Gatlin, L. A. and Nail, S. L. (1994). Protein purification process engineering. Freeze drying: A practical overview. *Bioprocess Technol.* (18): 317-367.

Jay, J. M., Loessner, M. J. and Golden, D.A. (2005). Food protection with high temperature, and characteristics of thermophilic microorganisms. Pp. 415-441 *in* Modern food microbiology, 7th ed. SpringerScience+Business Media: New York.

Komiyama, N. H., Miyazaki, G., Tame, J. and Nagai, K. (1995). Transplanting a unique allosteric effect from crocodile into human haemoglobin. *Nature* 373 (6511): 244-246.

Merchant, M., Roche, C., Elsey, R. M. and Prudhomme, J. (2003). Antibacterial properties of serum from the American alligator (*Alligator mississippiensis*). *Comp. Biochem. Physiol., B.* 136: 505-513.

Merchant, M., Thibodeaux, D., Loubser, K. and Elsey, R. M. (2004). Amoebacidal effects of serum from the American alligator (*Alligator mississippiensis*). *J. Parasitol.* 90: 1480-3.

Merchant, M., Pallansch, M., Paulman, R., Wells, J., Nalca, A.and Ptak, R. (2005a). Antiviral activity of serum from the American alligator (*Alligator mississippiensis*). *Antivir. Res.* 66: 35-38.

Merchant, M., Roche, C., Thibodeaux, D. and Elsey, R. M. (2005b). Identification of alternative pathway serum complement activity in the blood of the American alligator (*Alligator mississippiensis*). *Comp. Biochem. Physiol., B.* 141: 281-288.

Merchant, M., Mills, K., Leger, N., Jerkins, E., Vliet, K. A. and McDaniel, N. (2006). Comparisons of innate immune activity of all known living crocodilian species. *Comp. Biochem. Physiol., B.* 143: 133-137.

Siruntawineti, J., Chaeychomsri, W., Vajarasathira, B., Tuntirungkij, M. and Temsiripong, Y. (2003). Complememt Activity of Thai Freshwater Crocodile (*Crocodylus siamensis*) Serum. Pp 1-3, SB-195O *in* Proceeding of the 29th Congress on Science and Technology of Thailand. Khon Kean, Thailand, 20–22 October 2003.

Siruntawineti, J., Chaeychomsri, W., Vajarasathira, B., Ritwichai, A., Ong-aat, T. and Temsiripong, Y. (2004a). Blood Parasites of *Crocodylus siamensis* in Thailand. Pp. 456-460 *in* Proceeding of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Darwin, Australia, 24–29 May 2004. IUCN: Gland.

Siruntawineti, J., Chaeychomsri, W., Vajarasathira, B., Ong-aat, T. and Temsiripong, Y. (2004b). Efficacy of Siamese crocodile (*Crocodylus siamensis*) serum on bacterial growth inhibition. Pp. 465-468 *in* Proceeding of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Darwin, Australia, 24–29 May 2004. IUCN: Gland.

Siruntawineti, J., Chaeychomsri, W., Pokharatsiri, A., Vajarasathira, B., Chitchuankij, N. and Temsiripong, Y. (2004c). Crocodile blood as food supplememt: its effects on hematological values in Wistar rats. Pp 1-3, F0019 *in* Proceeding of the 30th Congress on Science and Technology of Thailand. Bangkok, Thailand, 19-21 October, 2004.

Siruntawineti, J., Chaeychomsri, W., Vajarasathira, B. and Temsiripong, Y. (2005). Evidence for primary immune response to *Salmonella paratyphi* A in Wistar rats after feeding by crocodile blood. Pp 1-3, F0032 *in* Proceeding of the 31st Congress on Science and Technology of Thailand. Nakhon Ratchasima, Thailand, 18-20 October 2005.

Study And Conservation Crocodilians In Africa

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

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.

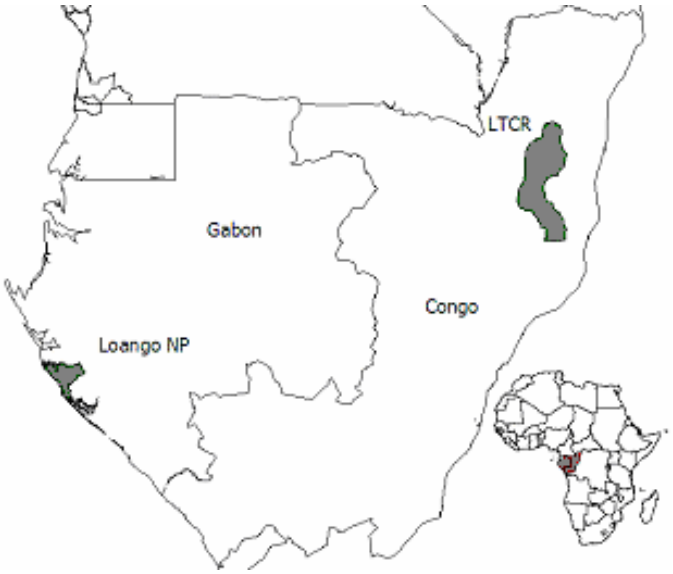

Figure 6: Study sites

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)

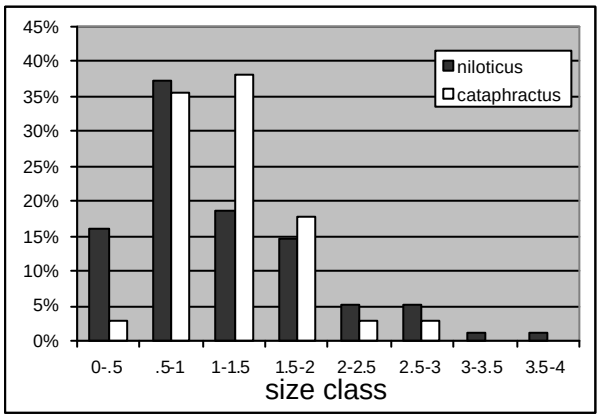

Figure 2: size class distribution of Nile and slender-snouted crocodiles in Loango NP and the LTCR

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.

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).

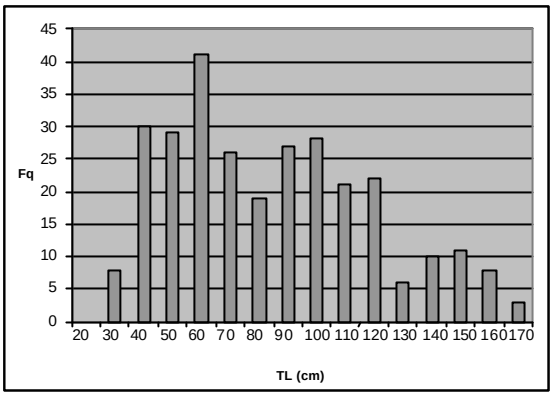

Figure 3: size-class distribution of dwarf crocodiles in the region of Loango NP,

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.

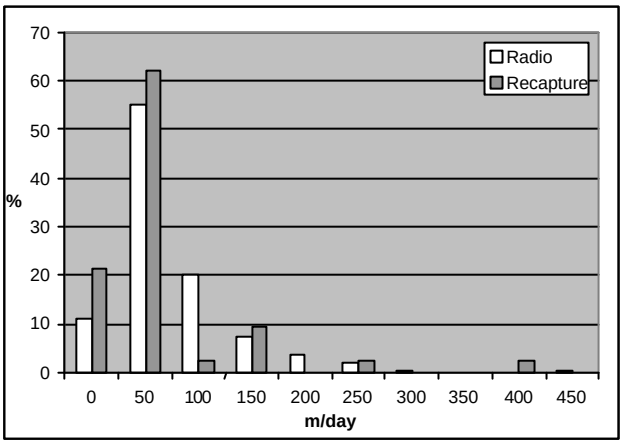

Figure 4: distribution of average daily dwarf crocodile movements based on recaptures and radio-telemetry data from the Louri stream (scaled using percent of frequency)

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.

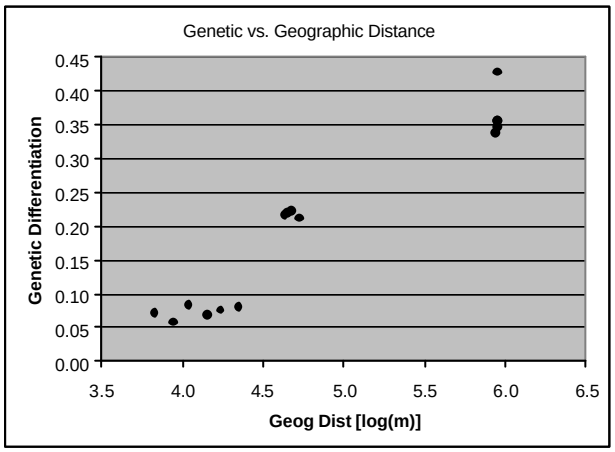

Figure 5: the relationship between geographic distance (straight-line) and average population genetic differentiation for dwarf crocodiles in Gabon and Congo

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.

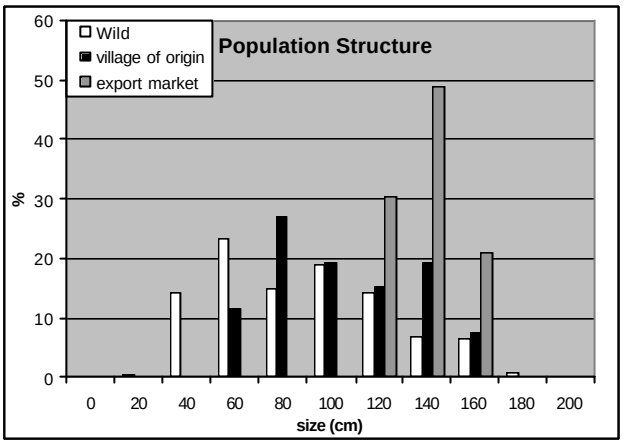

Figure 6: dwarf crocodile size-class distribution comparing wild captures, harvests recorded in local villages (or directly from hunters), and at export markets

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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7. References

Amato, G., Gatesy, J. and Brazaitis, P. 1998. PCR assays of variable nucleotide sites for identification of conservation units: examples from caiman. Pages 177-189 in R. DeSalle and B. Schierwater, eds., *Molecular Evolution: Approaches and Applications*. Birkhauser, Basel, Switzerland.

Behra, O. 1987. Etude de repartition des populations de crocodiles du Congo, du Gabon et de la R.C.A. Parc Zoologique de Paris, Muséum National d'Histoire Naturelle, Paris.

Caswell, H. 2001. *Matrix population models : construction, analysis, and interpretation*. Sunderland, Mass, Sinauer Associates.

Efoakondza, B. 1993. Mensurations, comptage, pesage et commercialization du crocodile nain dans le nord du pays (Congo) *Osteolaemus tetraspis*. WCS, Brazzaville, Congo.

Gatesy, J. and Amato, G. 1992. Sequence similarity of 12S ribosomal segment of mitochondrial DNAs of gharial and false gharial. *Copeia* 1: 241-243.

Gatesy, J., Amato, G., Norell, M., DeSalle, R. and Hayashi, C. 2003. Combined support for wholesale taxic atavism in Gavialine Crocodylians. *Systematic Biology* 52(3): 403-422.

Hutton, J.M. and Woolhouse, M.E.J. 1989. Mark-recapture to assess factors affecting the proportion of a Nile crocodile population seen during spotlight counts at Ngezi Zimbabwe and the use of spotlight counts to monitor crocodile abundance. *Journal of Applied Ecology* 26(2): 381-396.

Jenkins, R.W.G. 1987. The World Conservation Strategy and CITES; principles for the management of crocodilians. Pages 27-31 in G. J. W. Webb, C. Maniolis and P. J. Whitehead, eds., *Wildlife Management: crocodiles and alligators*. Surrey Beatty & Sons, Chipping Norton.

Kendall, W.L. 2001. The robust design for capture-recapture studies: analysis using program MARK. International Wildlife Management Congress.

Kofron, C.P. and Steiner, C. 1994. Observations on the African dwarf crocodile, *Osteolaemus tetraspis*. *Copeia* 1994(2): 533-535.

Lebreton, J.-D. and Clobert, J. 1991. Bird population dynamics, management and conservation: the role of mathematical modelling. Page 105–125 in C. M. Perrins, J.-D. Lebreton and G. J. M. Hirons, eds., *Bird Population Studies*. Oxford University Press, Oxford.

Mueller, U. and Wolfenbarger, L. 1999. AFLP genotyping and fingerprinting. *Trends in Ecology & Evolution* 14: 389-394.

Nichols, J.D. 1987. Population models and crocodile management. Pages 177-187 in G. J. W. Webb, S. C. Manolis and P. J. Whitehead, eds., *Wildlife management: crocodiles and alligators*. Surrey Beatty & Sons, Chipping Norton.

Pauwels, O.S.G., Barr, B., Sanchez, M.L. and Burger, M. 2006. Diet records for the dwarf crocodile *Osteolaemus tetraspis tetraspis* in Rabi oilfields and Loango National Park, southwestern Gabon. *Hamadryad* 31(1): in press.

Pollock, K.H. 1982. A capture-recapture sampling design robust to unequal catchability. *Journal of Wildlife Management* 46: 752-757.

Poulsen, J. and Clark, C. 2002. Feasibility study report of the Lac Tele Community Reserve, Dec 2000 - July 2002. Wildlife Conservation Society, New York. 140 pp.

Salvato, P., Battisti, A., Concato, S., Masutti, L., Patarnello, T. and Zane, L. 2002. Genetic differentiation in the winter pine processionary moth (*Thaumetopoea pityocampa- wilkinsoni* complex), inferred by AFLP and mitochondrial DNA markers. *Molecular Ecology* 11: 2435-2444.

Spencer, R.-J. 2002. Growth patterns of two widely distributed freshwater turtles and a comparison of common methods to estimate age. *Australian Journal of Zoology* 50: 477-490.

Vos, P., Hogers, R., Bleeker, M., Reijans, M., van de Lee, T., Hornes, M., Frilters, A., Pot, J., Peleman, J., Kuiper, M. and Zabeau, M. 1995. AFLP: a new technique for DNA fingerprinting. *Nucleic Acids Research* 23: 4407–4414.

Webb, G.J.W., Buckworth, R. and Maniolis, C. 1983. *Crocodylus johnstoni* in the

McKinlay River area, NT. Growth, movement and the population age structure. *Aust. Wildl. Res* 10: 383-401.
Webb, G.J.W. and Smith, A.M.A. 1987. Life history parameters, population dynamics and the management of crocodilians. Pages 199-210 in G. J. W. Webb, S. C. Manolis and P. J. Whitehead, eds., *Wildlife management: crocodiles and alligators*. Surrey Beatty & Sons, Chipping Norton.
White, P.S. and Densmore, L.D. 2001. DNA sequence alignments and data analysis methods: their effect on the recovery of crocodilian relationships. Pages 29-37 in G. C. Grigg, F. Seebacher and C. E. Franklin, eds., *Crocodilian Biology and Evolution*. Surrey Beatty & Sons, Chipping Norton, Australia.
Wilkie, D.S., Sidle, J.G. and Boundzanga, G.C. 1992. Mechanized logging, market hunting, and a bank loan in Congo. *Conservation Biology* 6: 570-80.

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°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 sahéliens. 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.

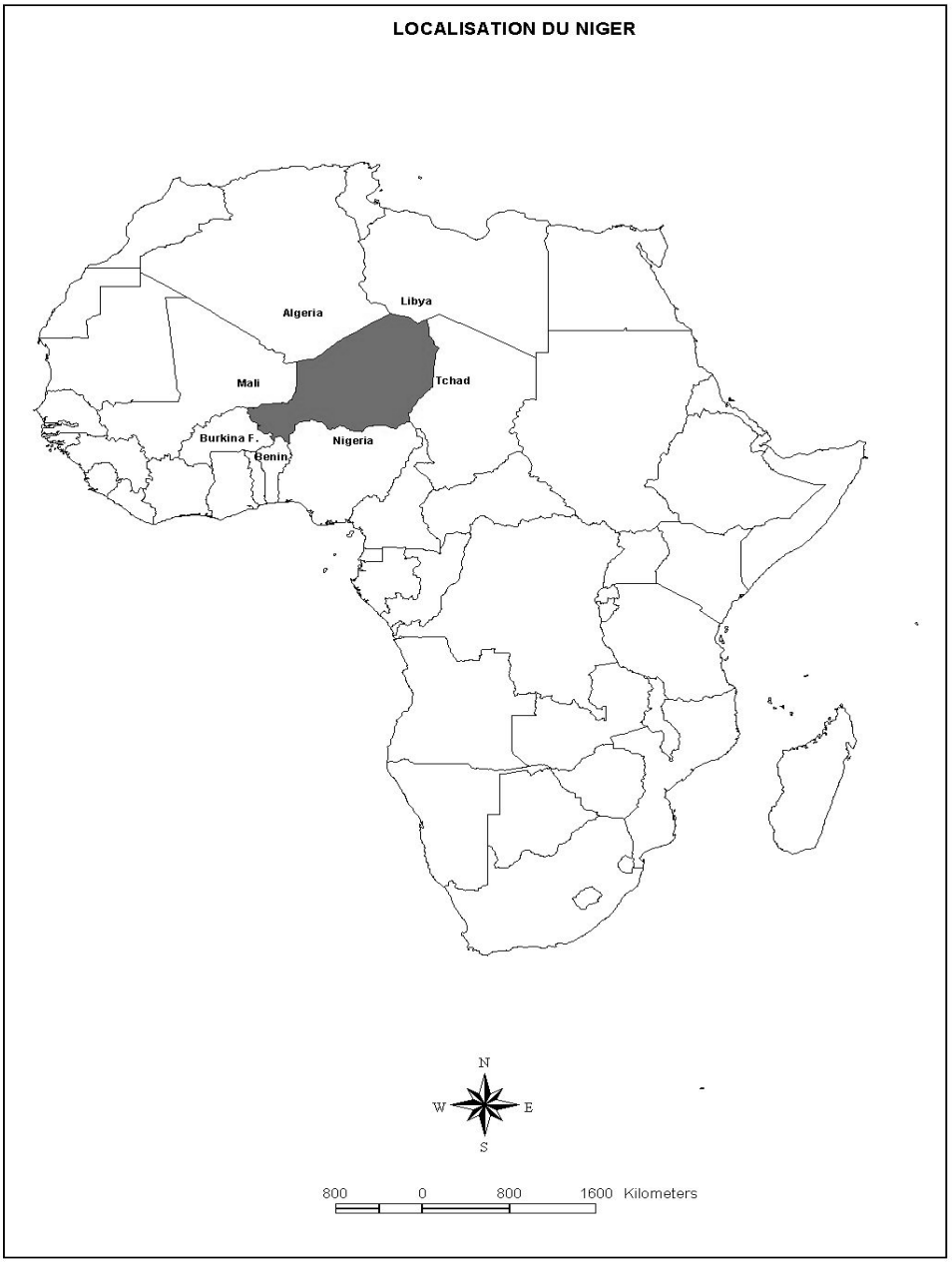
2. Présentation du Niger

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.

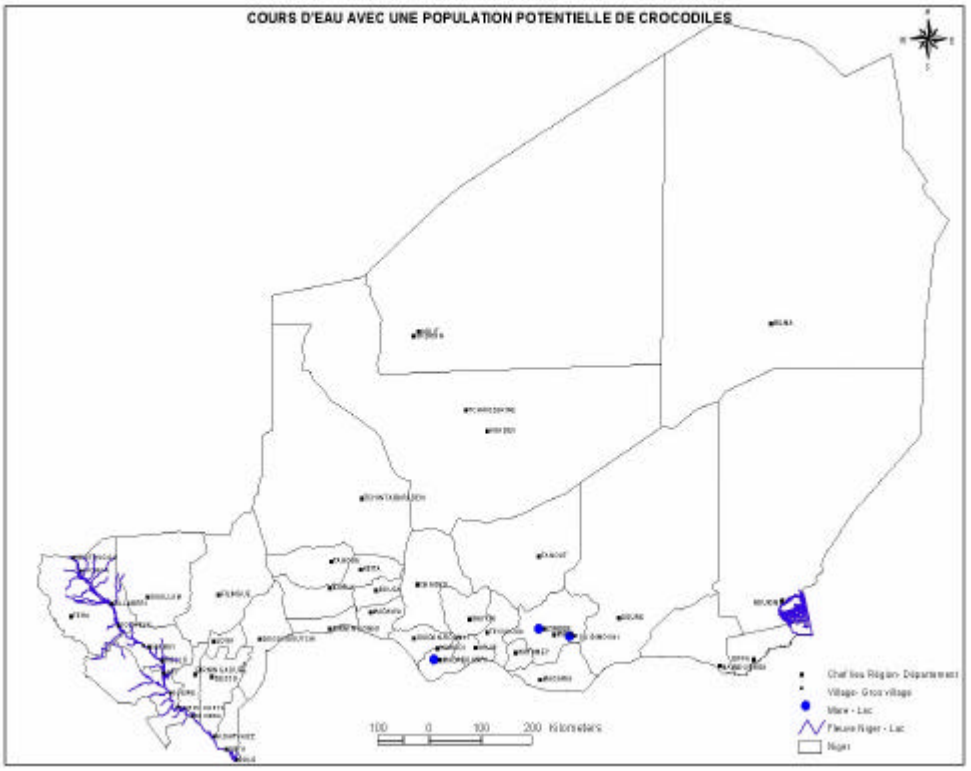
3.4. Localisation du crocodile du Nil au Niger

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

7. Bibliographie

Acte de séminaire, 1989, « la faune Nigérienne », in séminaire atelier sur la faune, DFPP, 47p.

DDE. Z., 1998, situation des crocodiles dans la commune de Zinder, in rapport d'activités, RN, 5p.

Hamissou H. G. 2004, procédure de gestion des aires de conservation, in rapport de stage, 64p.

Ibrahim I.A., 2005, « importance socio-économique de l'élevage du Crocodile dans la vallée du Dendi en république du Niger » in Rapport de stage, Ecole pour la formation de spécialistes de faune, Rep. Du Cameroun ; 26p.
Massalatchi M.S.,1998, état des lieux du crocodile du Nil, in rapport de mission, UICN, 5p.
République du Niger, 2004, Code Rural, Recueil des textes, Secrétariat Permanent, Comité national du Code rural et Ambassade de France au Niger, pp64.

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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12. References

Blake, D. K. 1990. Status of the Nile crocodile in Natal, South Africa – June 1989. Unpublished Internal Report.

Bruton, M. N., 1979. The Amphibians, Reptiles, Birds and Mammals of Lake Sibaya. *In*: B.R. Allanson (ed.), *Lake Sibaya. Monographiae Biologicae 36*, p246-285. Dr. W. Junk bv Publishers, The Hague.

Child, G. & Chitsike, L. 2000. *in* Wildlife Conservation by Sustainable Use. Prins, H. H. T., Grootenhuis, J. G. & Dolan, T. T. (Ed.) Ownership of Wildlife. Kluwer Academic Publishers.

Combrink, A.S., Korrubel, J. L., & ROSS, J.P. 2005. Population Survey of *Crocodylus niloticus* (Nile Crocodile) at Lake Sibaya, Republic of South Africa. University of Natal. Unpublished Masters Thesis.

Hill, B. J. 1979. Bathymetry, morphometry and hydrology of Lake Sibaya. *In*: B.R. Allanson (ed) *Lake Sibaya. Monographiae Biologicae*. (36):34-41. Dr. W. Junk bv Publishers, The Hague.

Hutton, J. M. & Loveridge, J. 1999. Resolving conflicts between crocodiles and man. Version 1. Available on the Internet at:
http://www.resourceafrica.org/documents/1999/1999_nile_crocodiles.pdf

Hutton, J., Ross, J.P. & Webb, G. 2001. Using the Market to Create Incentives for the conservation of Crocodilians: A Review. IUCN/SSC Crocodile Specialist Group.

Jacobsen, N. H. G. & Blake, D. K. 1991. Crocodiles and the Law in South Africa. Unpublished Report.

Kyle, R. 2004. Resource Use in the Indigenous Forests of Maputaland: Are Conservation Strategies Working? *In*: Lawes, M.J., Eeley, H.A.C., Shackleton, C.M. & Geach, B.G.S. (Eds.), Indigenous Forests and Woodlands in South Africa. University of KwaZulu-Natal Press, pp. 713-736.

Leslie, A. J. 1997. Ecology and physiology of the Nile crocodile, *Crocodylus niloticus,* in Lake St Lucia, South Africa. PhD Dissertation. Drexel University, USA.

Mountain, A. 1990. *Paradise under pressure*: St Lucia, Kosi Bay, Sodwana, Lake Sibaya, Maputaland. Southern book publishers, Johannesburg.

Pooley, A. C. 1969. Preliminary studies on the breeding of Nile crocodile *Crocodylus niloticus* in Zululand. Lammergeyer 10: 22-44.

Porter, R., T. & Blackmore, A.C. 1998. *In* St Lucia System, South Africa. Information sheet for the site designated to the List of Wetlands of International Importance in terms of the Convention on Wetlands of International Importance, especially as Waterfowl Habitat. South Africa Wetlands Conservation Programme. KwaZulu-Natal Nature Conservation Service.

Ross, J.P. 1999. Biological Basis for the Sustainable Use of Crocodilians. *In*: Fang, T., O. Montenegro & R. Bodmer (Eds.) Manejo y Conservacion de la Fauna Silvestre en America Latina: 275 – 280.

Ross, J.P. & Godshalk, R. 1994. Sustainable Use, an Incentive for the Conservation of Crocodilians. *In*: La Conservacion y el Manejo de los Caimanes y Cocodrilos de Latin America. A. Larriera & L. Verdade (eds.). Banco Bica Press. Santa Fe.

Taylor, R.H., Conway, T., Dickson, C., Combrink, X., Ferguson, H., Gerber, J. 2006. A Strategy for the Conservation of the Nile crocodile (*Crocodylus niloticus*) in the Greater St Lucia Wetland Park. Version 3.1. Ezemvelo KZN Wildlife Unpublished Internal Report.

Thorbjarnarson, J. 1992. *Crocodiles – An Action plan for their Conservation*. IUCN/SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Tinley, K. L. 1976. The Ecology of Tongaland – A Wildlife Report. The Natal Branch of the Wildlife Society.

Ward, M. C. 1985. Crocodile count at Lake Sibaya – July 1985. Unpublished Internal Report. Bureau of Natural Resources. KwaZulu Natal.

Ward, M. C. 1986. Aerial survey of Lake Sibaya - 1986. Unpublished Internal Report. Bureau of Natural Resources. KwaZulu Natal.

Ward, M. C. 1990. Extract from Lake Sibaya Aerial Survey – July 1990. Unpublished Internal Report No. 11/9/3/2. Bureau of Natural Resources. KwaZulu Natal.

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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

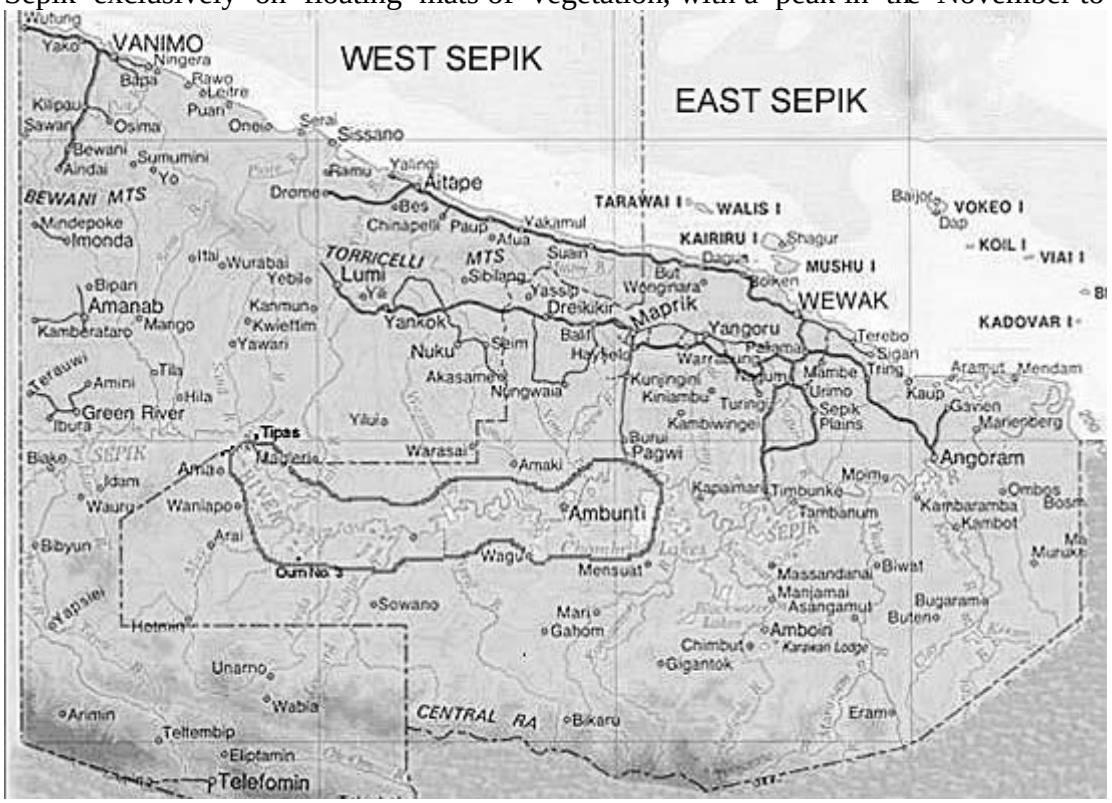

Figure 1. East and West Sepik provinces with outline of egg harvest area.

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).

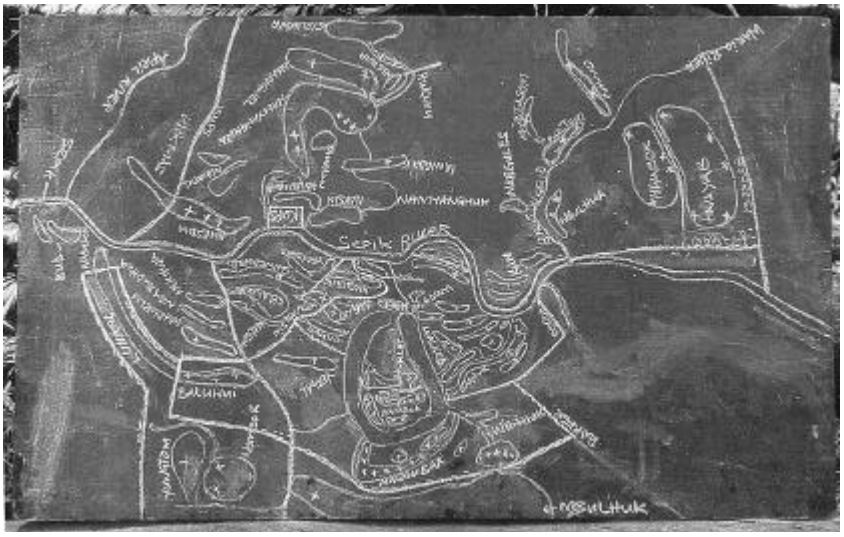

Figure 2. Map of nesting areas in Kubkain village domain.

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.).

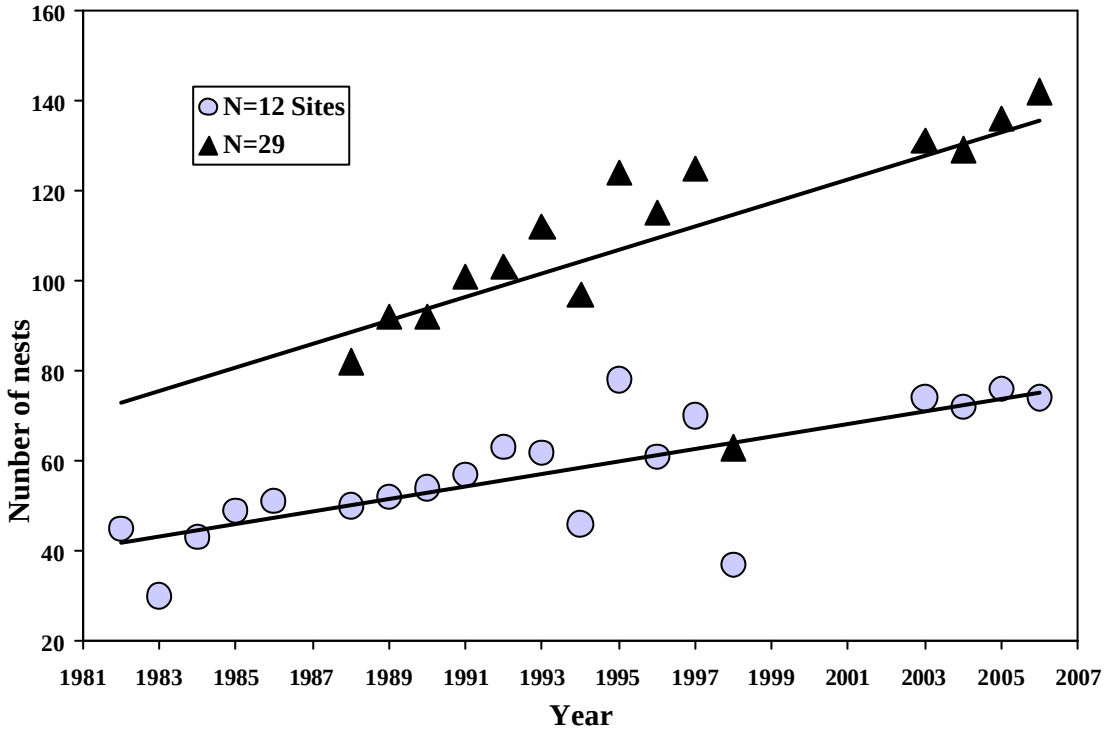

Figure 3. Linear regression of two sets of *C. porosus* nest count data (n=12, n=29) from consistently surveyed sites 1982-2006 and 1988-2006, each showing a trend of significant increase in nesting (p=0.0001 and p=0.003 respectively).

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).

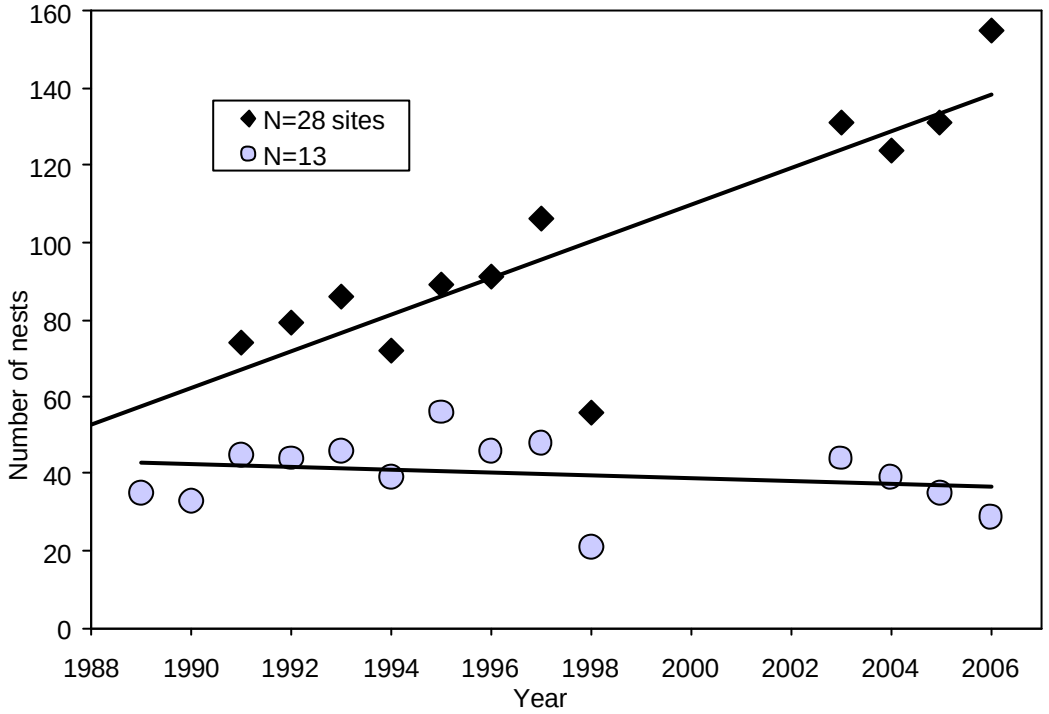

Figure 4: Linear regression of *C. porosus* nest counts at landowner-secure sites (n=28) surveyed consistently 1991-2006 (p=0.000006), and landowner-disputed sites (n=13) surveyed consistently 1989-2006 (p=0.38).

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.

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).

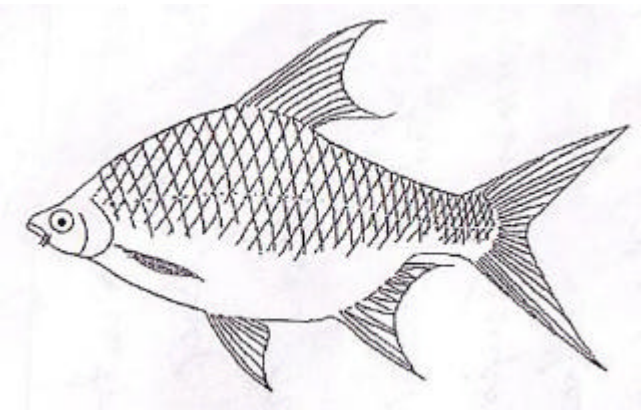

Figure 5. Java carp *Puntius gonionotus*

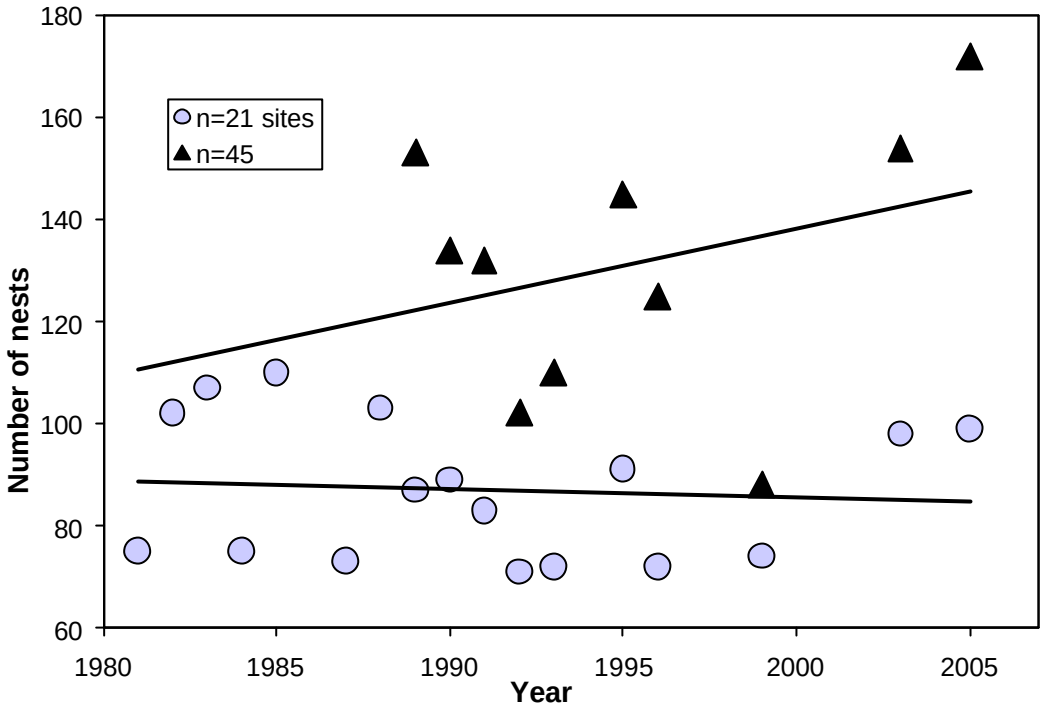

Figure 6. Linear regression of *C. novaeguineae* nest counts at sites surveyed consistently 1981-2005 (n=21) and including additional sites surveyed consistently 1989-2005 (n=45).

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).

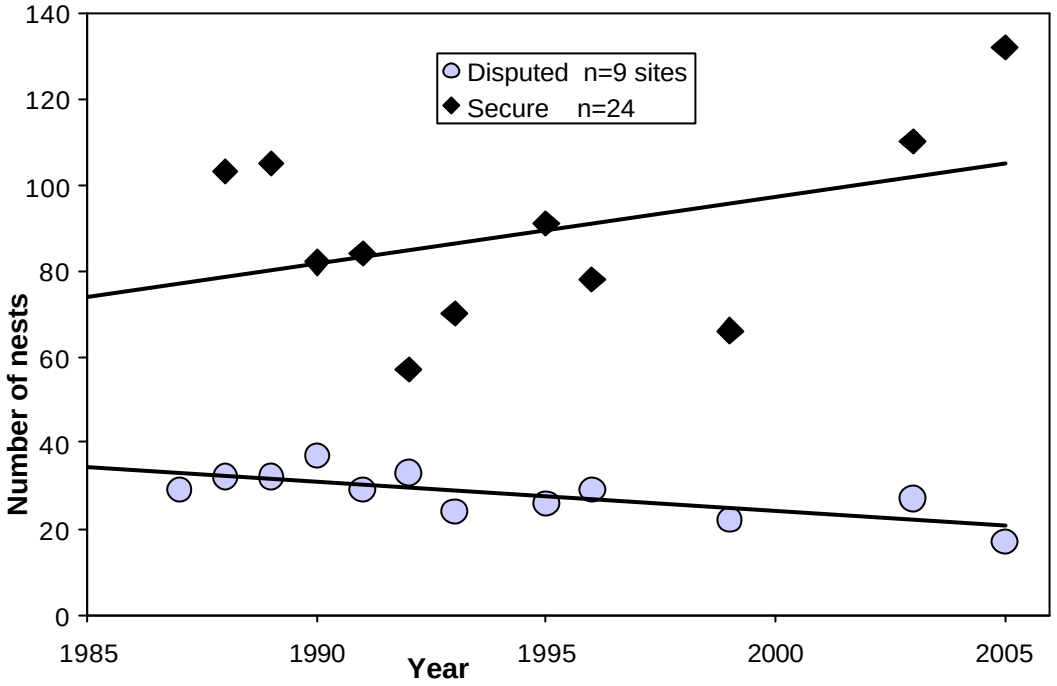

Figure 7. Linear regression of *C. novaeguineae* nest counts at landowner-secure sites (n=24) surveyed consistently 1987-2005 (p=0.23), and landowner-disputed sites (n=9) surveyed consistently 1988-2006 (p=0.006).

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.

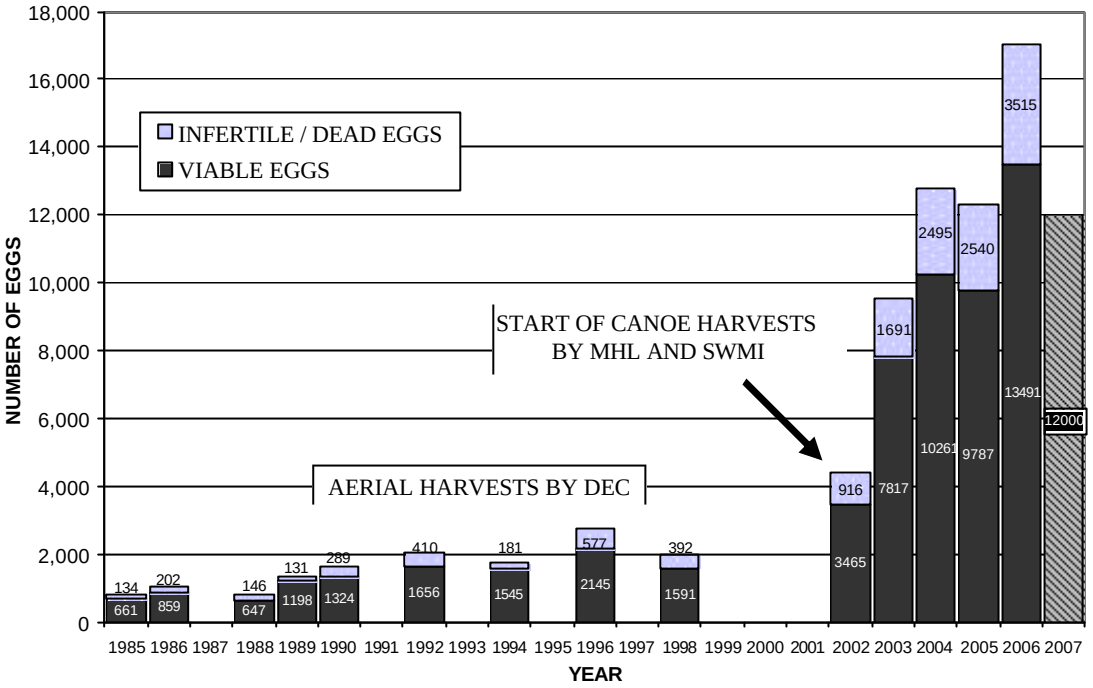

Figure 8. Saltwater crocodile egg harvests in the middle and upper Sepik, 1985-2006.

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.

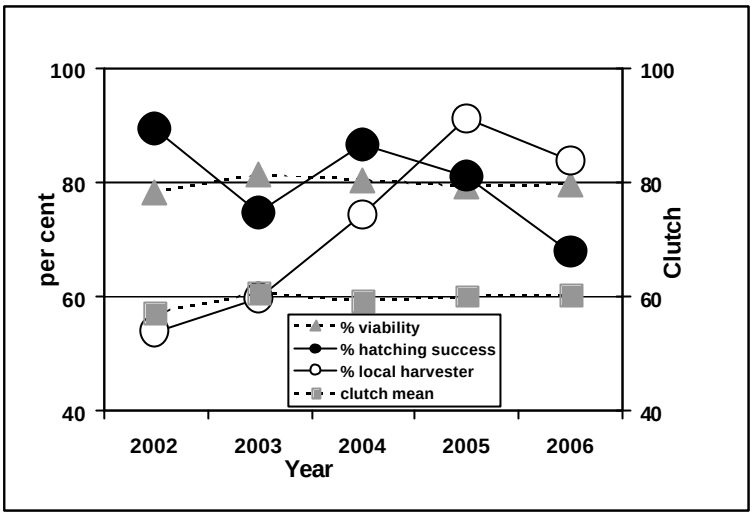

Figure 9. Clutch parameters, hatchability and local participation in recent *C. porosus* egg harvests.

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.				

6. Literature Cited

Chambers, R. 1992. Relaxed and participatory rural appraisal notes on practical approaches and methods. Notes for participants in the workshop held in Chiang Mai on November 19-20, 1992. Social Research Institute. Chiang Mai University, Thailand.

Cox, J., Genolagani, J.-M., Gowep, B., Kula, V., Petasi, I., and Solmu, G. 1994. March 1994 nesting survey of *Crocodylus porosus* in the Sepik River region of Papua New Guinea and an updated review of the saltwater crocodile monitoring program. Technical report to Department of Environment and Conservation. Waigani, PNG.

Cox, J. 1998. Annual survey of *Crocodylus porosus* nesting in the middle Sepik Region, Papua New Guinea 16-22 March 1998. Technical report to Department of Environment and Conservation. Waigani, PNG.

Cox, J. H. 2002. Participatory Rural Appraisal (PRA) techniques for conservation of crocodile nesting habitat in the Middle Sepik. Technical report no. 1. GEF Small Grant PNG/98/G52 07/OP2. UNDP. Port Moresby.

Cox, J. H. 2005. The crocodile egg harvest programme in Papa New Guinea: Mainland Holdings links commerce, conservation and community development. Consultancy report to Booker-Tate Ltd. and Mainland Holdings Ltd. Lae, PNG.

Cox, J. H. and G. Solmu. 1996. Crocodile Egg Harvests as an Effective Conservation Tool: the Papua New Guinea Experience 1985-1996. Pp. 396-409 in Proceedings of the 13th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Santa Fe, Argentina, 13-17 May 1996. IUCN: Gland.

Cox, J. and Solmu, G. C. 2002. Community-driven conservation of crocodile habitat in the Middle Sepik region, Papua New Guinea. Pp. 257-265 in Proceedings of the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Gainesville, Florida, USA, 7-10 October 2002. IUCN: Gland.

Downes, M. 1978. An explanation of the national policy for the crocodile programme. Wildlife Division publication 79/10. Waigani, PNG.

Elsey, R. M. and Kinler, N. 2004. Louisiana's alligator program: adapting management as populations recover and risk of unsustainable use decreases. Pp. 92-101 in Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Darwin, Australia, 23-30 May 2004. IUCN: Gland.

Genolagani, J-M. and Wilmot, J. M. 1988. The status of crocodile populations in Papua New Guinea. 1981-1988. Pp. 122-150 in Proceedings of the 10th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Gainesville, Florida, 23-27 August 1990. IUCN: Gland.

Genolagani, J-M. and Wilmot, J. M. 1990. Status of *Crocodylus porosus* and *C. novaeguineae* populations in Papua New Guinea: 1981-1990. Pp. 23-27 in Proceedings of the 10th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Gainesville, Florida, 23-27 August 1990. IUCN: Gland.

Genolagani, J-M. and Cox, J. 1992. March 1992 nesting survey of *Crocodylus porosus* in the Sepik River region of Papua New Guinea and a summary review of the saltwater crocodile monitoring program. Department of Environment and Conservation, Port Moresby.

Grant, N. 1996. Community entry for ICAD projects -- the participatory way. PNG Biodiversity Conservation and Resource Management Programme. Department of Environment and Conservation, UNDP. Port Moresby.

Hollands, M. 1984. The Status of Crocodile Populations in Papua New Guinea. Pp. 1-23 in Proceedings of the 6th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Victoria Falls, Zimbabwe and St. Lucia, South Africa, 19-30 September 1982. IUCN: Gland.

Hollands, M. 1986. A Preliminary Examination of Crocodile Population Trends in Papua New Guinea from 1981-1984. Pp. 219-228 in Proceedings of the 7th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Caracas, Venezuela, 21-28 October 1984. IUCN: Gland.

Kula, V. and J. Meru. (1998). March 1998 nesting survey of *Crocodylus porosus* in the Sepik River region of Papua New Guinea. Field Report No. 1/98. National Crocodile Management Unit, Department of Environment and Conservation. Port Moresby.

Manolis, C. 1995. Monitoring *Crocodylus porosus* nests in Papua New Guinea. A review with recommendations. Wildlife Management International. Karama, NT, Australia.

Olivieri, S. and Hutchinson, C. 1993. Biodiversity Priorities for Papua New Guinea. Annotated map. Conservation International. Washington.

Sepik Wetlands Management Initiative (SWMI). 2006. Interim assistance for community-driven conservation of biologically distinct wetlands in the middle and upper Sepik. Technical Report to WWF-PNG Freshwater Habitat Conservation Programme. Port Moresby.

Sine, R. and Genolagani, J. 2005. After two decades of aerial nest surveys of *Crocodylus porosus* in the Sepik River region, what are the significant implications for Papua New Guinea's international trade and domestic conservation efforts? Report to Department of Environment and Conservation. Waigani, PNG.

Sine, R. and Kula, V. 2006. Status of *Crocodylus porosus* and *C. novaeguineae* in Papua New Guinea after twenty-five yeas (1981-2006) of aerial nesting surveys. In Proceedings of the 18th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Montélimar, France, 19-23 June 2006. IUCN: Gland.

Solmu, G. C. 2002. Participatory Rural Appraisal. A report produced in participation with the Sepik Wetlands Management Initiative. Report to Department of Environment and Conservation. Waigani, PNG.

Solmu, G. C. 2004a. *Crocodylus porosus* nest counts survey in the middle-upper Sepik River region (22nd – 28th March 2004). Report to Department of Environment and Conservation. Waigani, PNG.

Solmu, G. C. 2004b. Status of *Crocodylus porosus* and *Crocodylus novaeguineae* Conservation and Management in Papua New Guinea (1981 – 2004). Pp. 195-203 in Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Darwin, Australia, 23-30 May 2004. IUCN: Gland.

Solmu, G. and Kula, V. 2003. *Crocodylus porosus* annual nests counts surveys in the middle Sepik region of PNG (9th – 15th March 2003). Report to Department of Environment and Conservation. Waigani, PNG.

Swartzendruber, J. F. 1993. Papua Niugini ripot bilong luksave long kamap bilong konsevesen: Tok pisin ripot. Biodiversity Support Program. Landover, Maryland, USA.

Webb, G. J. W. 1991. 'Wise use ' of wildlife. *J. Nat. Hist*. 25: 823-825.

Webb, G. J. W. and C. Manolis 1989. Grahame Webb's Crocodiles of Australia. Reed Books, Frenchs Forest, NSW.

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 individuals.
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.

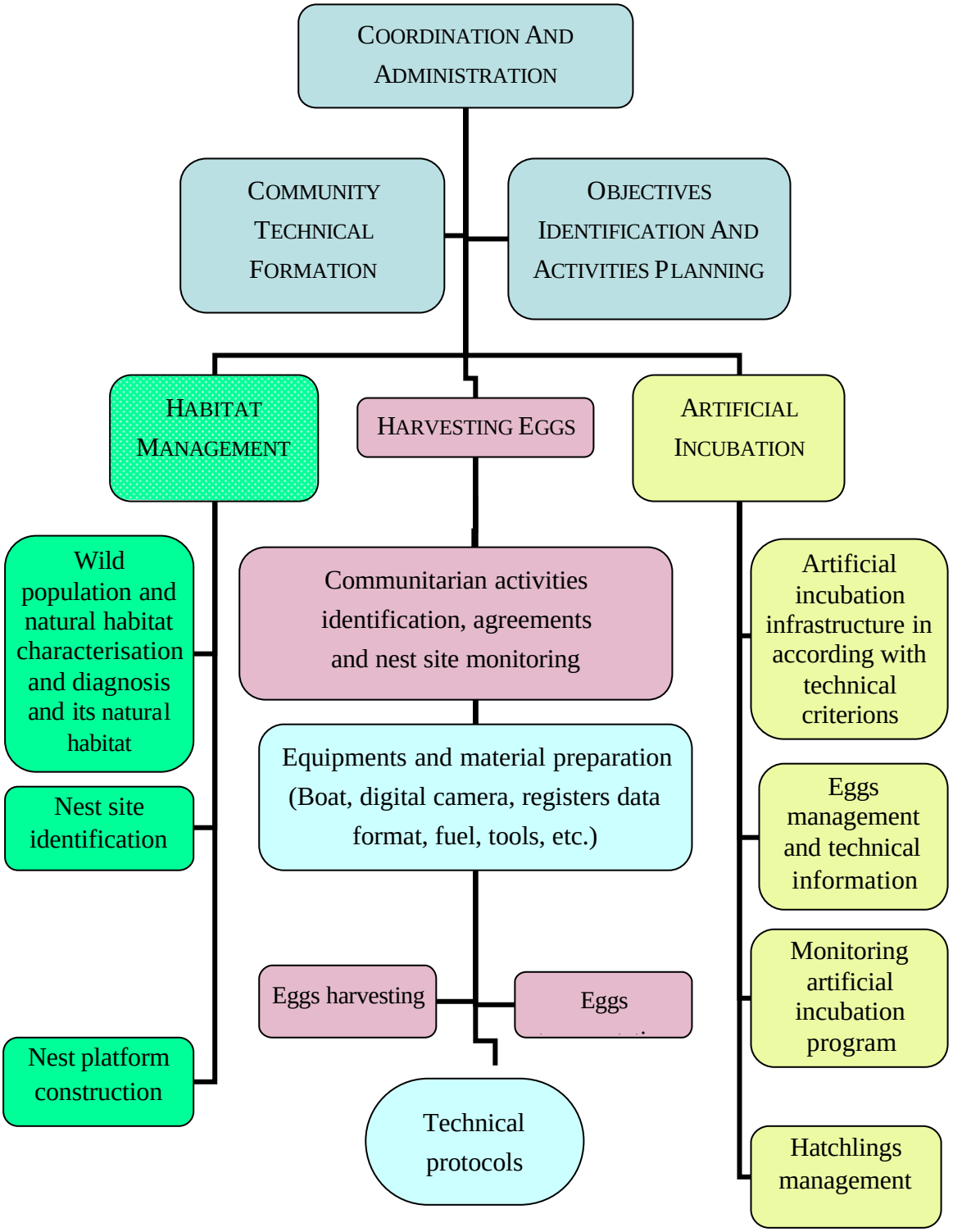
The program is leader by the environmental regional authority –Corporacion Autonoma Regional de los Valles del Sinù y del San Jorge – CVS - and it has been count with the support of Environmental Minister, Alexander von Humboltd Research Institute, Conservation International CI Colombia, Fonade, Nature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

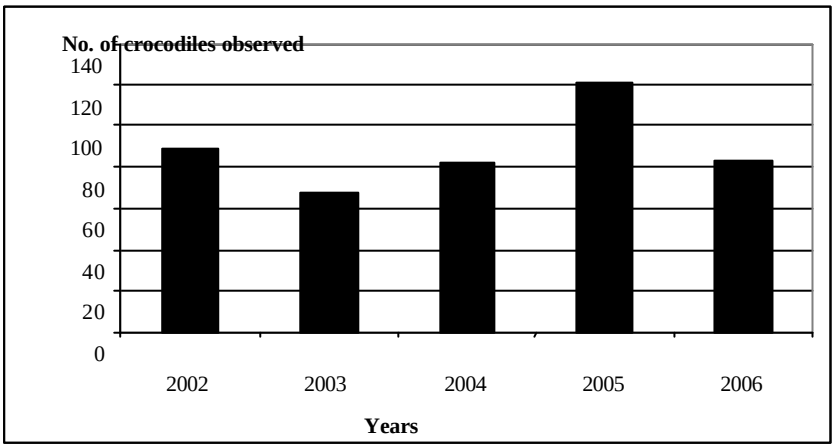


Figure 1. Total number of Crocodylus acutus observed in the Cispatá Bay, during five years. Córdoba -Colombia.

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.

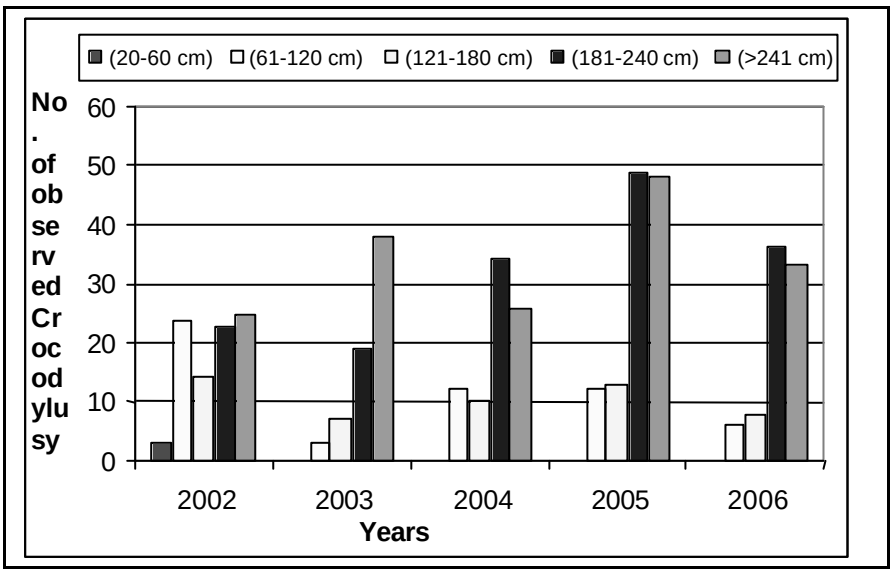


Figure 2. Crocodylus acutus classes frequency distribution observed during 5 years of monitoring program in the Bay of Cispatá, Córdoba, Colombia.

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

5. Bibliography

Ulloa-Delgado & Sierra-Díaz, 2002. Crocodiles and swamps of the bay of Cispatá, Córdoba, Colombia. Report Final Phase I. Characterization and diagnose of the populations of *Crocodylus acutus* Cuvier, 1807 and their natural hábitat. Minambiente, Acofore, OIMT, Foundation Nature, UAESPNN, Agrosoledad and CVS. Cartagena of India, Bolivar. p. 117.

Ulloa-thin & Cavanzo-Ulloa, 2004 Characterization and diagnosis of populations' of *Caiman crocodilus fuscus* and their natural habitat in the Bay of Cispatá, Department of Córdoba. CVS. Colombia, Hunt, 120 p.

Ulloa-Delgado & Sierra-Díaz, 2004. Community training for the conservation of the wild populations of crocodiles at Bay of Cispatá, Department of Córdoba. Final report would consult at Institute of Investigations of Biological Resources, Alexander von Humboldt. Support of the Project Mangroves of Colombia MAVDT-CONIF-OIMT, Regional Autonomous Corporation of the Valleys of the Sinú and of the San Jorge (CVS); and International trading of Leathers C.I. Zobem CORP.

Ulloa-Delgado & Sierra-Díaz, 2005. Experimental pilot project for the conservation of the *Crocodylus acutus* for local communities in the mangroves of the Bay of Cispatá, Córdoba. Final report 2004-2005. Regional Autonomous corporation of the Valleys of the Sinú and of the San Jorge (CVS). Agreement Fonade Not. 193041.

Ulloa-Delgado; Sierra-Díaz & Cavanzo-Ulloa, 2005. Experimental pilot project for the conservation of the *Crocodylus acutus*, in the bay of Cispatá, Córdoba. Report final season of 2003. Conservation International -Colombia. It programs of scholarships Jorge Ignacio Hernández Camacho. Initiative of threatened species.

Ulloa-Delgado & Sierra-Díaz, 2006. Experimental pilot project for the conservation of the *Crocodylus acutus* by local communities in the mangroves of the Bay of Cispatá, Córdoba. Final report 2005-2006. Regional Autonomous corporation of the Valleys of the Sinú and of the San Jorge (CVS). Agreement Fonade No. 193041.

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).

[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).

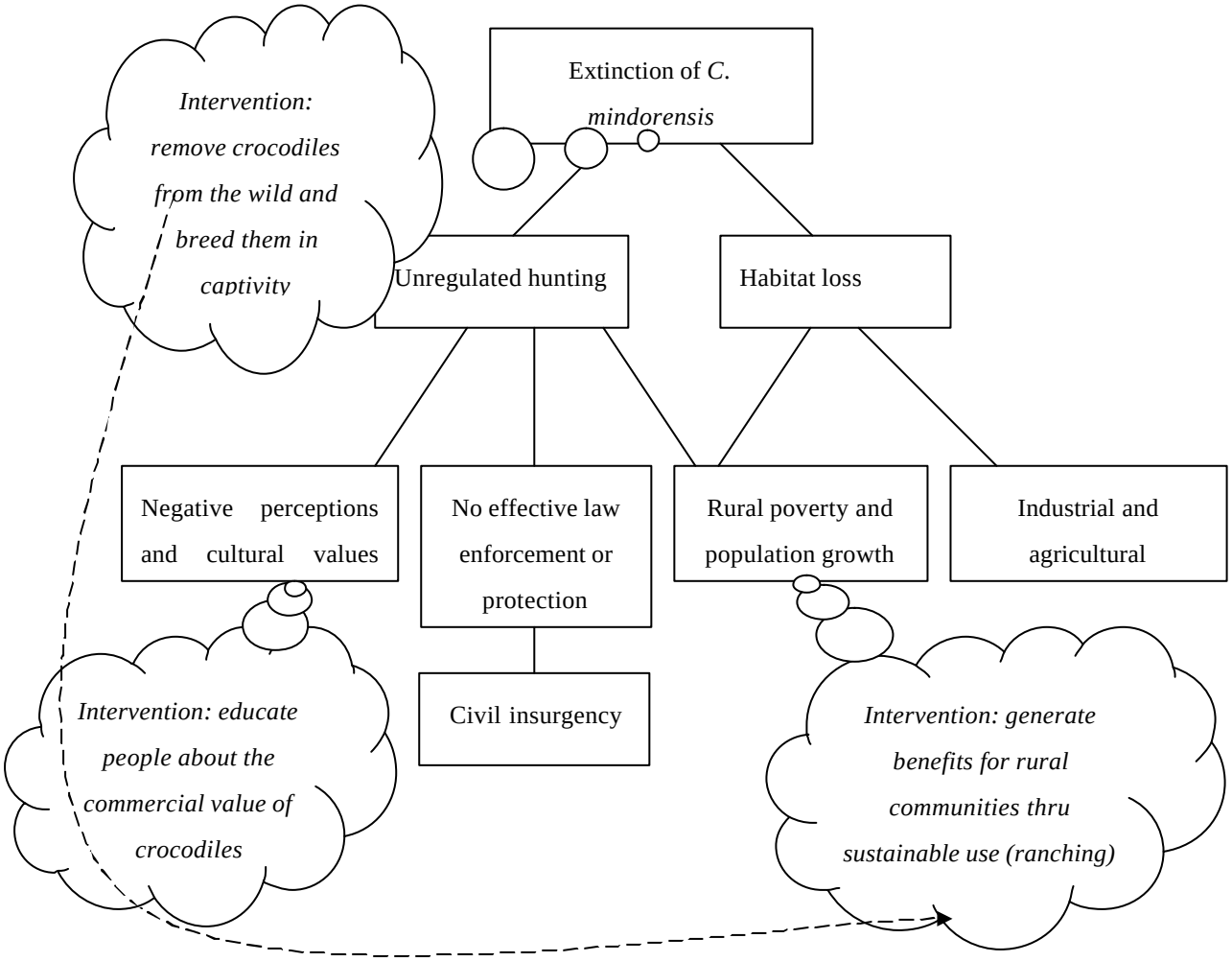
The establishment of crocodile sanctuaries, one of the central aims of CFI, has now been largely abandoned. Several large wetlands were identified by CFI as potential sites where crocodiles could be reintroduced and that could, in the long term, form a base for ranching by local people: the Agusan and 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)

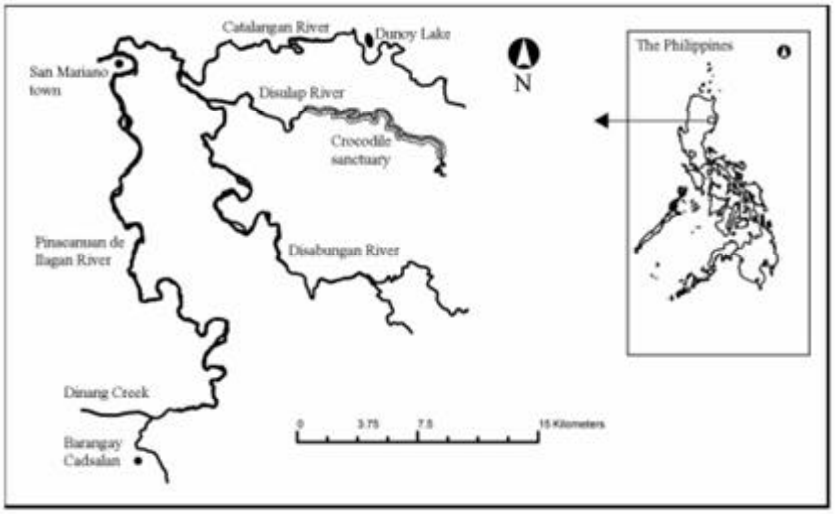


3. The CROC project

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.

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[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).

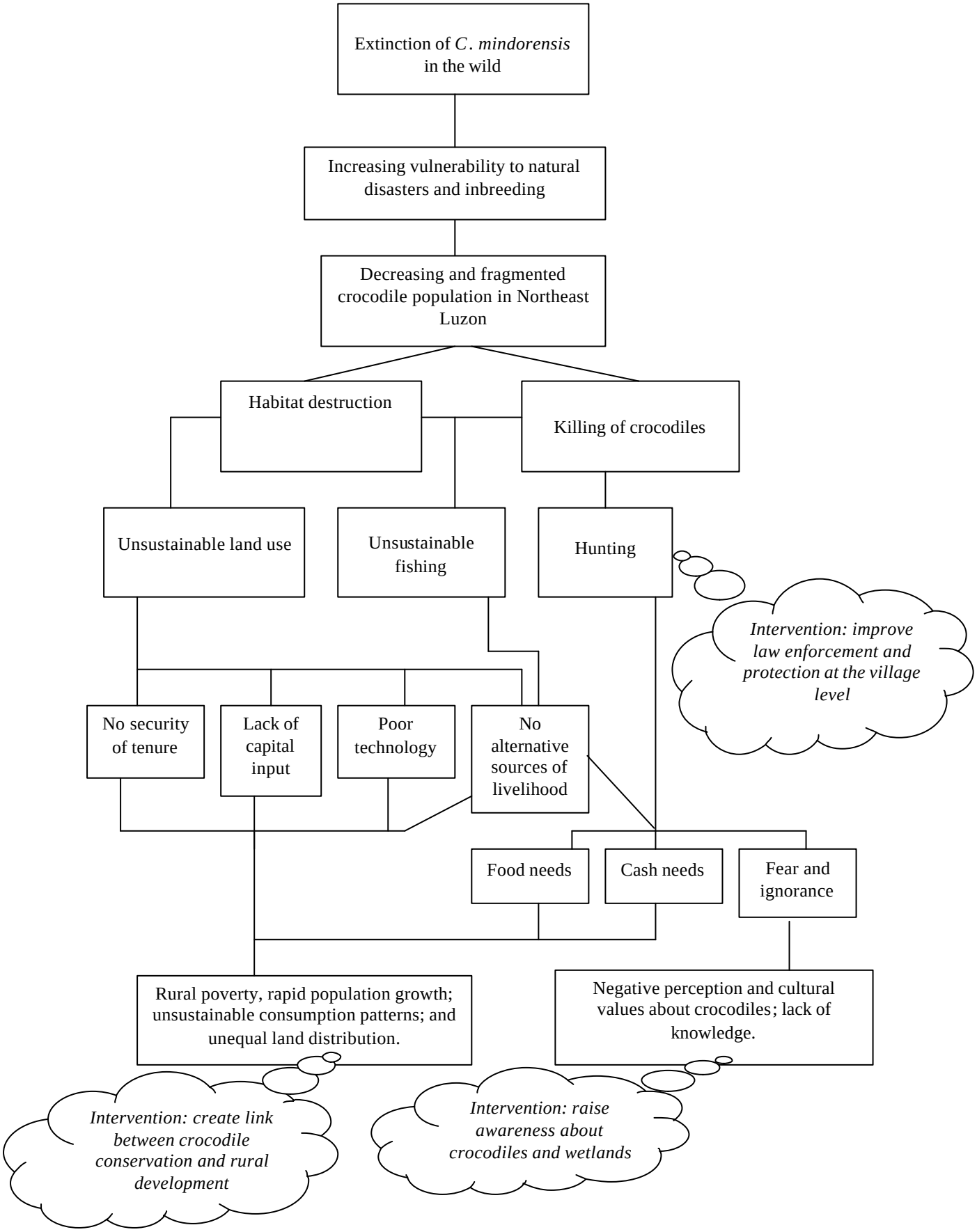
[10] Direct cash benefits can, for example, be generated through ecotourism. However, this is, at present, not a viable option because of the remote location, the absence of facilities and the peace and order concerns. Sustainable use, which generates income for local communities in other countries,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

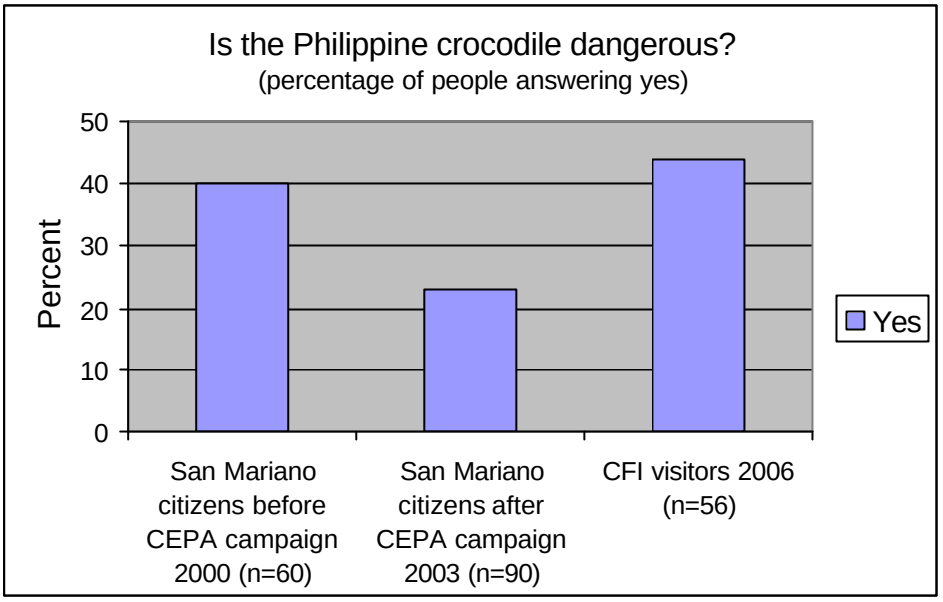
[12] Among the indigenous people of the Philippines crocodiles are often revered and are often considered a symbol of power or male virility.

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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7. References

Banks, C. (comp.) 2005. *National Recovery plan for the Philippine crocodile, Crocodylus mindorensis (2003-2006)*. 2nd edition. DENR and the Royal Melbourne Zoological Gardens, Manila.

Crocodile Faring Institute (CFI). 1995. *The beauty of the beast; conserving crocodiles in the Philippines*. CFI comprehensive report 1987-1995. DENR. Puerto Princesa.

Cureg, M.C, A.M. Bagunu, H.P. Ponce, and J.G. Valencia (eds). 2005. *Strengthening sustainable management of wetlands for the benefit of people and crocodiles in the Sierra Madre*. CROC project. CVPED. Cabagan.

There are no large (opportunity) costs for a particular set of actors because of crocodile conservation. Crocodile sanctuaries are relatively small, and people continue to use the resources in these areas in a sustainable way.

Hines, T.C. and C.L. Abercrombie III. 1987. The management of alligators in Florida, USA. In *Wildlife Management: crocodiles and alligators* edited by G.J.W. Webb, P.J. Whitehead and S.C. Manolis. Surrey Beatty & Sons Pty. Limited. Chipping Norton.

Hollands, M. 1987. The management of crocodiles in Papua New Guinea. In *Wildlife Management: crocodiles and alligators* edited by G.J.W. Webb, P.J. Whitehead and S.C. Manolis. Surrey Beatty & Sons Pty. Limited. Chipping Norton.

Messel, H., F.W. King, G.J.W. Webb and C.A. Ross. 1992. *Summary report on the workshop on the prospects and future strategy of crocodile conservation of the two species (Crocodylus mindorensis, Crocodylus porosus) occurring in the Philippines*. CFI. Puerto Princesa City.

Miranda, J.S.Q., M. van Weerd and J. van der Ploeg. 2004. Devolving crocodile conservation to the local level: the case of Philippine crocodile conservation in the municipality of San Mariano, Northeast Luzon, the Philippines. In: *Crocodiles*. Proceedings of the 17th working meeting of the Crocodile Specialist Group. IUCN, Gland and Cambridge. p. 309-316.

National Statistical Coordination Board (NSBC). 2003. *The Philippine statistical yearbook 2003*. NSBC, Makati.

Ong, P.S., L.E. Afuang & R.G. Rosell-Ambal (eds). 2002. *Philippine biodiversity conservation priorities; a second iteration f the national biodiversity strategy and action plan*. DENR-PAWB, CI, University of the Philippines and FPE. Quezon City.

Ortega. G.V. 1998. Philippine crocodile conservation. Comprehensive report. In: *Crocodiles*. Proceedings of the 14th working meeting o the CSG. IUCN, Gland and Cambridge. p. 101-134.

Ortega, V.G., P.A. Regoniel & M.L.M. Jamerlan. 1993. Philippine crocodiles: their conservation, management and future sustainable use. *The Asian International Journal of Life Sciences*. p 121-139.

Rebong, G. and R.Q. Sumiller 2002. Captive breeding of C. mindorensis at PWRCC. In *Philippine crocodile (Crocodylus mindorensis) conservation workshop* edited by R.C. Lazaro. NMSNP-CP. Plan International. Cabagan.

Regoniel. P.A. 1997. Sexual dimorphism in the Philippine freshwater crocodile (Crocodylus mindorensis Schmidt). *Sylvatrop*. Technical Journal of Philippine Ecosystems and Natural Resources 5 (1&2): 35-43)

Ross, P.J. 1998. *Crocodiles, status survey and conservation action plan*. 2nd edition. IUCN/SSC Crocodile Specialist Group, Gland and Cambridge.

Snyder, N.F.R., S.R. Derrickson, S.R. Beissinger, J.W. Wiley, T.B. Smith, W.D. Toone and B. Miller. 1996. Limitations of captive breeding in endangered species recovery. *Conservation Biology*, Vol. 10, No. 2, p. 338-348.

Tarun, B., J. Guerrero, D. Rodriguez, S. Telan, M. van Weerd and J. van der Ploeg. 2004. The current distribution and population size of the Philippine crocodile and Estuarine crocodile in Northeast Luzon, the Philippines. In: *Crocodiles*. Proceedings of the 17th working meeting of the Crocodile Specialist Group. IUCN, Gland and Cambridge. p. 166-173.

Thorbjarnarson. J. 2005. Philippines. *IUCN Crocodile Specialist Group Newsletter* Vol. 24 (3): 10-12.

Thorbjarnarson, J. 1999. Crocodile tears and skins: international trade, economic constraints, and limits to the sustainable use of crocodilians. *Conservation Biology* Vol. 13 (3): 465-70.

United Nations Environment Program (UNEP) and the Department of Environment and Natural Resources (DENR). 1997. *Philippine biodiversity; An assessment and action plan*. Bookmark, Makati City.

Van der Ploeg, J. & M. van Weerd. 2005. Contested crocodiles? Philippine crocodile conservation and indigenous peoples' rights in the Northern Sierra Madre. In: *The future of the Sierra Madre: responding to social and ecological changes* edited by J. van der Ploeg & A.B. Masipiqueña. CVPED. Golden Press. Tuguegarao. p. 339-362.

Van der Ploeg, J. & M. van Weerd. 2004. Devolution of Natural Resource Management and Crocodile Conservation: The Case of San Mariano, Isabela. In: *Philippine Studies* 52, no. 3 (2004): p. 345-82.

Van Weerd, M. 2002. The status and conservation of the Philippine crocodile Crocodylus mindorensis in the Northern Sierra Madre, Luzon, the Philippines. p. 97-107. In: *Crocodiles*. Proceedings of the 16th working meeting of the Crocodile Specialist Group. IUCN, Gland and Cambridge.

Van Weerd, M. 2000. Update on Philippine crocodile occurrence in the Northern Sierra Madre Natural Park. In: *IUCN Crocodile Specialist Group Newsletter* Vol. 19 (4): p. 12-14.

Van Weerd, M., G. van Boven and J. van der Ploeg. 2004. Using communication to involve local communities and local governments in protected area management: two related cases from Northeast Luzon, Philippines. In: *Communicating Protected Areas* edited by Hamú, D., E. Auchincloss and W. Goldstein. Commission on Education and Communication, IUCN, Gland and Cambridge. p. 139-154.

Van Weerd, M. and J. van der Ploeg. 2004. Conservation of the Philippine crocodile Crocodylus mindorensis in NE Luzon, the Philippines. An update. In: *Crocodiles*. Proceedings of the 17th working meeting of the Crocodile Specialist Group. IUCN, Gland and Cambridge. p. 277-283.

Van Weerd, M. and J. van der Ploeg. 2003. A new future for the Philippine crocodile Crocodylus mindorensis. *Sylvatrop*, the technical journal of Philippine ecosystems and natural resources 13 (1 and 2): p. 31-50.

Van Weerd, M. and A.A. General. 2003. Conserving the Philippine crocodile in the Northern Sierra Madre: the results of three years research and conservation action. Pp. 17-33. In: *The Sierra Madre Mountain Range: Global relevance, local realities* edited by J. van der Ploeg, A.B. Masipiqueña and E.C. Bernardo. CVPED. Golden Press, Tuguegarao.

Webb, G. and C. Manolis 1989. *Australian crocodiles; a natural history*. New Holland Pub. Sydney.

Wildlife Conservation Society of the Philippines (WCSP). 1997. *Philippine red data book*. Bookmark Inc. Makati City.

World Conservation Union (IUCN). 2005. *IUCN Red List 2005*. www.redlist.org downloaded on 4 March 2005.

World Conservation Union (IUCN) 2002. IUCN Technical Guidelines on the Management of Ex-situ populations for Conservation. www.iucn.org/themes/ssc/publications/policy/exsituen.htm. downloaded on 29 June 2006

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.

Crocodiles In Zoos: A Contribution To Their Conservation

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.

7. References

Ballouard, J.M., Cadi, A., Oison, J, Priol, P. and Ciliberti, A. with the collaboration of T. M. Maskey, L. Fougeirol, Bed Bahadur Khadka and J. Roberts. 2005 Gharial conservation in Royal Chitwan National Park, Nepal: Gharial Status, December 2005 Results from the first sustained of released gharial. Second report 2003-2004. 41 p

Cadi, A. 2005. Gharial Conservation in Royal Chitwan National Park, Nepal – New nursery construction at Kasara. 8 p.

Maskey, T. M. and Percival, H. F., 1994. Status and Conservation of Gharial in Nepal. Submitted to 12th Working Meeting Crocodile Specialist Group, Pattaya, Thailand, May 1994.
Whitaker, R. and Basu, D. 1981. The gharial (*Gavialis gangeticus*): a review. J. of the Bombay Natural History Society, Vol. 79, pp. 531

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.

6. Further Reading

Döcke, F. (1975). Veterinärmedizinische Endokrinologie. Fischer Verlag.

Donhauser, J. I. (1997). Blutreferenzwerte Europäischer Landschildkröten (*Testudo hermanni, Testudo graeca, Testudo marginata, Agrionemys horsfildii*). PhD thesis, Ludwig- Maximilians-Universität, Munich.

Franklin, C. E. et al. (2003). Comparison of stress induced by manual restraint and immobilisation in the estuarine crocodile, *Crocodylus porosus*. Journal of Experimental Zoology 298A: 86-92

Jessop, T. S. et al. (2003). Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australien freshwater crocodiles. General and Comparative Endocrinology 132:161- 170

Lamnek, H. F. (1996). Saisonale Einflüsse auf Blutparameter und Sexualhormone bei der Europäischen Sumpfschildkröte (*Emys orbicularis*). PhD thesis, Ludwig-Maximilians- Universität, Munich.

Lance, V. A. & Elsey, R. M. (1986). Stress-induced suppression of testosterone secretion in male alligators. Journal of Experimental Zoology 239: 241-246

Lance, V. A. & Elsey R. M. (1998). Physiology of reproduction and captive breeding in the American alligator. in Proceedings of the 14th Working Meeting of the Crocodile Specialist Group, Singapur 14. – 17. July 1998. IUCN

Lance, V. A. et al. (2004). Rapid suppression of testosterone secretion after capture in male American alligators (*Alligator mississippiensis*). General and Comparative Endocrinology 135: 217-222

Löser, J. (2000) Krankheiten der Krokodile. PhD thesis, Ludwig-Maximilians-Universität, Munich.

Morici, L. A. et al. (1997). Effects of long-term corticosterone implants on growth and immune function in juvenile alligators, *Alligator mississippiensis*. Journal of Experimental Zoology 279:156-162

Siruntawineti, J. & Ratanakorn, P. (1994). Hematology and serum chemistry of captive false gharial (*Tomistoma schlegelii*) in Thailand. in Proceedings of the 12th Working Meeting of the Crocodile Specialist Group, Pattaya, Thailand 1994. IUCN

Sommerlad, R. & Baur, M. (2004). Der Sunda-Gavial. *Tomistoma schlegelii* (Müller, 1938) – kann dieses einzigartige Krokodil überleben? DRACO Nr. 20, Jahrgang 5 (2004-4): 54-67

Spanner, A. et al. (1997). Excretion profiles of some reproductive steroids in the faeces of captive Nepalese red panda (*Ailurus fulgens fulgens*). Reproduction, Fertility and Development 9: 565-570

Stacy, B. A. & Whitaker, N. (2000). Hematology and blood chemistry of captive mugger crocodiles (*Crocodylus palustris*). Journal of Zoo and Wildlife Medicine 31(3): 339-347

Turton, J. A. et al. (1997). Relationship of blood corticosterone, immunoglobin and haematological values in young crocodiles (*Crocodylus porosus*) to water temperature, clutch of origin and body weight. Australian Veterinary Journal 75: 114-119

Whitaker, N. & Andrews, H.V. (2000). Growth rates of the false gharial (*Tomistoma schlegelii*) and size at sexual maturation in captivity. in Proceedings of the 5th Working Meeting of the Crocodile Specialist Group, Vanadero, Cuba, 17. – 20. January 2000. IUCN

Zilber, A. et al. (1990). The effect of high temperature and increased day length on growth and survival of captive Nile crocodile, *Crocodilus niloticus* during the cold season in Kenya. in Crocodiles. Proceedings of the 10th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN – The World Conservation Union, Gainsville, Florida, USA, 23. – 27. April 1990. IUCN

Zilber, A. et al. (1990). The effect of light regime and temperature on growth rate, survival and body condition of young captive Nile crocodiles, *Crocodilus niloticus*. in Crocodiles. Proceedings of the 10th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN – The world conservation Union, Gainsville, Florida, USA, 23. – 27. April 1990. IUCN

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.

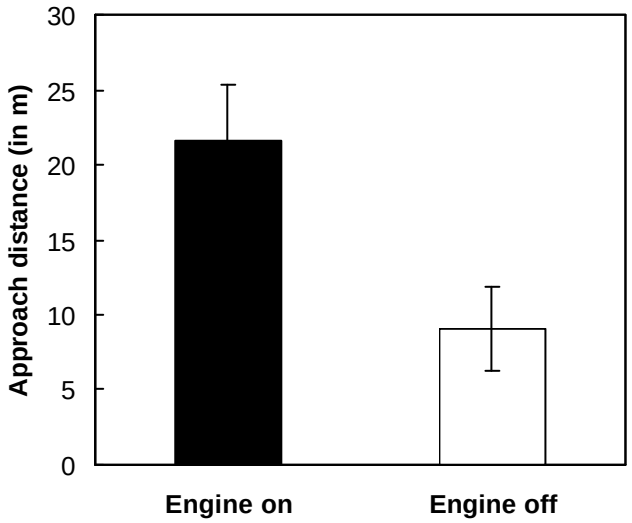

Figure 7: Approach distances (mean ± standard error from raw data) of spectacled caimans according to approach mode: engine on and paddling with engine off.

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).

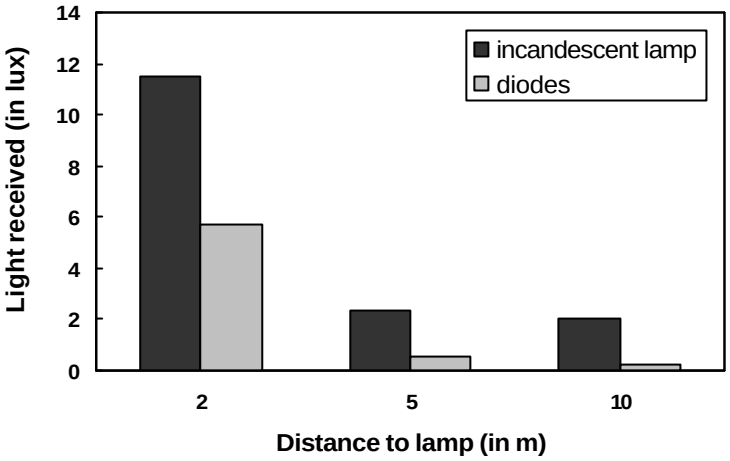

Figure 8: Light emitted by headlights with incandescent lamp or with diodes, and received at different distances.

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.

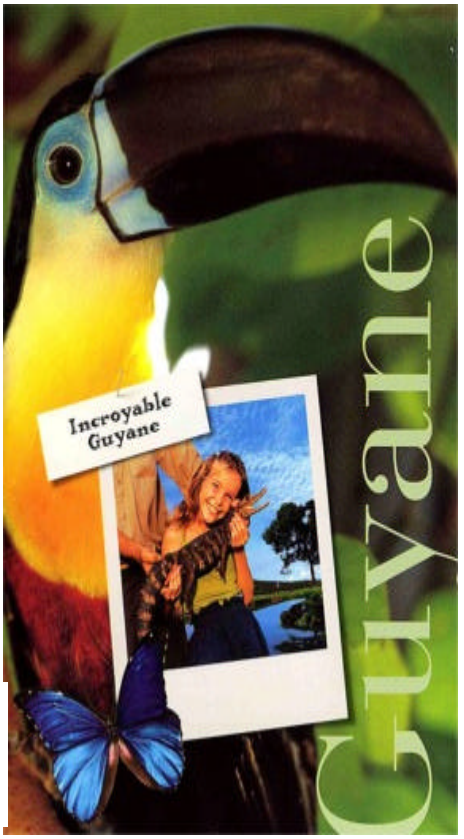

Figure 3:
Leaflet for the promotion of tourism in French Guyana
(Source: Guyana'sTourism Committee)

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.

6. Ackowledgments

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7. Bibliography

Asanza, E.R., 1999. Black Water and White Water lake systems of the Ecuadorian Amazon and the ecology of the Black Caiman (*Melanosuchus niger*). Dissertation Abstracts International Part B: Science and Engineering 60 (5): 1959.

Bookbinder M.P., E. Dinerstein, A. Rijal, H. Cauley & A. Rajourias, 1998. Ecotourism's support of biodiversity conservation. Conservation Biology 12(6): 1399-1404.

Carney K.M. & W.J. Sideman, 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22(1); 68-79.

Cisneros, F., Mendez, D. & P.A. Van Damme, 2006. Distribution, legal hunting patterns and conservation of *Caiman yacare* and *Melanosuchus niger* in the Bolivian Amazon. *In* Crocodiles. Proceedings of the 18th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Da Silveira R., 2002 Conservação e manejo do jacaré-açú (*Melanosuchus niger*) na amazônia brasileira. *In* L. M. Verdade & A. Larriera (Eds.). Conservação e manejo de Jacarés e Crocodilos da América Latina. Vol. 2. Piracicaba/SP, Brazil, 150 pages.

De Groot R. S., 1983. Tourism and Conservation in the Galapagos Islands. Biological Conservation 26: 291-300.

Garber S.D. & J. Burger, 1995. A 20-yr study documenting the relationship between turtle decline and turtle recreation. Ecological Applications 5(4): 1151-1162.

Gaunt, A.S. & C. Gans, 1969. Diving bradycardia and withdrawal bradycardia in *Caiman crocodilus*. Nature 223: 207-208.

IUCN, 2006. The IUCN red list of threatened species. Available at: www.iucnredlist.org (6 October 2006).

Jessop T.S., A.D. Tucker, C.J. Limpus & J.M. Whittier, 2003. Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australian freshwater crocodiles. General and Comparative Endocrinology 132(2003): 161–170.

Klein M.L., S.R. Humphrey & H.F. Percival, 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9: 1454-1465.

Lance V.A. & R.M. Elsey, 1999. Plasma catecholamines and plasma corticosterone following restraint stress in juvenile alligators. Journal of Experimental Zoology 283: 559–565.

Müllner A., K.E. Linsenmair & M. Wikelski, 2004. Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (*Opisthocomus hoazin*). Biological Conservation 118: 549–558.

Rebêlo, G.H. & L. Lugli, 2001. Distribution and abundance of four caiman species (Crocodylia: Alligatoridae) in Jau National Park, Amazonas, Brazil. Revista de Biologia Tropical 49(3-4): 1095-1109.

Republic of Brazil, 2006. Transfer of the population of Black Caiman *Melanosuchus niger* of Brazil from Appendix I to Appendix II of CITES. CITES AC22 Doc. 21.2. Available at: www.cites.org/eng/com/AC/22/index.shtml (6 October 2006).

Romero L.M. & M. Wikelski, 2001. Corticosterone levels predict survival probabilities of Galpágos marine iguanas during El Niño events. Proceedings of the National Academy of Sciences of the United States of America 98: 7366-7370.

Ron, S.R., A. Vallejo & E. Asanza, 1998. Human influence on the wariness of *Melanosuchus niger* and *Caiman crocodilus* in Cuyabeno, Ecuador. Journal of Herpetology 32(3): 320-324.

Thoisy B. de & M. Blanc, 2001. Les Caïmans noirs sur la Réserve Naturelle des Marais de Kaw-Roura. Distribution, abondances, statut, perspectives d'étude. Association Kwata/Association Arataï. 14 p. + annexes.

Thoisy B. de, 2002. Les Caïmans noirs sur la Réserve Naturelle des Marais de Kaw-Roura. Bilan de l'année 2001. 9 pages + annexes.

Thorbjarnarson, J., 1998. *In* J. Perran Ross (Ed.). Crocodiles. Status survey and conservation action plan [Online]. 2nd Ed. IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. 167 pp. Available at: http://www.flmnh.ufl.edu/natsci/herpetology/act-plan/plan1998a.htm (6 October 2006).

Tiplet P., A. Sournia, E. Joyeux & S. Le Drean-Quenec'hdu, 2003. Activités humaines et dérangements : l'exemple des oiseaux d'eau. Alauda 71(3): 305-316.

Von Mühlen, E., B. Marioni, R. Da Silveira, 2006. Monitoring the distribution, abundance and breeding areas of Black (*Melanosuchus niger*) and Spectacled Caimans (*Caiman crocodilus*) in the sustainable development reserve Piagaçu-Purus, Central amazonia, Brazil. p. 112. *In* Crocodiles. Proceedings of the 18th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Webb, G.J.W. & H. Messel, 1979. Wariness in *Crocodylus porosus* (Reptilia: Crocodilidae). Australian Wildlife Research 6: 227-234.

Wikelski, M. & S.J. Cooke, 2006. Conservation physiology. Trends in Ecology & Evolution 21: 38-46.

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.

3. References

Asanza, E. 1999. Black water and white water lake systems of the Ecuadorian Amazon and the ecology of the black caiman (Melanosuchus niger). Unpublished dissertation, University of Georgia (USA).

Da Silveira, R., W. Magnusson. 1999. Diets of Spectacled and Black Caiman in the Anavilhanas Archipelago, Central Amazonia, Brazil. *J. Herpet.* 33: 181-192.

De Thoisy, B. "Black caiman (*Melanosuchus niger*) study in French Guiana – a 4-years record." Poster session, 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group, Darwin, Australia, 27 May 2004.

Farias I. P., R. Da Silveira, B. de Thoisy, L. A. Monjelo, J. Thorbjarnarson, and T. Hrbek. 2004. Genetic diversity and population structure of Amazonian crocodilians. *Animal Conservation* 7, 265-272.

Gorzula, S. and J. Woolford. 1990. *Crocodilian resources in Guyana*. Draft report to CITES.
Medem, F. 1983. *Los Crocodylia de Sur America*. Vol. 2. Bogota: Ed. Carrera.
Thorbjarnarson and Da Silveira. 2000. Secrets of the Flooded Forest. *Natural History* 109(2):70-79.

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).

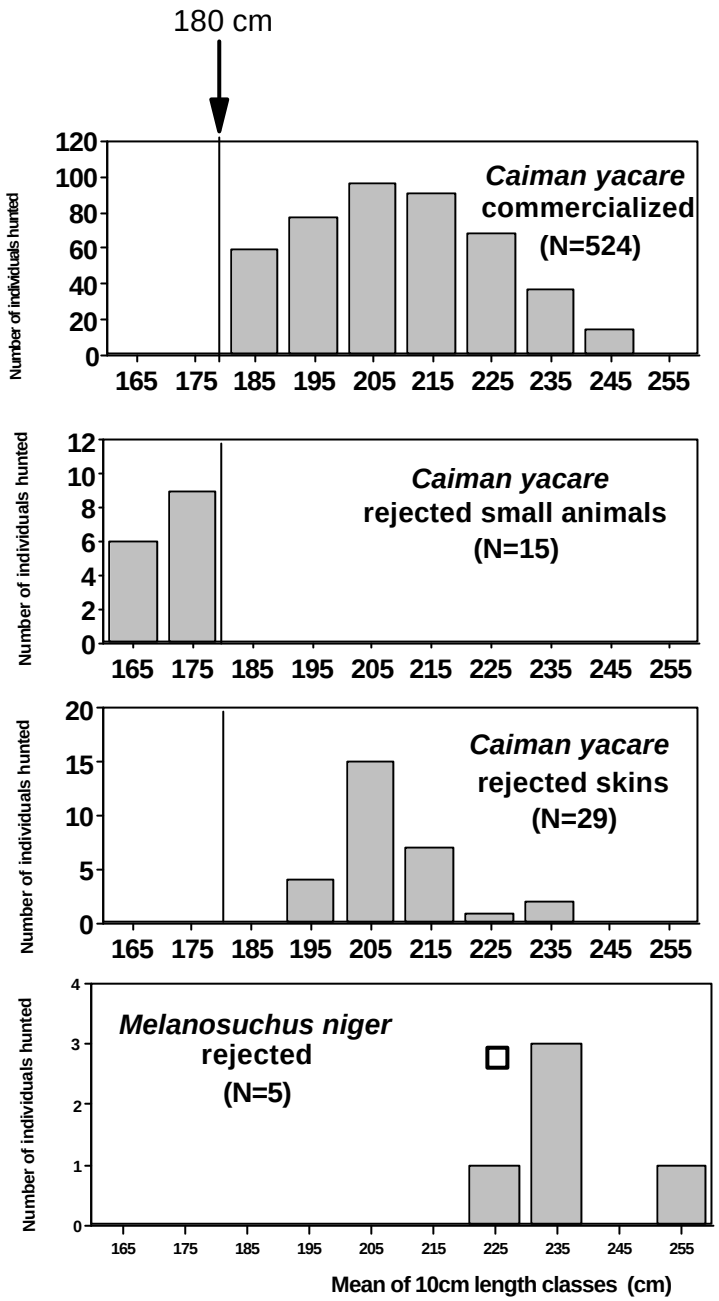

Figure 2. Length frequency distribution of hunted caiman (*C. yacare* and *M. niger*) in the Ichoa river floodplain. The vertical line shows the *C. yacare* size limit established

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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6. Literature Cited

Aguilera, X., (2002). Estado de las poblaciones del *Caiman yacare* y *Melanosuchus niger* en la cuenca del río Ichilo. Maestria en Ecologia y conservación Cochabamba, Bolivia. 123 pp.

Cisneros F. and Van Damme, P.A. (2005). Observaciones sobre la morfometría del lagarto (*Caiman yacare*) y del caiman negro (*Melanosuchus niger*) en el TIPNIS (Bolivia). *Revista Boliviana de Ecología y Conservación Ambiental* 17(77): 86-94

Cisneros, F. (2005). Distribución y estado poblacional del *Caiman yacare* y *Melanosuchus niger* en la cuenca del río Ichoa (TIPNIS). Tesis de Licenciatura. U.M.S.S.

Ergueta, P. and Pacheco L.F. (1990). Los cocodrilos (Orden Crocodylia) de Bolivia. *Ecología en Bolivia* 25(8): 69-81

Hines, T. and Abercrombie, C. (1987). The management of alligators in Florida, USA. pp. 47. In: G. WEBB, C. MANOLIS y P. WHITEHEAD (Eds.) Wildlife management: Crocodiles and Alligators. Surrey Beatty & Sons Pty. Ltd. NSW. Australia.

King, F. W. (1995). A Programme for the Sustainable Utilization and Management of Caiman in Bolivia. CITES Project Proposal. Doc. SC.35.11. Annex 8. Project S-089.

Llobet, A. and Goitia, E. (1997). Abundancia y estructura poblacional del *Caiman yacare* en lagunas de la llanura inundable de los ríos Ichilo y Chapare (Bolivia). *Revista Boliviana de Ecología y Conservación Ambiental.* 2(39): 47

Llobet, A. and Aparicio, J. (1999). Abundancia, estructura poblacional y perspectivas de aprovechamiento de *Caiman yacare* en cinco estancias del Departamento del Beni. pp. 285-293. In: Fang, T.G., Montenegro, O.L. & Bodmer, R.E. (Eds.). Manejo y conservación de fauna silvestre en América Latina. Instituto de Ecología. La Paz, Bolivia.

Llobet, A., Pacheco, L.F. and Aparicio, J.K. (2004). Analysis of the Program of conservation and use of the spectacled caiman (*Caiman yacare*) in Bolivia, and recommendations to improve it. In: Proceedings of the 17th Regional Meeting of the CSG, Darwin, Australia. IUCN – The World Conservation Union, Gland, Switzerland.

Medem, F. (1983). Los Crocodylia de Sur América. Universidad Nacional de Colombia. Bogota, Colombia. 10(3): 20-129.

Ojasti, J. (2000). Manejo de Fauna Silvestre Neotropical. F. Dallmier (Ed.). SIMAB Series Nº. 5. Smithsonian Institution/MAB Program. Washington DC. USA. pp. 290.

Rios, N. (2003). Estado de conservación del *Caiman yacare* en la TCO Tacana. Tesis de Licenciatura Universidad Mayor de San Andrés. La Paz-Bolivia. 80 pp.

Ross, P. and Godshalk, R. (1999). El uso sustentable, un incentivo para la conservación de cocodrilos. *In:* Fang, T.G., Montenegro, O.L. and Bodmer, R.E. (Eds.) Manejo y Conservación de Fauna Silvestre en América Latina. Instituto de Ecología. La Paz Bolivia. 443 pp.

Ruiz, E.. 1988. Ecología del lagarto (*Caiman yacare*) en la Estación Biológica del

Beni, Informe preliminar para el centro de datos para la conservación. La Paz, Bolivia. pp 58.
Velasco, A. and Ayarzaguena, J. (1992). Proyecto MARNR-CITES: Situación actual de las poblaciones venezolanas de babas (*Caiman crocodilus*), sometidas a aprovechamiento. MARNR-PROFAUNA. Caracas, Venezuela.
Velasco A.G., Colonine, R. De Sola and H. MacCallum, H. (2003). The Effect of sustained harvesting on wild Population of *Caiman crocodilus* (Baba) in Venezuela
Webb, G., Manolis, C., Otley, B. and Heyward, A. (1992). Crocodile Management and Research in the Northern Territory. *In:* Crocodiles. Proceedings of the 11th Working Meeting of the Crocodile Specialist Group. Victoria Falls. Zimbabwe. IUCN-Word Conservation Union, Gland, Switzerland.

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.

7. Bibliografía

Genolagani, J and Vilmont, J. 1990. Status of crocodile populations in Papua New Guinea : 1981 – 1988. In: Crocodiles, Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN, Gland Suiza.

Hutton, J and Child, g: 1989. Crocodile management in Zimbabwe. In. Crocodiles, Their Ecology , Management and Conservation. IUCN, Gland, Switzerland.

Larriera, A. 1994. Caiman latirrostris ranching Program in Santa Fe, Argentina, with the aim of management. In: Crocodiles, Proceedings of the 12th Working Meeting of the Crocodile Specialist Group, IUCN, Gland Suiza.

Ministerio del Medio Ambiente-Instituto Nacional de los Recursos Naturales y Renovables (INDERENA) 1994. Manual para la evaluación de poblaciones de Crocodylia en Colombia.

Ministerio del Medio Ambiente. 2000. Guía para la evaluación de poblaciones de fauna silvestre.

Ministerio del Medio Ambiente-C.S.B.-CORPOMOJANA-CORANTIOQUIA, CORPAMAG-C.V.S. 2002. Plan de manejo integral de los humedales, subregión de la depresión Momposina y cuenca del río Sinú.

Ministerio del Medio Ambiente- Instituto de Investigaciones de Recursos Biológicos Alexander Von Humboldt. 2000. Estado y distribución de los Crocodylia en Colombia.

Parks and wildlife service of the Northern Territory Australia. Management plan for *Crocodylus porosus* in the Northern Territory 2005 - 2010

Seijas A., Cuevas H. y González N. 2003. Adaptación al medio natural de babas (*Caiman crocodilus*) criadas en cautiverio. Interciencia. vol. 28 nº 6.

Thorbjarnarson, J. 1992. Crocodiles. An action plan for their conservation. H. Messel, F.W. King and J.P.Ross (eds) IUCN. Switserland.

Velasco A. & De Sola R. 1999 Programa de manejo de la baba (*Caiman crocodilus*) de Venezuela. Vida Silvestre Neotropical. 8(1-2):10-17. ISBN 0889-3284.

Webb, G., Manolis, C., Otley, B., Heyward, A. 1992. Crocodile Management and Research in the Northern territory. 1990 – 1992. In: Crocodiles, Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN, Gland Suiza

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.