: mean number of progeny per breeding female per year = 30 ± 5.

After the 500 year-lapse we simulated, the estimated probability of extinction was 0.1380 ± 0.015. Seen as the inverse, 0.86% probability of survival was obtained. Throughout the 500 runs (500 years each) and with an initial population of 30,000 individuals, none of the end populations went below 4,500 individuals. These results are consistent with a high elasticity of the species, as actually demonstrated by its spontaneous comeback after 30 years of hunting ban in Mexico (no significant reintroductions or population supplementation has been attempted). Nevertheless, we emphasize that more data on the actual breeding pool will be needed to gain more insight through modelling. The main product of modelling is progressively improving diagnostics, not arriving to rigid, final numbers (see the following graphics; Figure 5).

Modelling also considered that high heterozygosity has been documented for *C. moreletii* in northern Belize (H = 0.49; Dever *et al*., 2002); this is higher than that documented for *Alligator mississipiensis* (H = 0.46; Glenn *et al*., 1998). A relatively high index of inter-population migration has been documented in Belize (Nm = 5.15; Dever *et al*, 2002). Minimal individual movement can contribute to genetic diversity by panmyxis (Wright, 1931). With current evidence, no genetic bottlenecks would be anticipated for the near future.

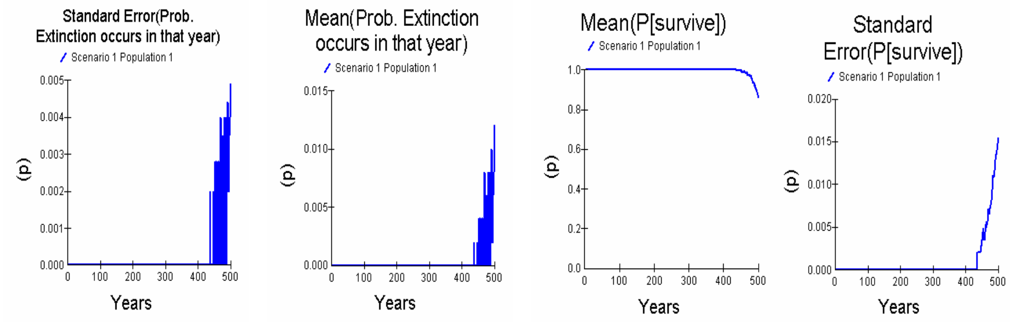


Figure 5. Main results of the simulation of population trajectory modelled with the parameters described above, for a population of *C. moreletii* 1/3 of that actually estimated with current field data. (Vortex 9.42; Lacy *et al.*, 2003; 500 runs).

10. Conclusions

Data at hand and pertinent analyses strongly suggest an effective comeback of a resilient taxon, after nearly critical depletion of natural populations by 1970. Prohibition of commercial hunting of wild specimens would seem to be the most important factor in this phenomenon in Mexico, since no restocking has been performed in the country.

During the last decades, designation of more protected areas has also played an important synergic role for conservation of this crocodile. In this sense, legal and administrative structures in Mexico seem to have been strong enough, so as to permit the recovery of *C. moreletii* as seen today. These strengths are still growing, since environmental laws have increased in number, coverage and detail during the last 15 years. Concomitant development of the law-enforcement capacities of Mexico includes the creation and operation of a nationwide General Attorney Office for Environmental Protection (PROFEPA-SEMARNAT). Also important for crocodile conservation in the country, is the fact that Mexican government continually receives input from an officially recognized consulting organ for crocodile conservation and sustainable use (COMACROM), integrated by individuals from the academy, NGOs, registered crocodile breeders, and other stakeholders.

Thus, current evidence indicates that *Crocodylus moreletii* is no more an endangered nor threatened taxon. Its current status in the IUCN Red List (LR-cd, now LC) and Mexico's NOM-059 (Pr) is congruent with the findings. The status of the species in the U.S. ESA and in CITES would merit revision, according to current results.

Based on these findings, Mexico presented and officially submitted a proposal for the reclassification of Morelet's Crocodile in the U.S. Endangered Species Act at the X Annual Meeting of the Canada/Mexico/US Trilateral Committee for Wildlife and Ecosystem Conservation and Management (Zacatecas, Mexico 2005), considering the importance of reviewing the status of the species after 35 years of its inclusion. The proposal places an emphasis on congruence with the Red List (IUCN) and the Mexican NOM-059-SEMARNAT-2001, which rank *C. moreletii* as LR cd (now LC), and Under Special Protection (Pr), respectively.

The results here summarized do not imply, in any sense, that commercial use of wild Morelet's crocodiles is warranted. Any ranching, or other extractive projects, must await availability of detailed research and monitoring on particular populations, and critical evaluation of results.

Recently, a tri-national workshop (Belize-Guatemala-Mexico Trinational Workshop on Management and Conservation of Morelet's Crocodile) held in Mexico City (April 2006), fostered the development of a regional strategy for the conservation and sustainable management of the species, aimed to ensure cooperation for the conservation of the species in the long term, along its whole distribution range. The Trinational Workshop defined an agenda: tasks, timing and responsible persons/agencies. This initiative is a follow up of results derived from the Petén Agreement (2001) and has resulted in agreements for the implementation of the strategy. The three countries plan to:

? Carry out population surveys in properly defined priority areas (systematic and coordinated monitoring, with standardized field work methods and techniques).

? Develop a shared information system (biological and geographical).

? Identify priority areas and routes (for conservation, surveillance, and with future potential for ranching).

? Support and develop education programs and outreach materials.

? Promote personnel training / experience exchange (including field techniques and surveillance).

? Promote species' friendly productive projects (closed cycle farms and, eventually, future ranching), along with the development of a licit regional market and a certification strategy for *C. moreletii* products in the three countries.

? Raise funds in support of the activities and tasks outlined in the strategy.

Also, a tri-national Coordination Group supported by three Consulting boards (Scientific-Technical, Management, and Law Enforcement) was established, and specific progress indicators were defined according to the strategy's goals.

Based on the above, government offices (agencies) in Mexico, Guatemala and Belize would be expected to promote and support periodic updates of field data in all three countries, so that this first evaluation can be updated, and conservation decisions can be agreed upon in a timely, appropriate fashion.

11. Credits

Field surveys and database: COPAN Project (J. Domínguez-Laso y L. Sigler, Coordinators). Scientific advice and research: O. Sánchez. General coordination and support: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO; H. Benítez, J. Álvarez-Romero, P. Mosig, and A. García-Naranjo).

Management issues: Dirección General de Vida Silvestre (DGVS-Semarnat; (O. Ramírez, E. García y L. Urbano). Law enforcement aspects: Procuraduría Federal de Protección al Ambiente (PROFEPA-Semarnat; E. Mendoza, H. Barrios). Other Workshop participants were: P. Ponce, A. Reuter, O. Hinojosa, J. Alarcón, P. Carton de Grammont, G. Casas, X. Aguilar, F. León, O. Fernández. IUCN/SSC Crocodile Specialist Group (A. Velasco, J. P. Ross, M. Muñiz).

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Study And Conservation Of Crocodilians In Other Parts Of The World

Crocodiles And The IUCN Red List: Opportunities And Challenges

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Abstract: The IUCN Red List of Threatened Species produced by the Species Survival Commission (SSC) of the World Conservation Union has as its central goal the identification of species at risk of global rather than national extinction. It was designed to be an international call for conservation action, for irreversible losses of global biodiversity, and it has proved remarkably successful.

The categories of threat to which species are assigned, and the criteria for each category have evolved over the last 25+ years. Today they rely heavily on quantitative estimates of population size, distribution and trends in both, combined with biological criteria such as generation time. . This system has improved the objectivity with which species are assigned to a category of threat, but problems remain.

With regard to the criteria, for crocodilians three generations is too long a time scale to assess past status, or for predicting future changes in status resulting from conservation action. The "global extinction" level of resolution of the IUCN Red List is too broad for wide-ranging crocodilian species. There is an urgent need for a protocol capable of more fine-scale evaluations, such as at the national level, if the Red List is to have more utility at the grass-roots level of preventing extinction. .The current risk categories for crocodilians are too broad and variable to provide an index of priorities for conservation action:

Another important issue is to separate the often confused issues of species risk and conservation priority. The designation of conservation priority should certainly use risk of extinction as a principle determinant, but should also consider other parameters that are deemed of conservation importance. This may include items such as taxonomic uniqueness, and the existence (or absence) of successful on-going conservation programs are needed. For instance, if the CSG were to decide that taxonomic singularity is an important characteristic in determining conservation priority, and two species were considered to have the same level of risk of extinction risk, but different values of taxonomic uniqueness (e.g., the Siamese crocodile and gharial), a higher priority would be given to the more taxonomically distinct species (in this case the gharial as a monotypic genus). The challenge for the CSG is to define which are the most important characteristics, other than IUCN categories of risk of extinction, to be used for defining conservation priorities.

Effects Of Hurricanes Katrina And Rita On Alligators (*Alligator mississippiensis*) In Louisiana

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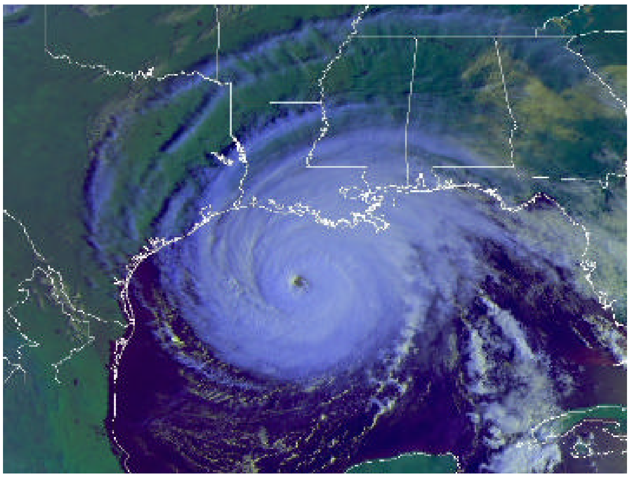
Astract: Coastal Louisiana was impacted by two devastating hurricanes in 2005. Hurricane Katrina struck southeastern Louisiana on 29 August, and Hurricane Rita hit southwestern Louisiana on 24 September. Massive tidal storm surges inundated coastal marshes with high salinity waters across virtually the entire coast of Louisiana; which is prime alligator habitat. Some direct alligator mortality was observed; but overall impact of these storms on alligator habitat remains to be seen. Direct physical damage to wetlands through scour, scrapes, erosion, and rolling has been noted, and high salinities have been accentuated by lower than usual winter rainfall after the storms, which might have tempered the deleterious salinities. Effects of these storms on the 2005 wild alligator harvest are reviewed, as are effects seen on regional commercial alligator farming operations. Blood samples were taken from wild alligators (n = 57; size range 68.6 cm to 213.4 cm total length) in February and April of 2006 to assess stress (via plasma corticosterone and electrolyte levels) due to the hurricane; although superimposed severe drought conditions have developed making interpretation difficult. Annual coastal nesting surveys are scheduled for late June/early July 2006 which will provide additional data on alligator habitat alteration resulting from these hurricanes. A record 507,000 alligator eggs were collected in summer 2005 as part of Louisiana's egg ranching program; many of these might have been lost due to flooding of eggs or direct mortality of young hatchlings had the landowners/ranchers not participated in the egg ranching program. This provides strong support for the concept of sustained use of wildlife resources, which otherwise would have been lost to natural mortality.

1. Introduction

The state of Louisiana has a large alligator population with annual coastal production of some 30,000 to 40,000 nests. Hurricanes Katrina and Rita struck the Louisiana coast on 29 August and 24 September 2005 respectively.

While Hurricane Katrina primarily impacted southeastern Louisiana coastal marshes, Hurricane Rita inundated the entire Louisiana coast and struck with particularly devastating force to southwestern Louisiana. This paper will outline some of the effects noted thus far on Louisiana's alligator habitat, population, wild harvest, farming/ranching industry, and research program.



Hurricane Rita approaches coastal Louisiana

2. Habitat Impacts

The parishes of Plaquemines, St. Bernard, Orleans, and St. Tammany were impacted significantly by Hurricane Katrina (Jefferson to a lesser extent). Marshes throughout these Parishes were inundated by a tidal surge of high salinity water. Although the direct physical damage to the wetlands have not yet been quantified, initial over flights indicated extensive damage to some wetland areas, in particular the Delacroix marshes in Plaquemines and St. Bernard Parishes. An estimated 600,000 acres of primarily intermediate and brackish coastal marsh alligator habitat was adversely impacted.

Hurricane Rita's storm surge flooded the entire coastal wetlands to some degree, with the parishes in southwest Louisiana being most affected. The tremendous tidal surges associated with Rita flooded millions of acres of coastal alligator habitat with high salinity flood waters. Extensive inland fresh marshes in southeast Louisiana were flooded with 5 - 7 parts per thousand (ppt) salinity water. By mid-October water levels were returning to normal levels and salinities had moderated although large fresh marshes in Terrebonne Parish still had water salinities in the 2 - 4 ppt range.

In south central Louisiana (Iberia and eastern Vermilion Parishes) marshes and inland areas were flooded with 5 - 9 ppt water. The marshes north of White Lake had salinities in the range of 2 - 4 ppt. The marshes on either side of Freshwater Bayou had salinities ranging from 7 - 11 ppt on the north end to 15-20 ppt on the south end. Marshes between White Lake and the Mermentau River, south of Grand Lake had salinities in the range of 7 - 14 ppt. Marshes west of the Mermentau River to Johnson Bayou had salinities ranging from 16 to 24 ppt. These salinities were all recorded on 30 September 2005.

Although large alligators tolerate high salinities better than hatchling or juvenile alligators, nesting in salt marshes is rare. High salinity waters became “trapped” in some marshes and some large landowners were unable to pump off this excessive water for many reasons (pumps for water control management were often damaged and not functional after the 10 - 20 foot storm surge passed; diesel fuel difficult and costly to obtain, land managers and employees displaced from homes and work places). Normally rainfall in Louisiana would temper these high salinities, but fall and winter rainfall after the hurricanes was limited. Since the initial surge salinities have moderated to some degree, however they remain much higher than normal in most habitats as of spring 2006.

Flooded Rockefeller marsh 26 September 2005

Note barge washed up onto marsh vegetation and floodwaters flowing over

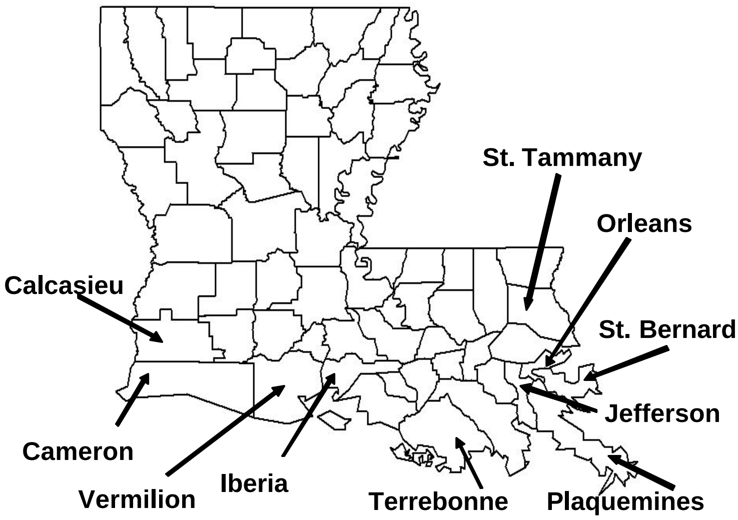
The overall impact of the storms on coastal marsh habitats will take some time to assess. Direct physical damage to wetlands through scour, scrapes, erosion and rolling will be best assessed through digitizing land/water ratios before and after the storm events. The excessive salinities measured immediately following the storm surge in southwest Louisiana are cause for concern. Salinity levels from 8 - 20 ppt in fresh water marshes and 15 - 24 ppt in the intermediate and brackish marshes of Cameron and Vermilion Parishes will likely have significant impacts on vegetative composition (and future nesting habitat suitability) in both the short and long term. Even the moderate salinities of 3 -5 ppt in the fresh marshes of Terrebonne and other eastern parishes are reason for concern. The critical factor will be how long these high salinities persist before drainage and moderation of salinities occurs. Many of the marshes in southwest Louisiana have to drain through limited outlet points, thus increasing the flood period and further impact on vegetation.

Flooded scalded marsh 26 September

Normal healthy marsh with alligator

3. Wild Alligator Harvest Impacts

The opening of the 2005 wild alligator season was delayed from September 7 to September 14 due to the impact of Hurricane Katrina on alligator hunters, alligator processors and dealers, and on the entire infrastructure needed to conduct the statewide harvest season. Hunters in numerous southeastern parishes were displaced and dealers and processors were unable to obtain refrigerated trucks, truck drivers, ice, gas and other required supplies, which in many cases were diverted to relief efforts. The damage to the banking infrastructure hindered the dealer's capability of obtaining sufficient capital to buy alligators. Additionally some dealers could not access their computer data bases and many were without electrical or telephone service. Alligator harvest quotas were high in 2005, as the nesting effort was the third highest on record; and prices were strong.



Louisiana parishes most affected by 2005 hurricanes

Hurricane Katrina impacted alligator hunters primarily in Jefferson, Plaquemines, St. Bernard, Orleans, and St. Tammany Parishes. Many of the alligator hunters lost their homes and boats and simply were not able to harvest alligators in 2005.

Of the allotted harvest in these parishes an estimated 1,800 alligators, valued at nearly $400,000, were not harvested. Under normal circumstances these animals would move through buyers and processors, creating jobs for workers processing, sorting, grading and shipping these skins to tanners. Other lost income includes businesses selling supplies (fuel, food, bait, etc.) to hunters. Future harvest in these areas may be reduced due to loss of quality alligator habitat. Additionally, at least one alligator processing plant in Venice was destroyed.

Hurricane Rita's storm surge flooded coastal marshes throughout coastal Louisiana, delaying efforts of alligator hunters to complete their 2005 harvest allotments. An estimated 75 - 80% of the allotted harvest had been completed when Rita struck on September 24th. Within a 5 - 10 day period most hunters from Iberia Parish eastward were able to resume their hunting activities. Hunters in Cameron, Vermilion, and Calcasieu faced a more catastrophic situation with severely flooded marshes, loss of homes and displacement for months. Only a portion of the alligator hunters in southwest Louisiana were able to resume their hunting activity. An estimated 1750 alligators valued at $389,000 were not harvested. Additional economic impact included loss of jobs in the processing industry and loss of sales of supplies to hunters. Harvest quotas in the affected areas may be reduced in future years due to the impact of high salinity flood waters on fresh, intermediate and brackish marshes. Processing facilities in Cameron and Vermilion parishes were damaged and at least one facility in Cameron Parish was destroyed.

Statewide, despite the catastrophic hurricanes 30,142 wild alligators were harvested (82.4% of the 36,577 tags issued) based on shipping records as of 27 April 2006. The percent harvested may increase slightly to approximately 85% of tags issued as additional late shipments are made. Prices were excellent in 2005 at $34.50/foot total length, as compared to $22.50/foot in 2004, $13.00/foot in 2003, and $16.00/foot in 2002.

4. Wild Alligator Nest Production/Alligator Egg Collection Impacts

Hurricane Katrina may impact wild nest production and future egg collections in Plaquemines, St. Bernard, Orleans and St. Tammany Parishes. In these parishes an estimated 3,683 nests are produced on privately owned wetlands while an estimated 750 nests are produced on public lands. While all permitted 2005 egg collection activities were completed prior to Hurricane Katrina, it is anticipated that the 2006 nest production and subsequent egg collections may be impacted. The marshes in Plaquemines and St. Bernard Parishes in the area of the Caernarvon Freshwater Diversion were damaged by storm surge and saltwater intrusion. Initial aerial observations indicated significant physical marsh damage to large areas of vegetated wetlands. This area has been particularly productive in recent years and nest production may be affected by as much as 50% in selected areas in 2006 and in future years. The superimposed drought conditions that have developed since the hurricanes may influence nesting in 2006 as well.

Virtually all of coastal Louisiana was flooded from the storm surge associated with Hurricane Rita. An estimated 37,700 alligator nests are produced annually on nearly three million acres of coastal alligator habitat.

The marshes in Cameron, Vermilion and Calcasieu will be most affected long-term by the high salinity flood waters. Privately owned alligator habitat in these parishes total over 800,000 acres and annually produces nearly 10,000 alligator nests. Storm impacts to these wetlands include direct physical damages to selected areas, and high salinity flood waters scalded some marsh vegetation and may cause long term damage (if not conversion to unproductive "open water") to thousands of acres of fresh marsh and intermediate marsh vegetation.

Further habitat analysis to assess vegetative recovery in spring and summer 2006 and 2007 will be necessary before we can realistically assess impacts to future alligator populations and subsequent nest production. After Hurricane Andrew in 1992, alligator nesting rebounded to pre-storm levels by the next year (St. Mary parish) or the following year (Terrebonne parish). Of note, Hurricane Andrew affected only a few central Louisiana parishes, while Katrina and Rita affected the entire coast, with a far higher storm surge than that seen in Andrew. Limited outlet/drainage points exist in southwest Louisiana, thus saltwater remained trapped for months after Hurricane Rita. Also, the lack of normal winter rains, prolonged spring drought, and unusually warm temperatures have led to evaporative water losses following the hurricanes of 2005, especially in southwest Louisiana, which may adversely influence alligator nesting in 2006. Aerial observations done in April 2006 show little vegetative recovery in large expanses of fresh and intermediate coastal marsh in southwest Louisiana, fortunately central and southeast parishes are showing evidence of recovery (J. Linscombe, pers. comm.); again it is difficult to separate storm effects from recent drought effects in southwestern parishes.

5. Alligator Farming Industry Impact

Numerous alligator farms in several southeastern Louisiana parishes were affected by Hurricane Katrina. Some 18 farms with a collective December 2004 inventory of over 285,000 alligators were impacted. Hurricane Rita affected ten alligator farms in three parishes in southwest Louisiana, with collective inventories of about 150,000 alligators as of December 2004. As per communications with most affected farmers, direct mortality from either hurricane was not excessive (estimated at 7461 hatchlings and 821 non-hatchling alligators) at approximately 1.36% of the total statewide on-farm inventory as of December 2005. One farmer lost 50 eggs that had not yet hatched when Hurricane Katrina made landfall and flooded his facility. Farmers were proactive and when possible moved alligators to other locations. Some alligators escaped due to rising flood waters; exact counts of these losses can only be estimated until the entire year's crop has reached market size. Some farmers have noted that alligator losses may be lower than they previously estimated, as they have recovered alligators as they cleared debris from their farm facilities.

Flooded alligator farm Forked Island,

Destroyed alligator farm Creole, Louisiana

Structural damage to numerous farms was significant and extensive financial losses in terms of equipment were noted (tractors, storage sheds, pumps, generators, hot water heaters, walk-in freezers, refrigerators, incubators, barns, etc). All farmers were sent a detailed questionnaire with their December 2005 year end annual report to document estimated hurricane related losses. Estimated financial losses provided by alligator farmers in terms equipment and facility damage (excluding value of live alligators lost) were $74,800 from Hurricane Katrina and $1,839,640 from Hurricane Rita. Additional losses were estimated by farmers of $48,050 and $5,200 in feed losses from Rita and Katrina respectively. Additionally, losses of alligator meat worth $2,000 and hides valued at $4,000 were reported from Hurricane Katrina. Actual losses may be higher than these estimates, as not all farmers responded to the questionnaire. Two small farms were completely destroyed in Cameron Parish.

Similar damages were noted in March 2006 when Cyclone Larry hit south of Cairns, Queensland with winds up to 290 km/hr. One crocodile farm in the area sustained some $40,000 (AUD) in damages from the storm (C. Manolis, pers. comm.).

The long term effects of these stresses on alligator hide quality could appear over the next one to two years. Short term alligator growth was adversely affected by the storm stressors and loss of heating capabilities (no electricity for several weeks) on a few farms farms. Short term lack of water interrupted cleaning schedules but to our knowledge concerns that West Nile virus outbreaks due to standing water were not realized.

Some alligator farmers are also dealers, and hurricane damages were incurred to dealers' warehouses, check stations, processing facilities etc. as described above for wild alligator impacts. These processing facilities are used year round to process farm, wild, and nuisance alligators. Reports from various dealers indicated that wild hide inventories from the September 2005 harvest were secured immediately after the storms and moved to protected locations.

Louisiana's alligator farmers and ranchers may have prevented large scale losses of newly hatched wild alligators (Rita), and/or flooding of unhatched eggs (Katrina) by having removed the eggs from the marsh under the Department sanctioned egg ranching program (Joanen et al. 1977).

This has always been a key component of our "sustained use" philosophy in terms of endorsing the collection of wild alligator eggs under strict guidelines and quotas. A record high of 507,315 eggs were collected by ranchers in Louisiana in 2005. Undoubtedly a large number of these would have died due to storm surge and salt-water intrusion had they not been collected.

Flooded alligator nest

Submerged eggs in flooded nest cavity

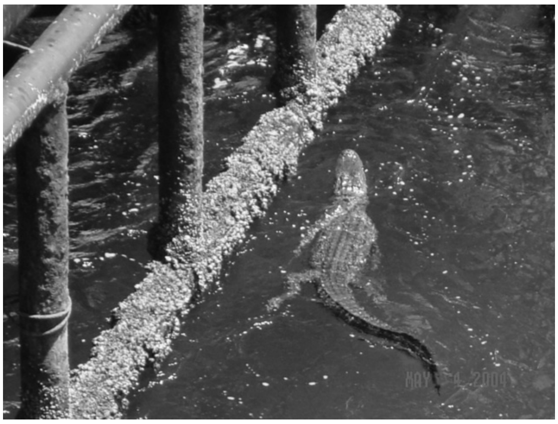
Habitat changes and degradation as described above may limit alligator nesting habitat in future years, due to salt-water intrusion and possible loss of marshes, if conversion to open water occurs. Short and long term impacts will have to be assessed to determine the impact to future alligator populations.

Numerous alligator farmers also suffered severe personal losses to their homes due to flooding and wind damage/tornadoes; to some extent repair and rebuilding to their farming operations were delayed briefly while farmers tended to repair of their homes and displaced family members.

6. Salt stress physiology

Several prior physiological studies have been conducted on the ability of yearling/juvenile alligators to tolerate water of increasing salinity (Lance and Lauren 1984, Lauren 1985, Morici 1996, Lance et al. 2001). In these studies, yearling alligators maintained in captivity in water of varying levels of salinity showed increased levels of stress hormone (plasma corticosterone) at salinities of 10 ppt or higher. Plasma electrolytes and osmolality also increased. Adverse effects seen were cessation of feeding, weight loss, and at the higher salinities (15 - 20 ppt) mortality after 3 - 4 weeks of exposure. A limited study of twelve newly hatched alligators (maintained at 0, 5, 10, or 13 ppt salt water for two months) showed they tolerate higher levels of salt water rather poorly; with weight loss occurring at 10 ppt. Two of the three hatchlings maintained at 13 ppt were in poor condition at the end of the trial and the third was emaciated and died after 68 days of exposure (LDWF biannual report 1972).

However, we have seen adult alligators in salt-water far offshore (Elsey 2005) and have documented dispersal of alligators long distances (Elsey et al. 2001, Elsey el al. 2004), perhaps to move to more favorable environmental conditions. After Hurricane Rita, some alligators were observed moribund or dead near/adjacent to the Gulf of Mexico (M. Merchant pers. comm.). Of note, "nuisance" alligators are often seen in this area, along the beach/shoreline in Holly Beach, Rutherford Beach, and Constance Beach in Cameron parish in southwest Louisiana; likely having moved from nearby coastal brackish marshes or from the man made ship channels (Elsey 2005). Another observer noted some 8 – 12 dead alligators (juvenile and adults) in the Gulf of Mexico during two days of aerial flights by helicopter after Hurricane Rita, but also observed hundreds of live alligators (J. Jackson, pers. comm.).



Alligator photographed in the Gulf of Mexico, 56 km south of Marsh

In order to assess possible salt stress on alligators, we collected blood samples from 57 wild alligators on Rockefeller Wildlife Refuge in early 2006 (size range 68.6 cm to 213.4 cm). Ideally we would have preferred to collect these samples in closer proximity to the storm event, however logistics prohibited earlier field work and collections. Three collecting trips were made; on February 8 (n = 12), February 27 (n = 21), and April 6 (n = 24). Salinity data were collected at each trip; as of April 6 water salinities ranged from 7.4 – 12.5 ppt, and may have been reflecting drought conditions superimposed on trapped salt-water resulting from storm surge. Most alligators caught appeared healthy and vigorous at capture; although by the April 6 sampling period rainfall still had not moderated salinities, and some of the smallest juveniles were not as robust as normal. Reasonable numbers of alligators were seen for collections done at that time of year (February); though perhaps in not as high densities as in past capture attempts by the April collecting trip. Additional sampling in May showed many alligators had moved from drying impounded habitat into adjacent canals, but body conditions appeared good. Analyses of plasma corticosterone (stress hormone) from these samples are pending, and will be published elsewhere in a separate document.

Direct mortality of wild alligators appeared limited, but certainly some mortality was seen, in alligators of all size classes. Hot, humid conditions during August and September in Louisiana may have led to rapid decomposition of small alligator carcasses which then went undetected.

Several large dead alligators were observed but the exact cause of mortality was inexact (drowning, blunt force trauma, salt stress, etc). After Hurricane Audrey in 1957, alligator mortality was also found not to be as excessive as anticipated (Ensminger and Nichols 1957); of note alligator populations were much lower in Louisiana in 1957 than in 2005. Our observations after Hurricane Rita revealed some unusual instances where alligators inexplicably appeared in dense clusters in habitats not particularly more favorable than surrounding areas.

7. Toxicology

Shortly after Hurricane Katrina hit, concerns developed that environmental contaminants might be enhanced with rupture of gas lines and release of toxic chemicals from petrochemical industries etc. A study using samples collected approximately 20 days after Katrina hit new Orleans included evaluation of tissues from one alligator (a "road kill") and several snakes; these did not contain excessive toxicant (metals and organochlorine pesticides) concentrations (Presley et al. 2006). As part of another study, a large series of tissue samples were collected from some 160 adult alligators statewide by LDWF after Hurricane Katrina, but prior to Hurricane Rita for heavy metals evaluations. Results are pending, and further collections will be made if any unusually high concentrations are detected.

8. Research Facility/Rockefeller Refuge

Hurricane Rita was a large, strong (Category 3) hurricane which made landfall in southwest Louisiana on September 24, 2005 at Sabine Pass, about 50 miles west of Rockefeller's headquarters in Grand Chenier. Sustained winds of 110 miles per hour were estimated at Lake Charles, Louisiana (monitoring equipment was lost), the storm surge in the Grand Chenier area was up to 15 feet, and numerous tornadoes developed.

Alligator holding tanks before Rita

Alligator holding tanks 2 months after Rita

CSG members who have visited Rockefeller may recall that many of the buildings at Rockefeller were elevated on pilings, after having been damaged or destroyed in Hurricane Audrey in 1957.

Thankfully this limited damage to the present office. However, most other buildings were damaged significantly (work shop, lumber shed, airboat sheds, dormitories, etc). Numerous structures were entirely washed away, including the field laboratory which many CSG members have used over the years.

Over half the staff at Rockefeller lost their entire homes, and most others have extensive damage which will take months or years to repair. The entire staff was displaced from their homes, but were all rapidly back to work (albeit with lengthy commutes from 50-60 miles away). Plans are underway to repair and rebuild with improvements and continue the work done there in marsh enhancement, and research and management of alligators, waterfowl, and fisheries resources.

Flooded workshop and office building at Rockefeller Headquarters

Damaged and flooded alligator holding tanks 26 September 2005 (two days after landfall)

By February 2006, we were able to resume field research on alligators, and initiated several studies as described above, as well as other collaborative studies not mentioned herein. Temporary storage buildings were moved on-site and a temporary laboratory and alligator holding facilities have been established.

9. Conclusions and summary

While the narrative above can only review general observations on hurricane effects noted thus far, our main concerns are vegetative changes and habitat loss due to the massive coastwide storm surge brought on by both hurricanes, made worse by lack of rainfall and inability to drain off trapped saltwater for months after the hurricanes. Louisiana is fortunate to have over 4 million acres of excellent alligator habitat, which should provide haven for alligators pushed temporarily away from their normal range by the storm surge.

Annual coastal nesting surveys will be done in late June and early July 2006, and will give us a better index of marsh recovery or possibly document habitat loss, if present. The long term effects of these habitat alterations remain to be seen; fortunately alligators are resilient and we are optimistic that populations will recover from the direct mortality seen from both storms, which is difficult to quantify.

Our wild egg "ranching" program has long been considered a success in wildlife management. This was even more pronounced in 2005, as a record 507,315 wild alligator eggs were collected and incubated at commercial alligator farms. Certainly a large portion of these would have died from flooding or loss of hatchlings with saltwater inundation immediately post-storms had they not been collected as part of the egg ranching program. This clearly illustrates the benefits of sustained use management.

Louisiana's annual wild autumn alligator harvest was a success in 2005, despite setbacks from both storms. We anticipate when all hides have been shipped that some 85% of the CITES tags issued will have been used; which is remarkable as so many of the trappers involved reside in coastal parishes and were forced to evacuate, and were displaced due to the hurricanes. We plan to maintain an active harvest program as our annual surveys dictate and see no immediate changes in the structure of our successful wild harvest. Quotas will continue to be established based on annual nesting surveys, analyses of the nesting survey data from the five most recent years, size classes and sex ratios taken in the annual harvest, and night count surveys.

Alligator farmers and ranchers suffered very limited "on farm" mortality of live alligators (1.36%). Despite large economic losses of equipment and facilities, affected farmers and ranchers rapidly resumed operations and with essentially no interruption in production of hides, which was maintained through the initial recovery period.

The alligator research program centered at Rockefeller Wildlife Refuge in Grand Chenier was affected by loss of the field laboratory and extensive damage to the alligator incubators and holding facilities. The office was essentially spared, as were all records and data. As soon as staff members were able to safely return and begin field work, surveys and collections of alligators to evaluate hurricane effects were initiated. Numerous collaborative projects are underway and we plan to rebuild and upgrade the research facility.

Analyses of samples from several projects related to hurricane effects on alligators are pending, including plasma corticosterone and electrolyte levels, tissue samples for heavy metals and contaminants, general health profiles from serology, and dispersal studies from alligators marked and tagged prior to the hurricanes. As noted, some of these will be difficult to interpret, as they may be due to the superimposed drought which has developed in the months following the hurricane, and could be a result of either stressor.

10. Acknowledgements

We thank numerous LDWF employees who collected salinity data and assisted in capture of alligators at night for blood sampling, including Phillip "Scooter" Trosclair, Dwayne LeJeune, Jeb Linscombe, and George Melancon. We appreciate Dr. Mark Merchant's generous loan of lab supplies, use of his lab and freezer space for the first two sampling trips, and help catching alligators in late February. Brandy Williams provided technical expertise in preparation of the manuscript.

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Status And Monitoring Of The American Alligator In The Everglades Of Southern Florida, USA

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Abstract: The American Alligator (*Alligator mississippiensis*) was abundant in the pre-drainage Everglades of southern Florida, USA. Alligators once occupied all wetland habitats in South Florida, from sinkholes and ponds in pinelands to mangrove estuaries during periods of freshwater discharge (Craighead 1968, Simmons and Ogden 1998). Nearly all aquatic life in the Everglades is affected by alligators in some way (Beard 1938). As a top predator in their ecosystem, alligators undergo an extraordinary change in body size, consuming different prey items as they grow (Mazzotti and Brandt 1994). As ecosystem engineers, alligators create trails and holes that provide aquatic refugia during the dry season and concentrate food items for larger predators. Alligator nests provide elevated areas for nests of turtles and snakes, and for germination of plants less tolerant of flooding (Craighead 1971, Kushlan and Kushlan 1980, Enge et al. 2000). Alligator activity also keeps many small creeks in the freshwater mangrove zone, alligator holes, and areas around tree islands from becoming overgrown with vegetation. It is possible that alligator activity creates firebreaks providing protection for woody vegetation and various animal species (Craighead 1968, Simmons and Ogden 1998). Water present in holes during the dry season provides critical habitat for nesting female and juvenile alligators (Mazzotti and Brandt 1994, Kushlan and Jacobsen 1990) and provides open water necessary for alligator mating (Garrick and Lang 1975).

Land development and water management practices have reduced spatial extent and changed hydropatterns of many habitats within the Everglades (Mazzotti and Brandt 1994). As a result of these habitat alterations, alligators are now less numerous in prairies, shorter (< 8 months) hydroperiod marshes, and mangrove fringe areas. Further, canal construction has significantly altered alligator habitat. The effects of artificial habitats such as canals on alligator populations as well as creation and maintenance of alligator holes had not been studied until recently. Canals within the Everglades serve as dry season refugia for alligators throughout the greater Everglades ecosystem. Adult alligator density (especially males) is higher in canal habitats than in natural marsh interior (FFWCC unpub. data, Morea 1999).

Canals may provide suitable habitat for large alligators, but unlike alligator holes, they are not suitable for smaller alligators, smaller marsh fish, or foraging wading birds. Characteristics of alligator habitats have changed with creation of canal systems now present in the Florida Everglades (Kushlan 1974).

Restoration of pre-canal hydropatterns and ecological function in the Everglades is underway. Relationships among dry season refugia, aquatic fauna, wading birds, and alligators have been identified as key uncertainties in the Comprehensive Everglades Restoration Plan (CERP, U.S. Army Corps of Engineers 1999, RECOVER 2003). Due to the alligator's ecological importance and known sensitivity to hydrology, salinity, habitat, and total system productivity, the species was chosen as an indicator for restoration assessment. A number of biological attributes (relative density, relative body condition, nesting effort, and nesting success) can be measured, standardized methods for monitoring have been developed, and historical information exists for alligator populations in the Everglades. These attributes can be used to determine ecological responses at different spatial and temporal scales, and are instrumental for constructing ecological models used to forecast restoration effects. Relative abundance of alligators is expected to increase as hydrologic conditions improve in over-drained marshes and freshwater tributaries. As canals are removed, alligator density in adjacent marshes and use of alligator holes are expected to increase. As hydroperiods and depths approach natural patterns, alligator growth, body condition and nesting success should improve.

At all life stages, crocodilians integrate biological impacts of hydrologic conditions (Mazzotti and Brandt 1994, Rice et al. 2005, Mazzotti 1999, Mazzotti and Cherkiss 2003). Further, crocodilians are important indicators because research has linked three key aspects of Everglades' ecology to them: 1) Top predators such as crocodilians are directly dependent on prey density, especially aquatic and semi-aquatic organisms thereby providing a surrogate for status of many other species. 2) Drier (nests) and wetter (trails and holes) conditions created by ecosystem engineers like alligators provide habitat for plants and animals that otherwise would not be able to survive. This increases diversity and productivity of Everglades' marshes (Kushlan and Kushlan 1980, Palmer and Mazzotti 2004, Campbell and Mazzotti 2004) and, therefore, alligator monitoring can indicate overall health of the marsh. Finally, 3) distribution and abundance of crocodilians in estuaries is directly dependent on timing, amount, and location of freshwater flow (Dunson and Mazzotti 1989, Mazzotti and Dunson 1989). Alligators and crocodiles will exhibit an immediate response to changes in freshwater inputs into the estuaries.

Correlations between biological responses and environmental conditions contribute to understanding of species' status and trends over time. Restoration success or failure can be evaluated by comparing recent and future trends and status of crocodilian populations with historical population data and model predictions. Importantly, these data can be used in an analysis designed to distinguish between effects of restoration and natural patterns such as hurricanes or droughts.

We have developed and implemented a monitoring program for alligators in the Everglades designed to assess restoration effects across several temporal scales including body condition (short term, seasonal to 3 years), abundance (3-5 years), alligator hole occupancy (5-7 years), and nesting (10-12 years). While the monitoring program is in the early stages, we are beginning to recognize patterns.

In general, adult count densities were much lower in the Everglades than elsewhere in Florida (north-central Florida used for illustration in figures) except for canals (Fig. 1). Our canal counts are only conducted during spring when adjacent marsh water depths are relatively low. As the marsh dries, animals move into canals. However, in the natural marsh areas where animals cannot access canals during the dry season, count densities are extremely low. While Everglades populations were probably never as dense as those in the more eutrophic waters of north-central Florida, densities in many current natural areas are certainly depressed. We think this is due to a combination of the natural low-nutrient state of the Everglades in combination with loss of habitat and water management practices.

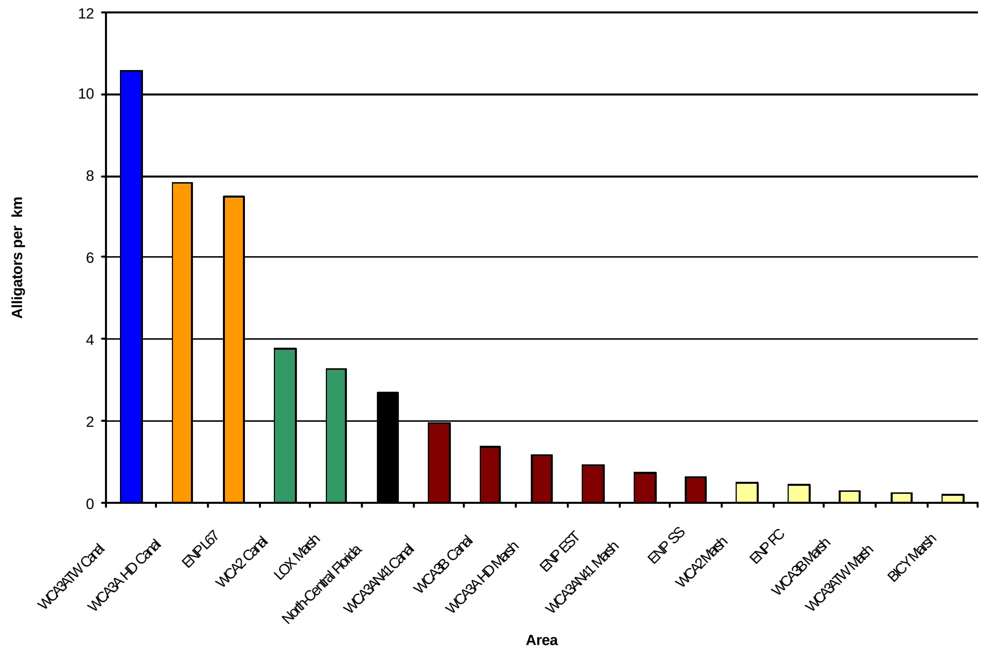

Figure 1: Mean observed density (alligators/km) of adult populations (?175 cm) of alligators counted during night-light survey in south Florida, 1998-2005. Central Florida counts are for comparative purposes only and are taken from Rice et al. (1999).

The largest difference between both north-central Florida and alligator populations in the Everglades is in the juvenile size class (Fig. 2). Historically, the Everglades probably had somewhat lower populations of juvenile alligators due to lack of nutrients which contributes to the relatively low number of eggs produced by adult females. However, hatch rates of eggs in the Everglades are relatively high and hatchling production throughout the Everglades could approach that currently found in north-central Florida and equal that found in the densest population in the Everglades, A.R.M. Loxahatchee National Wildlife Refuge (LOX-Marsh).

Two causes of this difference have evidence: (1) nest flooding during certain years leading to reduced hatchling production; and, (2) decreased juvenile survival from predation and cannibalism during extreme dry periods. As water recedes below ground surface, juvenile alligators must seek refuge in areas such as alligator holes inhabited by larger alligators and other predators. Since alligators require up to 15 years to attain breeding size and all non-adult alligators are exposed to cannibalism, a single extreme drought can remove large proportions of many years production from the population. Our densest alligator population in the Everglades, LOX-Marsh, does not have the extreme dry downs in the survey area that lead to increased predation and cannibalism and nesting is protected from most flooding by the many tree islands available for nest construction.

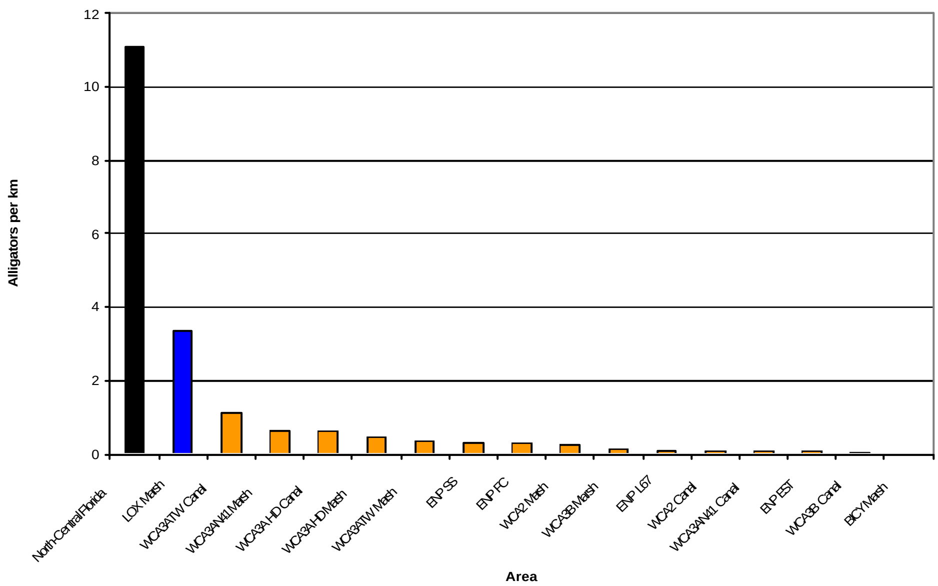

Figure 2: Mean observed density (alligators/km) of juvenile populations (25-124 cm) of alligators counted during night-light survey in south Florida, 1998-2005. Central Florida counts are for comparative purposes only and are taken from Rice et al. (1999).

Further information can be obtained by contacting the authors for a copy of our comprehensive report published in 2006. This report contains details of other components of our alligator monitoring program as well as a similar program for the American crocodile (*Crocodylus acutus*).

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The Status Of American Crocodiles (*Crocodylus acutus*) At Turkey Point Nuclear Power Plant, Florida, USA

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Abstract: Florida Power & Light's Turkey Point Nuclear Power Plant has been a recognized habitat for the American crocodile, *Crocodylus acutus*, since the first nest was discovered in 1978. It has been designated critical habitat by the United States Fish and Wildlife Service (USFWS) since 1979. Since that time Turkey Point's closed loop cooling canal system has provided a suitable environment for the American crocodile's nesting and development. By the end of the crocodile-nesting season in 2005 the total number of successful nests had increased to 255 and the number of hatchlings captured, processed and released was up to 3,774. A closely monitored and ever developing crocodile program at Turkey Point has contributed to the discovery of an increasing number of burrows and has been a catalyst towards a large population increase in the number of juvenile and adult endangered American crocodiles residing in the area. It is estimated that the total number of animals at the Turkey Point location is approximately 400.

1. Introduction

The American crocodile, *Crocodylus acutus,* has a wide range throughout the estuarine coastal communities in much of the Caribbean. Populations exist on both the Caribbean and Pacific coasts of Mexico and Central America. It is found on the northern coast of South America, south to Peru, on the islands of Hispaniola, Jamaica, and Cuba. Florida is the northernmost extent of its range, and the only portion of the United States that it occurs. Historically, American crocodiles ranged from Lake Worth on the east coast of Florida, around the southern tip, including the Florida Keys, up to Pinellas County (Tampa) on the west coast. Currently, its range is limited to the southernmost Florida counties and the Florida Keys (Miami-Dade, Collier, Monroe and Lee).

2. History

At the turn of the 20th century, there may have been between 1,000 and 2,000 American crocodiles in Florida (Ogden, 1978). The crocodile population was depleted by urbanization, loss of habitat and hunting. By the 1970s, the population size was estimated at 100 to 400 animals (Ogden, 1978). In 1989, the population was estimated to be 220 +/- 78 adults and sub-adults (Kushlan and Mazzotti, 1989).

Recent trends estimate the population at approximately 1,000 animals (United States Fish and Wildlife Service, 1999).

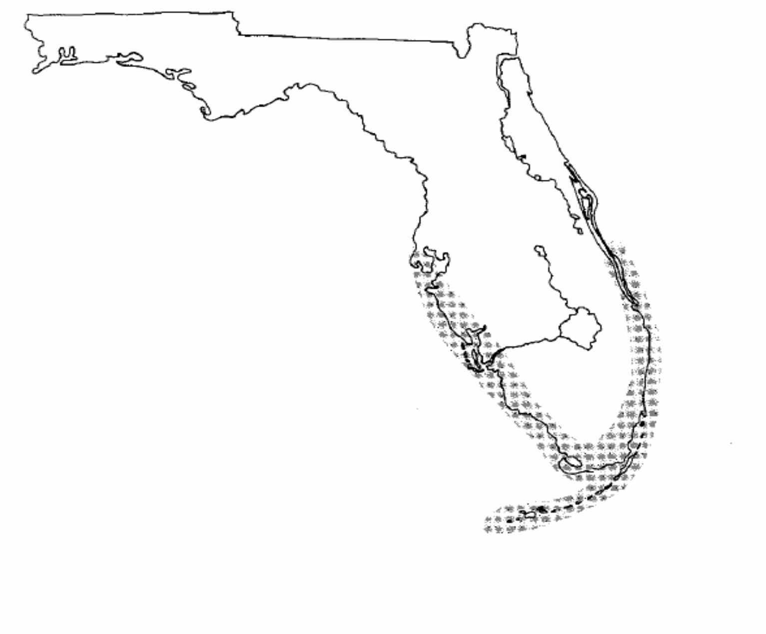

Figure 1: Historical Range of the American Crocodile in Florida

Figure 2: Current Range of the American Crocodile in Florida

Florida Power and Light's (FPL) Turkey Point power plant is located in extreme southern Miami-Dade County. The plant is bordered on the north and east by Biscayne National Park, to the west by a freshwater (Everglades) marsh, and south by a Red mangrove, *Rhizophora mangle*, tidal estuary. The actual power plant consists of two fossil fuel and two nuclear reactors. A fifth unit, to be powered by natural gas is currently under construction. As a result of the power generating units, a cooling canal system was required and engineers designed the closed loop cooling canal system (CCS). This system began operation in 1972. Within the CCS, there are 270 linear kilometers of canals and twice that number in shoreline habitat. Canals are 60m wide and one meter deep. Water is hyper-saline, and tends to range between 35 and 55 parts per thousand. Separating the canals are earthen berms 25-30m wide that rise up anywhere from 1.0 meter to 3.0 meters above the mean high tide line. The berm substrate is a combination of peat, marl, sand and soil. Within the berms are fresh-water ponds initially constructed by accident to regulate the spoil from the dredge. After it was discovered that the female crocodiles utilize the fresh water ponds for nesting, a program was instituted in coordination with the canal maintenance department. This program designs and constructs ponds in crocodile sanctuary areas other than the original sanctuary areas. Throughout the CCS, 32 areas on selected berms ranging in length from 30 meters to 300 meters have been set aside for use by the crocodiles. The original intent was to keep the areas in a natural state and keep heavy equipment out. As a result this procedure, the sanctuaries have become monocultures of invasive exotic vegetation. The program now schedules regular maintenance to clear the exotic vegetation and if the situation warrants, to dig new ponds.

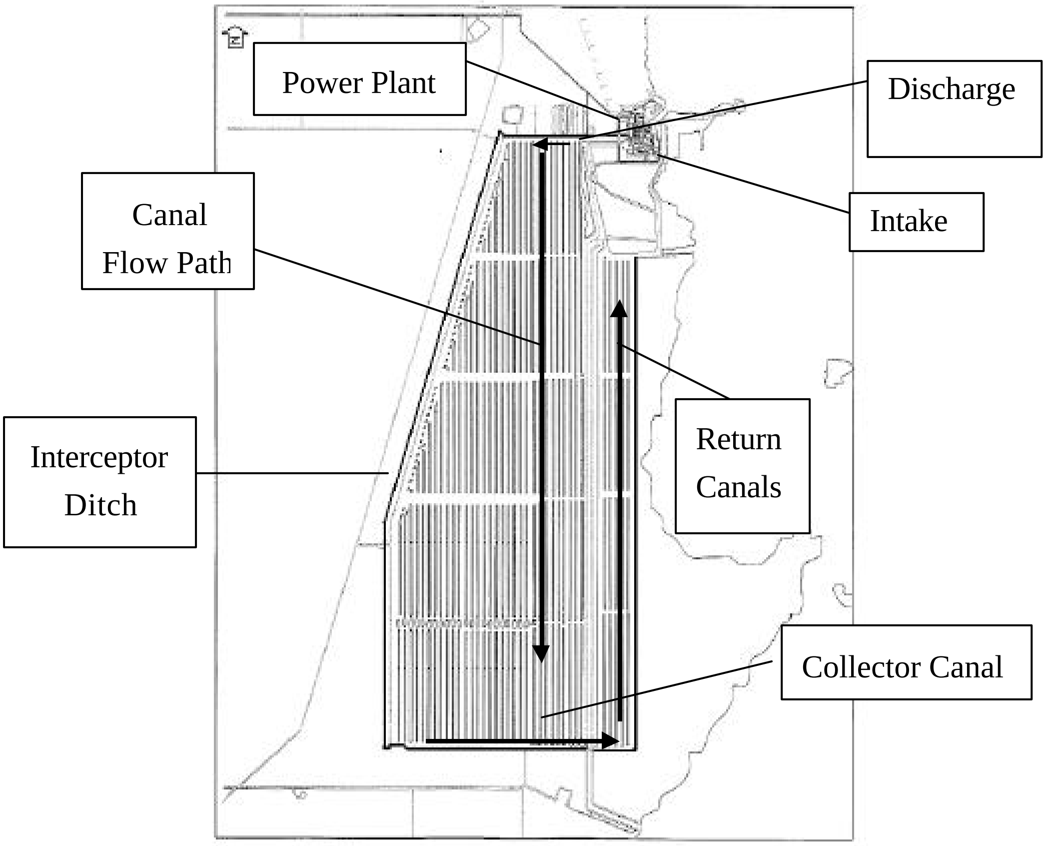

Figure 3: Map of Cooling Canal System at Turkey Point

Crocodiles were first discovered in the CCS in 1976. The first crocodile nest was uncovered by a backhoe working on the berms within the CCS in 1978. That discovery was the impetus for FPL's crocodile management plan. It is a necessary program that conducts surveys to monitor the crocodile population within and adjacent to Turkey Point site. The survey types are coordinated to coincide with the annual cycle of the crocodile. In the months of April and May, airboat surveys are conducted during the night to locate adults within the system. Areas are marked where adults are present, then checked during daytime hours to look for possible nesting activity. Day and night surveys are conducted in June, July and August. Nests are located; hatchlings are captured and brought back to the lab for processing. Biometric data is then recorded. (Collection of the following measurements: snout-vent length, total length, head length, head width, weight and the animal is sexed) Their scutes are clipped to show the origin of the animal and to assign a number. Then they are microchipped at the right side of the base of their tail for further identification purposes. They are released near the site of capture.

For the rest of the year, miscellaneous surveys are conducted via truck or airboat to monitor the population. One standardized survey, the Interceptor Ditch (ID) survey, consists of monitoring a 9.0km fresh water canal that is 6 meters deep. This particular survey began in 1982 and continues to this day. It is used as a barometer to calculate the number of adult crocodiles residing in the area.

The resident crocodile population at Turkey Point nuclear power plant has steadily increased since the animals were discovered on the site in 1976. According to Gaby et al (1985) the resident population of non-hatchling crocodiles consisted of a minimum of 19 adult, sub-adult and juvenile crocodiles. In 1995, the number of non-hatchling crocodiles at the power plant was estimated at 24-30 (Brandt et al 1995).

There has also been a steady increase of successful crocodile nests at Turkey Point since the inception of the monitoring program. Since 1978, there have been a total of 255 successful nests at Turkey Point. For a ten year period from 1978 through1989, there were 24 successful nests. From 1990 through 1999, there were 121 successful nests. The six years between 2000 through 2005 produced 110 successful nests. There has also been steady increase in number of hatchlings captured. The total number of hatchlings from 1978 through 2005 is 3,736. From 1978 through 1989, there were 285 hatchlings captured and processed. From 1990 through 1999, there were 1,940 captured and processed. From 2000 through 2005, there were 1,511 captured and processed. However, the number of hatchlings collected does not account for all of the hatching success. On many occasions, by the time researchers reached the hatched nest site, the female has moved the brood into areas inaccessible to the researchers. Out of 24 nests in 2005, nine successfully hatched without any captures. It is estimated that 33% of the successfully hatched nests are moved to inaccessible areas prior to capture attempts.

The present population is estimated at 400 total animals. Based on data collected during the aforementioned surveys, the population is estimated to be as follows: P=N/(AFE), a method developed by Chabreck, (1966) who used this formula to estimate alligator populations in Louisiana. Kushlan and Mazzotti (1989) also utilized this formula (1989).

According to Chabreck's formula, P=Population, N= number of nests, A=percentage of adults in the population, F=the percentage of females in the adult population, and E=the percentage of adult females actually nesting. It is estimated that the adults make up 16% of the population, of which 75% are females and 50% of those females nest every year. Putting numbers into the equation comes up with the estimated population size: P=24/(.16 X 0.75 X 0.5) or 24/0.06=400.

3. Discussion

Increased population size at Turkey Point is the result of on-site nesting in the CCS. Although man-made, the CCS provides ideal habitat for American crocodile nesting. The entire area is restricted-access and protected by security guards, this makes it an ideal location for crocodiles because they are shy and reclusive and prefer quiet waters. The berms provide crocodiles with leeward protection, regardless of the wind direction and strength. The actual substrate on some of the areas within the CCS have the correct combination of peat, marl, sand and soil which provides for proper drainage and nest incubation. As a result of the ideal conditions, there are several areas in which the crocodiles are communally nesting. There are very few nest predators present. The main nest predator, which is becoming more frequent, is the introduced, invasive fire ant, *Solenopsis invicta*. The fresh-water ponds on the interior of the berms are ideal for hatchlings, since the canals are hypersaline. The ponds provide shelter and a way to avoid the high levels of salinity. (Dunson, 1982, Ellis,1981) Once the ponds' use by nesting female crocodiles was discovered, certain areas within the CCS were targeted to dig new ponds. Typically, the females nest on or near the berm housing the pond. Once the nests hatch, she carries the hatchlings into the actual pond. This behavior takes place whether the nest is adjacent to the pond or a distance of up to two kilometers. Hatchlings remain within the ponds during daylight hours, crossing over into the CCS in the evenings to feed.

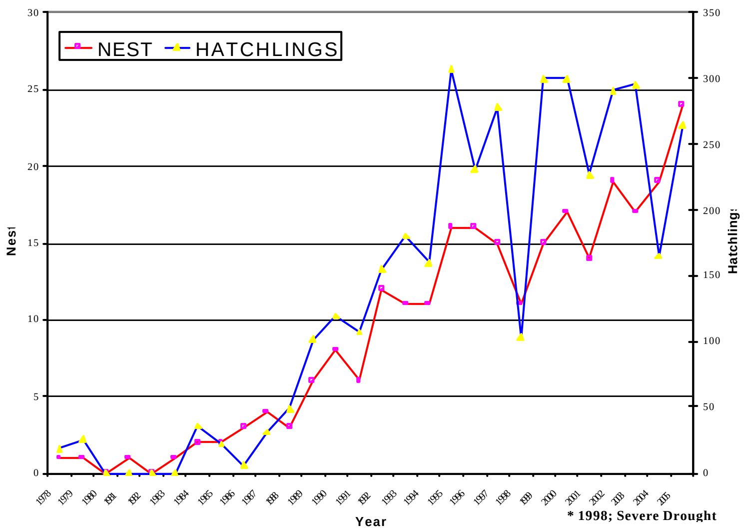

Figure 4: Chart comparing the number of Nests vs. Hatchlings 1978 to 2005

The transient crocodile population within the CCS is trending towards permanency. During the early years of the CCS, crocodiles would utilize the Interceptor Ditch for recruitment and breeding, only to disperse afterwards. After several years, the adult crocodiles (male and female) began constructing burrows within the CCS and in the ponds within the berms. There has been an increase in number of burrows from 1980's to present (Figure 5).

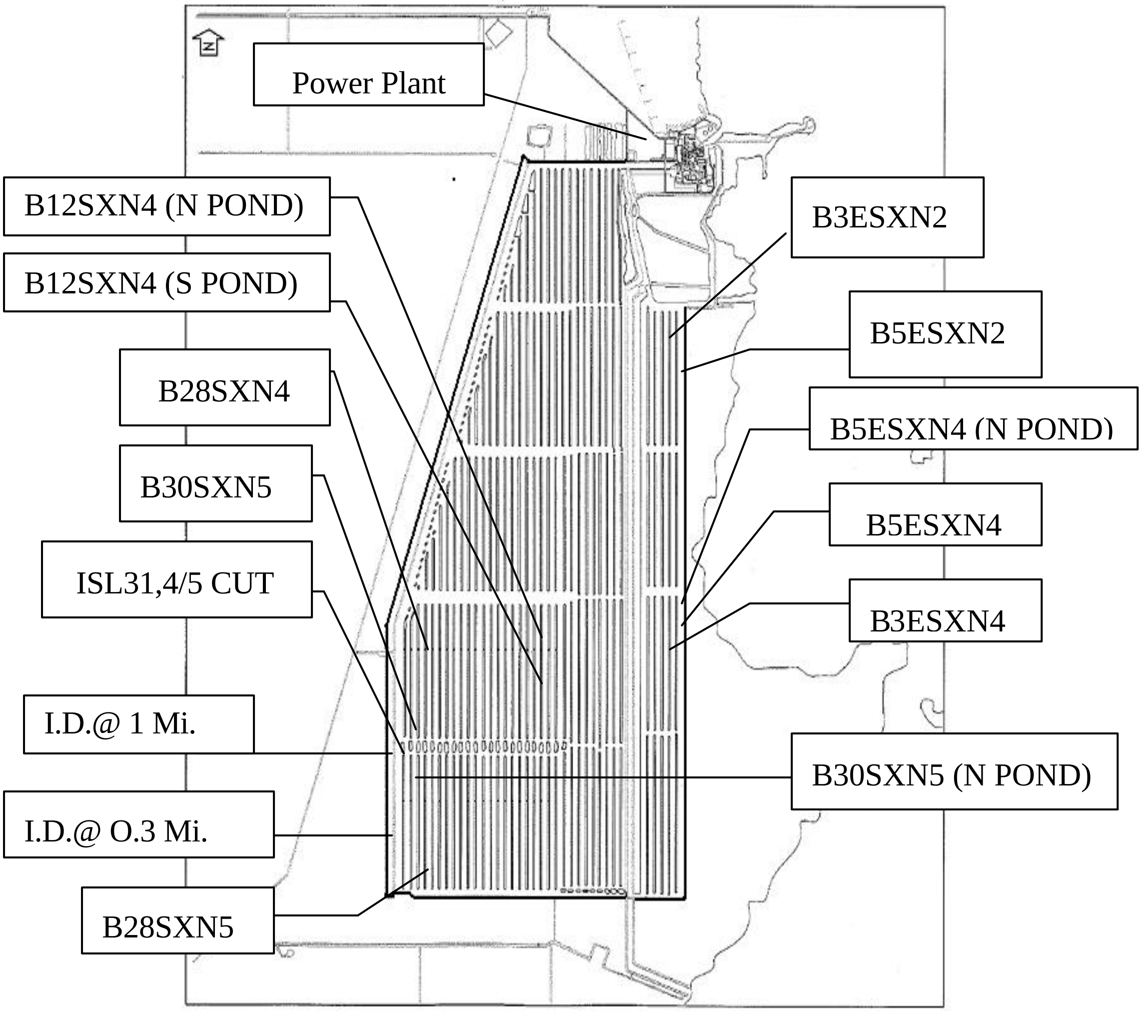

Figure 5: Map of crocodile burrows from 1978 to 2006

Hatchlings also utilize the burrows and have been noted as early as 1990 to retreat into the burrow when disturbed. Hatchling crocodiles have been captured near the entrance to caves under the observation of the female. In one instance, (Wasilewski, pers observation 2005) during a daytime nest survey, a crocodile nest was discovered to have recently hatched. Twenty-five hatched eggs were counted within the nest cavity and in an adjacent pond, however no hatchlings were present. Upon returning to the area that following night, twenty-five hatchling eyeshines were discovered in the pond. When disturbed, the hatchlings retreated to a recently excavated cave at the northwest corner of the pond. Upon rounding up all the hatchlings and stationing someone at the entrance to the cave, all twenty-five animals were captured.

4. Conclusion

In summary, the man-made cooling canal system of Turkey Point provides all the natural history requirements for adult crocodiles in southern Florida. Within the CCS exists ample habitat for successful nesting and rearing of young crocodiles. The question remains regarding the carrying capacity of the CCS. The design of the CCS, with 32 canals on the west side and 6 canals on the east side makes for an unusual array of habitat. Communal nesting should continue and it may be years before this carrying capacity will be reached. Increasing population on the site has resulted in dispersal of crocodiles to adjacent areas. Turkey Point animals have been captured as far as 25km from the plant. Conversely, crocodiles from Everglades National Park and Key Largo have been seen and captured at Turkey Point. As a result of the increases in the crocodile population, there have been increasing reports of “nuisance” crocodiles within urban areas. This has caused the United States Fish and Wildlife Service (USFWS) and the Florida Game and Fresh Water Fish Commission to revisit their management plans. As of March 2005, the USFWS proposed legislature to down-list the American crocodile from “Endangered” to “Threatened” status.

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Status Of *Crocodylus porosus* And *C. novaeguineae* In Papua New Guinea After Twenty-Five Years (1981-2006) Of Aerial Nesting Surveys

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Abstract: Additional aerial nesting surveys of the saltwater crocodile *Crocodylus porosus* and New Guinea Freshwater crocodile *C. novaeguineae* in the middle and upper Sepik River of Papua New Guinea were conducted in 2005 and 2006.
These population monitoring surveys are part of an ongoing effort by the Department of Environment and Conservation over the past twenty-five years to ensure that continued harvests of skins, live juveniles and eggs in PNG are sustainable.

Survey results infer that wild populations of both species are viable in the Sepik, and by extension other areas of PNG. Using regression analysis, the *C. porosus* nesting trend indicates a significant increase while that of *C. novaeguineae* is stable. Recent year increases in nesting are considered attributable to a continual conservation awareness campaign and conservation incentives built into an expanded *C. porosus* egg harvest.

The number of crocodile skins exported from 1997 to 2005 is fairly consistent at approximately 30,000 annually. An analysis of export statistics reflects a stable harvest over these years for each species and supports the view that exploitation at current levels is not detrimental to wild populations.

The Status of the Siamese Crocodile in Cambodia

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Abstract: The Siamese crocodile (*Crocodylus siamensis*) is one of the most endangered of the world's crocodilian species and is listed as Critically Endangered by the IUCN. Cambodia is now considered the last stronghold for the species and surveys over the last six years by the Forestry Administration and Fauna & Flora International have revealed a severely depleted and scattered population. Crocodiles have been confirmed from 35 sites (30 rivers/wetlands) across 11 provinces, mostly in the more remote areas in the southwest and northeast of the country.

The majority of these sites have been identified by the discovery of only one or two individuals, and such sites probably contain very low numbers of crocodiles. Breeding has been confirmed or suspected from 10 different sites over the last six years, but it seems that a number of these sites have been destroyed or had large crocodiles captured over the last couple of years. The total number of viable sub-populations within Cambodia is probably extremely low.

Threatening processes continue to impact on the species, with habitat destruction and alteration, fishing practices and the illegal capture of live crocodiles to stock crocodile farms continuing to severely hamper the recovery of the Siamese crocodile in Cambodia.

1. Introduction

The Siamese crocodile (*Crocodylus siamensis*) was once common and widespread throughout the wetlands of Southeast Asia, with an historic range including Indonesia, Malaysia, Thailand, Laos PDR, Cambodia, Vietnam and possibly Myanmar and Brunei. Recent reports (Baird 2001; Bezuijen *et al.* 2005; Cox 2004; Daltry *et al.* 2003, Nguyen *et al.* 1995; Ross 1998, Platt and Tri 2000, Simpson and Han 2004; Temsiripong 2001; Thorbjarnarson *et al.* 2004) now suggest that the species has undergone a severe decline in numbers and distribution, and that viable populations are no longer present in Thailand, Vietnam or Java (Indonesia). The status in Malaysia is unknown, while populations in Kalimantan (Indonesia) and Laos are thought to be small (Bezuijen *et al.* 2005; Kurniati *et al.* 2005). Cambodia now represents the last stronghold for the species, although here too the species is greatly depleted and fragmented.

Given the greatly reduced distribution and numbers of Siamese crocodiles, the IUCN has classified the species as Critically Endangered (IUCN 2006), making it one of the most threatened of the world's 23 crocodilian species. It has been rated by the IUCN/SSC Crocodile Specialist Group as a species with the highest need for wild population recovery (Ross 1998) and is fully protected under Cambodia law.

The decline of the Siamese crocodile in Cambodia has been caused by a combination of factors, probably starting hundreds of years ago with the widespread conversion of wetlands and forests for the cultivation of rice and other produce, a practice which continues today as the human population expands. Crocodiles were also persecuted for the value of their skins, being killed and collected for crocodile farms, the first of which was established in 1945 (Cheang and Ratanakorn 1994). The collection of live crocodiles intensified during the 1980s and 1990s, driven by the high price of animals (Thuok and Tana 1994) and the unregulated expansion of the crocodile farming industry. Cambodia now has over 900 farms or crocodile raising facilities (Jelden *et al*, 2005), and the poorly regulated farming industry still continues to pose a serious threat to the species (SCWG 2004b). The illegal collection of wild Siamese crocodiles for the farming industry continues today and is the greatest single factor restricting the recovery of the crocodile populations in Cambodia (Simpson and Han 2004).

The Crocodile Specialist Group's (CSG) Siamese Crocodile Working Group (2004) recognised the serious threat that poorly regulated trade had on the remaining wild populations and recommended a CSG review of crocodile conservation and management in Cambodia. The CSG carried out the review in February 2005 and provided recommendations to enhance the conservation of wild populations and management of the crocodile farms (see Jelden *et al.* 2005).

Within Cambodia, the Siamese crocodile has been the focus of a conservation initiative by the Forestry Administration and Fauna & Flora International since 2001, after the discovery of a breeding population in the Cardamom Mountains in 2000 (Daltry and Chheang 2000; Daltry and Momberg 2000). The establishment of the Cambodian Crocodile Conservation Programme (CCCP) was specifically designed to conserve and protect the Siamese crocodile through an integrated approach of surveys, research, education, law enforcement, capacity building, and community-based conservation.

Although the Cambodian Crocodile Conservation Programme undertakes a wide range of conservation initiatives, this paper will focus on the results of Siamese crocodile surveys carried out over a 6 year period (2001-2006) in Cambodia. The primary objectives of these Cambodian surveys were to:

1. Evaluate and distribution and status of the Siamese crocodile.
2. Identify the historic and current threats to the Siamese crocodiles.
3. Provide recommendations for future conservation and management.

2. Methods

Crocodile field surveys were carried out during the dry seasons of 2001-2006, usually between the months of December to April, when lower water levels allowed crocodiles or their sign to be more easily detected. Survey teams varied in size from 3-7 people and usually comprised of 2-4 trained CCCP staff, a guide and 1-2 security personnel from the police or military. Surveys were undertaken by walking along the banks of rivers or wetlands, or by boat transport when available or appropriate. The location of all sightings of crocodiles and their sign was recorded using Garmin™ global positioning systems (GPS) or 1:50,000 topographic maps.

A number of methods were employed to detect crocodiles which included daytime searches for crocodiles or their sign (dung, tracks, slides, burrow, nests, etc) and night-time spotlight surveys. Due to the variability of the habitats, access to boats or other logistical difficulties, no standard technique was used to determine crocodile numbers across all sites. At each site only a single method was adopted, ie. crocodile numbers were based on <u>only</u> tracks, <u>or</u> dung, <u>or</u> spotlight results, etc not a combination of all signs found. All tracks and dung were measured and the minimum number of crocodiles at each site was estimated based on the size of each sign type (see Daltry *et al.* 2003 for further details).

A dry season crocodile 'site' has been arbitrarily defined for the sake of this paper, and two or more sites may in fact be a continuous area, especially during the wet season.

We have defined a ‘site’ to include crocodiles (a group or a single animal) that are separated from others during the dry season by natural barriers such as mountains, large water falls, tidal waters or at least 10km of shallow river water (less than 1m). Distinguishing between one dry season ‘site’ and the next can be difficult in long rivers, and we have used a distance of 30km to arbitrarily define two sites, although this may have no real biological meaning.

During the course of surveys, numerous informal interviews were conducted which shed light on the current and historical crocodile distribution, threats and local perceptions. Reports were often used to define survey search areas but such information was regarded as a mere “report” until it could be confirmed. Reports from local residents of an area were found to be much more reliable than from people residing far from the report site. Reports of crocodiles were categorised as a current report (after 2000) or an old report (before 2000).

Surveys initially focused on the Cardamom Mountains, in the southwest of Cambodia for the majority of 2001-2003, but later shifted to other areas in the country after information was gathered through interviews and other sources.

3. Results

3.1. Distribution and Abundance

Area	**Site**	**Province**	**Estimated no. of crocodiles** (all ages)
Cardamom Mnts	Pursat River (upper)	Pursat	3+
Cardamom Mnts	Pursat River (lower)	Pursat	4+
Cardamom Mnts	Pim River	Pursat	1+
Cardamom Mnts	Veal Veng Marsh	Pursat	ca. 40
Cardamom Mnts	Koi and Krau Rivers	Pursat	14+
Cardamom Mnts	Russei Chrum (upper)	Koh Kong	1+
Cardamom Mnts	Russei Chrum (lower)	Koh Kong	1+
Cardamom Mnts	Kiew River (Upper)	Koh Kong	5+
Cardamom Mnts	Kiew River (Lower)	Koh Kong	1+
Cardamom Mnts	Kep River	Koh Kong	10+
Cardamom Mnts	Tatai River (Upper)	Koh Kong	2+
Cardamom Mnts	Tatai + Touch Rivers	Koh Kong	11+
Cardamom Mnts	Tatai River (Lower)	Koh Kong	5+
Cardamom Mnts	Areng River (Upper)	Koh Kong	1+
Cardamom Mnts	Areng River (Central)	Koh Kong	ca. 30
Cardamom Mnts	Trapeang Rung	Koh Kong	11+
Cardamom Mnts	Kompong Chey	Koh Kong	7+
Cardamom Mnts	Sre Ambel River*	Koh Kong	2+
Cardamom Mnts	Kul River, Botum Sakor	Koh Kong	1+
Srepok	O’Plai River (Srepok River)	Mondulkiri	1+
Srepok	Srepok River*	Mondulkiri	2+
Srepok	O’Lieou River (Srepok	Mondulkiri	1+

	River)		
Sesan	Sesan River	Ratanakiri	1+
Sesan	O'Lalay River	Ratanakiri	3+
Sekong	Sekong / O O'Kampa River	Stung Treng	8+
Sekong	O'Chay River	Stung Treng	2+
Preah Vihear	O'Kandal River	Preah Vihear	1+
Preah Vihear	Sen River	Preah Vihear	1+
Preah Vihear	Bung Pdak*	Preah Vihear	1+
Kampong Thom	Porung River	Kampong Thom	1+
Tonle Sap	Chi Kreng	Siem Reap	2+
Tonle Sap	Fishing Lot #1*	Siem Reap	2+
Stung Treng	O'Talas River	Stung Treng	4+
Anlong Veng	Anlong Veng	Oddar Menchey	3+
O'Te	O'Te River*	Kratie	1+
		TOTAL	184

Crocodile surveys carried out over the past 6 years (2001-2006) have covered more than 1170km and targeted over 56 major rivers and streams (plus additional lakes and swamps). At least 184 individuals have been confirmed (Table 2, Fig. 1) across 11 provinces in a total of 32 dry season sites. Some of these dry season sites may in fact be continuous but are represented by at least 30 rivers or wetlands. The distribution of sites identified, indicate that crocodiles are widely scattered and fragmented across the country, with the majority of sites being confirmed by the presence of only a small number of individuals (Table 2). The Cardamom Mountains, in the Southwest of the country, however harbors 19 of the 35 sites and represents the species' stronghold in Cambodia, with over 80% of identified found here.

Significant numbers of crocodiles (identified or estimated as more than 20 individuals) (Table 2) have only been identified from two sites - the Veal Veng marsh and Areng River - and both sites are now the focus of community-based crocodile conservation strategies (Daltry *et al*. 2004, 2006).

Table 2. Confirmed dry season crocodile sites in Cambodia (2001-2006), with a conservative estimate of the minimum number of crocodiles found at each site.

* Information provided by Dept of Fisheries, WCS, WildAid and WWF

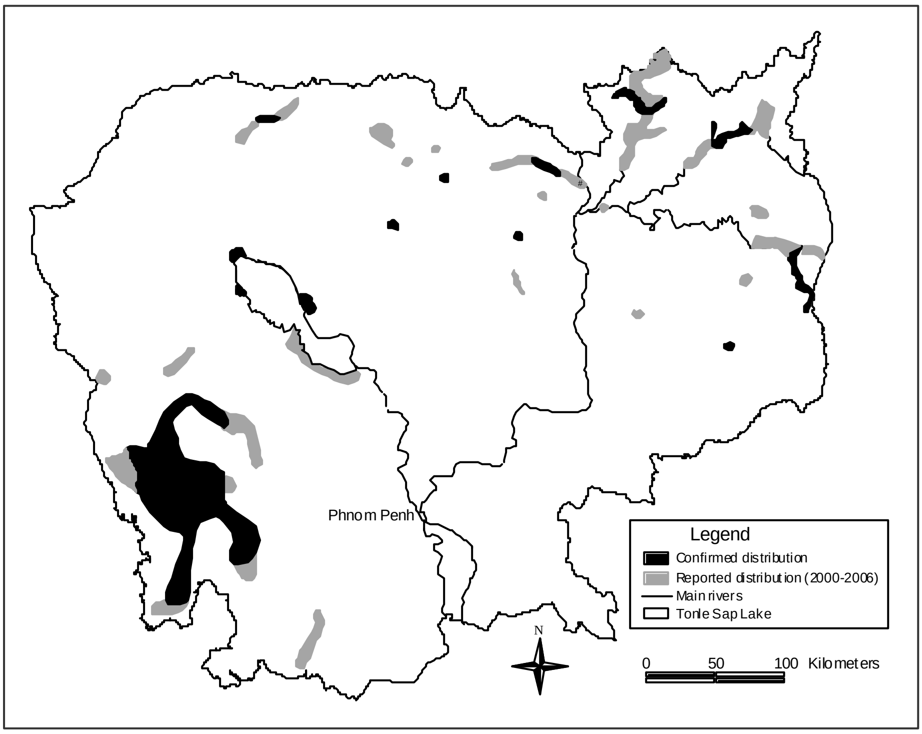

Figure 1. Confirmed (dry season) and reported crocodile sites in Cambodia (2001-2006).

3.2. Breeding

Breeding has been confirmed through the identification of nests, hatchlings or assumed from reports of the capture of wild hatchling crocodiles. Ten (10) breeding sites have been identified throughout Cambodia since 2001, and much like to the distribution of crocodiles in Cambodia, the breeding sites are scattered throughout the country. These sites have been identified in 7 provinces from 5 general locations (Table 2).

Worrying though, are reports over the last few years (2004-2006) that nests or hatchlings have not been seen from a number of earlier nesting sites (2001-2003), where consequently reports of the capture of large crocodiles have been made. Permanent habitat destruction (through land clearing and burning) at some sites have also resulted in an absence of nesting recently.

Table 2: Known or assumed nesting areas identified in Cambodia since 2001

Location	Province	Sites (river or area)
Cardamom Mnts	Pursat	Veal Veng
Cardamom Mnts	Koh Kong	Areng, Sre Ambel (upper, lower), Botum Sakor
Tonle Sap	Battambang	Prek Taol
Tonle Sap	Siem Reap	Chi Krang
Mondulkiri	Mondulkiri	Srepok
Ratanakiri	Ratanakiri	Sesan
Stung Treng	Stung Treng	OTalas
Kampong Thom	Kg Thom	Porung

3.3. Interviews

Interview results have provided information on a number of topics but specifically on the recent sightings of crocodiles, hunting or other threats. Local residents of rivers and wetlands often spend considerable time on the water, and so have a much better chance of seeing crocodiles than that during a survey of short duration. A number of areas were identified by local residents as having crocodiles present but we were unable to confirm this by direct observation during field trips. These areas are shown in Figure 1 as 'recent reports'.

Although not the primary objective of our project, we have nevertheless gathered reports from a number of sources, which indicate that wild crocodiles were still being killed or captured during the period mid 2004 – mid 2006 (Appendix 1). The majority of crocodiles, whether intentionally or incidentally caught, were then sold on to traders or crocodile farms in Cambodia. Of the 57 crocodiles reportedly taken from the wild, 89% (51 crocodiles) were for the crocodile trade, while three were killed intentionally or accidentally, and three were later released by authorities. Details of crocodiles caught in Cambodia prior to 2004 can be found in Simpson and Han, (2004) and SCWG (2004a).

4. Discussion

4.1. Status

The Siamese crocodile population in Cambodia has been severely depleted, and remaining groups are now small and scattered throughout the country. Dry season surveys carried out in 12 Provinces over the last six years indicate that crocodiles are found in the more isolated areas of the country and are often very difficult to find.

Of the 35 sites (in 11 provinces) so far identified, most probably contain only a handful of individuals, with only two sites – Veal Veng marsh and Areng River – estimated to contain more than 30 individuals (Daltry *et al* 2003, Simpson and Han 2004). Although surveys in the last two years have focused on areas in the north and northeast of the country, the Cardamom Mountains in the Southwest of Cambodia is still considered the stronghold for the species with 54% of identified sites and more than 80% of known animals being found here.

Surveys have identified or estimated at least 184 individuals, but this number probably represents only a proportion of the real population. Hunting has been prevalent throughout Cambodia, especially during the 1980s and 1990s (Thuok and Tana 1994) and remaining crocodiles are extremely wary of disturbance or lights. Identifying crocodiles under these conditions, and from other sign (tracks and dung), will considerably underestimate the real number of crocodiles in an area. Thus, obtaining a population estimate for Siamese crocodiles based on survey results obtained so far, under varying conditions and methods, is difficult at best, and we have made no attempt to do so. Bezuijen *et al* (2005) considered estimates made for Lao *C. siamensis* populations (based on nesting) to overestimate of the real population. This said however, we consider the population of Siamese crocodiles in Cambodia to be extremely small and probably comprised of less than 200-250 adults.

A complete census of Cambodia's waterways has not yet been achieved and there is a good possibility of finding other crocodile sites in the future. However the likelihood of finding other significant viable populations seems low, as most of the survey areas targeted were based on the historical records and local reports. Of 35 dry season sites known, possibly less than 10 now support known breeding areas and only two of these breeding sites contain a significant number of crocodiles (estimated 20+ individuals). The number of breeding areas has diminished since 2001, with land clearing and the killing or capture of adults from some of these sites resulting in a lack of nesting in recent times.

4.2. Threats to the Crocodiles of Cambodia

Siamese crocodile populations in Cambodia have been severely depleted over the last century. The conversion of wetland habitats for agriculture and the active hunting of crocodiles for their skins and to stock crocodile farms, have greatly reduced their distribution and abundance across the country. Many threats continue today, which jeopardise their existence and hamper their recovery of remaining scattered crocodile populations.

4.2.1. Trade in wild crocodiles

All crocodiles are protected by law in Cambodia, but despite this, the collection of wild crocodiles for trade was reported as the single most important factor threatening Siamese crocodiles in 2004 (Simpson and Han 2004). This is still clearly the case today as more than 57 wild crocodiles have been reportedly captured for sale since mid 2004. As documenting the illegal trade in wild crocodiles is not a primary aim of our project, this number probably represents only a fraction of the real number taken over the last two years. Once wild caught crocodiles enter one of the 900+ farms in Cambodia, they are then impossible to distinguish from captive bred animals, and can then be readily traded nationally or internationally.

Although there are only 6 CITES registered farms in Cambodia, many of the exported consignments from these farms are made up of crocodiles purchased from the multitude of smaller non-CITES farms (Jelden *et al*. 2005), making the export of wild-caught crocodiles not only possible, but probable. Trading crocodiles for export between CITES and non-CITES farms is clearly in breach of CITES regulations (Thorbjarnarson 2003), but controlling such transactions in Cambodia will prove difficult. The Department of Fisheries has started to address many of the recommendations of the Jelden *et al.* (2005) Cambodian CSG review.

A whole range of issues relating to farm and trade problems, threats and possible solutions are discussed in detail by the CSGs Siamese Crocodile Working Group (SCWG 2004) and the Crocodile Specialist Group's mission to Cambodia (Jelden *et al* 2005). In general however, stricter farm monitoring, policing and adherence to CITES and national laws are needed before there will be any chance of a population recovery for the wild Siamese crocodiles of Cambodia.

4.2.2. Habitat Destruction

Crocodile habitat in Cambodia continues to be degraded through the increased drive for more agricultural land. Land around water sources, such as rivers and lakes are prime areas for development, and the associated disturbance along these waterways reduces available areas for crocodiles to thrive. Large tracts of flooded forest around the Tonle Sap Lake for example have been cleared and burned (SCWG 2004b), and such action has already destroyed known nesting sites from 2002 and 2004. That said however, Cambodia still has large forested areas which provide excellent crocodile habitat. Many of these areas are within protected landscapes which will provide some protection against wholesale land clearing. The prime reason for the severe decline in Siamese crocodiles in Cambodia is not from the destruction of crocodile habitat, as it is for other critically endangered crocodilians, such as the Chinese alligator (Ross 1998), but because of the persecution of the crocodiles themselves.

4.2.3. Fishing Practices and Disturbance

With the vast number of rural Cambodians undertaking some form of fishing, the chances of crocodiles coming into contact with fishing gear is high. Many of the crocodiles sold to farms in Cambodia in the last few years have been captured (often accidentally) in legally set fishing gear such as nets, traps and hooks (Daltry *et al.* 2003; Howard 2001; Simpson and Han 2005). Of the two crocodiles caught for a radio-tracking study (see Simpson *et al* this volume) both had large hooks imbedded in their bodies. Illegal fishing with explosives, poisons and electro-fishing gear is also frequent in Cambodian waterways and such methods are also known to kill crocodiles (Daltry *et al*. 2003; Simpson *et al*. 1997; Nguyen *et al*. 2005). Fishing related deaths and captures continue to pose a threat to the recovery of Siamese crocodile populations, especially in areas where breeding occurs. Once again the impact of such captures could be lessened if national laws relating to the wild crocodiles were heeded – and live crocodiles were released again after capture.

4.2.4. Other Threats

The killing out of fear, retribution or for meat does occur, although the reports over the last two years have been uncommon.

One large crocodile was reportedly eaten by indigenous residents in Ratanakiri province (caught in fishing net) while another crocodile (2m long) was shot in a small lake after upsetting local fishermen (Simpson and Han 2005). The removal of even a few crocodiles (especially large mature individuals) can impact significantly on depleted populations and such activities must be reduced in order for populations to recover.

One of the indirect threats now facing the crocodiles of Cambodia is that the population is now so scattered, that viable groups may only be represented in a few of the 32 sites identified. Such isolation may result in crocodile sites that may not have both mature males and females present, or that such breeding groups are so small that inbreeding may be a problem in the future.

5. Recommendations

Detailed recommendations relating to farming, trade and management issues are provided by Jelden *et al.* (2005), while general recommendations relating to the conservation of Cambodia's wild Siamese crocodile populations are:

1. The illegal trade in wild crocodiles needs to be curtailed with specific focus on the monitoring of crocodile farms. Farmers must be educated regarding national and international laws pertaining to crocodiles and trade.
2. Extend surveys to new areas and provinces to gain a more complete understanding of the distribution and status of the species
3. Monitor known populations in order to determine if conservation strategies are working effectively
4. Increase and promote public awareness of crocodiles and national laws pertaining to them
5. Increase and encourage the participation of local communities in helping to conserve local crocodile populations
6. Undertake detailed research in order to increase our knowledge of crocodile biology and ecology ie. studies on movement or genetics
7. Increase and promote public awareness of crocodiles and national laws pertaining to them

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8. Appendix 1.

Reports of captured / dead crocodiles gathered by CCCP from mid 2004-mid 2006

? 1 large (2.0 -2.4m) crocodile found dead in Areng river (skin hangs in CCPF ranger station at Thma Bang), photos by CCCP end 2004 (death unknown, possibly drowned)
? 1 large crocodile reported captured from Sre Ambel river in 2005 (DoF - CSG report) (trade)
? 2 small crocodiles taken from Veal Veng marsh in 2005 (trade)
? 1 large crocodile caught from O'Talas in Dec 2005 by people from Kampong Thom (trade)
? 1 large (2m) crocodile shot from small lake in Dec 2004, skin in Ta Veng, Sesan River (retribution or security)
? 1 large crocodile (3.5m) drowned in a fishing net near Sesan River in 2002 and was eaten by locals (food)
? ca 42 hatchlings taken from nesting areas in Chi Krang July 2004 (trade)
? 1 crocodile electrocuted from Tapeang Plurng late 2004 ? (trade)
? 2 large crocodiles caught in fishing Lot #1 ? and offered to DoF (DoF) 2005 (re-release)
? 2 small crocodiles caught Moung Russei River (Battambang) mid 2004 (trade)
? 2 crocodiles caught from Sre Ambel area in 2004 and sold in Phnom Penh (Sovannara, DoF) (trade)
? 1 large crocodile confiscated from fishermen by rangers and released into Srepok River, March 2004. (photos) (re-release)

Philippine Crocodile Conservation In Northeast Luzon: An Update Of Population Status And New Insights Into *Crocodylus mindorensis* Ecology

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Abstract: The critically endangered and endemic Philippine crocodile *Crocodylus mindorensis* used to occur on most of the larger islands of the Philippines but is now very rare. Recent survey data is lacking for most historically know distribution localities. The population in Northeast Luzon is currently the only which is well known and studied in the wild. Distribution, population size, population structure, reproduction and mortality are being monitored since 1999. In addition, ecological and behavioral studies are being conducted. In 2005, three crocodiles have been radio-tagged and their movements are being monitored. The studies provide new information on the ecology and life history of *C. mindorensis*. This information is important as an input into the conservation program which is being implemented in the project area.

1. Introduction

Two crocodile species are found in the Philippines, the estuarine crocodile *Crocodylus porosus* and the endemic Philippine crocodile *Crocodylus mindorensis* (Groombridge 1987, Ross 1998). The Philippine crocodile is listed as globally critically endangered (IUCN 2006). The estuarine crocodile is not listed as threatened on a global scale but is severely threatened in the Philippines (Ross 1998). This paper focuses on *C. mindorensis*.

Crocodile surveys in the Philippines

Published information on the distribution of both crocodile species in the Philippines remains rare. C.A. Ross conducted surveys in southern and central Philippines (Mindanao, Visayas and Palawan) in 1981 (Ross 1982, Ross and Alcala 1983) and recently published an account on crocodile observations in northern Philippines (Dalupiri island) in 1990 (Ross 2005). Ross (1982) has also inventoried museum specimen collection localities, which provide the best source of information on the historical distribution of crocodiles in the Philippines.

Aoki (1985) observed *C. mindorensis* on Mindoro during the mid 1980's. Alcala *et al.* (1987) collected information on crocodiles on Negros. Ortega added information gathered during the 1990's, mainly from secondary sources (Ortega *et al.* 1993, Ortega *et al.* 1994, Ortega 1998). Rebong and Sumiller (2002) reported on capture localities of the Philippine crocodile in the wild in 1990-1992 on Mindanao and Busuanga for a captive breeding program.
Pontillas conducted targeted surveys in areas with historical and recent accounts of crocodiles on Luzon, Mindoro, Busuanga and Mindanao in 1999 and 2000 (Pontillas 2000). Manalo (2003) conducted estuarine crocodile surveys in southern Palawan. Oliveros *et al.* (2005) conducted surveys on the Babuyan islands in 2005. Since 1999 we have been conducting crocodile (both species) surveys in northern Luzon (van Weerd 2000, van Weerd 2002, Tarun *et al.* 2004). These surveys are part of a larger conservation program which is especially focused on protection of the Philippine crocodile in its natural habitat (van Weerd 2002, van Weerd and van der Ploeg 2004, Miranda *et al.* 2004, van der Ploeg and van Weerd these proceedings). Since 2004 we conduct more in depth ecological studies of Philippine crocodile behavior, diet and movement patterns (as promised in Tarun *et al.* 2004).

2. Methods

2.1. Distribution and population size

We gathered all published information on the historical and current distribution of *C. mindorensis* and, combined with our own information, used this to construct a distribution map and locality table for the species. The literature sources are mentioned above and in the table. In addition we have used unpublished information from various colleagues to complement the map (Frederick Pontillas, Ely Alcala, Rainier Manalo). It is impossible to construct a reliable current distribution map as recent data for many localities lack, especially for Mindanao. We have therefore indicated whether localities refer to observations before or after 1999. Similarly it is impossible to reliably estimate the total current population size of *C. mindorensis* in the wild. Based on the findings of Ross (1982), Ortega (1998) and Pontillas (2000) however it is evident that the Philippine crocodile survives in only very few localities, at extremely low densities.

2.2. Philippine crocodile surveys in northern Luzon

Our own survey work in northern Luzon started in 1999. Several Philippine crocodile localities were identified then and have been monitored every three months unless weather and safety conditions did not allow for this (see van Weerd 2002). Interviews among fishermen and hunters have been conducted to identify additional localities. Sometimes crocodiles are accidentally caught as a by-catch in fishing nest and, more often, as by-catch of electro fishing. Electro fishing (using car battery electricity to stun and collect fish and shrimps) is illegal in the Philippines but is widely practiced. Within the Northern Sierra Madre we are usually informed when crocodiles have been caught, and have been able to release caught crocodiles back into the wild. Crocodile catch information leads to the identification of new distributional localities.

Suspect new localities are visually inspected during the day for tracks, feces and crocodiles. Night surveys, using standard spotlighting, are conducted in these sites as well.

Surveys are usually on foot as lakes and rivers in the mountainous areas of northern Luzon are too small or too shallow to use boats. Identified localities are visited at least once a year for a crocodile survey, using repeated night spotlight surveys for three nights.

We use three size/age classes: 1) hatchlings are new-born crocodiles, they stay in that category till the next calendar year and then move to the juvenile category (hatchlings are born in June-August) 2) all crocodiles that are not clearly adult are placed in the juvenile/sub-adult category and 3) evidently large crocodiles (c. > 1.8 m.) are placed in the adult category. It is very difficult to estimate crocodile size in the field, especially during night surveys, but the survey team is very experienced and the three night repetition offers opportunities to triple check observations. The maximum count for one night is taken as count result. Survey methods and surveyors have been constant since 2000 providing comparable population monitoring information from year to year. Identified localities in the municipality of San Mariano are surveyed every three months.

2.3. Ecological studies

Dunoy Lake in San Mariano provides an excellent locality to conduct ecological and behavioral studies on crocodiles. Anecdotal information from people of Dunoy suggested that crocodiles go to nearby Catallangan River during dry season and, when water levels rise in the wet season, return to Dunoy Lake. In the wet season, crocodiles can be observed almost every day in Dunoy Lake. We have built an observation tower at the side of this lake to conduct behavioral observations. Crocodile micro-habitat use, activity budgets, interactions, prey choice and hunting behavior are being studied here. Results will be presented elsewhere when studies have progressed further.

2.4. Telemetry methods

To study movements of crocodiles in the Dunoy Lake area, one adult female and two juvenile females were caught using baited snare-traps. After measuring and sexing, these crocodiles were radio-tagged with custom-made VHF radio-transmitters with whip antennas (Advanced Telemetry Systems Inc., Isanti, Minnesota) and released at capture spots. The transmitters were attached using a method following Kay (Kay, 2004a). Kay placed transmitters between the nuchal scales of preferably large individuals, but since *C. mindorensis* is a small species, the transmitters were attached between the double caudal verticils.

Crocodiles were tracked manually. This paper deals with observations made between May and September 2005 but the telemetry study continues at the time of writing (June 2006). All transmitters have survived till this date. The radio-signal was received using a 3 Element Folding Yagi-antenna connected to a model FM-100 receiver. Locating the animals occurred cautiously and when possible, binoculars were used to avoid disturbance. As soon as a crocodile was located within approximately 50 meters, GPS coordinates were noted and its habitat was described.

Spatial analyses were performed using ArcView GIS software (version 3.3; ESRI, Redlands, California) in conjunction with the animal movement analyst extension, AMAE, version 2.0 (Hooge and Eichenbach 2001).

Geo-referenced maps (scale 1:50,000) were used as a base layer. Home range estimations were made using the mid-stream linear range method (Tucker *et al.* 1998, Kay 2004b) and in addition fixed kernel home ranges (50% and 95% probability) were calculated.

3. Results

3.1. Historical and current distribution of the Philippine crocodile

Figure 1 provides an overview of *Crocodylus mindorensis* observation localities in the entire country. Numbered localities refer to observations since 1999, letter coded localities to observations before 1999. Table 1 provides the locality names, last observation year and source of information.

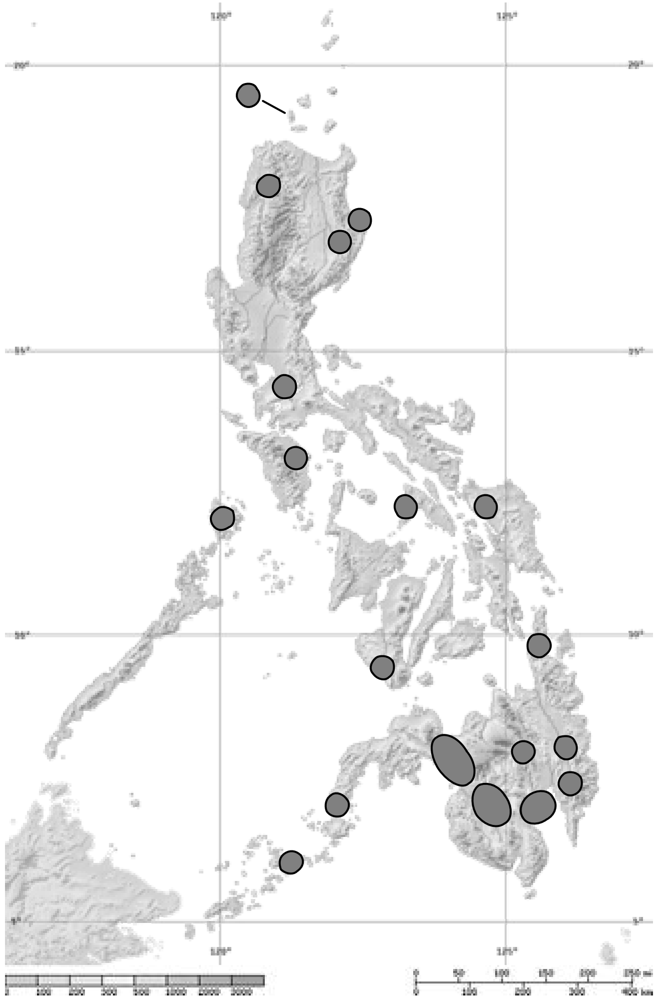

Figure 1: map of the Philippines with *C. mindorensis* observation localities.

Table 1: overview of historical and recent *Crocodylus mindorensis* observation localities in the Philippines

Loc code	*Last obs.*	*Localities*	*Area/Province(s)*	*Island*	*Source(s)*
Recent observations (since 1999)					
1	2005	Caucauayan Creek	Cagayan Province	Dalupiri (Babuyan islands)	Oliveros *et al.* 2005
2	2004	Binongan River	Abra Province	Luzon	Manalo pers. comm.
3	2006	Dungsog Lake Dunoy Lake Catallangan River Disulap River Dinang Creek Diamallig Creek	Cagayan valley, San Mariano, Isabela Province	Luzon	This paper
4	2006	Po River Dicatian Lake Dibukarot Creek	Coastal plains Pacific Ocean, Isabela Province	Luzon	This paper
5	1999	Pulangui River	Bukidnon	Mindanao	Pontillas 2000
Observations before 1999					
A	Before 1981	Manila Laguna de Bay	Laguna de Bay area	Luzon	Ross 1982
B	1993 [1]	Vicinity of Naujan Lake Caituran River	Mindoro Oriental	Mindoro	Schmidt 1935, 1938 Ross 1982 Aoki 1985 Ortega 1998 Pontillas 2000
C	1993 [1]	Dimaniang Dipuyai River Busuanga River	Busuanga	Busuanga (Calamian islands)	Schmidt 1956 Ortega 1998 Pontillas 2000
D	Before 1981	-	Mandaon area	Masbate	Ross 1982
E	Before 1981	-	-	Samar	Ross 1982
F	1990s [2]	Pagatban River Ilog River	Negros Oriental	Negros	Ross 1982 Alcala *et al.* 1987 Ely Alcala pers. comm. Manalo pers. comm.
G	Before 1981	Placer	Surigao del Norte	Mindanao	Ross 1982
H	1994 [1]	Agusan Marsh	Agusan del Sur	Mindanao	Ortega 1998 Pontillas 2000
I	1979	Nabunturan	Compostela Valley	Mindanao	Ross 1982
J	Before 1981	Tagum Malita	Davao	Mindanao	Ross 1982
K	1992	Linguasan Marsh	North Cotabato South Cotabato Maquindanao	Mindanao	Ross 1982 Rebong & Sumiller 2002
L	1992	-	Misamis Occidental Lanao del Norte Lanao del Sur Zamboanga del Sur	Mindanao	Ross 1982 Rebong & Sumiller 2002
M	1981	Zamboanga City	Zamboanga del Sur	Mindanao	Ross 1982
N	Before 1981	-	Jolo	Jolo (Sulu islands)	Ross 1982

[1] no observations in 1999 (Pontillas 2000, Pontillas pers. comm..)
[2] no observations since 1999 (Ely Alcala pers. comm.)

3.2. Philippine crocodile distribution and population size in northern Luzon

Table 2 shows the current distribution and population size of the Philippine crocodile in the Northern Sierra Madre.

In the first half of 2006, 25 non-hatchling crocodiles (10 adults and 15 juveniles/sub-adults) were counted in eight different localities. San Mariano remains the most important distribution area with five distinct localities with permanent crocodile residence and 21 crocodiles. Crocodiles have in the past been observed in several other rivers in San Mariano (Kamalaglagan Creek, Disabungan River, Ilaguen River; see van Weerd 2002), it seems that these areas do not have a permanent reproducing population but are used temporarily or by roaming crocodiles, similarly to the seasonal use of Catallangan River near Dunoy Lake.

At the Pacific Ocean side of the Sierra Madre, three localities have Philippine crocodiles in three different municipalities. Po River in Maconacon is a newly identified Philippine crocodile locality after a fisherman accidentally caught a live adult male crocodile here early 2006 which was subsequently identified as *C. mindorensis* and released at the capture spot.

In 2005, *C. mindorensis* was also confirmed at Cacawayan Creek on Dalupiri Island off the north coast of Luzon (Oliveros *et al.* 2005). In 2001 and 2004 captive Philippine crocodiles and crocodile tracks were found near and along Binongan River in Abra Province in the Cordillera mountains of northern Luzon, confirming the presence of the species in this central Luzon mountain area. There have been additional but as yet unconfirmed reports of crocodile localities here (Pontillas pers. comm., Manalo pers. comm., van Weerd 2002).

Table 2: Current distribution and population size of *Crocodylus mindorensis* in the Northern Sierra Madre

No.	*Locality*	*Municipality*	*Year*	*Month*	*Adult*	*Juv/sub -adult*	*Total*
1	Disulap River	San Mariano	2006	May	2	1	3
2	Dunoy Lake	San Mariano	2006	April	2	6	8
3	Dungsog Lake	San Mariano	2006	May	1		1
4	Dinang Creek	San Mariano	2006	May	2	6	8
5	Diamallig Creek*	San Mariano	2006	June	1		1
6	Dicatian Lake	Divilacan	2006	Feb		2	2
7	Dibukarot Creek	Palanan	2006	Feb	1		1
8	Po River*	Maconacon	2006	Jan	1		1
Total					10	15	25

* New Philippine crocodile locality identified since last CSG meeting report (Tarun *et al*. 2004)

3.3. Monitoring Results

Figure 3 shows the results of eight years monitoring of the crocodiles in San Mariano. Survey effort and methodologies are comparable from 2000 onwards. During the period 2000-2002, there was yearly successful breeding. In 2003 breeding failed completely as a result of adverse weather conditions. Breeding in 2004 only yielded two hatchlings (Dunoy). Breeding in 2005 was more successful with hatching nests in Dunoy and Disulap. At the time of writing one nest near Dunoy Lake has hatched (17 surviving hatchlings) whereas two nests near Disulap River and Dinang Creek are being monitored.

Successful breeding and hatchling survival are of extreme importance for a recovery of the crocodile population in San Mariano. A successful breeding year is followed by an increase of the non-hatchling population (recruitment of hatchlings into juvenile category) whereas unsuccessful years such as 2003 and 2004 are followed by a dramatic decline of the crocodile population. This is probably the result of a combination of recruitment failure and increased natural mortality of juveniles as a result of the same adverse conditions that impair successful breeding.

The adult population has remained fairly constant since 2001, a minimum of three reproducing females is present. Several sub-adults in Dunoy Lake, Disulap River and Dinang Creek are expected to reach reproductive size (> 1.5 m., Ortega 1998) within the coming three years.

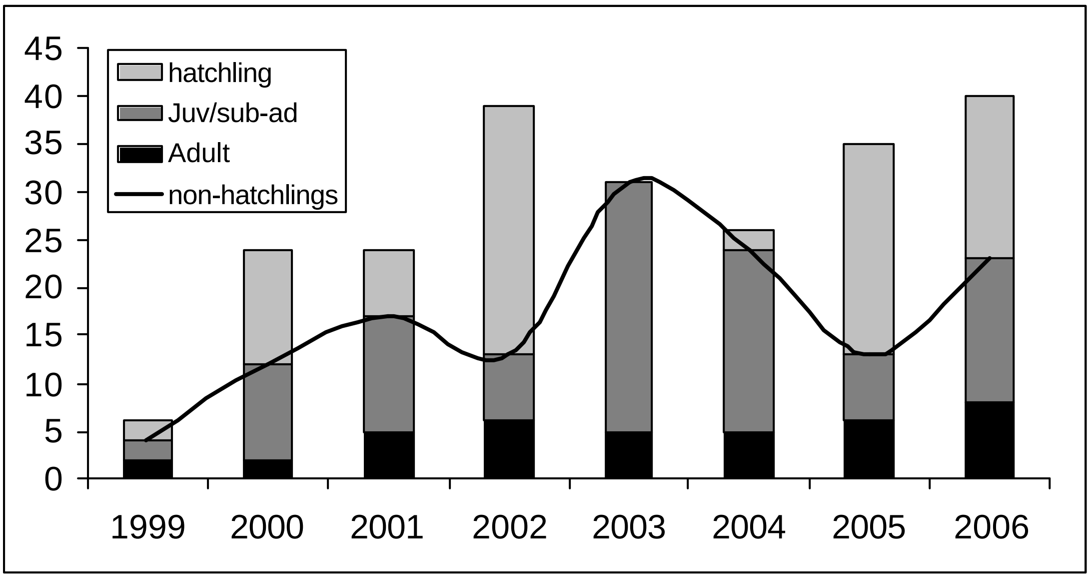

Figure 2: monitoring results of permanent Philippine crocodile localities in San Mariano 1999-2006. In July 2006 an additional 27 hatchlings were born from two nests in the wild, these have not been included in the graph.

3.4. Breeding

Since 1999 five Philippine crocodile nests have been found and four additional successful breeding events have been recorded on the basis of new hatchling observations. All nests were mound nests, usually very close to water. In June 2005 a nest was found on the banks of Disulap River.

The nest was in the vicinity of an exit of a crocodile burrow (<2 meters away) and was located on the boundary of secondary forest on a steep river bank 5.9 meters from the river with dimensions 124x152x43 cm (short axis x long axis x height in middle). It was composed of sand and vegetation (grass, twigs, vines). Grass grew atop of the nest. The nest was located 1.7 meters above the water line but 2.0 meters below the high water level mark (which is reached during flashfloods after typhoons). When the nest was found by local inhabitants an adult crocodile was reported lying atop of it but other than that parental care or nest protection was not observed.

On July 13 the eggs started to hatch. Of 23 eggs, 19 hatched. Ten hatchlings were killed by ants that bit them to death in the nest, possibly attracted by remains of the eggshells. It was decided to collect the nine surviving hatchlings and these are now being kept in a head-starting program. Due to inter-specific fighting only four survive to date, they are all kept separately now. A new nest was found in May 2006 on another location along Disulap River and was permanently guarded by the local crocodile protection group. Eggs were first found on May 18, hatching started July 22 (incubation time: 66 days). Of 26 eggs, 22 hatched (the other four were found to contain dead embryos). One egg was double-yolked and yielded live twin hatchlings which died soon. Three other hatchlings died, 18 remain and have been collected for head-starting.

In August 2005 near Dinang Creek a mound nest was located in a harvested corn field. A local farmer who did not realize this plowed the nest accidentally under. Despite an effort to retrieve eggs and incubate them artificially all eggs were lost. A new nest was found here in June 2006, on another location, which has been guarded by a local crocodile protection group. On 27 July this nest yielded nine live hatchlings.

In June 2006 a nest was also found near Dunoy Lake. This mound nest was located 1.5 meter away from the lake and was also composed of vegetation. Hatching started June 28 and yielded 22 hatchlings. Two hatchlings were predated by Rufous Night-heron *Nycticorax caledonicus* which breed in a small colony near the lake. Three hatchlings remain in the lake and 17 were collected and are kept in the head-starting program, all survived at time of writing. Table 3 gives an overview of Philippine crocodile nesting in San Mariano since 1999.

Table 3: history of Philippine crocodile nesting in San Mariano

Locality	*Hatching date*	*No. hatchlings*	*No. eggs*	*Hatchling fate*
Disulap	August 2000	8	25	1 observed after 1 year, 0 after 2 years
Dunoy	August 2002	12	Unknown	9 observed after 1 year. 3 in Dunoy in 2006 (c. 1 m. long)
Dunoy	August 2004	2	Unknown	2 observed after 1 year, 1 observed in 2006.
Disulap	13 July 2005	19	23	10 killed by ants. 9 collected for head-starting (4 surviving)
Dunoy	August 2005	3	Unknown	2 observed after a year (2006)
Dinang	-	0	Unknown	Nest accidentally destroyed by farmer August 2005
Dunoy	28 June 2006	22	Unknown	2 killed by Rufous Night-Heron 17 collected for head-starting. 3 in lake
Disulap	22 July 2006	23*	26	Twins and 3 others died soon after hatching. 18 are kept in head-starting
Dinang	27 July 2006	9	Unknown	9 in Dinang Creek

* including one case of twins

Egg laying in captivity by *C. mindorensis* was from February – October at the Crocodile Farming Institute on Palawan, with a peak around May – June which is at the onset of the rainy season there (Ortega 1998). Incubation time was 79-89 days and average clutch size was c. 25 eggs (Sibal *et al.* 1992). Multiple nesting (multiple clutches) was reported in some cases. Another idiosyncrasy reported for some females was hole nesting (Ortega 1998). In captivity on Negros, egg laying occurred between April and August which is from dry season (April) till onset of rainy season. The one female which was studied here produced multiple clutches in some years (up to three clutches spread over April - August), always using the same nest site and building a mound nest. Mean clutch size was 15.7 and incubation time 77-85 days. The female guarded the nest and assisted in opening the nest at hatching and transporting hatchlings to the water (Alcala *et al.* 1987).

In the wild in northeast Luzon, where the rainy period usually starts at the end of May, egg laying seems to take place at the height of the dry season till the onset of the wet, from half April – June. Clutch size was 23-26 in the three instances where we have been able to find out the number of original eggs laid. Hatching rates seem to vary considerably (0-23), possibly a result of nest predation, and in one case a nest was completely lost. Clutch size seems to be similar to captivity but incubation time of the one nest where we were able to monitor this reliably was with 66 days much shorter. In Disulap there are indications of attempts at hole nesting or a combination of hole and mound nesting. A striking difference with breeding in captivity is that all nests have been found at different locations within a general locality whereas we doubt more than one adult female is present per locality. Whether this is a result of a limitation of suitable breeding spots in holding pens or crocodiles in northern Luzon following a different strategy need to be studied further. A large public information campaign on crocodile nests, active nest monitoring and protection and the head starting program are expected to increase hatching rates and hatchling survival.

3.5 Crocodile movements

Three female crocodiles have been caught in the Dunoy Lake-Catallangan River area during this study; one adult female crocodile with a TL of 185 cm (C1) and two female juvenile crocodiles with a TL of 90.5 cm and 94 cm. (C2 and C3 respectively).

Table 4 provides summary statistics for these individuals and their recorded movements.

Table 4: Summary statistics for three Philippine crocodiles radio-tracked between May 2005 and September 2005

	C1 (Zenni)	*C2 (Aida)*	*C3 (Inday)*
Frequency (MHz)	154.382	154.020	154.041
Date captured	27-May-2005	16-June-2005	17-July-2005
Body mass (kg)	25.5	2.1	2.0
Total length (cm)	185	90.5	94
Snout –Vent Length (cm)	84	44	45
Tail (cm)	101	46.5	49
Total number of fixes	49	29	15
Total number of locations (n)	10	11	2
Maximum distance moved from release location	4.3 km	2.9 km	0.3 km

Female C1 was radio-tagged on May 27 and released on the bank of the river. On May 28, she was located in Dunoy Lake, where she stayed till June 7. From June 8-10 she traveled to a location 4.3 km. upstream the river. From June 11 to September 2, C1 remained at the same location. Rate of movement calculated over the period May 27 until September 02 was 0.04 km day-1; when calculated only over the period of actual movement (June 8 - 11), rate of movement was 0.94 km day^{-1}. In November 2005 she was back in Dunoy Lake.

Female C2 was radio-tagged on June 16 and released on the bank of the river. On June 18 she was located in a small pool amidst dense reed vegetation where she remained up to and including June 23. Between June 24 and July 7 all fixes acquired on her concerned river locations. On July 9 she was in a small pool next to the river and on July 11 she moved to a big pool (A). From July 15 – August 16 C2 continued moving to upstream river locations or small pools next to the river up to 2.9 km from the release spot but then returned to the large pool (A) and remained there. In November 2005 she was back in Dunoy Lake. Rate of movement calculated over the period June 16 - September 02 is 0.07 km day^{-1}. When rate of movement is calculated over the periods that she moved most, July 6 to July 16 and August 01 to August 06, rates of movements are respectively 0.13 day^{-1} and 0.29 km day^{-1}.

Female C3 was radio-tagged July 17 and released on the bank of the river. From August 2 - 4 she was located in the river at the location of her release. On August 5 she was located in Dunoy Lake, where she remained the rest of the study and where she was regularly observed. The shortest distance between Lake Dunoy and location of release is 0.26 km. Rate of movement from July 17 to September 02 is 0.01 km day^{-1}.

3.6. Size of home ranges and habitat preference

The size of home ranges for C1 and C2 has been estimated with fixed kernel probabilities of 50% and 95% and with mid stream linear distance (figure 2; table 5). C3 only used two locations and stayed most of the study time in Dunoy Lake.

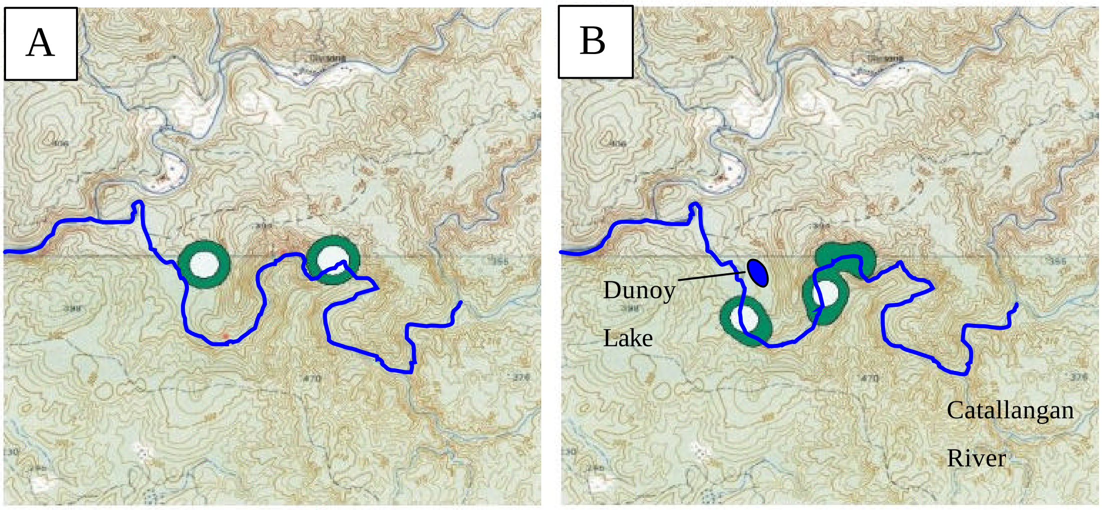

Figure 3: Fixed Kernel home range estimations with 50% and 95% probabilities for C1 and C2.
A: Fixed kernel home range size of C1. The inner circle is the 50% probability home range, the outer dark circle the 95% probability home range.
B: Fixed kernel home range size of C2. The inner circle is the 50% probability home range, the outer dark circle the 95% probability home range.

Table 5: Home range estimations of the radio-tagged crocodiles (May – September 2005)

Crocodile	*Kernel 50% probability*	*Kernel 95% probability*	*Mid stream linear distance*
C1	27 ha	79 ha	4.3 km
C2	24 ha	110 ha	2.9 km
C3	N.A.	N.A.	N.A.

The three crocodiles showed differences in movement patterns. The maximum distance moved from the release spot was greatest for C1 (4.3 km), followed by C2 (2.9 km) and C3 (0.3 km). Although C1 covered the greatest distance, C2 moved more frequently over small distances. C3 moved less frequently compared to both other crocodiles and covered the smallest distance.

During 2005, eight crocodiles were regularly observed in the Dunoy Lake/Catallangan River area: two adults (incl. C1), three larger juveniles (c. 1 m. TL, incl. C2 and C3) and three smaller juveniles (c. 0.5 m. TL). The smaller juveniles remained in the lake during the entire year. The larger juveniles made excursions to Catallangan River where C2 moved over a distance of 2.9 km. and stayed in several pools and the river itself for varying periods of time. C3 made excursions to the river but stayed most of the time in Dunoy Lake. C1 and an untagged other adult crocodile spent most of the year in the river where C1 stayed for prolonged periods in deeper parts of the river with good hiding places offered by big boulders and underwater caves (Table 6).

Table 6: Descriptions of the sites where the radio-tagged crocodiles spent most of their time

Crocodile	*Coordinates*	*Category*	*Description*
C1	N 16?59'57.7" E 122?10'26.6"	River	Secondary forest along the river. A small cave is situated underneath some rocks, with an entrance underwater. The river width is between 10 and 15 meters.
C2	N16?59'42.5" E 122?09'57.2"	Pool	Small, shallow pool (12.5 x 6.3 meter, 1.1 meters deep), bordered by secondary forest on one side. A boulder lies opposite to the forest bordered side. The pool is surrounded by dense reed vegetation.
C3	N 16?59'55.7" E 122?09'29.3"	Lake	Dunoy Lake (100 by 50 meters). On the eastern side it is bordered by dense vegetation. On the western side vegetation is less dense. On the southern side a little stream is situated.

Seasonal movement of crocodilians in relation to water levels is a phenomenon reported for many crocodilian species e.g. *Caiman crocodilus* (Ouboter and Nanhoe 1988, Coutinho and Campos 1996), *Crocodylus johnstoni* (Webb *et al.* 1983), *C. porosus* (Kay 2004b), *Alligator mississippiensis* (Goodwin and Marion 1979) and *C. novaguineae* and *C. porosus* in New Guineae (Montague 1983), but in all these species animals tend to congregate more during dry season and disperse more during wet season.

The seasonal shift in habitat preference in *C. mindorensis* in our study area seems to follow an opposite pattern showing more solitary dispersal and movement during the dry season and sedentary congregation in Dunoy Lake during the wettest period of the year. A similar pattern was found for *C. intermedius* in Venezuela which became mainly sedentary at maximum river levels and started moving again when river levels dropped (Munoz and Thorbjarnarson 2000). There are two possible explanations for this pattern: 1) Dunoy Lake is not suitable for larger crocodiles and high crocodile densities during the dry season when lake level falls to as low as 0.5 m. and lake size diminishes to less than 0.5 ha. 2) Catallangan River is not suitable for crocodiles during the wettest part of the year when river currents can become very strong. More field data is needed to test which hypothesis, or a combination, explains *C. mindorensis* movement patterns in this area best. What is evident is that there are age/size differences in habitat preference and movement patterns. Smaller crocodiles stay longer (or entirely) in lake habitat compared to larger crocodiles and have smaller home ranges.

4. Consequences for conservation

The crocodile population in the northern Sierra Madre is critically small but is the best known population of the country. Recent data lack for many historical distribution areas of *C. mindorensis* but a lack of observations, both on distribution and population size, during surveys in the 1980's and 90's (Ross 1982, Alcala *et al.* 1987, Ortega 1998) and 1999/2000 (Pontillas 2000) indicate that the Philippine crocodile is on the brink of extinction in the wild. The municipality of San Mariano has the largest *C. mindorensis* population presently known to exist in the wild.

Our conservation project here (the Crocodile Rehabilitation, Observance and Conservation = CROC Project) which is focused on co-habitation of people and crocodiles, and on participation of local people and institutions in crocodile conservation (Miranda *et al.* 2004, van Weerd and van der Ploeg 2004, van der Ploeg and van Weerd these proceedings) is trying to create conditions in which the crocodile population can recover to viable levels. We use biological, socio-economic and socio-cultural data as an input to adapt the conservation approach to best reach this aim.

Crocodile population monitoring data for San Mariano show that good breeding years are followed by recruitment of hatchlings into juveniles the following year. Hatchling survival rates seem to be very high during these good years. In bad years, probably a result of adverse weather when typhoons cross near and over San Mariano causing extreme flashfloods, breeding fails and juvenile mortality seems to be high as well. The relation between typhoons, rainfall and crocodile population fluctuations needs to be studied further. Pronounced natural fluctuations in crocodile population size as a result of typhoon impact must always have occurred in northern Luzon (Mindanao is located south of the typhoon belt). But in an extremely small population such as here, stochastic variation can easily wipe the population out.

Successful breeding is of the greatest importance for a recovery of the population to a more resilient and viable level. Following the accidental destruction of a nest near Dinang in 2005 the project has put much more focus on nest protection.

Community crocodile protection groups which have been established to guard local crocodile sanctuaries (Miranda *et al.* 2004) have been trained to protect nests as well. In 2006 three nests were discovered and guarded by this group (with 20 surviving hatchlings in Dunoy, 18 in Disulap and 9 in Dinang as a result). A community information and awareness program was set up to inform everybody on the importance of crocodile nests and the do's and don'ts when a nest would be found. A reward was established for each hatchling that would be born within the boundaries of a community; this reward (500 Pesos = c. 10 US$/hatchling) is deposited to the local community development fund. Following the killing of hatchlings in a nest in Disulap by ants in 2005 the project has also embarked on a hatchling collection and head-starting program in co-operation with the local government of San Mariano. Hatchlings will be collected when acutely threatened and will be raised for about 1.5 years when they have reached a size which will increase their survival chances. They will then be released back into the wild. Currently four juveniles from the 2005 nest and 35 hatchlings from the 2006 nests are being held in the head-starting program.

The results of the telemetry study have also been used to adapt the conservation program. A much larger area is used by crocodiles in the Dunoy Lake area than we had previously thought. Conservation efforts need therefore be targeted to a larger area as well and not only concentrate on the lake which we did previously. Dunoy Lake seems especially important as a breeding area and a safe area for hatchlings and small juveniles. Disulap River, which is very similar to Catallangan River, seems to have very low hatchling survival rates even in "good" years. The ever strong current here could be responsible for washing hatchlings away.

This happened in 2000 when three tail-marked hatchlings were captured by fishermen 10 km. downstream from the nesting area. To create more favorable conditions for hatchlings in the Disulap River area we have started the construction of an artificial pond on an elevated river bank in May 2006. This pond will be fed by a natural spring and small creek and eventually become part of the natural system. The idea is to introduce the head-started hatchlings of the 2005 and 2006 nests here. We will monitor the evolution of the pond into a natural wetland and hope the resident crocodile population will start to use it in a similar manner as in the Dunoy system leading to increased natural hatchling survival rates and a recovery of the crocodile population.

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Implementation Of China Action Plan For Conservation And Reintroduction Of Chinese Alligator

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Abstract: This paper covers progress made from the June of 2004 to the current, and problems encountered and suggestions for the next few years for conservation and reintroduction of Chinese Alligator. The paper comprises 4 parts. Part 1 introduces the background for developing the China action plan for conservation and reintroduction of Chinese Alligator. Part 2 presents the progress on main components of action plan in recent two years, including the monitoring and current status of the current wild populations, progress on the reintroduction programme, scientific research activities, public education and other issues. Part 3 describes the main problems encountered during implementation of the action plan. The last part proposes actions that plan to be taken in the next few yeas.

1. Introduction

The Chinese alligator (*Alligator sinensis*) is one of the world's most endangered crocodilian. Thorbjarnarson (1999) reported that the wild population is less than 200 individuals with annual decreasing rate of 4-6%. The largest population size in one site only consists of 10-11 individuals (total 4 sites) and usually only one of them is female. Most colonies consist of 2-5 individuals. The wild population has been brought to the brink of extinction by habitat loss and human population pressures on its wetlands habitats in the lower and middle Yangtze River valley.

However, the Chinese alligator is a good candidate for reintroduction because wild populations are approaching extinction but a large captive population exists.

To ensure the species does not become extinct in the wild, the State Forestry Administration (SFA) of China issued "China Action Plan for Conservation and Introduction of Chinese Alligator" (2002) in the International Workshop on Conservation and Reintroduction of Chinese Alligator, Hefei, China, 2001. Meanwhile, the alligator was also listed as the one of 15 species of National Wildlife Conservation Project in 2001. Since then, China Government paid more attention to the protection and management of the wild populations and their habitats, as well as speed up the process of releasing project.

This paper concludes the implementation of the action plan in recent two years, problems encountered and next steps to establish new breeding populations in areas of suitable habitat and strengthen protection and management of the existing wild populations.

2. Progress on components of action plan

2.1. Monitoring and current status of the wild populations

2.1.1. Current status of the wild populations

Based on the results of the questionnaires and daylight surveys of burrows and prints, quantitative nocturnal spotlight surveys were conducted by Anhui Normal University (ANU) and Anhui National Nature Reserve for Chinese Alligator (Abbreviated as the ANNRCA, which occupy the same staff with the Anhui Breeding and Research Center for Chinese Alligator in Captivity.) from July to August of 2005 in areas most likely to have wild alligator populations. The survey area covered 119 sites of 79 villages in 41 towns of 7 counties (Xuanzhou District, Guangde County, Jingxian, Langxi, Ningguo, Nanling and Wuhu) in Anhui Province, including 13 key protection sites of the reserve.

During this survey, we counted 32 wild Chinese Alligators in 11 sites not including 66 young alligators incubated in 2005. According to the method of wild population estimation for freshwater crocodiles formulated by Chairman Grahame Webb, the direct counts would be 60-70% of the actual size of the wild population. We estimate that the current size of the wild Chinese Alligator population in Anhui is no more than 120 individuals, most remaining as single individuals or small, non-reproducing groups. The population is fragmented into 19 isolated small local populations with 1-10 individuals each. Among them, 6 colonies consist of above 5 individuals such as Changle, Zhongqiao, Heyi, Hongxing reservoir, Zhuangtou and Zhucun, the remaining 13 colonies consist of 1-4 individuals each including Tianguan, Zhalin, Meicun, Yanglin Forest Farm, Zhangcun and Jiagu. The results of this survey refer to the table 1.

It is worthwhile to mention is that we found two new distribution sites - Tianguan and Meishan, where no alligator occurred since 1999.

Table 1: Actual count and estimated number of wild alligators in Anhui in 2005

County/District	Site	2005 survey (individual)		
		Actual Count	Number by questionnaires	Estimated number
Nanling County	Heyi	3	2	4-6
	Changle*	4	12-13	7-9
	Tianguan**	1	1	1-2
	Zhalin*	2	2	3-4
	Others			6
Jingxian County	Shuangken*	2	4-5	3-4
	Zhongqiao*	1	5-6	6-7
	Others			6
Xuanzhou District	Hongxing*	9	18-19	13-15
	Zhuangtou	4	2-4	6-7
	Meicun**	1	3	2-3
	Limucun	0	1	1-2
	Others		5	14-19
Langxi County	Zhangcun*	1	2-3	2-3
	Others			4
Guangde County	Zhucun*	4	8	6-7
	Others		4-5	8-10
Total		32	69-77	96-114

Notes: One asterisk indicates that the site is one of the key 13 protection sites of the reserve. Double asterisks indicate the site is new distribution site.

From the counts occurred in 1999, 2000, 2002, 2003 and 2005 (Table 2), the results indicated that the wild population of Chinese Alligator tend to be stable in recent years.

Table 2: Comparison of actual counts of the wild alligators in Anhui in recent years

County/District	Site	Actual counts (individual)				
		1999	2000	2002	2003	2005
Nanling County	Heyi	1	-	0	1	3
	Changle	5	4	3	3	4
	Tianguan	0	0	0	0	1
	Zhalin	3	0	2	1	2
Jingxian County	Shuangken	3	3	2	3	2
	Zhongqiao	1	1	6	2	1
Xuanzhou District	Hongxing	4	0	2	4	9
	Zhuangtou	2	0	3	4	4
	Meicun	-	-	-	-	1
	Limucun	0	-	1	0	0
Langxi County	Zhangcun	1	-	1	0	1
Guangde County	Zhucun	3	0	2	2	4
Total		23	8	22	20	32

Note: Actual counts in 1999, 2000, 2002 and 2003 were sourced from Y. Z. Ding and X. M. Wang 2004.

2.1.2. Breeding status of the wild populations in recent years

To protect and reinforce the wild populations, the ANNRCA started to incubate the eggs of wild alligators in the natural conditions since 2003. In recent years, the nests, eggs and hatchlings of wild alligators apparently increased year by year (Table 3). The alligators in Zhongqiao have successfully bred for a few consecutive years. The alligators released to Hongxing in 2003 started to breed in 2004 and 2005. It is worth to mention that the alligators in Changle successfully bred in recent two years after no breed record for a few years. In addition, we found two nests without eggs in Shuangken during survey period of 2005, which indicated the alligators would breed in the near future. In a word, with the enforcement of the protection and management, the wild population would increase gradually. However, the survival rate of the wild hatchlings is very low. To address this issue, ANNRCA organized a experts workshop to discuss how to improve

Table 3: Breeding status of the wild alligators in recent years

Year	Nest No.	Site	Clutches	Fertilizing rate	Hatchlings	Incubation Rate	Note
2000	1	Zhongqiao	19	100%	17	89.50%	Wild incubation
2002	2	Zhongqiao	18	100%	18	100%	Artificial incubation
		Hongxing	25	100%	20	80.00%	Artificial incubation
2003	2	Zhongqiao	22	100%	18	81.90%	Wild incubation
		Hongxing	28	89.30%	23	92.00%	Wild incubation
2004	3	Hongxing	25	100%	25	100%	Wild incubation
		Hongxing	28	100%	25	89.30%	Wild incubation
		Changle	22	——	9	40.91%	Wild incubation
2005	4	Changle	40	——	39	97.50%	Wild incubation
		Zhongqiao	12	75.00%	8	66.67%	Wild incubation
		Hongxing	29	75.86%	15	51.72%	Wild incubation
		Hongxing	27	66.67%	4	14.81%	Wild incubation
Total	12		295	(91±13.88)%	221	(78.49±25.79)%	

2.2. Progress on the reintroduction programme

2.2.1. A trial release in Gaojingmiao Forest Farm

The Chinese alligator is a good candidate for reintroduction because wild populations are approaching extinction but a large captive population exists. The release of captive-reared crocodilians has been successfully used as a means of restocking or reintroducing wild populations of crocodilians in a number of countries, including India and Venezuela. In these and similar projects, reintroductions were made possible by the existence of protected areas containing suitable habitat.

In 2003, 3 captive-reared alligators were released and monitored using radio telemetry in Hongxing Reservoir. Primary results show the releasing project is success based on the success breeding in 2004 and 2005. Due to the limitation of the existing habitat, reintroduction of Chinese Alligator will be unique approach to re-establish the wild populations. Therefore, the ANNRCA planed to initiate the reintroduction project since 2003. The releasing site is located in Gaojinmiao Forest Farm (E119°12.132’, N31°00.978’) covering about 466 hectares. Due to the state-owned forest farm, conflicts between the alligators and local residents can be controlled to the lowest extent.

To ensure smooth implementation of the reintroduction project, the main activities have been accomplished by the ANNRCA as the followings:
The valleys contain a variety of shallow and deeper water, freshwater habitats mixed with vegetated terrestrial areas for basking and nesting.
The soil type is suitable for burrowing.
Ensuring enough water resources and water capacity for the newly established ponds.
Coordinating with the local communities and stakeholders, and obtaining their supports.
Totally 6 artificial ponds were newly constructed up to now, to ensure natural suitable wetlands habitats can be available. Meanwhile, a number of man-made islands were also built to serve as terrestrial retreats and nesting sites
According to the requirements of the existing wild populations achieved from the former research – Quantitative evaluation of the habitats by the wild Chinese Alligators, the ANNRCA re-established vegetation diversity including submerged, floating and or emergent vegetation and benthos communities providing an adequate prey base for Chinese Alligators.
In late April of 2006, 6 alligators were released and monitored after health examination and pedigree registration.
Details would be presented in the paper to be developed by Prof. Wu Xiaobing from College of Life Sciences (CLS) of Anhui Normal University (ANU), which would be included in the proceedings of 18th CSG working meeting. Any interesting agency or individual like to know the specific progress of reintroduction project, please feel free to contact Prof. Wu (Email: wuxb@mail.ahnu.edu.cn).

2.2.2. A feasibility research on the reintroduction of Chinese Alligator in Zhejiang Province, China
Proposed reintroduction site (N119º38¹-119º39¹, E30º45¹-30º46¹) is adjacent to the existing Changxing Breeding and Research Center for Chinese Alligator (CBRCCA) with a total of 100 hectares, where the local residents have ever caught the wild alligators in 1974. The site comprises of paddy fields, ponds and mudflats. Benthos communities include fishes, shrimps, crabs, shells, and other reptile and amphibian. Changxing County Government promised to provide fund to rent land and political support for introduction of Chinese Alligator in this area. Currently the feasibility research was accomplished by Changxing Institute of Forest Inventory and Planning, with technical support from East Normal University of China, Zhejiang University and the National Wildlife Research and Development Center of SFA. Main contents include:

(1) Conduct analysis of soil type, water quality, vegetation types, nature enemy, potential agriculture development, water supply and distribution, and human disturbance of the proposed reintroduction site in comparison with the former research results of the existing wild populations of Chinese Alligator.
(2) According to the habitat selection requirements of the wild populations, different habitat types including shallow and deep water, vegetated terrestrial areas for basking and nesting, a few internal islands for burrowing were designed.
(3) Re-establish the vegetation diversity including submerged, floating and or emergent vegetation and benthos communities providing an adequate prey base.
(4) Establish 2-3 wild monitoring stations and purchase related equipments and yachts and so on.

(5) Propose the specific process and objectives for the introduction project in middle and long terms.

Details refer to the Feasibility Research Report on Reintroduction of Chinese Alligator in Zhejiang Province (2005).

2.3. Scientific and research being undertaken

2.3.1. Establishing the pedigree of the Chinese Alligators in captivity of ABRCCA

The project was financially supported by the State Forestry Administration of China and Anhui Forestry Department, which is undertaking by the CLS of (ANU) together with the National Wildlife Research and Development Center (NWRDC) of SFA. The project is to establish the pedigree for the most captive population and make markings, which would benefit to select suitable alligators for the releasing project.

2.3.2. Genetic variation and genetic conversation in population of Chinese alligator

The research was completed by the CLS of ANU in the late 2005, which was funded by National Nature Sciences Foundation of China. The study applied the techniques of micro-satellite DNA and MHC polymorphic gene sequence to analyse genetic structure and polymorphism of MHC genes, and to recognize the molecular mechanism in this endangered species. Meanwhile, individual identification method was also built based on the analysis of genetic variation between the wild and captive populations. Finally a reasonable genetic management scheme was developed to maintain the genetic diversity of this species to the largest extent.

2.3.3. A feasibility study of reintroducing Chinese alligator to Yancheng Biosphere Reserve, Jiangsu Province, China

The proposal was developed by Mr. Teng Liwei from School of Life Science of East China Normal University, and approved by the BP conservation programme. Duration of this project is from May of 2006 to April of 2007. The main aim is to provide the scientific basis for reintroducing the Chinese alligator in Yancheng Biosphere Reserve and develop an effective conservation program for this critically endangered species to ensure its long-term survival in the wild. We will evaluate the study area through analyzing the biological requirements (water quality, food resource, soil condition, vegetation) and socio-economic requirements (human interference, pollution, their impacts on agriculture and local human, opinions of local people to the proposed reintroduction project) to reintroduce the Chinese alligator.

2.3.4. Behaviour monitoring of released Chinese Alligators in Anhui, China

The project was funded by the National Geographical Society of USA and undertaken by the CLS of ANU. In addition, NWDRC also provide co-funding to support this monitoring activity. The monitoring was initiated in the late of this April for 6 released alligators in Gaojinmiao Forest Farm and will be finished by the end of 2007, which would provide reasonable suggestions of management and conservation for the released alligators. Meanwhile, the results would benefit to evaluate the success or failure of the releasing project.

2.4. Public education

2.4.1. Pubic education in the ARBCCA

In recent years, Anhui Breeding Center strictly separated the breeding area from the tourism area, which allowed the tourists can only approach the tourism area and avoided the human disturbance for the captive breeding populations. Meanwhile, the center enhanced the capacity building for the public education staff including interpretation and design.

2.4.2. Public education film

A public education film for Children, “Dear Chinese Alligator”, was contracted between Changxing County Government and Haitian Film Co. of Zhejiang Province in June of 2004. The local county government invested about 500 thousand USD to support producing this public education film. The film would help raise the public awareness for protection of Chinese Alligator, and popularize one harmonious spirit between human being and alligators.

2.4.3. Public education in CRBCCA

Construction Project for Chinese Alligator’s Breeding Base at Changxing County of Zhejiang Province was completed and opened to the public in May 1st holidays of 2005. The new center was divided into four areas with a total area of 10 hectares: breeding area, integrated office area, main entrance area and tourism area. Breeding area is composed of 20 breeding ponds with a total area of 2 hectares, where is strictly separated from other three areas and not allowed to the public. Only the tourism area covering 4 hectares is open to the public.

2.5. Others

2.5.1. Master plan of Anhui National Nature Reserve for Chinese Alligator (2006-2015)

In 2005, the ANNRCA authorized the Academy of Forestry Inventory and Planning (AFIP) to develop the master plan for the reserve. In Feb. of 2006, the plan was accepted at the experts workshop hosted by the Anhui Forestry Department. Main contents of the plan include designs for protection and management, public education, scientific research and monitoring, infrastructures and cooperative project, community co-management and ecotourism. The major change is to adjust the function zones and total area of the reserve.

Anhui Provincial Nature Reserve for Chinese Alligator was established in 1982 and was promoted as the national nature reserve in 1986. The reserve is located in the conjunctions of low-hills in South Anhui and plains along the lower reaches of Yangtze River. The coordinates is in the range from E118°30'~119°35' and N30°18'~31°18'. The former reserve covers 88 villages of 52 towns in 5 counties. Currently it just covers 56 villages of 18 towns in 5 counties. The total area is decreased from the original 43300 ha to the current 30824 ha. Number of the protection sites are also reduced from the original 13 sites to the current 10 sites (Table 4).

The principle why we modified the area and function zones of the reserve is to cover all existing habitats with wild alligators and potential habitats as much as possible except some isolated sites with limited suitable habitats, to avoid the habitat fragmentation and isolated to the largest extent, to ensure genetic exchange of the variant colonies and to make the population reinforcement and long-term survival.

Compared the adjusted reserve with the former one, the significance mainly include: (1) benefit to control the destruction to the suitable habitats by human beings, (2) benefit to reinforce the wild population; (3) benefit to conduct protection and management business, (4) benefit to mitigate the conflicts between the communities and nature reserve.

Table 4: Comparison of 10 adjusted protection sites with 13 original protection sites in ANNRCA

County/District	Original No.	Protection site	1990	2006
Guangde County	1	Zhucun	-	+
	2	Jiagu*	-	
Langxi County	3	Huangshugang*	-	
	4	Zhangcun	-	
	5	Wangjiamen*	-	
		Gaojingmiao		++
Xuanzhou District	6	Yanglin	-	+
	7	Hongxing	-	+
		Zhuangtou		++
Jingxian County	8	Shuangkeng	-	+
	9	Yantan*	-	+
	10	Zhongqiao	-	+
Nanling County	11	Zhalin	-	+
	12	Changle	-	+
	13	Xifeng*	-	

Note: The asterisk indicates no alligator was found since 1999 except one alligator was observed in Jiagu protection site in the supplementary survey in August of 2005. The dash indicates the site is one of the 13 original protection sites established in 1990. One plus sign indicates the site is original protection site and double plus signs stand for the new protection site under the adjustment.

3. Problems encountered

3.1. Lack of key technical supports

With regard to the protection of the wild young alligators, it is difficult for us to find a suitable approach to increase their survival rate and avoid preyed by the egrets and other hunters.

Regarding some theoretical issues for the introduction of Chinese Alligator, such as a Minimum Viable Population (MVP) and a minimum suitable habitat area, need to be determined based on the current and next releasing trial.

3.2. Lack of appropriate management protocols for the existing wild populations and their habitats

Even the surveys showed the wild populations of Chinese Alligator maintain stable in recent years, most colonies consist of a few individuals in about 20 separately ponds.

So far, an appropriate management protocols for the existing wild populations and their habitats was not developed yet. It is difficult to ensure the effective management of their habitats and long-term survival of the wild populations.

3.3. Lack of jurisdiction of the land with wild populations and their surroundings

Even the Anhui Provincial Government established the Anhui Provincial Nature Reserve for Chinese Alligator in 1882 and the reserve was promoted as the National Nature Reserve in 1886 by the State Council of China, due to the lands owned and managed by local residents or communities, it is always a impediment for the reserve to coordinate with the local communities concerning the water supply and movement of the alligators.

3.4. Lack of enough suitable wetlands habitat for releasing project

Currently, due to the lack of natural habitat is the greatest impediment to conservation programs, re-establishing wild Chinese alligators would be critical and unique. The ultimate success or failure of efforts to establish wild populations of Chinese alligators will depend on the identification (or restoration) of areas of suitable wetlands habitat, and the development of appropriate management plans. Therefore, trial programs, involving small numbers of animals that are closely monitored, will be important for determining the feasibility of these types of programs.

3.5. Lack of appropriate methodology and equipments

Even the staffs of the ANNRCA have some experiences in the wild population counting, complete skills and methodology of wild population counting and monitoring need to be systematic and standardized through receiving certain training. Otherwise, the data would be controversial. In addition, the field equipments for monitoring and patrolling also need to be increased to ensure theses activities can be conducted regularly.

3.6. Lack of conservation fund

It is a common issue for conservation and management of wildlife in China as well as other countries worldwide.

4. Key actions recommended

4.1. Conducting releasing projects

(1) In Gaojinmiao Forest Farm, we would continue to monitor 6 released alligators in this late April to collect the basic information about the movement range, requirements of different habitats for roosting, basking, burrowing and nesting, and other ecological information. The results would benefit to evaluate the effect of the releasing trial. Also the experiences would be adopted in the conservation and management of the next releasing project.
(2) With regard to the releasing project in Chongming Wetland Park in 2006, which was proposed by the Shanghai Forestry Department and WCS. Currently 12 Chinese Alligators were imported from USA to the CBRCCA in this mid May. A feasibility report will be developed by PhD John Thorbjarnarson in cooperation with Shanghai Forestry Bureau and sent for approval of the SFA of China.

(3) Regarding the reintroduction project of Chinese Alligator in Zhejiang Province, the feasibility report was developed and sent for approval of SFA of China in November of 2005. Currently it is still in the process of review and approval. If approved in 2006, first step would restore the wetlands habitats according to the requirements of wild Chinese Alligators.

4.2. Staff training

As mentioned in the 16th CSG meeting, the SFA of China likes to dispatch the domestic technical and management staff to receive some technical training tour overseas. In this regard, we would keep in close touch with the CSG members to make this happen.

4.3. Developing the management plan for the ANNRCA

Since the establishment of the nature reserve for conservation of Chinese Alligator in Anhui, no management plans have been prepared. In order to effectively guide various management work of the reserve and promote reinforcement of the wild population, development of management plan for the ANNRCA is unique and critical to the long-term survival of Chinese Alligator. The management plan will focus on the process of integrated wetland management planning and the whole process of stakeholders and local community participation.

4.4. Conducting public education activities

The public education plans for ANNRCA and CNNRCA will be developed separately in the next few years to guide the reserve to conduct variant forms of public education activities. First step would collect and analysis the current and historical public education activities occurred in these reserves, then conduct questionnaire survey to identify different targeted groups, lastly would develop the public education plan according to the needs of different targeted groups. The main objectives would increase the public awareness of conservation of Chinese Alligator and their habitats.

4.5. Try to get more technical inputs from domestic and international colleagues

During the implementation of the China action plan for conservation and reintroduction of Chinese Alligator, we are still lacking of some key technical supports to promote the action plan to be implemented smoothly. In the future, we will keep in close touch with related domestic and international colleagues to get more technical inputs, especially from the members of CSG. Meanwhile, we appreciate any interesting agency or individual to do research of Chinese Alligator in China.

4.6. Expand the channels of fund-raising

Species conservation needs concerns and supports from the whole society. In the future, we will distribute our achievements and progress timely to raise more attention and supports from any potential agency or individuals.

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News In Research On Crocodilian (Biology, Taxonomy, Anatomy, Physiology, Behaviour Etc…)

Ecology Of Reproduction Of The American Crocodile In Cuba

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Abstract: In the Monte Cabaniguan Wildlife Refuge there is a high annual mortality rate in American crocodile eggs resulting from four major factors: 1) subterranean flooding of nests, 2) the excavation of prior nests by ovipositing females, 3) dropping eggs on the surface of the nesting beach instead of in excavated nests, and 4) female crocodiles not returning to the nesting beaches to assist hatchlings in escaping from the nests.

We believe that factors 2 and 3 are the result of high density nesting conditions that result from a large population having to nest on a limited area of suitable beaches. Between 1993 and 2001 an annual average of 31.1 % of the nests and 26.1% of the total egg production were lost as a result of these factors. In some years the losses exceeded 50%. The significant loss of eggs that results from high density nesting can provide a biological basis for the commercial management of this population based on ranching.

American Crocodile (*Crocodylus acutus*) Egg Losses Related To Nesting Females Behaviour, At The Delta Del Cauto Wildlife Refuge, Cuba

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Abstract: In the Monte Cabaniguan Wildlife Refuge there is a high annual mortality rate in American crocodile eggs resulting from four major factors: 1) subterranean flooding of nests, 2) excavation of prior nests by females, while laying, or while assisting hatchlings, 3) laying on the surface of the nesting beach instead of in excavated nests, and 4) females non returning to the nesting beaches to assist hatchlings going out from the nests. We think that factors 2 and 3 are the consequence result of high density nesting conditions that result from a large population having to nest on a limited area of suitable beaches. Between 1993 and 2001 an annual average of 31.1 % of the nests and 26.1% of the total egg production were lost as a result of these factors. In some years the losses exceeded 50%. The significant loss of eggs that results from high density nesting can provide a biological basis for the commercial management of this population based on ranching.

Resumen: En el Refugio de Fauna Delta del Cauto se produce anualmente una alta mortalidad de huevos de Cocodrilo americano, como resultado de cuatro factores principales: 1) inundación subterránea de los nidos, 2) excavación, en el momento de ovipositar o al asistir a la eclosión, de nidos previamente puestos por otras hembras, 3) abandono de nidadas sobre la superficie del suelo, o en el agua, en lugar de realizar la puesta en nidos excavados y 4) falta de asistencia materna en el momento de la eclosión. Consideramos que los factores 2 y 3 están asociados a densidades de nidos que son el resultado de una abundante población teniendo que nidificar en un área limitada de playas apropiadas. Entre 1993 y 2002 un promedio del 31.3% de los nidos y el 26.1% del total de huevos se perdió como resultado de esos factores. En algunos años las pérdidas excedieron el 50% de los huevos. Las pérdidas significativas de huevos que resultan de las altas densidades de nidos en las áreas de anidamiento, pueden proveer de una base biológica para el manejo de esta población, basado en el rancheo.

1. Introduction

The American crocodile (*Crocodylus acutus*) is widely distributed along the coastal swamps, estuarine rivers, lakes and reservoirs of the Northern half of the Neotropical Region, where it plays an important ecologic role as top predator and "landscape engineer" of those wetland ecosystems. The species is categorized as "vulnerable" (IUCN), and listed in CITES Appendix I (Thorbjarnarson 1991). In the Cuban Archipelago, the American crocodile is also well distributed on the main island of Cuba, the Isle of Youth and many offshore keys. The largest local population of this species on its entire range is located along the coast of the Gulf of Guacanayabo, in the Wildlife Refuge Delta del Cauto, on the provinces of Las Tunas and Granma, Southeast Cuba (Rodriguez 2000, Varona 1986).

The American crocodile is mainly a hole nester, but depending on factors supposedly related to nest site conditions, it might also make mound nests (Campbell 1972; Ogden 1978; Mazzotti 1983). In locations where suitable nesting habitat is scarce, seasonal migration of the gravid females to the nesting areas and gregarious nesting in high densities has historically been reported, as for Lake Enriquillo, in the Dominican Republic (Thorbjarnarson 1989). This phenomenon has been rarely reported during the last decades, but must studies have been conducted in areas where the crocodile populations have been severely depleted through commercial over-exploitation. Nevertheless, many local populations of the American crocodile are experiencing a process of recovery, and gregarious nesting might become not so rare in the future.

2. Study area

Delta del Cauto is a wildlife refuge located South of the Las Tunas and Granma provinces (Jobabo, Cauto River, Yara and Manzanillo municipalities), along the shore of the Gulf of Guacanayabo, with a surface of 626 km2 (approximate geographic position: 20^{o} latitude N; 77^{o} longitude W). This Wildlife refuge constitutes the most important coastal wetland ecosystem of the eastern portion of Cuba (Jobabo and Virama swamps). In 2002 it was declared as Ramsar site.

The local population of *C. acutus* was studied during the decade of the 70´s of the past century by Ramos (1979) and systematically since 1987, population and reproduction biology studies have been performed by the authors. The abundance, structure and population dynamics, the nesting ecology and its productivity in relation with edaphic, geomorphologic, climatic and behavioral variables have been described in detail (Alonso and Rodriguez 1998, Alonso et al. 2000. Rodriguez et al. 2002). The general results show the presence of an abundant, healthy population with a tendency to growth that has been qualified as "the best conserved local population of the species in all its geographical distribution area" (Ross pers.com).

C. acutus nesting in this wetland is concentrated in a few beaches scattered along the gulf shoreline, and in a two hectares patch of raised land within the mangrove swamp, situated 2 km inland. Five of these nesting areas have remained active during the study period, and other five have been active part of the time. Both permanent and temporary nesting areas cover a surface of 9.8 hectares, altogether (Table 1; Figure 1). As a consequence, crocodile nesting will be performed in a gregarious manner and in high density.

3. Methods

Crocodile nesting activity was recorded during regular daily or weekly visits along the annual reproductive period (February to July) from 1993 to 2002. A total of 2025 nests of *C. acutus* were analyzed on 5 permanent and 5 temporary nesting beaches. Nest fate and causes of nest and egg loss in particular, were recorded after analyzing nest content or remains during hatching-season visits (mid May – early July). Recent nests were located and marked with individually numbered wooden stakes. A sample of nests was excavated to record the depth of the nest chamber, clutch size, egg viability rates (percent of banded eggs in nests > 24 hr old), and egg dimensions and mass (N = 5).

When females dropped their eggs on the surface of the soil without burying them we classified these as discarded clutches. Discarded eggs were collected to calculate total number, and measured.

From mid-May to early July the number of nests that had hatched since the previous visit was noted based on evidence of nest excavations and eggshell remains. At each nest we counted remains of eggs that had hatched, and recorded the number of eggs that had died during incubation. When eggs were found to have no indication of embryonic development they were considered to be unviable. If full-term embryos were found in the opened nest these were marked and released with nearby groups of hatchlings.Nests were considered to be successful if at least one hatchling emerged successfully. During this period nests ready to hatch could be located by the vocalizations of the full-term embryos. When vocalizations in these nests had stopped for a period of more than 2 days, nests were considered to have been abandoned by the female. In some cases we were able to locate abandoned nests by exit holes left by hatchlings that were able to dig themselves out. These nests were excavated and if it was found that at least one hatchling had emerged from the nest (= 1 empty eggshell within the still buried nest and a small exit hole to the soil surface), it was considered a successful nest.

Four camera traps were situated and activated during the nights in the nesting area of Jobabito, in order to document females' behaviour during the nesting events.

4. Results and discussion

A significant fraction of the eggs produced annually by adult females are lost through one or the other of three forms of female behavior: a) Discarded nests (when females layed their eggs on the surface of the soil without burying them); b) Excavation of prior nests, and c) Nest desertion. Over the 10-year period of this study, an average of 31.1 % of all nests and a 26.1% of the estimated egg production was lost due to the combination of these factors. In some years this value was above 50%.

Discarded eggs (103 clutches) represented a 5.1 % of total clutches. Discarded clutch size was significantly smaller than normal nest clutch size ($t = -16.51$; $p < 0.0001$; n discarded eggs = 103, n normal nests = 369). Mass of discarded eggs was also significantly smaller than egg mass in normal nests ($t = -17.85$; $p < 0.0001$; n discarded eggs = 497, n normal nests = 370; Figure 2). Regression analysis of discarded clutches with nest density was significant ($p = 0.016$; Figure 3).

These results suggest that discarded clutches are left by smaller, younger females (new recruits in many cases), which lay smaller eggs and less numerous clutches than the bigger and older ones, and that might be unable to locate suitable nesting sites, or that have lost agonistic interactions with larger females on nesting beaches, under conditions of high nesting densities. This interpretation is supported by clear evidence of aggressiveness between females obtained with the aid of automatic cameras (Figure 6), and by the *in situ* analysis and interpretation of foot prints and tracks associated to these events.

Excavation of prior nests happens when a female extracts another's female clutch from the ground, when opening her own nest in order to lay her clutch, or during the hatch, when digging in the ground in order to assist her offspring to get out of the nest. The affected clutch can be totally destroyed (all eggs are exposed, eventually smashed, and killed) or partially destroyed (when some eggs remain viable in the ground, and eventually hatch). Partially destroyed nests averaged 9.1 % of the total number of nests. If totally destroyed nests had been left in the ground, they would have represented the 10.4 % of the total number of nests, with annual values ranging from 1.6 % to 21.8 % (Figure 4). Regression analysis of both totally and partially destroyed nests with nest density were significant ($p < 0.05$ in both cases, Figure 5).

When females do not return to open their nests, the young remain trapped inside the egg cavity and only a small fraction escape by digging their way to the surface. A total of 200 nests (11.6 % of all nests analyzed) were deserted during the period of study. Of a sample of 148 deserted nests examined, 122 hatchlings were determined to have escaped, representing 5.3% of the total number of eggs in these nests.

We didn't find a close relationship between the incidence of deserted nests and nest density.

Nest or clutch losses attributable to these three female behavior-related causes represented the 61.9 % of total losses; the remaining 38.1 % are nest losses associated to climate events such as nest flooding and nest washout, after heavy rainfalls, or due to wave and tide action in exposed seafront beaches. Nest site conditions such as altitude, soil composition and exposition to wave and tide action modulate the effect of climate events on nest survival (Rodriguez et al. 2002). These site conditions and nesting densities were found to behave as interacting factors; E.g.: beaches with better nesting conditions show higher nesting densities than sub-optimal sites, while high nest densities on optimal sites would force sub-dominant females (e.g.: through agonistic encounters) to utilize sub-optimal nest sites, with a consequent foster of embryonic mortality. Also female behavior, and climate related factors are likely to interact, as in the case of nest desertion, which has ever increased after flooding events or severe drought during the incubation time, throughout the period of study.

Sustainable utilization through ranching is especially suitable to such areas as DCWR, where large quantities of eggs and hatchlings are lost during the incubation process, as effect of natural factors. An average of 2000 eggs could be recovered every year by collecting them at an early stage of incubation in sub-optimal nest sites and beaches with high nesting densities.

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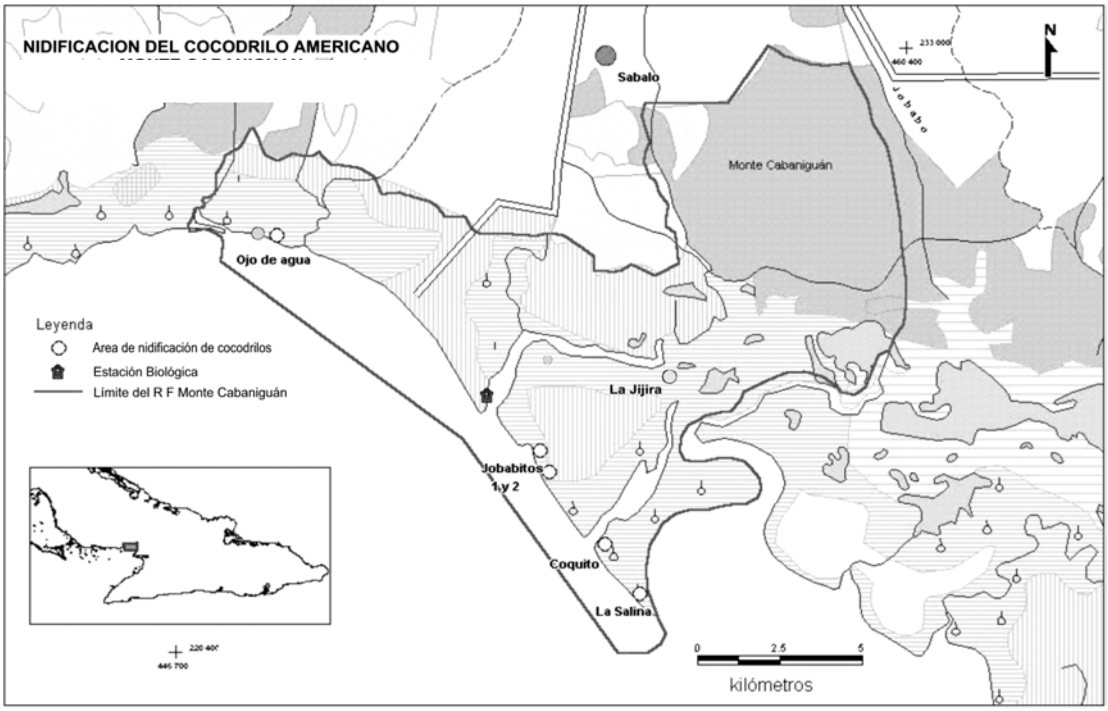
6. Tables & figures

Table 1. *C. acutus* gregarious nesting areas in the Delta del Cauto Wildlife refuge (Rodriguez, Alonso and Berovides 2002).

Area Name	**Surface (hectares)**	**Maximum nest number and density (nests/hectares)**	**Year of maximum nests**
Soloburen*	2.7	17-6.29	1997
Ojo de Agua*	1.9	21-11.05	1997
Boca de Jobabo	0.2	4-20.0	1995
Alto de la Jijira*	2.0	28-14.0	2001
Jobabito*	0.8	101-126.3	1998
JobabitoII	0.4	5-12.5	1995
Jobabito III	0.2	8-40.0	1995
Jobabito IV	0.2	3-15.0	1995
Boca de Patabanes	0.2	15-75.0	1996
La Salina*	1.2	94-78.3	2001
TOTAL	9.8		

* Permanent nesting areas

Figure 1. *C acutus* permanent and temporary nesting areas in the western sector of the Delta del Cauto Wildlife Refuge.



AMERICAN CROCODILE NESTING SITES

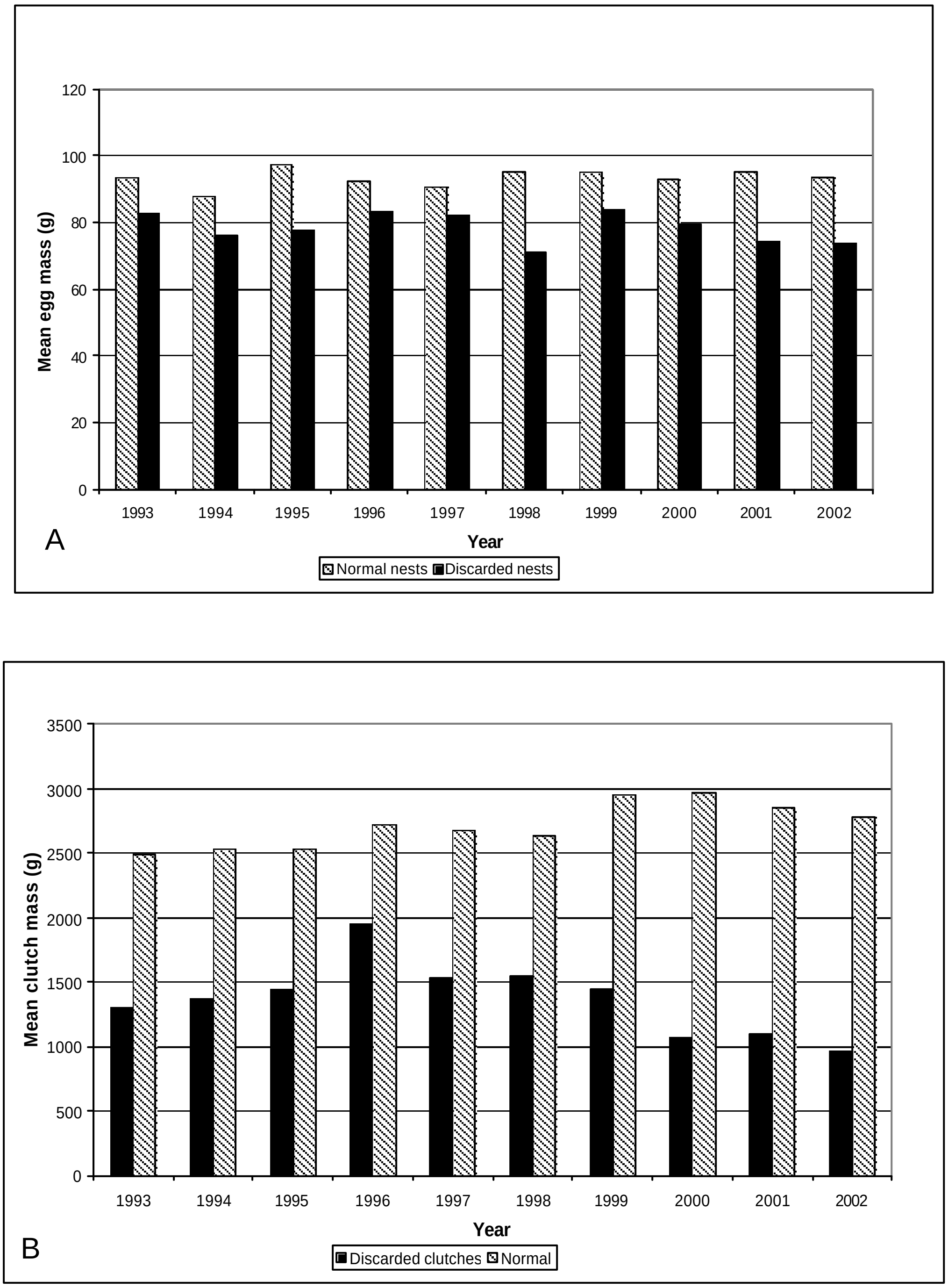


Figure 2. Relation between egg mass (A) and clutch mass (B) of normal nests vs. discarded clutches.

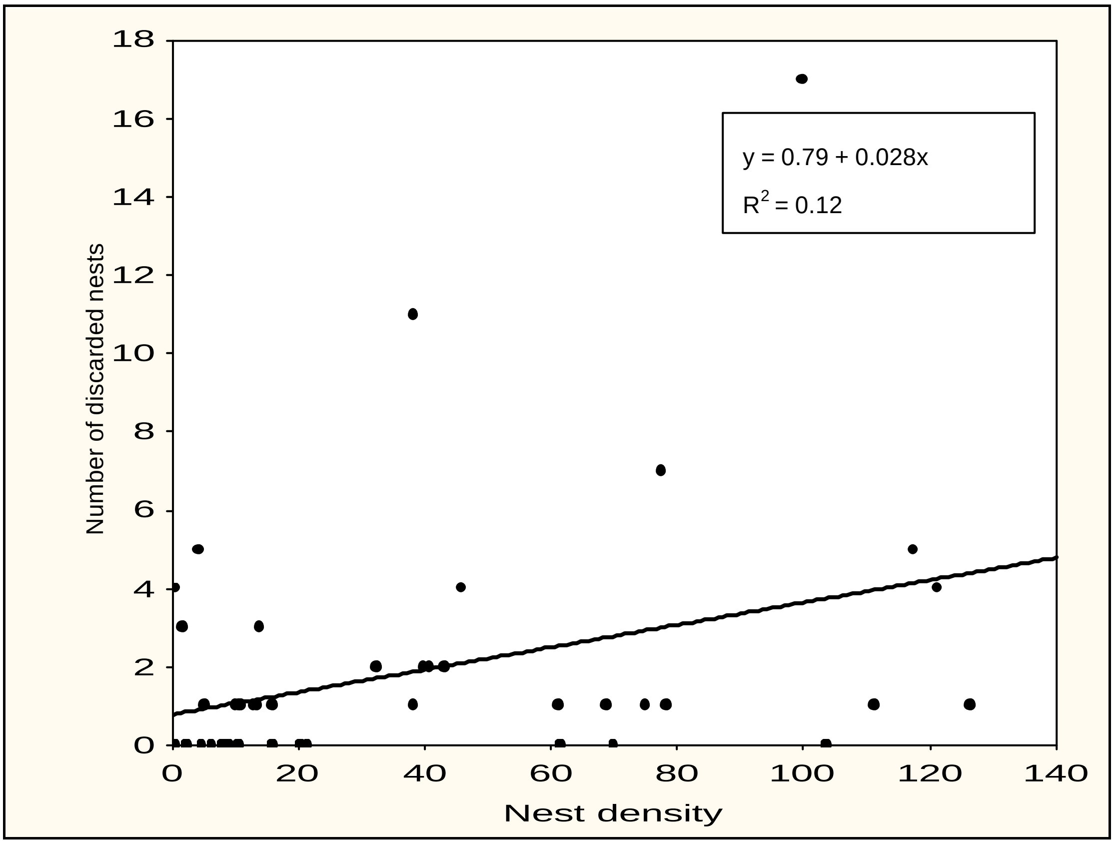


Figure 3. Regression line between discarded nests and nest density

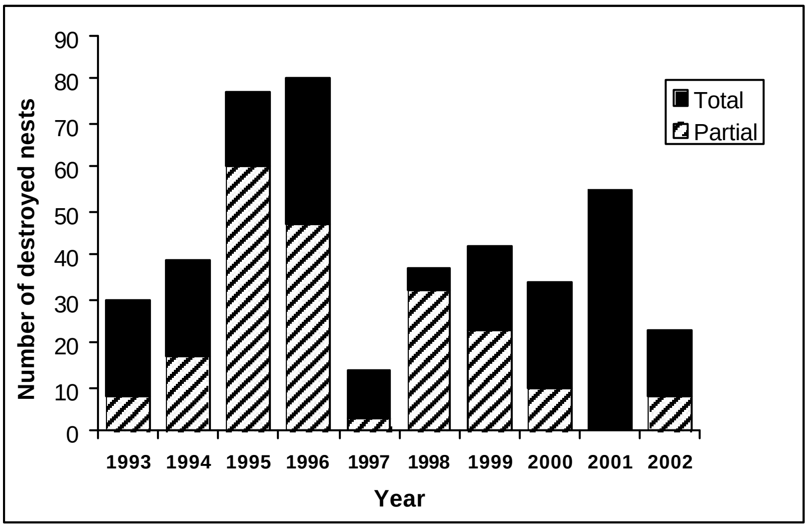


Figure 4. Number of totally and partially destroyed nests between 1993 and 2002.

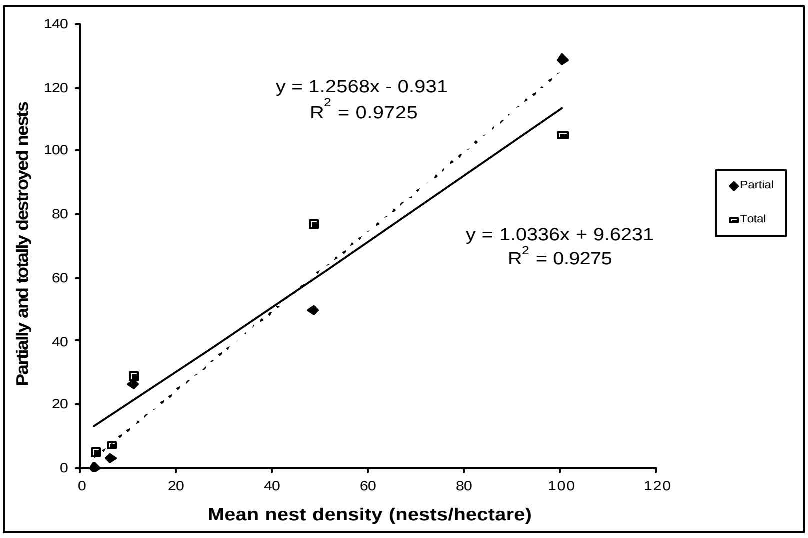


Figure 5. Relation between totally and partially destroyed prior nests and mean nest density along the study period.

Figure 6. Camera trap photographs showing agonistic relationship between ovipositing females, at the Jobabito nesting area.

Body Temperature As Indicator Of Mating In *Crocodylus acutus*: Breeding Behavior Compromises Thermoregulatory Behavior

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Abstract: There is little information on thermoregulation of large crocodiles during breeding activities, specifically in the wild. We provided important data on thermal relations on large American crocodiles during the breeding cycle.
Two populations of *Crocodylus acutus*, (wild n = 63; captive n = 61) were studied during six months when mating, copulation and nesting occur. Cloacal temperatures were taken on a monthly basis on animals ranging in size from 1.8 m to 4.5 m. A new finding shows that body temperature has a significant relation with breeding cycle during the peak of reproductive displays in wild males and females (stress and reproductive hormones of females peak on March). Body temperature decreases during mating peak of the species in our area ($P < 0.05$). Captive population did not present any relation because of high temperature in the ponds. In all Crocodilian species, mating and reproductive displays occurs in water. That effect produce a significantly decrease in body temperature in wild American crocodiles. For that reason mating behavior compromises thermoregulatory behavior during mating season, resulting in a decrease in body temperature until it reaches the same temperature as the water.
Thermoregulatory and reproductive behaviors and optimum body temperature during breeding cycle are discussed.

Key words: *Crocodylus acutus*, México, body temperature; reproductive peak, copulation, wild.

Effect Of Climate On Sex Ratio In Caiman

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Abstract: Evidences of climate effect on ecosystems and species have been increasing in last years. However, the potential effects of climate variability on crocodilians sex ratio have not been evaluated in natural conditions.
This study's objective was to determine the effect of climate variability on sex ratio in natural population of caiman, *Caiman crocodilus*, in Caño Negro National Wildlife Refuge located in the Northern region of Costa Rica. We measured temperature in caiman nest to evaluate if there is a relationship between incubation temperature and weather variables. We observed a relationship of nest temperature with minimun temperature and precipitation. Furthermore, we captured 103 caimans to evaluate sex ratio and to predict caiman's age using Von Bertalanffy model, this model can predict the approximate borned age of each caiman. We analyzed the relationship between precipitation pattern and sex ratio using the oldest caiman age. We observed a negative correlation between number of borned males by year and precipitation during 90´s decade. Viability of caiman population can be affected in the future if this situation continues.

Comparisons Of Innate Immune Activity Of All Known Living Crocodilian Species

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Abstract: Serum samples from all twenty-three known living members of the Crocodylia were tested for antibacterial activity against eight bacterial species. These data were used to generate an immune profile for each crocodilian species. Statistical analyses revealed that the three different family lineages of crocodilians, Alligatoridae, Crocodylidae, and Gavialidae, were distinguishable by their immunological activities. For instance, species within the Alligatoridae and Crocodylidae exhibited remarkable immune activity similarities to others in their own families. Comparisons of the members of the different families, however, revealed substantial differences in immune profiles. Furthermore, species that are in the same genus were shown to exhibit more immune similarities to each other than to members of other genera within the same family. Finally, our immunological analyses reveal that *Tomistoma schlegelii* aligns more closely with the Gavilidae than the Crocodylidae.

Habitat Use And Movement Of Wild Siamese Crocodiles In Cambodia

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Abstract: The ecology and wild habits of the critically endangered Siamese crocodile (*Crocodylus siamensis*) are poorly understood, despite being discovered more than 200 years ago. Recent studies in Cambodia have shown that Siamese crocodiles can be found in slower moving rivers, lakes and marshes to an altitude of 600m, and even smaller oxbow lakes of less than 1m deep can provide suitable habitat during the dry season. Radio-tracking and observational studies show that burrows play an important role during the dry season, providing a refuge for numerous crocodiles of different sizes at the same time. Adult crocodiles can move overland between oxbow lakes and the river during the dry season, while juvenile individuals tend to remain in the lakes. During the wet season when rivers overflow their banks, crocodiles can move between adjacent riverside lakes via the flooded forest, or to areas otherwise unsuitable due to their shallow nature. Radio-tracking of an adult male has shown that his movement (so far during the dry season) has been restricted to an 11km section of river, with travel up to 4.5km per night. Further work will continue to elucidate movement patterns and habitat use of the Siamese crocodile in Cambodia.

Husbandry Techniques And Crocodilian Health Issues Applied To Conservation And Commercial Husbandry

Nile Crocodile (*Crocodylus niloticus*) Urine: Collection Technique, Chemical Parameters And Diagnostic Value

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Abstract: With crocodile farming in South Africa growing - more veterinarians should become involved with crocodile diagnostics. Wild crocodiles are also considered to be valuable bioindicators of aquatic ecosystem pollution. As such clinical pathology for this species is becoming more important. Collection of diagnostic samples from life crocodiles (farmed and wild) is mostly limited to blood sampling. The possibility of collecting clean urine from the Nile crocodile was investigated.

Urine samples were collected from farmed crocodiles just before slaughter. The technique of urine collection, using an ordinary dog catheter, will be discussed. Sketches and pictures will be used to illustrate the anatomy of the cloaca and the use of the catheter to collect urine.

Forty urine samples were evaluated for standard chemical parameters used in human and veterinary diagnostics. Serum samples from the forty crocs were also analysed for standard blood parameters. The urine and serum results will be discussed with special reference to the diagnostic value of crocodile urine.

1. Introduction

Environmental pollution is a problem all over the world[13]. Used chemicals and/or their products eventually become environmental pollutants by ending up in our rivers or dams as a result of: run-off from crops, soil and plants; being pumped via sewage into rivers; direct spraying of surface water to control pests; or after industrial accidents[1, 2].

A hypothesis was proposed that certain chemical pollutants might be able to disrupt the normal function of the body's endocrine system[1]. Today, these chemical pollutants are known as endocrine disruptors or endocrine disrupting compounds (EDCs), because they are thought to mimic natural hormones, inhibit the action of hormones, or alter the normal regulatory function of the immune, nervous and endocrine systems[1]. Many of these EDCs exhibit estrogenic activity, but some individual chemicals may also cause harm through anti-estrogenic, anti-androgenic and androgenic effects[13].

Aquatic species are directly affected by aquatic pollutants and considered to be ideal indicators of the chemical pollution situation in this ecosystem[2, 4, 5, 12]. These pollutants influence the normal physiological function of the endocrine organs[1, 3, 4, 5].

It is getting more difficult in South Africa and most probably also in the rest of the world to get permission to kill crocodiles or alligators from wild populations for research purposes. Permission is usually only granted for capture and immediate release of these animals, and most often only blood samples are collected. Aquatic toxicologists and endocrinologists, all over the world, are thinking of additional samples (e.g. skin biopsies, urine, etc) that could be collected from individual bioindicator animals that are caught for research purposes[7, 9, 10, 11] (L J Guillette, personal communication, 2005).

We investigated the idea of routine urine collection from crocodiles, so that it could be used as an additional sample for investigating aquatic ecosystem pollution in southern Africa. Urine samples from healthy pre-slaughter crocodiles were analyzed for standard urine parameters used in human and animal health examinations. Urine samples were also screened for steroids (see: Urinary steroid analysis in the Nile crocodile (Crocodylus niloticus) by Bekker L, Myburgh J, Spies J, Botha C, Swan G).

2. Materials and methods

Urine and blood samples were collected from healthy crocodiles just before slaughter from a crocodile farm ear the Veterinary Faculty, Onderstepoort.

2.1. Cloaca anatomy

Several Nile crocodiles, with an approximate length of 70-90cm, that were routinely submitted for diagnostic post mortem purposes were used for the anatomical study. The colon and cloaca of one specimen was dissected out and preserved in 10% formalin and the pelvic region including the cranial part of the tail to caudally of the vent of three further specimens were preserved *in toto* in formalin allowing colon and cloaca to fix *in situ.*

The loose specimen was opened longitudinally along the ventral midline and the specimens fixed *in situ* were split longitudinally from the ventral midline right through the spinal column.

2.2. Urine samples

Urine was collected with an ordinary dog urine catheter. The urine samples were collected in sterile laboratory containers. All the samples were kept on ice and centrifuged in the laboratory (after 60 minutes). The clean urine was transferred to sterile tubes and frozen until tested.

The following parameters were evaluated: Na, Cl, K, Ca, $P0_4$, Mg, creatinine, uric acid, NH_4, total protein and osmolality.

Plasma samples

Blood was collected with 22G 1.5” needle and 5ml syringe from the occipital vein. The blood sample was transferred immediately to heparin blood tubes. All the blood samples were centrifuged in the laboratory and the plasma samples frozen until tested.

The following parameters were evaluated: Na, Cl, K, Ca (total), Ca^{2+}, $P0_4$, Mg, urea, creatinine, uric acid, total protein, osmolality and glucose. For the Na, Cl, K and Ca^{2+} a Rapidlap 865 (Bayer) was used. Calcium (total), $P0_4$, Mg, urea, creatinine, uric acid, total protein and glucose concentrations were determined with a Nexct analyzer from Bayer. Osmolality was measured with an Osmomat analyzer.

3. Results

3.1. Cloaca anatomy

Our investigation revealed that the anatomy of the cloaca of the Nile crocodile closely resembles that of the Estuarine crocodile (*Crocodylus porosus*) from Australia[10].

There is a prominent muscular sphincter separating the coprodeum from the short colon. When filled with urine the urodeum widens and sags ventrally, giving the cloaca a conformation that is similar to that described for the ostrich[16]. There is muscular sphincter separating the proctodeum from the urodeum. Two papillae are visible in the dorsal aspect of the urodeum where the ureters enter the urodeum. Penis and clitoris lie ventrally in the proctodeum. The anatomy of the cloaca of the Nile crocodile is illustrated in Fig 1.

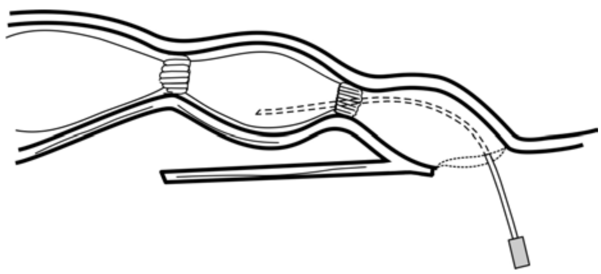

Fig. 1 Schematic illustration of the anatomy of the cloaca of the Nile crocodile and route of catheter is indicated

3.2. Urine and plasma results

A summary of the urine and plasma results is given in Tables 1 and 2, respectively.

Table 1 Summary of results: urine samples (n = 44 samples)

Parameter	**Mean**	**Median**	**SD**
Na (mmol/l)	5.53	2.80	7.42
Cl (mmol/l)	17.59	17.60	6.72
K (mmol/l)	28.02	23.05	14.94
Ca (mmol/l)	0.54	0.49	0.38
$P0_4$ (mmol/l)	11.99	8.75	11.45
Mg (mmol/l)	0.27	0.17	0.41
Creatinine (? mol/l)	109.50	55.00	211.48
Uric acid (mmol/l)	0.47	0.25	0.77
NH_4 (mg/l)	4 296.59	3 600.00	3 814.00
Total protein (mg/l)	152.09	46.00	301.45
Osmol (mosmol/kg)	225.14	231.00	33.54

Table 2 Summary of results: plasma samples (n = 44 samples)

Parameter	**Mean**	**Median**	**SD**
Na (mmol/l)	133.75	133.90	9.00
Cl (mmol/l)	110.23	111.00	11.01
K (mmol/l)	4.21	3.99	0.71
Ca (total) (mmol/l)	2.66	2.67	0.22
Ca^{2+} (mmol/l)	1.31	1.31	0.06
$P0_4$ (mmol/l)	1.56	1.49	0.44
Mg (mmol/l)	1.34	1.34	0.29
Urea (mmol/l)	0.35	0.20	0.24
Creatinine (? mol/l)	27.84	28.00	6.26
Uric acid (mmol/l)	0.30	0.22	0.22
Total protein (g/l)	63.13	63.13	9.95
Osmol (mosmol/kg)	297.57	296.00	21.83
Glucose (mmol/l)	6.43	6.40	1.24

4. Discussion

The use of urine samples as a routine diagnostic sample in crocodiles is possible (Fig. 1) - it is not difficult to collect the urine (easier than blood collection).

More research should be focused on the diagnostic value of crocodile urine, before it could be used routinely to evaluate the health status of individual animals, as is done in other farm animals[7]. Tables 1 and 2 could serve as baseline data for the Nile crocodile at this stage. To be investigated further.

The excretion of nitrogen via the urine in the Nile crocodile should also be investigated in depth[6, 8, 14, 15]. Herbert (1981) reported that alligators fed ad lib 5 days a week excreted the same amount of uric acid/day, but much more ammonia/day, than those fed a single meal after a long fast[6]. The value of this parameter to evaluate the feeding of wild crocodiles should be investigated further.

Steroids in crocodile urine are being investigated as part of a PhD study. The diagnostic value of steroid concentrations in crocodile urine, for the investigation of aquatic pollution, should become clearer after the completion of this investigation (Bekker L, Myburgh J, Spies J, Botha C, Swan G. Urinary steroid analysis in the Nile crocodile (*Crocodylus niloticus*)).

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Urinary Steroid Analysis In The Nile Crocodile (*Crocodylus niloticus*)

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Abstract: Excretion of steroid metabolites has been well studied in humans. However, nothing has been done in the Nile crocodile.

Juvenile crocodiles, two year old, were used. Urine was collected by using a urine catheter. Several samples were pooled together when individual samples showed low sensitivity.

Gas chromatography mass spectrometry was employed after solid phase extraction of steroids from urine collections, an overnight enzymatic hydrolysis, and derivatization of dried samples. Separation was achieved with split injection onto a capillary GC column, using electron impact ionization at 70 eV.

The total ion chromatogram in figure 1 obtained >30 peaks of which no mass spectra were identical.

Additional analytical methods to be employed in elucidation of the steroid structures include negative ion chemical ionization GC-MS and LC/MS/MS.

1. Introduction

Excretion of steroid metabolites has been well studied in humans[1 2 3 4 5 6]. However, nothing has been done in the Nile crocodile[7].

2. Materials and methods

Juvenile crocodiles, two year old, were used. Urine was collected by using a urine catheter. Several samples were pooled together when individual samples showed low sensitivity.

Gas chromatography mass spectrometry (GC/MS) was employed after selective extraction of steroids from urine collections in a five-step sample preparation. The urine samples were centrifuged at 3000rpm for 6 minutes. For each urine sample, one Varian Bond Elut C_{18} (octadecyl) solid phase extraction (SPE) cartridge was prepared on a vacuum extraction chamber as follows: the cartridges were primed with 10ml methanol, after which 10ml de-ionized water was aspirated. A volume of the centrifuged sample was measured out. 200µl of a C_{23} (IS) solution (200µg/ml) was added. The sample was loaded onto a designated cartridge, which was then washed with 10ml de-ionized water. The conjugated steroids were eluted into tubes with 4ml methanol. The eluates were dried under nitrogen gas, keeping the tubes in a heating block at 37°C.

Hydrolysis: to each dried eluate, methanol (100?l) was added. The solution was vortexed, and 5 ml of a sodium acetate/acetic acid buffer (0.2 M, pH 4.6) was added. This was followed by the addition of 200?l glusulase, and the mixture was vortexed. The tubes were stoppered and enzymatic hydrolysis was allowed to take place overnight at 50?C.

SPE (second extraction): the hydrolyzed mixtures were centrifuged for six minutes at 3000rpm. One aminopropyl (NH_2) SPE cartridge was prepared for each sample as follows: one gram sodium sulphate (Na_2SO_4) was placed into each cartridge on top of the aminopropyl layer. An adapter was connected to each NH_2 cartridge. The previously used C_{18} cartridges were primed as for the first extraction with 10ml methanol and washed with 10ml de-ionized water. The supernatants of the hydrolyzed mixtures were aspirated through the C_{18} cartridges, which were then washed with 10 ml de-ionized water. The C_{18} cartridges were connected on top of pre-prepared NH_2 cartridges and again connected onto the vacuum extraction chamber. The free steroids were eluted with 6ml ethyl acetate, into final tubes containing a second internal standard, cholesteryl n-butyrate (50µg) and C_{23} (20?g). The latter was added as an aid in monitoring column deterioration. The eluates were dried under nitrogen gas and derivatized.

Derivatization: a) Methoxylation - 100µl of a 10% *O*-methoxylhydroxylamin hydrochloride solution in pyridine was added to the dried residue. The mixture was incubated at 60ºC for 15 minutes. Silylation followed without removal of excess methoxyamine hydrochloride. B) Silylation - following methoxylation, 100µl N-Trimethylsilylimidasole (TMSI) was added to the incubation mixture. Additional incubation was allowed at 100ºC for two hours. The sample was allowed to cool down before opening the tube and transference to a vial. The vial could be stored at -20°C until GC-analysis was performed. Following storage, the mixture should be allowed to reach room temperature before injection.

Separation and detection: a HP 6890 gas chromatograph was used for gas chromatographic/mass spectrometric (GC/MS) analyses, utilizing a HP 5973 mass selective detector (Agilent technologies, Palo Alto, CA, USA). The system was facilitated with split/splitless injection systems. Data collection and integration was achieved with HP Chem. Station software.

Chromatographic conditions: helium (5,5 N) was employed as carrier gas, with a flow rate of 1.2 milliliter per minute. The ion source of the mass spectrometer was set to an electron voltage of 70eV. The split method of injection with a split ratio of 30:1 was performed in the chromatographic separations. 1µl sample was injected by auto injector onto GC/MS. The carrier gas (helium UHP) was employed in the splitter-system. The inlet temperature was set at 250°C. To determine the split ratio, the measured purge flow was divided by the carrier gas flow rate. The temperature program was as follows: initial isotherm 215°C for 3 minutes; program rate: 1.6°C per minute up to 226°C, second isotherm at 226°C for 3 minutes, second program rate: temperature ramped at 1.6 °C per minute up to 300°C, final isotherm of 5 minutes.

3. Results

The total ion chromatogram in Fig.1 obtained >30 peaks of which no mass spectra were identical.

Four of the EI (electron impact) m/z (mass:charge) spectra obtained from the peaks on the total ion chromatogram showed similarities to endogenous human steroids (androsterone/etiocholanolone, pregnanediol, pregnanetriol and 16a-OH-DHEA). The other (>30) spectra are still unidentified.

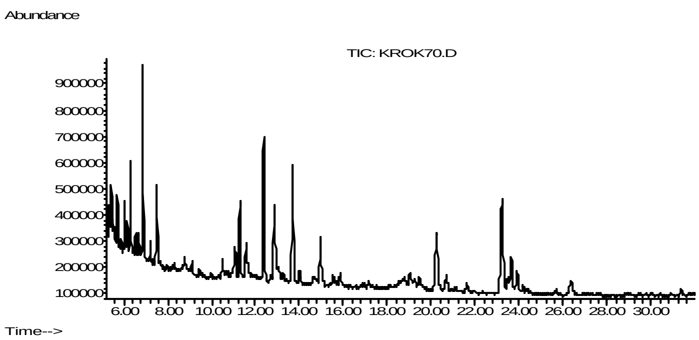

Fig. 1 Total Ion Chromatogram of a pooled urine sample of the Nile crocodile after selective extraction and derivatization.

4. Discussion

The sample collection technique is relatively simple and a-traumatic. Although all the samples were collected for healthy farm crocodiles, in future urine of crocodiles from polluted areas will be investigated. This will aid in the investigation to evaluate the significance of urine as an indicator of endocrine disruption.

Steroid profiling in humans can be indicative of numerous endocrine dysfunctions, including reproductive and thyroid disorders, enzyme deficiencies/excesses, hypo- and hypercortisism (including tumours of the adrenal), starvation.

Qualitative and quantitative investigation of steroids in crocodiles from clean and polluted areas, may serve as a diagnostic tool to investigate similar problems in crocodilians.

Additional analytical methods to be employed in structure elucidation of steroids include negative ion chemical ionization (NICI) GC-MS and Liquid Chromatography Tandem Mass Spectrometry LC/MS/MS.

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The Distribution of Lymphatic Tissue in the Oral and Pharyngeal Cavities of the Nile crocodile, *Crocodylus niloticus*

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Abstract: The distribution of lymphatic tissue in the oral and pharyngeal cavities of the Nile crocodile was studied in the heads of six 2.5 – 3 year-old, commercially raised, Nile crocodiles (*Crocodylus niloticus*). Lymphocytic accumulations were specifically associated with glandular tissue and epithelial specialisations in the oral cavity and were also found at the base of the dorsal gular fold where it abuts the palate. The rostral region of the maxilla contained glandular tissue between the incisor teeth which was associated with nodular lymphatic tissue that constituted gingival tonsils.

Between the glandular tissue and the surface of the tongue, and intimately associated with the secretory duct, were large aggregations of lymphatic tissue that formed lingual tonsils. The dorsal pharyngeal cavity was dominated by tonsillar tissue situated caudal to the internal nares. Numerous nodular and diffuse lymphatic accumulations were observed in the supporting irregular dense connective tissue of the laryngeal mound which dominated the floor of the pharyngeal cavity. This study revealed that diffuse and nodular lymphatic tissue is ubiquitous throughout the oral and pharyngeal cavities of the Nile crocodile. The presence of tonsillar tissue, particularly in the roof of the pharynx, should be considered as clinically important.

Enzootic *Mycobacterium Marinum* Infection(s) In A Population Of Mississippi-Alligators, *Alligator mississippiensis*

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Abstract: In a population of captive Alligator mississippiensis, several specimens died after displaying unspecific symptoms.
According to the results of the dissection, histopathological, and microbiological examinations a tuberculosis-like granulomatous infection caused by *Mycobacterium marinum* was diagnosed.
The zoonotic potential of *M. marinum* is being discussed as well as the resulting appropriateness of therapeutic treatment. Preventative measures to avoid spreading these infectious agents are stated.

1. Introduction

Mycobacteria are organisms ubiquitously found in the environment and are often detected in healthy as well as diseased reptiles (Brownstein 1984, Paré et al. 2006). Saprophytically and commensally living mycobacteria can generate diseases in impaired animals and this seems to apply particularly to fish, amphibians, and reptiles (Brownstein 1984). Infections can affect the skin or the respiratory system or they can become systemic (Wallach 1969). Sources of infection are contaminated soil, water or food (Thoen & Schliesser 1984).
Different species, which are known to produce infections in human beings, were isolated from reptiles, including *Mycobacterium marinum*, *M. avium* and *M. tuberculosis* (Frye 1991, Marcus 1981, Brownstein 1984). Potentially pathogenic varieties in reptiles are *M. fortuitum*, *M. cheloniae* and *M. thamnopheos* (Matlova et al. 1998). These are real saprobionics, which are widespread in nature and occur in food and water (Gedek et al. 1993).
M. marinum, *M. fortuitum* and *M. cheloniae* belong to the most common species, which can cause tuberculous diseases in fishes (Hoffmann 2005).

Mycobacterium fortuitum, *M. marinum* and *M. thamnopheos* belong to the class of fast-growing mycobacteria and lead to tuberculosis-like symptoms in poikilothermic animals.
Although mycobacteria are frequently isolated from cutaneous lesions in humans, they can also induce systemic diseases, which are merely accompanied by unspecific symptoms, such as anorexia, lethargy and emaciation (PARÉ et al. 2006).
In this context, tubercles can occur in all tissues and organs (Divers 1998). *M. cheloniae* was proven to cause osteoarthritis and systemic diseases in sea turtles (Greer et al. 2003). Zwart and Sassenburg (2005a) emphasize that osteomyelitis in snakes may be associated with tuberculosis and salmonellosis. Snakes exhibit granulomatous changes more frequently, possibly also in the subcutis and the oral cavity (Quesenberry et al. 1986). In chameleons a strong swelling of the limbs, due to massive formation of tubercles, complicated by circulation disorders, was detected (Zwart & Sassenburg 2005b).

1.1. Mycobacterial infections in crocodiles

Snakes, tortoises and lizards are frequently affected by Mycobacterium spp., whereas mycobacterioses seem to be rare in crocodiles (Ariel et al. 1997). Nevarez (2006), however, mentions many unpublished clinical cases of alligators with acid-resistant organisms, which correspond with mycobacteria. In the necropsy, these animals showed an existing pneumonia, which manifested itself in the form of multiple, white foci within the lung parenchyma of about 1-4 mm in diameter.
Mycobacterioses in farmed crocodiles is caused by mycobacteria from the environment by facultatively pathogenic species (Huchzermeyer 2002). Due to the specific temperature requirements of the causative agent, it is less likely that *M. tuberculosis* and *M. bovis* are able to infect crocodiles (Huchzermeyer & Huchzermeyer 2000).
Generalized granulomatous lesions were caused by *M. ulcerans* in *Crocodylus johnstoni* (Ariel et al. 1997) and by *M. avium* of porcine origin in *Crocodylus niloticus* (Huchzermeyer & Huchzermeyer 2000). Youngprapakorn et al. (1994) reported a number of crocodilian cases with granulomatous lesions of the lung, the trachea and the intestine caused by mycobacteria.
A granulomatous dermatitis is described with *Crocodylus porosus*, which was caused by an unknown mycobacterium (Buenviaje et al. 1998).
BLAHAK (1998) found acid-fast bacteria within granulomatous lesions in an *Alligator sinensis*, and *M. marinum* was isolated from four *Caiman crocodilus* of the London Zoo (Griffiths 1928).

1.2. *Mycobacterium marinum* as a causative agent of zoonosis - MOTT

In medical literature *Mycobacterium marinum*, as well as numerous other mycobacteria, belongs to the so-called MOTT. These are mycobacteria, which do not cause tuberculosis nor leprosy (**M**ycobacteria **O**ther **T**han **T**ubercle). Besides several human pathogenic species, many varieties belong to these, which can be less important for human beings.

MOTT-infections predominantly affect the lung (clinically, radiologically and histologically they can not be distinguished from a real lung tuberculosis), the lymph nodes, the skin (eczematous symptoms, which often result from water infections; the specific causative agent is *M. ulcerans*, which provokes the Buruli-ulcer in tropical areas) and create generalized infections, especially in human beings with reduced immune defence (Hof & Dörries 2005).
Due to the growth optimum of 33-35 °C, *M. marinum* prefers poikilothermic hosts (Clark & Shepard 1963), and the infections in humans are usually limited to the cooler areas of the body surface like the extremities (Ramakrishnan 2004).
As a result of infections created by the causative agent of fish tuberculosis (among others *M. marinum*), persistant granulomas, which are limited to the skin, appear in humans. Particularly the hands are affected (so-called swimming bath or aquarists granulomas). If the infection is not treated, usually a spontaneous healing occurs after a few months up to a year, whereas a specific treatment is quickly successful. However, a possible generalization cannot be excluded in immunodeficient persons, so that particular caution is advised with this group of people (Popp 1982; Hoffmann 2005). Powers and Fisher (2004) describe several cases of tendovaginititis, which were also caused by *M. marinum*.
Zoonotic infections with *M. marinum* from a reptile source have not yet been reported (Hernandez-Divers & Shearer 2002).
Apart from this, a survey of MOTT-infections (including *M. marinum*) in human beings is given in Bartralot et al. (2005).
Furthermore, the significance of *M. marinum* in food hygiene, with regard to fish and fish products used for human consumption is discussed at the moment (Hensel, personal report 2006). Throughout the last years more and more infections in farmed fish, amongst others pacific salmons, were observed.

2. Materials and methods

Three alligators from a larger farm were examined. One of them was at the Clinic— and died spontaneaously. The other both died at the farm and were prepared for morphological studies at another institution.
At necropsy pathological anatomical findings were noted. Specimens from parenchymatous tissues and lesions were fixed in 5% formaldehyde and embedded in paraffine. 5µm thick sections were stained with H and E, additionally Ziehl-Nehlson staining was done.
Further specimens of the organs as well as exudates from lungs were routinely examined in the bacteriological and mycological laboratory. Specific examinations were done for Mycobacteria by staining of smears according to Ziehl-Nehlson as well by differentiation with GenoType® Mycobacterium CM (Hain Lifescience).

3. Case history and results

In a population of about 35 - 40 captive *Alligator mississippiensis*, consisting of semi-adult, sub-adult, and partly very old adult animals, several animals from different groups without direct contact developed unspecific symptoms within the last twelve months. Despite several attempts at treatment the affected animals died.
Apart from the refusal to take up food and a slight weight loss the foremost symptoms were a reluctance to move and a recurring somnolence.

The cloacae were dilated and hypotonic. Clinically a viscous, grey-mucous urine, and a flaky, grey, turbid mucus within the mouth were observed.
Furthermore large quantities of flagellates were found in the urine. A moderate amount of fungi and *Citrobacter freundii* were detected in the oral cavity.
Two animals of the population died, but were initially not made available for pathological examination.
Another adult, female animal was admitted for treatment at the Veterinary Hospital for Fish and Reptiles, LMU, Munich.
The owner reported that the animal had shown emesis. Moreover, there was turbid mucus with a slightly sour smell within the oral cavity. The microbiological examination of the mucus showed a massive infestation of *Citrobacter freundii* and *Serratia rubida*. There was no fungal growth.
The blood test showed a discrete leukocytosis (9500/µl), slightly increased liver enzyme levels and no other abnormalities were detected. No bacterial growth was seen in the blood culture.
Treatment started with antibiotic therapy (Marbofloxacin) according to the antibiogram, additionally infusions, vitamin supplementation and Heparsal® were administered.
During treatment a bilaterally symmetric, mucous eye discharge developed, which showed massive growth of fungi (mould fungi and yeasts) according to the microbiology, but no bacterial growth.
Almost at the same time the animal started vomiting large amounts of flaky, grey-brownish, turbid mucus and several foreign bodies, among other things the padded handle of a crutch, a tennis ball, plastic bags and many legrings from birds (chickens and doves).
Thereupon the animal was sedated with Valium and narcotised intravenously with Propofol. After opening the mouth and blocking the jaws, oesophagus and stomach were examined manually.
In the area of mouth, tongue, root of the tongue, soft palate and glottis large quantities of petechiae were found, as well as widespread ekchymoses of the mucous membranes and ulcers with raised borders, up to the size of a lentil, with yellowish centre and reddish to black margins. Moreover, the mucous membranes of pharynx, oesophagus and glottis showed an increased tendency to bleed when touched.
In the stomach itself there were several sharp-edged stones and more legrings. Huge amounts of the above-described mucus and blood coagula were removed. Swab samples were taken from the stomach wall with the following results: massive growth of *Penicillium* spec. and *Trichosporon asahii*, *Streptococcus uberis* and *Citrobacter freundii* (multi-resistent). Consequently yet another symptomatic treatment followed with antibiotics according to an antibiogram, oral application of antimycotics, antacida und mucins as well as vitamin supplementation and infusion therapy. The general condition improved during treatment, however, anorexia remained and irregular skin lesions developed, especially palmar and plantar on the limbs. *C. freundii* was detected in these lesions.
About a month after admitting the animal to the clinic, it died unexpectedly.
Externally there was a moderate reddish discolouration in the area of the lower jaw and palmar and plantar on the limbs; healed abrasive injury in the area of the lower jaw; healed decubitus ulcers on all four limbs, an acute decubitus ulcer of about 4x5 cm with formation of rhagades on the left hind-leg, slight abrasive injury to the gingiva.

In the area of the tongue and of the lingual bulge there were cyanotic discolourations of the hyperaemic lingual papillae, on the left side of the lingual bulge aphthous changes of the lingual mucosa of about the size of pin heads, yellowish in the centre and blackish on the periphery, moderate “smudge-proof” reddening at the root of the tongue on the transition to the epiglottis.
Internal results showed (among other, secondary findings) a washed-out redness of the mucous membranes of the upper respiratory tract with clearly visible blood vessel injection, large amounts of viscous, flaky mucus. In the area of the pericardium a serous effusion of 20-25 ml was observed.
The lung was palpatorically extremely dense with foci in the parenchyma, distinct edema of the surrounding serous membranes, extreme atelectatic changes of the lung parenchyma with purulent-fibrous areas and nodules that were slightly raised above the surface, in the area of the distal lung extreme callosity on both sides with caseous areas in its periphery that showed necrosis in their centre. Within the parenchyma caverns had formed, filled with large quantities of turbid mucus and pancake-like masses.
Within the liver and the kidneys there were disseminated, pinhead-sized to millet-seed-sized, dense-elastic, yellow whitish nodules throughout the entire parenchyma.
The severely swollen spleen was interspersed with multiple disseminated, pinhead-sized to millet-seed-sized, yellow whitish, dense-elastic nodules. The parenchyma bulged out strongly from the surface of the cut area.
The mucous membranes of the gastrointestinal tract were highly reddened. In the area of the stomach several irregular ulcera up to the size of a 1-Euro-coin were spread over the leather-like surface of the mucosa. These ulcerative areas showed multiple, disseminated, expanded, irregularly map-like fringed patterns, severely indurated by connective tissue.
Hemorrhage was detected in the mesovaries.
Pathologically-histologically a focus-like, deep dermatitis was diagnosed, as well as large amounts of giant-cell granulomata in lung, liver, thyroidea, spleen, and kidneys. The lung contents showed numerous macrophages with acid-fast rods, whereas only very few of these rods could be detected inside the giant-cell granulomata and parenchymata.
Bacteriologically a systemic infestation with *Xanthomonas maltophila* and *Citrobacter freundii*, as well as considerable fungus-infestation was ascertained.
Furthermore Mycobacteria were isolated and identified as Mycobacterium marinum.
Thus a generalized, tuberculous-granulomatous mycobacteriosis was identified as the cause of death.
At about the same time, both of the above-described dead alligators were made available for taxidermy at the Institute of General Zoology and Neurobiology in Bochum. They were dissected and pathological-anatomical as well as pathological-histological findings analogous to the above-mentioned ones were discovered, although the aniamls had never had direct contact, and had been kept in entirely separate groups and enclosures. These animals likewise had acid-proof rods in the contents of their lungs, and Mycobacterium marinum was detected from their organs. The histological changes basically match the above-described ones.

4. Diagnosis

The diagnosis is based on the detection of acid-fast bacteria in Ziehl-Neelsen stains in combination with typical histological findings. The species identification can be made by PCR or by culture (Hof & Dörries 2005; PARÉ et al. 2006; Soldati et al. 2004).
The clinical diagnosis can be difficult but in the present case it can be made by biopsy (Zwart & Sassenburg 2005a) or by the examination of sputum samples out of the glottis or trachea. Divers 1998 considers endoscopic evaluation as possible. *M. marinum* can also be detected in contaminated water samples.
In the present case the diagnosis was ascertained by using dissection, Ziehl-Neelsen stain and also by culture.

5. Discussion and conclusions

In the present case the animals come from the same stock, but lived in different enclosures without direct contact to each other.
The only link exists in the contact to the keeper and the staff, who enter the enclosures and the water tanks without protective clothing. *Mycobacterium marinum* seemed to have been spread to the whole population by these human vectors and management. The contagiousness seems to be high and the infection of other animals cannot be ruled out. Due to the fact that M. marinum is known to be able cause the development of granulomatous to ulcerous changes of the skin, especially on the acra, it is necessary to point out the possiblility of infection to people who have contact to the animals. An examination of the other animals was recommended, in which sputum samples and possibly bioptates and water samples should be analyzed. The owner was advised to contact the appropriate public health department. Moreover, the staff of the involved institutes, who had direct or indirect contact to the animals, were asked to undergo an examination at the appropriate public health department, because the possibility of an infection of the skin via small lesions, or, indeed, a systemic infection, cannot be excluded. Indirect contact includes handling the sputum or other infectious material from the pathological examinations, as well as breathing in the aerosol in the dissecting room. Those people concerned were asked to have a lung check-up by the public health department.
Yamamoto et al.(1991) were able to cause an infection with granulomatous, tuberclelike lesions in the lungs of experimentally infected mice. Thus the assumption that *M. marinum* affects mainly the cooler areas of the arcra of homoiothermic animals, is relativised.
The risk of an infection is estimated as low, but possible. Persons, who are already immunosuppressed, are regarded as endangered.

Predisposing factors
Basically, in regard to ubiquitously spread causative agents, it has to be considered, to what extent predisposing factors play a part in the adhesion of these bacteria. The amount of the infectious agent is certainly of fundamental significance, but also the immune competence of the infected animals. The immune competence declines as a result of stress, as for instance insufficient temperature of the surroundings, frequent handling or invasive measures on the animals. In the present case social stress, crowding, territorial behaviour and social aggression seems to be of great importance.

Moreover, infrastructural parameters within the enclosures and possibly the food quality may have played a role. Generally, a classical factorial disease can be assumed. In contrast to this, the asserted mycoses of the animals seem to be a secondary condition, a resulting superinfection rather than a predisposing factor.

6. Treatment and prophylaxis

There is no report on a successful treatment of mycobacteria infections in reptiles, yet (PARÉ et al. 2006). In addition to the difficulties of treatment, there are indications of a zoonotic potential of mycobacteria (Hernandez-Divers & Shearer 2002). In case of clinically diseased animals, the option of euthanasia should be discussed with the owner (PARÉ et al. 2006). The expense factor along with the very reserved prognosis may further the decision making.

The prophylaxis is based on strict hygienic measures and on the avoidance of using raw meat from unreliable sources as animal food (Huchzermeyer 2002). Huchzermeyer & Huchzermeyer (2000), according to whose opinion the following hygienic measure is growing in popularity, state the possibility of exclusively using pellets as food. Another possibility, already mentioned by Huchzermeyer (1991), namely heat sterilization of raw food to avoid food-conditioned infections, before adding vitamins, is commonly used in South Africa, particularly with hatchlings (Huchzermeyer & Huchzermeyer 2000).

In the present case treatment with medicaments for the use in humans with atypical mycobacterioses is theoretically possible, but makes little sense.

First and foremost the entire alligator population ought to be examined by means of sputum samples, or possibly biopsies, and, where necessary, affected animals ought to be separated or even euthanised.

Furthermore the elimination of predisposing factors for the infection and of the spreading of the bacteria via the staff seem to be adequate measures.

Contact with the animals has to be subjected to strict hygienic criteria or, as the case may be, has to be prevented.

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Environmental Influences On Reproductive And Stress Hormones In *Crocodylus acutus* During The Breeding Cycle

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Abstract: No information related to specific environmental factors influence on reproductive and stress hormones is related in crocodilians. We present noteworthy information of environment influences on reproductive hormones in wild and captive Crocodylus acutus.

Two populations (wild n = 63; captive n = 61) were studied during six months when mating, copulation and nesting occur. Plasma estradiol ? 17, testosterone and corticosterone were assayed in each month. Air and water temperature, light intensity and humidity were recorded (Data loggers). Water level and salinity were recorded in the wild on a monthly basis. Data were analyzed using Bray Curtis ordination on Pc Ord 4.0. ANOVA, ANCOVA and linear regression were applied.Hormonal relationship with the breeding cycle, and the influences of the environment on reproduction and stress are described.
New findings show that the breeding cycle of males and females is asynchronic because of different microenvironment utilization, and behavioral differences between males and females. Temperature is the major factor influencing reproduction and light intensity is a secondary (synergic) factor, which influences are showed only in the wild. In captivity the latter factor is minimum or null because stocking density, high water temperature of ponds, dominance and impossibility of microenvironments use.

Key words: Crocodylus acutus; México; reproductive and stress hormones; environmental influence on reproduction; wild; captive; breeding cycle.

Febrile Response In The American Alligator (*Alligator mississippiensis*)

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Abstract: Juvenile American alligators (130-140 cm) that were injected intraperitoneally with bacterial lipopolysaccharide, and allowed to thermoregulate in a thermal gradient, exhibited higher internal body temperatures (T_bs) than control animals. The time to onset of the fever response was less than 5 hrs, and the duration was approximately two days. The magnitude of the response (maximum body temp.) varied from 2.6 ± 1.1°C higher than untreated control animals on day 1 and 3.5±1.2°C higher on day 2. The animals injected with pyrogen-free saline did not display internal body temperatures that were significantly different than untreated animals. Alligators injected with 10^7 heat-killed *Aeromonas hydrophila*, a common gram negative bacteria, exhibited T_bs 3.3±1.3°C higher on day 1 and 3.5±2.1°C higher on day 2. In contrast, alligators injected with gram positive *Staphylococcus aureus* and saline-injected alligators did not exhibit a febrile response. Alligators that were injected with bacterial lipopolysaccharide and maintained in a constant temperature environment did not exhibit elevated internal body temperatures, relative to control animals. These data suggest that the mechanism of the febrile response is behavioral in nature, as has been described for other reptiles.

Effects Of Bacterial Lipopolysachharide On Peripheral Leukocytes In The American Alligator (*Alligator mississippiensis*)

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Alligators were injected intraperitoneally with four different doses (10, 1.0, 0.1, and 0.01 mg/kg body weight) of a mixture of bacterial lipopolysaccharides (LPS) derived from three different types of bacteria (*Escherecia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*). Injection of the alligators with the LPS mixture resulted in a dose- and time-dependent increase in total peripheral leukocytes. Lymphocytes increased at days 3 and 4 post-injection, and decreased back to baseline levels at day 7 for all doses. Alligators that were not treated, and those injected with pyrogen-free saline, did not exhibit statistically significant changes in total leukocytes during the course of the study. Injection of alligators with 0.5 mg LPS/kg body weight derived from one of three bacterial species revealed that the leukocyte increases observed were not statistically different for all three types of LPS. The animals displayed the same increases in total counts and the levels of all circulating leukocyte types were not different between animals treated with a combination of LPS from all three bacterial species.

Wound Healing In The American Alligator (*Alligator mississippiensis*)

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Captive juvenile alligators were wounded using 4 mm punch biopsy tools. The wounded tissues were excised, using 8 mm punch biopsy tools, at 1, 2, 3, 7, 14, 28, 42, and 56 days after the original wounds were inflicted.

Histological examination of these alligator tissues revealed heavy fibrin deposition in the wound at days 1-3. In addition, unlike mammalian wounds where collagen synthesis does not occur until after the 5-7 day lag phase, collagen was present after only 1 day, and heavy collagen accumulation was evident by day 2. During the first two weeks collagen was deposited throughout the wound while leukocytes infiltrated the tissue. There was also an increased blood supply to these areas. Fibrin degradation occurred after day 14, and collagen resorption was apparent after day 7. By day 56, most of the tissue has healed and there is little fibrin and collagen present. The new tissue in the wound site was not distinguishable from the unwounded control tissue. These data show that the onset of wound healing occurs earlier than that seen in mammalian systems.

Genetic Characterization Of *Caiman latirostris* Populations In Santa Fe, Argentina, Applying RAPD And Isozymes Techniques.

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Results of a genetic population analysis of *C. latirostris* performed in Santa Fe (Argentina), using RAPD and isozymes techniques, are described. Blood and tissues samples of 41 individuals from 4 populations of Santa Fe province were obtained and 10 animals from Formosa province were used as a control.
DNA samples were amplified with 8 RAPD-primers, and PCR products were visualized on polyacrylamide gels. 233 RAPD markers were used to analyze genetic variability and population structure by presence-absence of bands. Results showed mid to low genetic diversity values, a high value of population differentiation (FST= 0.327± 0.283 SD), and an effective migration rate of Nm = 0.5. These data indicate that an important structure exists in all populations, with a scarce genetic flow between them, which suggests that each one has a similar behavior to a demo with its own characteristics. The analysis of genetic distances showed that genetic differences are in relation to geographic distances due to the high similarity found between nearby populations.

Up to the moment, 4 isozymes systems were analyzed, and all of them showed a heterozygosity value of 0 in the populations, in agreement with previous studies.

Developmental Toxicity Of The Hebicide Glyphosate (Roundup®) In *Caiman latirostris* Embryos.

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Glyphosate (N-Phosphonomethyl glycine) is the active ingredient of Roundup®, a broad spectrum, non-selective herbicide widely used in agriculture to control weeds in soya plantations and others crops. The relative low toxicity of the active ingredient glyphosate increases in the formulation Roundup® due to addition of surfactants.
In Santa Fe province, Argentina, some areas of the broad-snouted caiman (*Caiman latirostris*) habitat are near to agricultural zones were agrochemicals such as Roundup® are being used increasingly. Therefore, it was necessary to evaluate the potential contamination risk to which the specie is environmentally exposed.
Reptiles have been used in several studies as biological monitors of chemical agents contamination. The assessment of toxicological effects in embryonic development is a bioindicator of ecological risk that permits the analysis of possible consequences in subsequent stages of the animal life. The aim of this study was to evaluate the potential developmental toxicity of sublethal dosis of Roundup® in embryonic development of *C. latirostris*. We exposed 100 embryos to different concentrations of Roundup® at early embryonic stage and after hatching we examined morphological endpoints and evaluate genotoxic effects aplying two assays: the Micronucleus test and the Comet assay.

Does Time Spent In The Harvest Containers Affect *Caiman latirostris* Egg Hatchability?

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Abstract: In an attempt to improve egg-harvesting efficiency, we tested whether harvested eggs could be left for longer periods of time within containers without reducing hatching success. We maintained *C. latirostris* eggs collected by 'gauchos' within the harvest containers in the gaucho's houses for different time periods (<1 day, 2-7 days and more than a week), simulating the same procedures as if we were harvesting the eggs commercially.

We found no effect of time on hatching success. This result means that gauchos involved in the program can harvest eggs on their first visit to the nest, and hold them in containers until they can be sent to the incubation facilities, thus reducing the chances of losing eggs through predation or flooding.

The Temperature-Sensitive Period (TSP) During Incubation Of Broad-Snouted Caiman (*Caiman Latirostris*) Eggs

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Abstract: All crocodiles studied to date exhibit temperature-dependent sex determination. During the many weeks from egg laying to hatch there is a period of 10 to 15 d in the middle third of incubation (in the American alligator) during which the sex of the embryo is irreversibly fixed, referred to as the temperature-sensitive period or TSP. In this work we investigated the TSP in *Caiman latirostris* eggs incubated at female-inducing and male-inducing temperatures (29°C and 33°C respectively) by switching eggs from 29° to 33°C and vice versa at timed interval throughout incubation. Compared to *Alligator mississippiensis* the duration of the TSP was longer, and the onset of the TSP was at an earlier stage of incubation.
of Broad-snouted Caiman (*Caiman latirostris*) Eggs.

Caiman Latirostris Hatchlings: A Genital Morphology Characterization

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Abstract: The goal of this research was to charactrize the genitalia of hatchlings *Caiman latirostris*. We incubated fertile eggs (n=78) at constant temperatures of 30 and 33C, in order to obtain females and males respectively.

We measured (n 19) snout-vent length, total length and weigthed the animals.
The observations were made up with a Lupa Nikon SMZ-10. Gonads and external genitalia were photographed with an Olympus camera C-5000 and then the images were processed in IMAGE PRO-PLUS 4.5.0.29.
We measured three variables on clitero-penis: total length, vertical width and head width. Also calculated CTP volume and transversal area of the clitero-penis tip in AUTOCAD 7.0. Analysis doesn't show, at this moment, morphological differences in the genitalia of hatchlings between males and females of *C. latirostris*.

Classification And Comparison Of Juvenile Vocalizations Of *Caiman Latirostris*

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For the study of the hatching calls, originating eggs of 14 nests collected in the province of Santa Fe were used during the summer period 2002/03 from the ranching activities of the Proyecto Yacaré. Registries were taken from the vocalizations of hatchings during a sufficient time interval like registering the vocalizations that took place at the time of the hatching.

For the study of the annoyance, distress and contact calls were used animals of three different ages: new born (peri-natal period), of 8 and 20 months.
Using a personal computer and appropriate software came to the analysis and selection from the acoustic signals the obtaining from oscillogram, frequency spectrum and sonogram allowed the detailed characterization of the structures and acoustic properties of the hatching, annoyance, distress, and contact calls.

Variations in the structures and acoustic properties of the annoyance, distress and contact calls in relation to the age of the individuals appeared. The structures and acoustic properties of the hatching calls were highly variable between vocalizations of different nests. In individuals of 8 and 20 months of age, two different types of distress calls and contact calls were identified. The acoustic properties showed different variation patterns, depending on the type of call.

Photoperiod Effect On The Growth Rate Of *Caiman latirostris* (Daudin, 1802) Under Experinmental Conditions (Crocodylia: Alligatoridae)

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We reared 72 hatchlings of *Caiman latirostris*, coming from three different nests randomly distributed, under three different artificial lighting conditions: 12L:12D, 24L:0D y 0L:24D, during 60 days. We recorded the initial weight, the SVL, and the TL and we calculated the Specific Growth Index. We did the statistical analysis with ANOVA by mean of a factorial design of two factors: photoperiod and nest. We observed significant differences on the growth in relation with the nest of origin, but we did not find any differences considering the photoperiod treatment, neither on the interaction of the nest and the photoperiod.

Caiman yacare And *Caiman latirostris* Ranching Program In Formosa, Argentina.

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The north of Argentina is known to have still many places that have not been modified by human activities. The boost to programs of natural resources management contributes to the preservation of these ecosystems under the same conditions.

Since 2002, *C. yacare* and *C. latirostris* management program based on ranching technique is being developed in the province of Formosa. Before to start the annual harvests, population studies are carried out to evaluate the impact of the program. The continuous increase of harvested eggs along these years has produced an income to the regional economies. This is one of the best choices for habitat conservation, as well as for the well-being of its inhabitants.

At the moment, a growing production volume is being reached, with a harvest of eggs of about 40,000 a year. For that purpose, a slaughtering house has been built fulfilling the sanitary requirements of the European Union for the commercial use of the meat also.

Infestation Of *Caiman latirostris* Nests By Red Fire Ants (*Solenopsis invicta*)

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Abstract: *Solenopsis invicta* (RFA) reproduces during the warm months of the year, like most of reptiles do. RFA use alligators (in USA) and caiman nests (in Argentina) to establish new colonies. In Argentina, this topic did not call the attention of researchers previously. Our study was focused in the analysis of the percentage of *Caiman latirostris* nests infected by *S. invicta* under natural conditions in three nesting habitats: floating vegetation, savanna, and forest. During last caiman's nesting season (Dec. 2005 – Feb. 2006), we registered the presence of RFA in caiman nests. We also searched for ant's nests in the same places using quadrants. Data were analyzed by a Chi square test in order to know if RFA infection in the caiman nests was independent of habitats sampled. The amount of RFA´s nests in the habitats was analyzed by ANOVA where habitat type and place were the grouping variables. There were no differences in the amount of ant's nests between habitats. Our data showed that RFA's nests are equally represented in the habitats. On the other hand, the higher rate of infection in the floating vegetation habitat could be the result of weather conditions; repetition of this study could answer this issue.

Effects Of Low Oxygen Concentration On Development And Survivorship Of *Caiman latirostris*: Preliminary Results

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Abstract: Ambient conditions during incubation affect development and survivorship of reptilian embryos. In crocodilians, incubation temperature has a profound effect on incubation period, development rate and hatchling sex. It has been suggested that sex determination is more related to embryonic development rate than incubation temperature *per se*. Yet little is known about the effect of the gaseous environment on these parameters. Here we evaluated the effects of hypoxia on *Caiman latirostris* embryos.

We incubated 53 *C. latirostris* eggs at either of two temperature treatments (31ºC and 33ºC, producing 100% females and 100% males, respectively) and two O_2 concentrations (10% and 21%), in a factorial design. To evaluate differences in development among treatments, we opened eggs on days 28 and 42 of incubation (beginning and the end of the thermosensitive period). Incubation under hypoxia tended to reduce embryonic grow rates and survivorship, and increase the incubation period. No hatchlings were produced at 33ºC with low O_2 treatments, and hatching success at 31ºC with low O_2 concentration was reduced relative to that at normal O_2 levels.

Caiman latirostris Ranching Program In Santa Fe, Argentina: PROYECTO YACARÉ (CONVENIO MIN. PROD./MUPCN)

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Abstract: The numerous benefits obtained from the application of ranching programs in crocodilians have been described many times. The mainstay of these programs are its economic, social and environmental contributions. The most tangible results are evidenced in the progressive increase in the number of nests identified as consequence of more local residents involved in the program.

Proyecto Yacaré began in 1990 with the aim of monitoring and recovering *C. latirostris* population in Santa Fe, Argentina by means of the already mentioned management program. This way, *C. latirostris* transfer to Appendix II of CITES was achieved in this country. The release of more than 20.000 animals to its natural habitat - which makes it easier to observe liberated females that are in the reproductive stage-. And finally, the production of skin and meat for the domestic and international trade. The average egg harvest is of 10.000 eggs. All these achievements and the number of scientific papers place Proyecto Yacaré as a model enterprise of management and conservation worldwide.

Water Salinity Levels And Its Effect On *Caiman latirostris* Growth

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In this experiment, we have evaluated the effect of three different salinity levels on the growth of 54 *Caiman latirostris* hatchlings. We randomly distributed the animals coming from four different nests, and reared them during a period of 135 days. The concentrations we used were 0 ppt., 3,5 ppt. and 7 ppt. of marine salt. All the treatments were kept under similar conditions of captivity (density, temperature and feeding), except salinity. We collected data on weight, SVL and LT. We found differences on growth and fitness, but not in the survivorship between treatments.

It Is Possible To Recover The Slow Grower Caïmans In A Farming System

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In all crocodilian farming facilities, a number of animals show soon after hatch, to be “slow growers” or “dwarf”. During the rearing period of 2005, we taked 24 of these slow grower *Caiman latirostris* from the Proyecto Yacaré facilities. We transferred the animals from the 16 square meters pens for 300 caymans, to a plastic containers of 0,2 square meter. We reared the animals during 142 days, with the only difference of the full access to the food. We also used 18 “normal growers” as controls of the experiment.
At the beginnin, the slow growers (three month old at that time), were significatively smaller than the average for the specie at hatch moment. At the end, the slow grower caymans showed a daily increase of weight of 1,94 grams, compared with the controls, that showed a daily increase of weigth of 1,86 grams. The Specific Growth Index was of 0,59 for the slow growers, and 0,39 for the controls. On the other hand, the survivorship was of 71% for slow growers, and 100% for controls.

Caiman yacare And *Caiman latirostris* Ranching Program In Corrientes, Argentina: YACARE PORÁ

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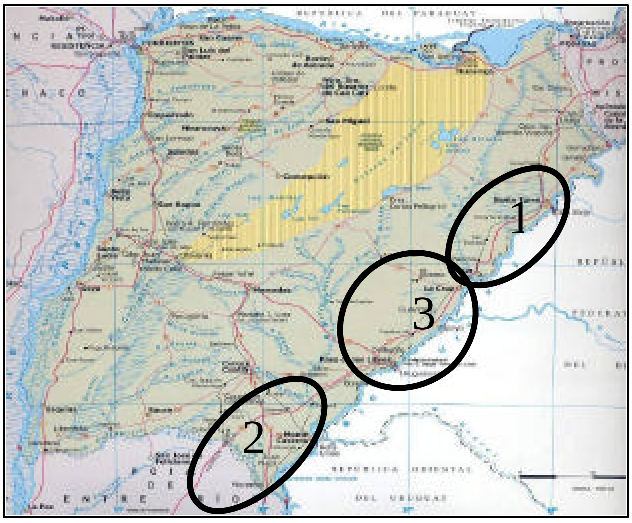
1. Introduction

Corrientes is undergoing a period of vast agricultural development. This entails an impending destruction of natural ecosystems if their sustainability is not regulated. With the aim to curb this process, a management plan based on the ranching technique was designed. By means of it, caiman resource is used in a sustainable way through a conservation strategy. So much so, that Yacaré Porá ranching program was put into practice in this province in 2004.



The reintroduction of captive-reared animals to the wild appears as a biologically and economically feasible tool to increase the size of populations.

Local inhabitants' commitment with this project it is evidenced in the duplication of the eggs harvested during the last two years. In turn, the beginning of the marketing stage is foreseen before the end of 2006.

Fig. 1. Maps of Corrientes Province, and work areas.

1.1 Location

Yacare Porá facilities are located in Ituzaingo, Corrientes, 230 km. away from this province's capital.

1.2. Surveys

Population monitoring is carried out each year to evaluate how the program impacts on natural habitat.

1.3. Working area

Three work areas have been established: Area 1, Area 2 and Area 3 (see map below). Each area is given a name that may coincide with some representative place of that area.

1.4. Harvest

Harvest begins early in December starting from the data that obtained from local inhabitants who inform about existence of eggs in the nests. The groups in charge of the harvest are formed by local inhabitants accompanied by properly qualified company staff who will transfer the eggs to the artificial incubator. In some cases and under certain conditions, harvest teams are formed in neighboring places to the areas where the nests will be removed. This is carried out mainly in very extensive areas such as areas belonging to the State. The best moment to harvest is early or late in incubation. It is very important that harvest takes place as early as possible. This way, it is unlikely to lose the nest (fires, flooding, predation, etc.).

1.5. Incubation

During the whole period of incubation, incubator's temperature and humidity data is controlled and recorded for later evaluation.

1.6. Hatch

Immediately after their birth, animals' caudal verticals are marked with a combination of cuts in their caudal verticils to identify nests; and a numbered metallic tag is set to allow each individual's monitoring. This has important advantages since it allows us to obtain individual data and nests projections. This way, projections will be very useful to determine different variables. Then, animals are put in pools – species are not mixed- which will have a density of about 10/12 animals by m^2. Pools are adapted with a heating system for animals to have a greater grow in less time. At the end of each year, releases are carried out according to species and what has been harvested in each area.

1.7. Release

Once cold months are over, animals are set free. These animals, which were not subjected to any particular treatment, are bigger than animals in the wild. The fact that they are bigger allows them to face challenges which animals from the wild will not overcome.

1.8. Trade

Up to now, there has not been any transaction – leather and meat- because animals are not big enough. Transactions are foreseen to begin in August. For this purpose, facilities are being built based on the requirements of the organisms in charge of controlling the implementation of standards regarding slaughtering.

2. Results and discussion

In some aspects, results were surprising. Above all in harvest places where one species or another was thought to have predominance, or else, there was no evidence of some of the species at all. Results of harvested nests per area were (fig. 2):

Area 1 -Virasoro - : At the beginning of the program, it was thought that it could be an important harvest area. It has very interesting places for the development of caiman populations and some physiognomic aspects which *C. latirostris* prefers. This area in particular has undergone a very important agricultural growth, which has outstandingly modified its habitat. This suggests that important caiman populations that used to be in this area have disappeared.

Harvests were low, but harvested eggs belong to the species previously mentioned.

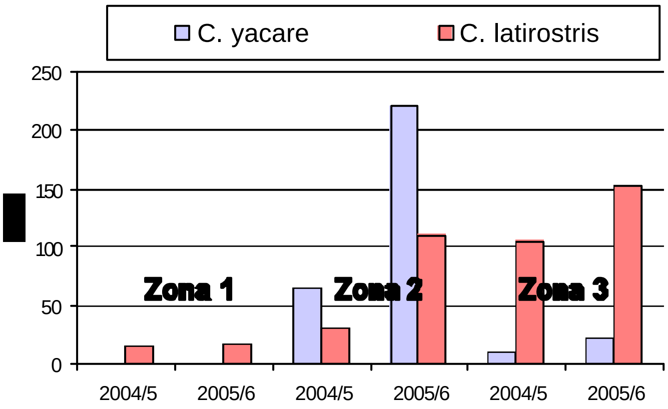


Fig. 2. Nests harvested by different year and zones.

Area 2. -Beron de Astrada- : This area was where bigger quantity of nests was identified. The amount *C. yacare* born hatchlings coincides with what was known up to now. This is a traditionally well-known area as being preferred by *C. yacare*. It was also remarkable the amount of *C. latirostris* harvested eggs.

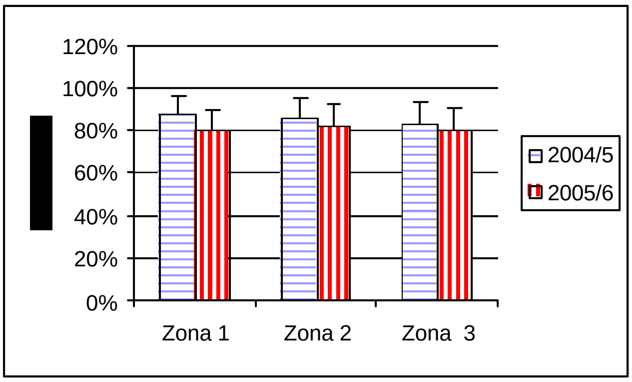


Fig. 3. Hatching average by years and work areas.

Area 3 - Alvear -: It has all the characteristics that coincide with what broad snouted caiman prefers**.** In spite of this, *C. yacare* nests were harvested. This suggests that regional characteristics are not determinant of one species or other, except for area 1 where only *C. latirostris* eggs were harvested. Generally, the comparison between harvested nests during the two years doubles, except for area 1, where habitat loss is evidently increasing. Lastly, the proportion among species of the harvested nests stays the same in 2004 as well as 2005.

A difference between the first and second harvest year can be observed if we compare the number of hatch eggs in relation to harvested nests (fig.3). The drop in birth average in area 1 may be due to several days of rain -200 mm^3- during December. Great number of nests stayed underwater and harvest was delayed because roads were impassable. The drop birth average is reflected in every area. One of the reasons could be the bigger amount of nests found with respect to the previous year, which causes a complete disorder. From the sustainable point of view of the program this is very encouraging, since the number of people involved in the harvest is larger. As we have already said, the impact is really verified in regional economy and the protection of natural habitats.

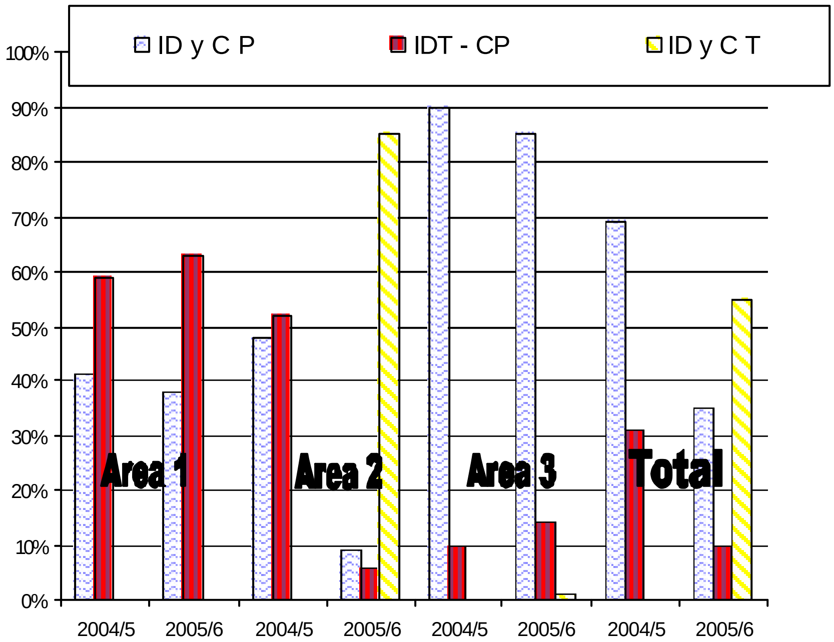


Fig. 4. Identification and eggs collection by different work

So much so that this effect was evaluated by incorporating local inhabitants in the identification of nests and the harvest of the eggs between the two years and different areas.

The variables evaluated between the 2 years harvest were (fig. 4): identification of the nest and harvest of the eggs by the staff of Yacaré Porá (ID and CP), identification of the nest by local inhabitants and harvest of the eggs by the staff of Yacaré Porá (IDT and CP) and lastly, identification and harvests by the local inhabitants (ID and CT). The result of the program in harvest areas has generated a great participation on the part of local inhabitants. If we take a look at the total of harvested nests, the largest quantity was that of ID and CT. It is also established that this situation had not been observed in the first year of harvest. The harvest of eggs by the staff of Yacare Pora was very important if we keep in mind that one of the major factors in embriological death in egg management programs is the movement of eggs. This, simply, is a fact that demonstrates how fast local residents learned to mark, harvest and transfer the eggs. Moreover, local inhabitants were taught to measure some variables related with the nest and the habitat where the nest was identified. All these data are being processed to elaborate a geographic information system based on the data obtained from the Yacare Pora program areas. The purpose is cover all over Corrientes.

The participation of bcal inhabitants in technical-scientific programs contributes to the alimentary autonomy of these local communities.

Regarding release and taking into account that it has only been a year of work, 700 animals approximately (420 *C. latirostris* and 280 *C. yacare*) have been given back into the wild. This decision was made based on population differences that can be easily observed. *C. yacare* is more abundant than *C.latirostris*. This is opposed to the number of *C. latirostris* harvested nests but it is shown in search intensity. Frequently, it is more difficult to find their nests due to the places they choose to live and to nest.

Besides, the demands of the search are balanced when leather is trade, since it is more expensive.

Some implications

Wetland natural resources are necessary for the development of numerous activities such as fishing, forestation, the use of the wild fauna, etc. In spite of this, wetlands have been classified as unproductive lands that should be drained. This conception is changing towards sustainable use, which will allow the recovery of some socioeconomic aspects of the area. This program maintains this principle as one of the most important factors that will allow us to refer to these wetlands as an alternative of conservationist production.

Antibacterial Activity Of *Caiman Latirostris* Serum

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The demand for the discovery of anti-microbial drugs leads to the testing of thousands of molecules coming from natural sources and from chemical modifications of natural compounds. Taking into account the many ways in which microorganisms penetrate and with no pathological signs, we may possibly think that they have a well developed immune system that provides them a quick and effective defense line. Several studies have been carried out *in vitro* and *in vivo* to detect the anti-microbial activity of some tissues belonging to different organs and the serum of some crocodilians species. This work tries to compare the antibacterial activity of *Caiman latirostris* serum and that of human being and also the serum of chicken as compared to a *Escherichia coli* stump. (ATCC 11105).

Sex-Specific Recombination In *Crocodylus porosus*: A Species With Temperature Dependent Sex Determination

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Abstract: The first evidence of genetic linkage and sex-specific recombination in the order Crocodylia is reported. This study was conducted using a resource pedigree of saltwater crocodiles consisting of 16 known-breeding pairs (32 adults) and 101 juveniles. A total of 21 microsatellite loci were available for analysis. Ten of the 21 loci showed linkage with four linkage groups: three pair-wise (Cj131/Cj127, CUD68/Cj101 and Cj107/Cp10) and one four-locus (Cj122, CUD78, Cj16 and Cj104) being found. Linkage analysis on the 21 loci revealed evidence of sex-specific differences in recombination rates. All seven non-zero inter-locus intervals were longer in females than males, with the four-loci linkage group 3-fold longer in the female than the male (41.63 cM and 14.1 cM, respectively). This is the first report of sex-specific recombination rates in a species that exhibits temperature-dependent sex determination (TSD).

1. Introduction

Haldane's (1922) law states that genetic recombination is lower in the heterogametic sex. Genetic maps from many species have been consistent with Haldane's (1922) prediction, but there are sufficient exceptions at the species (for example, sheep and the tammar wallaby) and chromosomal level to seriously question its general validity. All crocodilians, like some species of turtles and lizards, have temperature-dependent sex determination. An incubation temperature of $32^{o}C$ in the saltwater crocodile produces mostly males, whilst a $1^{o}C$ deviation decreases markedly the proportion of males produced. Therefore, it was expected that no sex-specific recombination would be discovered in *C. porosus*. However, we report the first evidence of genetic linkage and sex-specific recombination in the order Crocodylia. This study was conducted using a resource pedigree of saltwater crocodiles consisting of 16 known-breeding pairs (32 adults) and 101 juveniles. A total of 21 microsatellite loci were available for analysis. Ten loci showed linkage consisting of four linkage groups: three pair-wise (Cj131/Cj127, CUD68/Cj101 and Cj107/Cp10) and one four-locus (Cj122, CUD78, Cj16 and Cj104) linkage group. Conducting a sex-specific linkage analysis on the 21 loci revealed evidence of sex-specific recombination. All seven inter-locus intervals were longer in females than males, with the four-loci linkage group 3-fold longer in the female than the male (41.63 cM and 14.1 cM, respectively). The higher frequency of recombination in female crocodiles suggests that some aspects of the timing, duration or other biological features of female meiosis are responsible for the observed increase in recombination. Clearly sex chromosomes and genetic sex determination have nothing to do with it.

2. Methods and materials

139 individuals were sampled from Janamba Croc Farm (Northern Territory, Australia), consisting of 32 parents with an average of 6.7 offspring per family. Parents were wild-harvested and nothing was known about their relatedness. Parents were housed in unitised breeding pens, as known-breeding pairs, where mating errors could be excluded. Offspring were sampled at various opportunities and the clutch-of-origin was identified using clutch-specific scute cuts. Correct pedigree had previously been determined by Isberg et al. (2004).

Twenty previously developed microsatellites (FitzSimmons et al. 2001) were evaluated for polymorphism using PCR, and both an ABI 373 and ABI 3700 sequencer. CRI-MAP (Green et al. 1990) was used to detect evidence of linkage between all of the microsatellites tested.

3. Results and discussion

Using the 21 microsatellite markers, we found four linkage groups. Three were pair-wise linkages (Cj127 and Cj131; Cj101 and CUD68; Cj107 and Cp10), whilst the fourth linkage group consisted of four markers (Cj16, Cj104, Cj122 and CUD78; Table 1). These are the first reported genetic linkage groups in any reptile. In all cases involving non-zero recombination, the recombination rate is higher in females and for all four linkage groups, a sex-specific model of recombination fits the data significantly better than a model assuming equal recombination in males and females.

Table 1. The four linkage groups identified using 21 crocodile microsatellite markers. The recombination fractions (r) and LOD scores are presented for sex-averaged, male and female maps.

		Sex-averaged		Female	Male	Sex-specific
		r	LOD	r	r	LOD
Cj127	Cj131	0.19	6.97	0.25	0.09	8.24
Cj101	CUD68	0.06	8.78	0.16	0.00	10.58
Cj107	Cp10	0.14	3.29	0.22	0.00	4.76
Cj16	Cj122	0.00	7.53	0.00	0.00	7.53
Cj16	CUD78	0.10	8.09	0.15	0.06	8.76
Cj122	CUD78	0.00	3.31	0.00	0.00	3.31
Cj104	CUD78	0.12	6.52	0.25	0.03	7.75

Genetic maps from many species have been consistent with Haldane's (1922) prediction, but there are sufficient exceptions at the level of species (for example, sheep and the tammar wallaby) and individual chromosomes to seriously question its general validity (Moran and James 2005). All crocodilians, like some species of turtles and lizards, have temperature-dependent sex determination (Sarre et al. 2004). An incubation temperature of 32°C in the saltwater crocodile produces 86% males, whilst a 1°C deviation decreases markedly the proportion of males produced (16% at 31°C and 17% at 33°C; Lang and Andrews 1994).

The higher frequency of female recombination in crocodiles suggests that it is some aspect of the timing, duration or other biological features of female meiosis that is responsible for the general tendency for elevated female recombination and shows clearly that sex chromosomes and genetic sex determination have nothing to do with it.

These linkage groups are the first to be reported in crocodilians. With the eventual addition of more markers, this map can be extended to assist with MAS (Miles et al. 2006).

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5. Acknowledgements

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Towards A Microsatellite-Based Linkage Map For The Saltwater Crocodile *(Crocodylus porosus)*

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1. Introduction

Traditionally, genetic improvement programs have selected animals based on the measurable (phenotypic) performance of an individual and its relatives for economically important traits (reproduction, growth rates, survival, etc.). In general, this selection is undertaken with little or no knowledge of what is occurring at the DNA level. To bridge this gap, quantitative trait loci (QTL) studies are being conducted in many livestock industries and enable genotypic data to be incorporated into the selection process. The eventual aim is to select animals more efficiently aided by marker assisted selection (MAS) and increase the rate of genetic gain.

In order to develop a MAS program, we require a high resolution genetic linkage map. The first evidence of microsatellite linkage in the order Crocodylia was presented by Isberg *et al.* (2006). However, this map consisted of only 21 microsatellite markers. We report the development of an additional 600 microsatellite markers for the construction of the first dense genetic linkage map, and for future QTL mapping in the saltwater crocodile.

2. Constructing the first Dense Genetic Linkage Map for *C. porosus*

Constructing high-density genetic maps requires many polymorphic markers spaced evenly across the genome. After these markers have been evaluated on a resource pedigree, linkage analyses are performed to identify markers that are genetically linked together (in close proximity on a chromosome). Figure 1 illustrates the process of microsatellite marker development and linkage map construction.

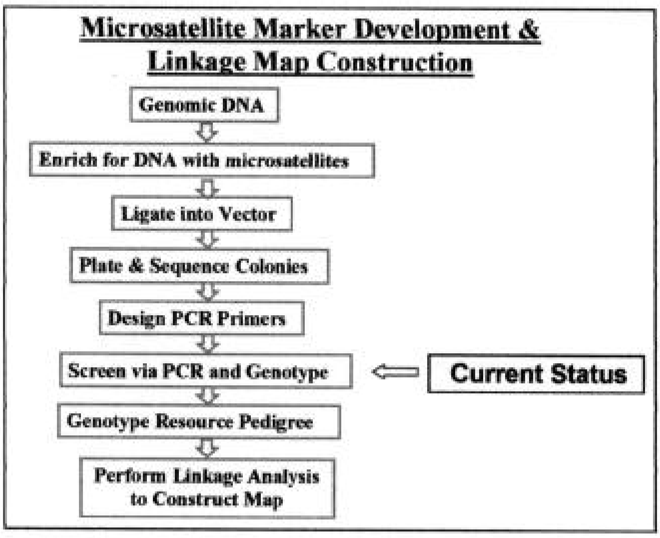

Figure 1. A flow chart of microsatellite marker development. Once the microsatellites are genotyped on our resource pedigree, a linkage map can be constructed

3. Genetic Linkage Maps

Linkage maps provide a true picture of the order of genes along a chromosome (Figure 2). Genes located on the same chromosome are physically linked. The term linkage refers to the tendency of two or more genes (or markers) on the same chromosome to be inherited together. The closer the two genes (or markers) are on the chromosome, the higher their probability of being inherited together. Markers tightly linked to QTLs or genes of economic importance can be utilised to detect the presence or absence of desirable genes in individuals for selection. This is known as Marker Assisted Selection (MAS).

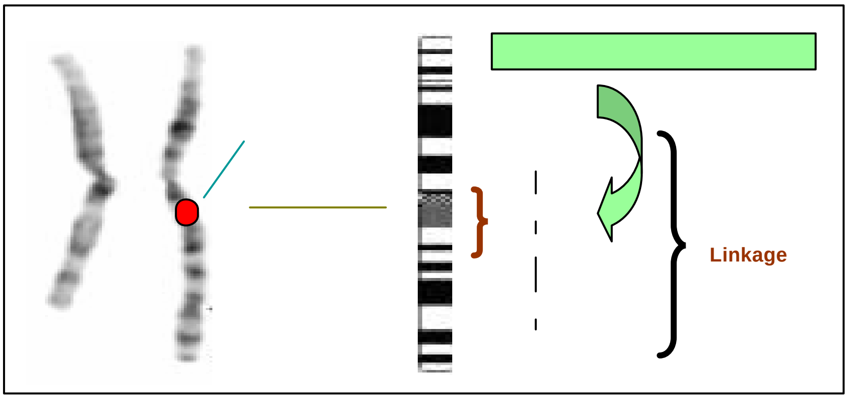

Figure 2. Illustrative example of genetic linkage between a marker and Quantitative Trait Loci (QTL) and associated linkage group.

The Applications – Quantitative Trait Loci (QTL) Mapping and Marker Assisted Selection (MAS)

A QTL is a region of DNA associated with a particular trait (e.g., growth rate). Though not necessarily genes themselves, QTLs are stretches of DNA that are closely linked to the genes underlying particular traits. A single phenotypic trait is often controlled by multiple genes. Consequently, many QTLs can be associated with a single trait. QTL studies are useful for identifying candidate genes for economically important traits and are being conducted in most livestock industries with the eventual aim to select animals more efficiently aided by MAS. MAS is a valuable adjunct to performance based selection since:

1.) Favourable alleles for economically important traits can be introduced into commercial populations from exotic stocks using Marker Assisted Introgression (MAI),

2.) Markers linked to QTL can improve selection accuracy by incorporating marker information into the estimation of breeding values, and,

3.) Marker information can increase selection intensity and reduce generation interval for traits difficult to measure or which are expressed late in life since genotyping can be achieved from day of hatch. This is especially important in a species whose generation interval is estimated at 13 years.

Before such selection tools can be developed for the industry, a comprehensive genetic map must first be constructed, and we have completed the first major step in this process.

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6. Acknowledgments

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A Strategy For Managing Crocodiles In The Greater St Lucia Wetland Park World Heritage Site, South Africa.

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Abstract: It has been recognised that within the context of maintaining the Greater St Lucia Wetland Park World Heritage Site as a healthy ecosystem, specific management actions are required for the needs of species such as Elephant, Rhino, Tsessebbe, Wild dog and the Nile crocodile (*Crocodylus niloticus*).

The conservation vision for *C. niloticus* is to maintain and restore viable crocodile populations as an integral part of all the waterbodies within the Park. *C. niloticus* is the largest predator of the Park's estuarine and freshwater habitats and plays an important ecological role. The Park includes the largest population in a single waterbody in South Africa (Lake St Lucia) and hosts one of the three remaining viable populations in the county.

Important management actions include the following: the maintenance and restoration of sufficient habitat to allow viable populations, conducting surveys for crocodiles and nests in all major waterbodies, protecting crocodile nesting and basking sites from disturbance, excluding cattle from breeding sites during the nesting season, preventing crocodile killings and the destruction of nesting sites, minimising negative interactions between crocodiles and local communities through the construction of "safe areas" for lake users and livestock, implementing awareness and educational programmes and removing potential problem crocodiles, minimising conflict between crocodiles and tourists through prominent signage, pamphlets and the capturing of potential problem animals, investigating methods to enhance the value of crocodiles to neighbouring communities and implementing a programme where communities receive benefits from living with crocodiles. All management actions are underpinned by scientific research.

This management strategy is directed to ensuring the long-term conservation of *C. niloticus* and their habitats in the Greater St Lucia Wetland Park World Heritage Site in partnership with neighbouring communities, who are fundamental to the success of this programme.

Two New Diseases: Chlamydiosis In *C. porosus* And Atypical Pox In *C. niloticus.*

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1. Chlamydiosis

Outbreaks of chlamydiosis have previously been reported in farmed Nile crocodiles in Southern Africa, either in the form of acute hepatitis or as chronic conjunctivitis (Huchzermeyer *et al.* 1994). In 2003 and 2004 very high mortality occurred in young Indo-Pacific crocodiles on a farm in Papua New Guinea (Fig. 1). During an investigation carried out in December 2004, 102 postmortem examinations were performed. Most of the examined crocodiles suffered jointly from conjunctivitis and an acute hepatitis (Fig. 2) associated with splenomegaly and swollen pharyngeal tonsils. Histopathological examination of liver specimens from these cases showed the presence of chlamydial colonies in the hepatocytes (Fig. 3).

After the introduction of strict hygienic measures together with a treatment with tetracycline, the mortality rapidly declined to the level of preceding years (Fig. 1).

2. Atypical pox

The literature on crocodile pox virus outbreaks in crocodiles and caimans has been reviewed by Huchzermeyer (2003). Winter sores in farmed Nile crocodiles (Fig. 4) were reported by Huchzermeyer (1996). Small pithole lesions in Nile crocodile skins were described by Huchzermeyer and Putterill (2004). Gerdes (1991) described the morphology of the crocodile pox virion. The genome of the crocodile pox virus from Zimbabwe Nile crocodiles was sequenced by Afonso *et al*. (2006). A thorough histopahological investigation of the lesions in the above mentioned conditions revealed the presence of discrete pox-like formations including inclusion bodies (Bollinger bodies) (Fig. 5) and a tendency of the affected epidermis cells to form column which penetrate into the depth of the dermis (Fig. 6). Electonmicroscopical examination of scrapings from such lesions showed that they contained morphologically identifiable poxvirus particles (Fig. 7). DNA was extracted from virions purified from the pithole lesion material. A 550 bp region of the viral genome was PCR-amplified using the sequence data of a unique region (contained within open reading frame 19) of the Zimbabwe crocodile pox virus for primer design. The amplification product was then sequenced (ABI sequencer) and compared with the Zimbabwe crocodile pox virus genomic sequence and was found to contain one additional nucleotide and seven substitutions. This virus appears to be responsible for a range of damaging skin conditions in Nile crocodiles and possibly also in other crocodilian species.
Strict hygienic measures (cleaning and disinfection of the indoors pens) led to a drastic reduction of the incidence of the associated lesions and thereby to an improvement of skin quality.

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Gross Pathology In The Long Bones Of Farmed And Wild Crocodiles.

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Stress-associated bone pathology in Nile crocodiles has been reported by Huchzermeyer (2002; 2003). Three cases of combined fibrous osteodystrophy, osteochondrosis and osteoporosis in adult and subadult *Crocodylus intermedius* and *C. acutus* were described by Blanco (1997). A detailed description of the morphology of the normal humerus does apparently not exist. The present study is based on a collection of bones from routine postmortem examinations of juvenile and adult farmed as well as adult wild Nile crocodiles, consisting of 26 humeri, 3 femora, 9 radii and 7 ulnae (Fig. 1) which were obtained by removing the soft tissues after boiling the legs. The humeri ranged in length from 21 to 220 mm.

The long bones consist of a proximal and a distal head and between the two the hollow shaft, the outer cortex around the inner marrow cavity. In the proximal third of the cranio-lateral aspect of the humerus is situated the prominent *tuberositas deltoidea* (Fig. 2). The area where the shaft joints the proximal and distal heads, practically always shows signs of active remodeling (Fig. 3). Here severe loss of bone substance is seen most often (osteoporosis) (Fig. 4). In advanced cases of osteoporosis there is also a collapse of the surface of the articulation (osteoarthrosis) (Fig. 5). Occasionally a slight bending of the shaft was seen (Fig. 6) or a slight rotation around the longitudinal axis (Fig.7). A small group of ulnae and radii showed a swelling of the shaft together in one case with the collapse of proximal joint surface (Fig. 8).

Osteoporosis and osteoarthrosis are degenerative processes caused by loss of calcium during severe and chronic stress. It is believed that increased blood levels of corticosteroids lead to an excessive excretion of calcium via the urine. This calcium is taken out of the active remodeling zones of the bone. Bending and rotation of the shafts could have happened earlier during a phase of nutritional osteomalacia (Huchzermeyer, 1986). However, no cases of active osteomalacia were seen in the present study. The swelling of the shaft could have been caused by an inflammation (osteitis, osteomyelitis). Generally the severity of the degenerative lesions increased with the size of the bones (age of the animal).

For most of the bones in this study the correspondent leg has been preserved in formalin for future histopathological study.

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The Gharial Report - India

Janaki Lenin; Romulus Withaker

P.O. Box 21, Chengalpattu 603001, India

Summary: Katerniaghat Wildlife Sanctuary is less than 5 km of gharial habitat in the State of Uttar Preadesh. Despite being a fragile and vulnerable habitat, sustains the most significant gharial population outside Chambal River with about 50-60 adults. Enforcement of wildlife laws is effective with boat patrols every morning and evening. The threats include illegal fishing, disturbance at basking and nesting sites by humans and livestock.

Son Gharial Sanctuary is 160 km of gharial habitat in the State of Madhya Pradesh. Two gharial nests were found in 2006 for the first time in 30 years. Recommendations for this Sanctuary include no further releases of gharial and intensive monitoring. Its long term sustainability lies in expanding its limits upto the State's border with Uttar Pradesh.

National Chambal River Sanctuary is thought to be the last stronghold of the gharial. It has been the focus of several decades of gharial conservation and re-stocking programs. The gharial population suffered a more than 75% crash between 1998 and 2006.

The causes for this decline are: (in order of decreasing severity):
Total lack of enforcement and political will, fishing, agriculture, sand mining, water extraction, turtle poaching and banditry & harassment of enforcement personnel.

Conservation Action Needed to get Gharial conservation back on track:

1. Focus on 5 countries – India, Nepal, Pakistan, Bangladesh and Bhutan
2. Enforcement and political will
3. Survey habitats in 5 countries
4. Captive rearing facilities to be upgraded in Phuentsholing, Bhutan.
5. Community participation in gharial conservation
6. Alternate livelihood options for poachers in Chambal, Son and Nepal.
7. Education and awareness – for Locals and Outsiders.
8. Enforcement of fishing and turtle poaching ban will stem the mortality rate.
9. Assess threats from dams and fishing in Nepal.

Workshops reports

CSG Industry Committee Workshop And Pane Discussion

(20 june 2006)

The CSG Industry Committee met in Montelimar with Don Ashley, Y. Takehara, M Sakamoto, E. Chiesa and T. Kralle present.

The primary focus of discussions were on the importance to pass the California bill to clearly legalize the sale of alligator and crocodile in that state and avoid confusion of exporters. (note: The California bill has passed and was signed by the Governor on September 29 which is effective January 1, 2007). The harmonization of the CITES Personal Effects Resolution was also discussed as a top priority and the Committee recognized the adoption by the European Union to harmonize legislation so all 26 EU member countries accept up to 4 crocodilian products as personal effects. Discussions continued with Japan to consider ways the Personal Effects Resolution could be implemented in that country, which committee members felt was important before retailers worldwide, would widely promote the personal effects exemption. In general the Industry Committee members felt all efforts to further streamline CITES permitting and expedite port inspections were important to the business. An updated CITES ID Manual for use by the trade, Customs and port inspectors continued as a priority along with support for compliance and enforcement initiatives that enure the crocodilian trade is legal, sustainable, verifiable and perhaps someday, certifiable.

Finally the work to enhance conservation education by removing more negative trade messages and replacing with positive images of sustainable use benefits to people and wildlife should be a continuing commitment. With world trade in classics reaching 600,000 skins in 2004 and exceeding 1.3 million skins a year including caiman, the Industry Committee felt it was important to better tell the "Marsh to Market" conservation success story of crocodilians.

Veterinary Workshop

(20 june 2006)

Fritz Huchzermeyer

The following delegates were invited to join the group:
Terry Cullen, Sam Seashole, Manuel Muniz and Maria paz Lopez.
The terms of reference were decided to be:
1 - Reduction of rearing mortality
2 - Improvement of skin quality
3 - Prevention of the spread of contagious diseases

The poxviruses and chlamydiosis were discussed in detail. It was decided to establish a monitoring network, to inform each other of new outbreaks and other new developments.

A detailed discussion ensued on the effect of stress on precipitating outbreaks of disease and in particular of the mechanisms of stress septicaemia.

Skin Quality Workshop

(21 june 2006)

Fritz Huchzermeyer

The workshop was attended by nine delegates. Fritz reported on progress with his work on the causative agent of a range of skin conditions in several crocodilian species. The conditions include pit holes, pix, brown spot, winter sores, tail necrosis and dermatitis on the underside of legs. All have a similar histopathology like the one proven to be associated with the pit holes in Nile crocodiles. It was decided to co-operate to confirm or otherwise this assumption and to find optimal solutions for the prevention and treatment of these conditions and also possibly get more work done on the DNA sequencing of the other crocodile poxviruses.

Further it was determined that the second condition of great concern is wrinkling or crinkling of the skin. Several hypotheses were put forward and here also it was decided to co-operate with the collection of data and later with possible laboratory investigation.

Fritz Huchzermeyer is to collect data and to co-ordinate the work on the above infectious skin conditions and Sally Isberg to do the same for wrinkling.

CSG's Tomistoma Task Force Workshop

(20 june 2006)

Ralf sommerlad

Participants: Oliver Arnoult (Act for Nature, Monaco), Markus Baur (Munich University, Germany), John Bendon (IUCN/SSC Iguana Specialist Group), Christian Buchert (DGHT AG Krokodile, Switzerland), Terry Cullen (The Cullen Vivarium Wildlife Conservancy, USA), Peter Dollinger (WAZA - Director, Switzerland), Gonzalo Fernandez-Hoyo (Tomistoma ESB-Koordinator, Fungirola Zoo), Bernadett Lapis (Research Institute for Fisheries, Agriculture and Irrigation, Hungary), Akira Matsuda (CSG-TTF), Pavel Moucha (General Curator Dvur Kralove Zoo, Czech Republic), Miroslav Prochazka (private keeper and Tomistoma Foundation, Czech Republic), Ivan Rehak (Chair EAZA Amphibien/Reptile TAG, Prague Zoo, Czech Republic), Katarina Rehakova (Prague,, Czech Republic), Uwe Ringelhan (DGHT AG Krokodile, Germany), Sam Seashole (Alligator Adventure, USA), Boyd Simpson (CSG-TTF), Ralf Sommerlad (CSG-TTF), Joe Wasilewski (CSG-TTF), Uthen Youngprapakorn (CSG-TTF).

The workshop was opened with the presentation of a report on activities of the CSG Tomistoma Task Force over the past few years. This included a summary of fund-raising activities and the completion of status surveys in West Kalimantan (2004) and Central Kalimantan (2005). Priorities for conservation action by CSG-TTF were also presented.

A very open brainstorming discussion was held regarding future priorities for conservation action. This included discussions on the need to create sustainable funding for continuation of the CSG-TTF's ongoing initiatives.

Some attendants proposed the purchase of large tracts of peat swamp forest in which Tomistoma still exist for the purpose of creating additional conservation areas. The participants supported the planning and organization of future surveys by Mark Bezuijen in Sumatra, as previously undertaken by Wildlife Management International. These could include follow up surveys of the Merang River and at Berbak National Park along with surveys considered to be a higher priority by CSG-TTF (i.e. the remaining swamp forest in Sumatra where no previous surveys have been conducted). Status surveys for Peninsular Malaysia were also discussed. Terry Cullen, who reported that he has visited this region in the past to observe wild Tomistoma, has offered $USD5000 towards the funding of a survey which would be conducted by Boyd Simpson. The TTF Chair thanked Terry Cullen for this generous offer, which was gladly accepted.

Status surveys in Peninsular Malaysia along with the continuation of surveys in Kalimantan and Sarawak are a high priority for CSG-TTF.

EAZA-ARTAG Chair Ivan Rehak will propose a campaign for “Endangered Crocodilians” to the EAZA board. This campaign would include activities conducted over a period of one year and which would involve every EAZA Institution. These campaigns are designed to promote awareness and conservation fundraising have been extremely successful in the past for tigers, turtles, i.e. “Shellshock Campaign,” and most recently for rhinos. Next year EAZA will have a campaign for promoting conservation issues regarding the worldwide amphibian crisis. Ralf Sommerlad will attend the EAZA Meeting in Madrid in October 2006 in order to support Ivan’s proposal.

Oliver Arnault of Act for Nature (in Monaco) offered support by his organization which is working closely which the German Organization ZGAP. This offer of support was gladly accepted as well.

Akira Matsuda will create a listserv to keep the workshop attendants as well as the “Friends of Tomistoma” and “TTF Partners” informed about news and recent activities.

The workshop closed with two very interesting presentations about husbandry and captive breeding of Tomistoma. Gonzalo Fernandez-Hoyo of the Fuengirola Zoo in Spain reported on the first captive breeding of Tomistoma in Europe. Uthen Youngprapakorn reported on the annual reproduction of Tomistoma at the Utairatch Crocodile Farm in Thailand. Uthen currently maintains two large breeding groups of Tomistoma at Utairatch and another enclosure is now under construction for the establishment of a third group. Over 700 Tomistoma have been hatched from eggs laid at this facility. These animals are being reared at Utairatch and they are also being reared at the Samutprakarn Crocodile Farm and Zoo.

Community-Based Crocodilian Conservation Workshop

(22 june 2006)

1. Introduction

1.1. Top-down approaches towards crocodilian conservation

Several threatened crocodilian species survive in small, fragmented populations in developing countries where crocodile conservation approaches have, for various reasons, so far not been very successful in creating possibilities for the protection and recovery of wild populations. Sustainable use and strict protection have often been cited as the most effective methods to conserve these crocodilians. Responsibility for, and decision making authority over, these solutions is generally placed in the hands of national governments. This centralized approach, often characterized as “top-down conservation”, has proved its potential in several countries; its pitfalls are also increasingly becoming clear.

Sustainable use of crocodilians has created benefits from crocodile conservation in various parts of the world. Sustainable use of wild crocodilians however is only possible when a species is not severely threatened. Crocodile farming, captive breeding and reintroduction schemes have been successful in augmenting captive populations and the restocking of historical distribution areas but have in some cases also contributed to a depletion of wild populations, or to problems with hybridization between species. Moreover, they have in some cases also contributed to a focus on *ex situ* crocodilian conservation and taken attention away from *in situ* conservation. Captive populations of several threatened crocodilians (eg. *A. sinensis, C. siamensis, C. mindorensis, C. rhombifer*) are many times larger than wild populations. Skewed political, financial and conservation attention for *ex situ* crocodilian conservation can perhaps be explained by the problems that *in situ* conservation pose: (local) public acceptance, human-crocodilian conflicts, sustainability, and the need for effective law enforcement.

Protected areas for crocodilians and other species are an effective way to protect wild populations. In many developing countries, however, protected area management and environmental law enforcement are seriously hampered by a lack of resources, capacities, a lack of political will, corruption or societal resistance. The lack of successes and the continued decline of wild populations have frustrated (inter)national crocodilian conservation programs in several countries.

1.2. Community-based crocodilian conservation

An alternative or complementary strategy to conserve wild crocodilian populations is to use community-based approaches, often labeled as "bottom-up conservation". Several developing countries (for example Indonesia and the Philippines) are actively experimenting with the decentralization and devolution of power from central governments to local governments, or even village counsels. This offers possibilities for conservationists to work on smaller scales, without the bureaucratic, political and financial constraints of the national level. Local solutions for local problems can sometimes be more effective in dealing with contextual threats to crocodilian populations than national conservation programs.

In developing countries rural communities intensively use and depend on natural resources, especially freshwater wetlands. Critically endangered crocodilians in countries like China, Vietnam, Thailand, Indonesia, the Philippines, or Cuba are threatened by hunting (for food, for trade, for crocodile farms, out of fear, or as pest eradication), unsustainable fishing methods, the disappearance of suitable habitat, and pollution. Population growth will only aggravate these threats in the near future. Top down approaches to address these threats are often ineffective as a result of weak governance.

Centralized management runs the risk of aggravating human-crocodilian conflicts in rural areas where national government policies often have little impact or are regarded as unjust or irrelevant by poor rural communities.

Participation of rural communities and local governments in decision making can create the right conditions for negotiated, generally accepted, legitimate and above all effective crocodilian conservation efforts. Combined with efforts to create tangible benefits from crocodilian conservation these might offer an alternative for failing top down approaches or an addition to supra-local policy frameworks.

1.3. Issues

There are few documented experiences with community-based crocodilian conservation. In order to strengthen these alternative approaches it is important to highlight and document the potentials and difficulties of working with rural communities. There are several issues that need be resolved:

- How to facilitate the functional participation of communities in crocodilian conservation?
- How to make sure there are benefits from crocodilian conservation for local communities and/or local governments, often in the (current) absence of possibilities of sustainable use or creating tourism revenue? How to make sure benefits are equally distributed so they will add to a widespread societal acceptance of crocodilian conservation?
- How to deal with human-crocodile attacks on humans and/or livestock?
- How to make community-based crocodilian conservation sustainable on the long term with the absence of government or continued donor support?
- How to make sure local legislation and policies are being implemented and laws enforced?
- How to create better links between *ex situ* conservation (crocodile farms, zoos) and *in situ* conservation and make sure *ex situ* programs contribute to the conservation of wild crocodilian populations?
- How can education and public awareness campaigns play an important role in creating local support for crocodilian conservation?
- What are the dangers and pitfalls of devolving decision making power and authority to local governments and communities? Is there a need for more checks and balances? How to make sure local crocodilian conservation activities fit in national and regional strategies?

We identified four main questions for the workshop that cover these issues:

1. How to mobilize community support for and community participation in crocodile conservation? (Communication)
2. How to create benefits from and incentives for communities that participate in crocodile conservation? (Incentives)
3. How to deal with human-crocodile conflicts? (Conflicts)
4. How to deal with governance issues such as institutional arrangements, devolution of power, legitimacy, transparency, accountability and sustainability? (Governance)

2. Workshop set up

The workshop was announced at the 18th CSG meeting website from April 2006 onwards. A downloadable document was available with the workshop rationale, goals and set up (edited into the introduction of this report). At the CSG meeting itself the workshop was advertised several times during paper presentation sessions, especially during session 7 (Wednesday) which dealt exclusively with community participation in crocodilian conservation. The workshop was open to anybody, i.e. to participants with personal experience in the subject but also to those who were interested to learn or develop ideas for future projects or who were just curious.

Despite a general lull in activities on Thursday afternoon about 30 people participated.

After a short general introduction on community-based conservation, what it could mean for crocodile conservation and the goals of the workshop, four sub-groups were formed to address the following topics:

1. Governance
2. Creating incentives
3. Mobilizing community support/communication
4. Crocodile-human conflicts

These sub-groups discussed among themselves what the main issues and possible solutions were regarding their specific topic in respect to community-based crocodile conservation. Inputs were noted bullet-type on presentation paper. After about an hour each group presented their output to the entire group. Outputs were briefly discussed. The workshop ended with a short discussion on how to proceed with the outcome (this is the result), on how to progress on information sharing and case history collection of community-based crocodile conservation projects and on the possible role of the CSG in this.

3. Workshop output

3.1. Introduction

The workshop introduction was followed by a short discussion on sustainable use of crocodiles. It was argued that communities need a commercial incentive to accept crocodile conservation and that sustainable use has proven its merits in providing this incentive. Several workshop participants remarked that this is true but that sustainable use of critically endangered species with very low population sizes in the wild is not an option as long as those species are severely threatened. Effective conservation and a recovery of the wild population of these species is a first condition before sustainable use could be considered an option. The workshop goal, as indicated in the rationale of the announcement document, was to especially discuss options for community participation in the conservation of these most threatened species. However, it was also noted that experiences with community participation in sustainable use/conservation projects (eg. Papua New Guinea) could provide important inputs for the development of programs that do not (yet) include sustainable use.

3.2. Output sub-groups

We have tried to summarize the points brought forward by the sub-groups in a systematic matter using log-frames and boxes. As many of the identified issues overlapped between sub-groups, general issues can be derived from them. Table 1 gives an overview of issues (that is problems, constraints, challenges) that were identified in the sub-groups. Issues are grouped below a main descriptive header (Context, Continuity/sustainability, Communication, Capacity, Crocodiles and Implementation). Where possible a general issue is identified from the inputs of the four groups.

Table 1: Issues identified in four sub-groups per main header. Last column shows the general issue if it was possible to define one.

Governance	Incentives	Communication	Conflicts	General issue
		Context		
Ignorance		Myths, misinformation and low opinion on crocs	Perceived threats/fear	Information
Cultural differences Language barriers	Cultural idiosyncrasies			Cultural differences
Lack of social coherence	Benefit sharing			Community organization
Keeping up with change	Changing markets (tourism, skins)			Change
Effective authority	Government stability			Authority
	Legal constraints			Legal issues
Scale	Carrying capacity (eg. tourism)	Two levels: target communities and general public		Scale
		Continuity/sustainability		
Short term commitments	Sustainability of incentive programs Long term vs. short term benefits			Sustainability
Unfulfilled community expectations				
	Link between incentives and crocodiles	Incentives needed to win community support		Incentives
		Communication		
Language barriers				
Differences in worldview/	Local interest and			Local support and participation

Governance	Incentives	Communication	Conflicts	General issue
norms	willingness to participate No control of how community adapts incentive programs			
		Capacity		
Lack of capacity		Conservation projects often do not hire communication specialist		Capacity needs
Accountability Power abuse	Benefit sharing			Accountability
		Crocodiles		
	Conservation status	Threats to crocodiles		Threatened crocodiles
	Increase of crocodile population leading to conflicts		Human injuries & fatalities Losses to livestock and fisheries Disruption to lifestyles/ livelihoods Perceived threats/fear	Human/ crocodile conflicts
		Implementation		
Projects need to be context-specific				Implementation
	Lack of time and funding for incentive projects	Lack of funding for communication programs		Funding
		Lack of case studies,		Cases

Governance	Incentives	Communication	Conflicts	General issue
		experiences and examples		

Key issues that were repeatedly identified as a problem that had to be solved for a community-based crocodile conservation project to succeed were:

Ignorance, misinformation, a low opinion on crocodiles and perceived threats from crocodiles (not to be confused with real threats that some species pose to people and livestock). Obviously these stand in the way of getting support for community-based conservation, but also might hamper getting support from higher authorities/government.

The workshop participants not only identified issues but also came with (ideas) for solutions. These are summarized per general issue (input from all four groups lumped) in Table 2.

Table 2: Suggested solutions to the issues defined during the workshop

General issue	Suggested solutions
Information	Information campaigns education programs: schools, village elders, teachers develop teachers manuals and include crocodiles in formal education system Involve media Search celebrity ambassadors to promote crocodile conservation Involve communities in research activities: - exchange of information
Cultural differences	Build on traditional beliefs/religions Actively solicit suggestions from communities Devolution of decision making to community level
Community organization	Identify key people in a community
Change	Use creativity/flexibility
Authority	Campaign for crocodile conservation at political levels as well Mobilize public (voters) to persuade politicians to put (crocodile) conservation on agenda
Legal issues	

General issue	Suggested solutions
Scale	
Sustainability	
Incentives	See box 1
Local support and participation	Actively solicit suggestions from communities Devolution of decision making to community level Involve communities in research activities: - trust/fun/interest Strive for fairness / sincerity / integrity / openness / trust Respect local knowledge and customs Adapt mutual learning practices Try to create an early win (direct gains) situation
Capacity needs	
Accountability	Look at legitimacy of community actions
Threatened crocodiles	
Human-crocodile conflicts	Education: - conflict avoidance - economic and ecological value of crocodiles Compensation Alternative livelihood development Removal of nuisance crocodiles Sustainable use of crocodiles
Implementation	Start with context specific problem analyses
Funding	Include enough funding for a communication specialist in conservation programs
Cases	Collect information on (un)successful cases as examples to encourage-discourage project activities

Many possibilities to create or enhance incentives for community-based crocodile conservation were put forward. These are summarized in Box 1. A division has been made between direct material (or financial), indirect material and immaterial incentives. The direct material incentives have further been sub-divided in a category where sustainable use is an option and where this is currently (species with extreme low populations) not an option.

Box 1: Possible incentives for community-based crocodile conservation (+ countries where these incentives have been established, based on inputs by participants so not complete)

Direct material

Without possibility of sustainable use

Tourism:

- fee to see crocodiles (South Africa)
- services to visitors (food/accommodation/transport/guides)

Local employment:

- paid researchers/field assistants (Guyana)
- incentives to teachers (Columbia)
- paid rangers/local community protection groups (Venezuela, Cambodia, Philippines)
- paid PA managers

With sustainable use of crocodiles

Ranching

- eggs/hatchlings

Farming

- Direct (share of) proceeds
- collection of food to sell to farms
- Process hides in communities (Venezuela, PNG)

Hunting

- Proceeds of selling of meat and skins
- Transporting services
- Handicraft production of crocodile derived products

Bio-prospecting

- Immune system studies
- insect repellent dung of crocodiles (Cambodia)

Indirect Material

Livelihood options

- link to development aid
- land allocation (Cambodia, Philippines)
- direct link enhancement income generation/food and crocodile conservation (Cambodia)

Provision of educational materials/improvement of general educational possibilities

Improvement of health care

Immaterial

Environmental benefits

- Crocodiles as flagship species of wetland conservation and sustainable fisheries (crocs = fish = food/income) (Philippines)
- Habitat conservation: environmental services (water, flood control, erosion control)

Tourism:

- pride
- local tourism: fun, interest

Empowerment

- better communication/community coherence (Guyana)
- involvement in environmental management
- increased local control over natural resource use
- knowledge how to avoid conflicts with crocodiles/awareness that crocodiles are not dangerous

Involvement of local communities in research activities: education/fun/pride/interest (Guyana, Philippines)

Religious, spiritual, nationalistic, intrinsic values (Philippines, Cambodia, Cuba)

Historical and/or cultural awareness (Venezuela, Cambodia)

The human-crocodile conflict subgroup came with four examples of possibilities to mitigate these conflicts. These are shown in Box 2. Two of these solutions are especially focused with the problem of livestock predation and livelihood (fisheries) disruptions, the other two deal with the direct threat that some crocodile species might pose to humans. Examples of countries are mentioned where programs use these solutions in reality.

Box 2: Examples of human-crocodile conflict mitigation possibilities

1. Aquaculture and alternative fishing methods (eg. India)
2. Changing livestock management practices (eg. Australia)
3. Nuisance crocodile management (eg. USA, Australia, India, Papua New Guinea)
4. Education programs (eg. Cambodia, Australia, Cambodia, Colombia, USA, PNG)

4. How further?

The workshop was by many participants, and by the conveners, considered a success. In two hours an inventory was made of issues that play a role in the establishment and implementation of community-based crocodile conservation projects and solutions were put forward to address these issues. Though there were several very experienced specialists present who contributed much with their actual experience, a two-hour workshop can obviously not be completely inclusive.

This report should therefore be regarded as a first attempt to evaluate the opportunities and constraints that relate to a relatively unexplored field in crocodilian conservation. Many participants have indicated that they would like to see examples of (un)successful crocodile conservation projects that work with communities. Others have asked for guidelines or a blueprint for community-based crocodile conservation. We doubt whether such a blueprint exists; one of the issues defined during the workshop was that local conservation programs need to be context-specific, i.e. would not use a blueprint but would make an assessment of the local situation and work from there in an adaptive manner. But there must be general lessons that can be learned from existing projects, eg. the identified necessity of involving communication specialists to design an effective and comprehensive communication strategy when working with communities.

5. Participants (who noted their names):

Janaki Lenin, Audrey Detoeuf-Boulade, Boris Marioni, John Thorbjarnarson, Jack Cox, Georgina Thomas, Dominic Rodriguez, Kent Vliet, BC Choudhury, Clara Lucia Sierra, Perran Ross, Kevin Wallace, Mitch Eaton, Alison Leslie, Xander Combrink, Paul van Damme, Christin Borgwardt, Rom Whitaker, Jenny Daltry, Jan van der Ploeg, Merlijn van Weerd

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Gharial Workshop

(22 june 2006)

Janaki Lenin (Acting Coordinator, GMTF), Romulus Whitaker (CSG Steering Committee) and Nikhil Whitaker (Chairman, GMTF)

At the 17th CSG Working Meeting in Darwin, Australia, in 2004, a report by R.K. Sharma and D. Basu showed that the gharial (*Gavialis gangeticus*) was in a state of rapid decline and that urgent action was needed. In response, several CSG members formed a task force now named Gharial Multi-Task Force (GMTF). At that time the statement of purpose and objectives was prepared and circulated by the Task Force Chairman, Nikhil Whitaker and the registration and groundwork for a gharial website (http.gavialis.org) was done by Akira Matsuda.

A workshop was organized at the 18th CSG Working Meeting to discuss the gharial situation and to push the GMTF into operation. The workshop was attended by 22 participants (listed below) and was divided into two phases.

Phase I

An update was presented on the current status of the Task Force. The website is due to be up and running very shortly and though sparse at the moment, inputs from various members for the different pages in the site are gradually coming in to be added to the site. It was suggested that a Core Group be formed to guide the activities and achieve the goals of the GMTF and that membership be open to anyone who is interested in the gharial and its conservation.

Tomistoma Task Force Chairman, Ralf Sommerlad mentioned that they generally drop any members who do not communicate or contribute.

The role of the international zoo community was discussed and it was agreed that building up awareness around the world was closely linked to zoo visitors being able to see this wonderful and unique crocodilian. Young, captive-bred gharial will be sent to overseas zoos from Indian crocodile breeding facilities like the Madras Crocodile Bank for this purpose, and in response these zoos and participating individuals have agreed to help raise funds and generate publicity for the GMTF for *in situ* gharial conservation in the range countries.

The workshop discussed urgent measures that need to be taken to try to reverse the decline of the gharial, which is reckoned to be due to:

a) closure of the gharial rehabilitation projects and withdrawal of financial support at the State and Central levels in India several years ago;
b) lack of political will and general disinterest by many of the key authorities in the plight of the gharial and river deterioration in general
c) gharial drowning and deliberately killing and de-snouting in nets by fishermen;
d) recent emergence of an illegal fishing/turtling mafia on the Chambal River;
e) already marginal habitats become less hospitable for gharial due to barrages, dams, canals, siltation, sand mining, water removal for agriculture, livestock and human disturbance at basking and nest beaches; and,
f) in the future, the environmentally disastrous plan to interlink India's major rivers.

Remedial measures include:
a) media blitz and local education programs to raise consciousness about the grave plight of this totally unique crocodilian;
b) restarting the gharial rehabilitation programs in the range states with Central Government support;
c) encouraging the Government of Nepal to revive its gharial rehabilitation project in Chitawan National Park and develop a collaborative program with India, as gharial move across the Nepal/India border;
d) continue and boost the gharial census surveys/monitoring/research in the main habitats, being the Chambal and Girwa in India and Rapti/Narayani in Nepal: scientific presence can be a vital conservation tool;
e) carry out surveys (both to confirm existence of gharial and to assess suitability of habitats for reintroduction in less known gharial habitats including the rivers in Punjab, West Bengal, Assam, Arunachal Pradesh and in the Kingdom of Bhutan, where it was suggested that the royal family be approached for endorsement of an all out effort to reintroduce and protect the gharial there. Since Myanmar once had gharial, it was also suggested that a habitat suitability survey be carried out there. Similar surveys are needed in Pakistan and Bangladesh to ascertain whether it is worthwhile starting rehabilitation schemes there.
f) it was suggested that a full-time, Gharial Conservation Coordinator be designated and funds be found for a salary, to ensure that this urgent work is carried out.

An Action Plan to undertake the remedial measures is in preparation. Like any such plan, it is only worth the paper it is printed on (or the cyber-space it is sent via) unless we all pitch in and do what we can to make it happen, according to our abilities.

Phase II

Because of the grave threat to the survival of the gharial it was deemed necessary to re-list it as "Critically Endangered". The rest of the Gharial Workshop was chaired by Perran Ross and devoted to running through the IUCN Red Data Listing criteria and to determine which criteria the Gharial fits.

After going through the various criteria, the latest census data compared with historical records and with the inputs from members from India and Nepal, it was determined that the gharial probably fits into Criteria A2 – Declining Population and Criteria B1 – Extent of Occurrence.

It was further determined that the gharial definitely fits Criteria C1 – Small Population Size and Decline. This is the concluding sentence from the draft up-listing proposal: "As detailed above in C1, in 2006 there were an estimated 145 breeding adults in the last remaining gharial habitats in India and Nepal. The decline from 302 in 1997 to 145 in 2006 represents a 48% drop across its range, qualifying the gharial, under these criteria, to be listed as Critically Endangered."

Comments will be sought from GMTF and CSG members of a draft up-listing proposal.

Participants: B.C. Choudhury (India), T.M. Maskey (Nepal), Bruno Gattolin (France), Antoine Cadi (France), Ivan Rehak (Czech Republic), Katarina Rehakova (Czech Republic), Janaki Lenin (India), Rom Whitaker (India), Christian Buchert (France), Markus Baur (Germany), Rene Hedigaard (Denmark), Eddy Even (Netherlands), Antoine Joseph (France), Terry Cullen (USA), Jean-Marie Ballouard (France), Ralf Sommerlad (Germany), Akira Matsuda (Japan/Australia), John Thorbjarnarson (USA), Perran Ross (USA), Jack Cox (USA), Sam Seashole (USA), Luc Fougeirol (France).