Figure 4

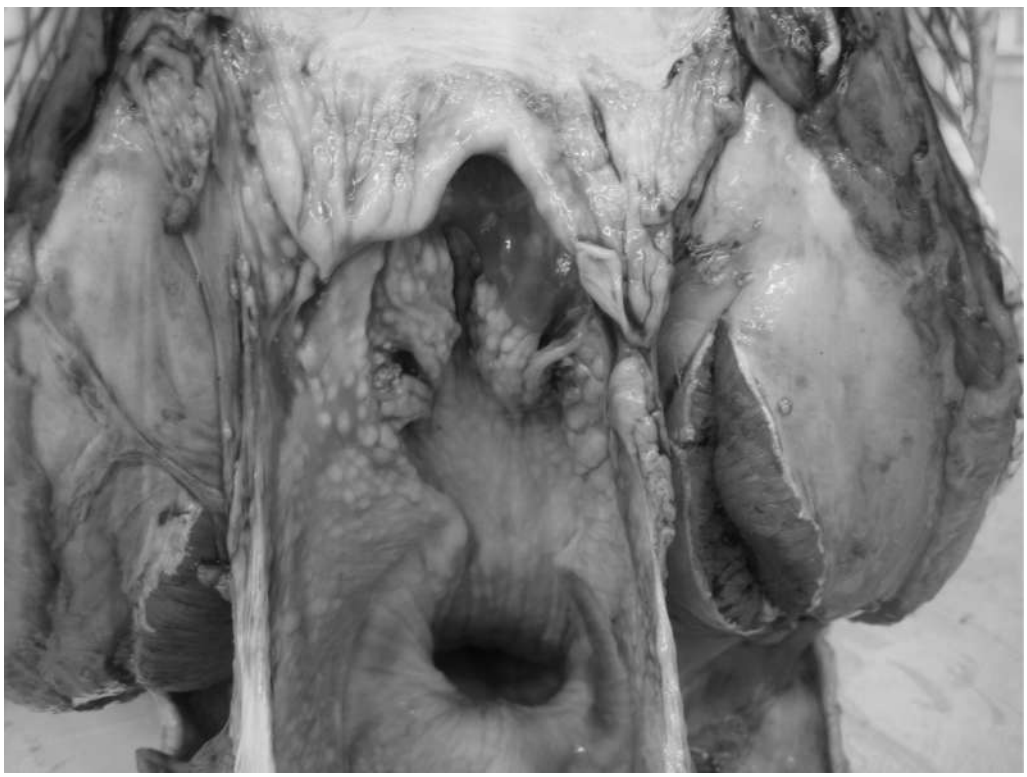

Figure 5

Occasional cloacitis consisted of fibrin discharge and nodules in older animals. (Figure 6)

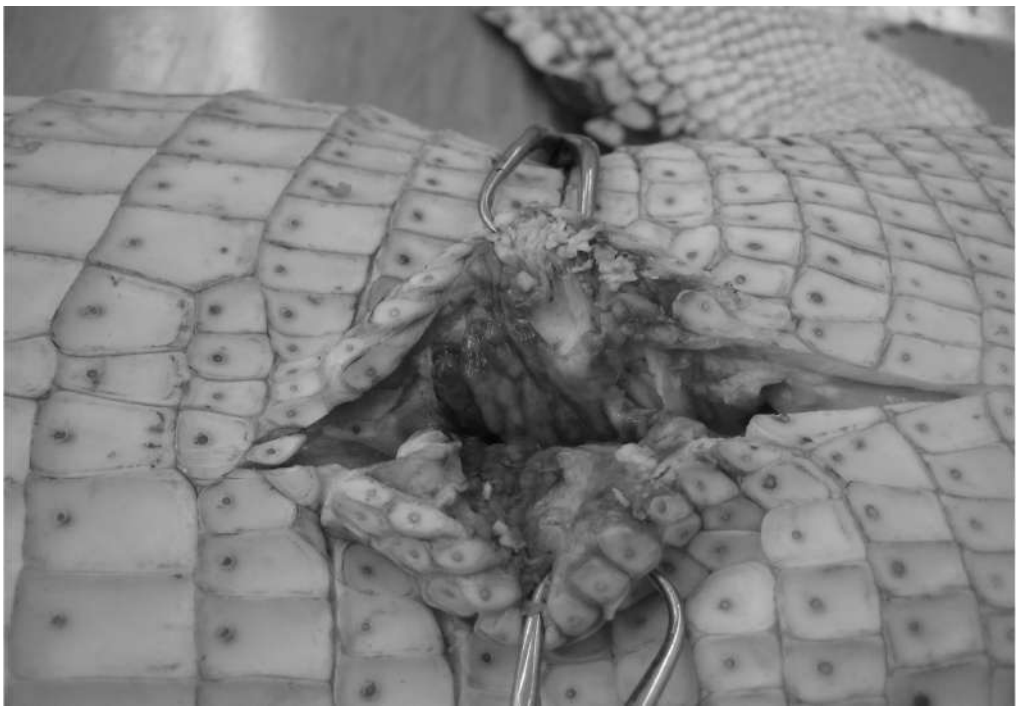

Figure 6

In histology the normal structure of columnar epithelial cells flattened out and therefore normal function of the cells was lost. (Figures 7-9)

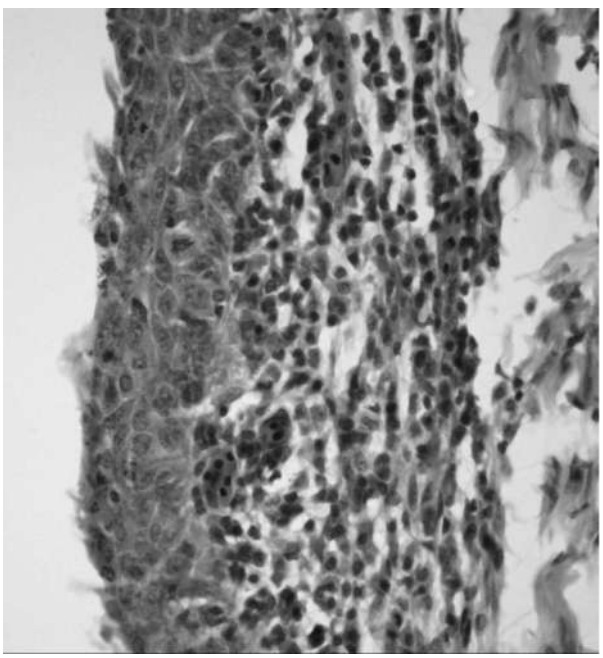

Figure 7- Conjunctiva

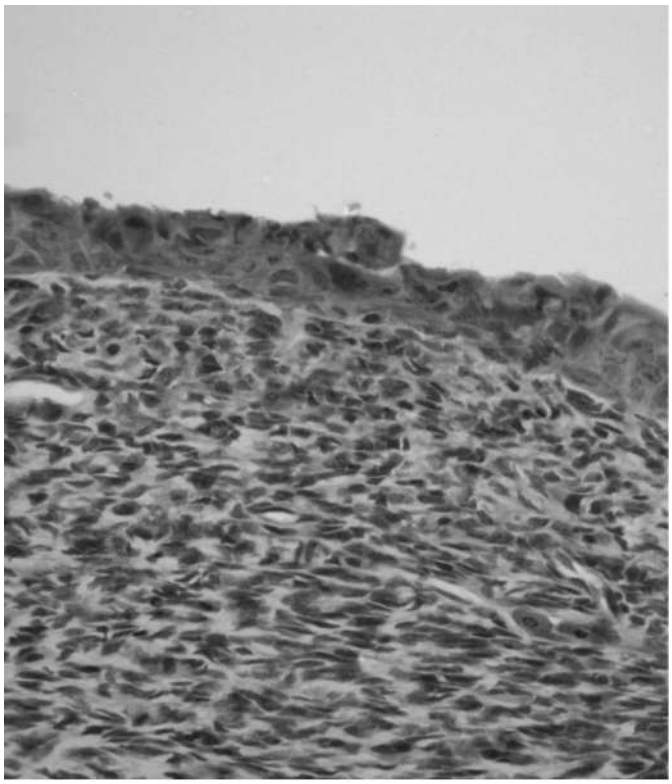

Figure 8- Pharynx

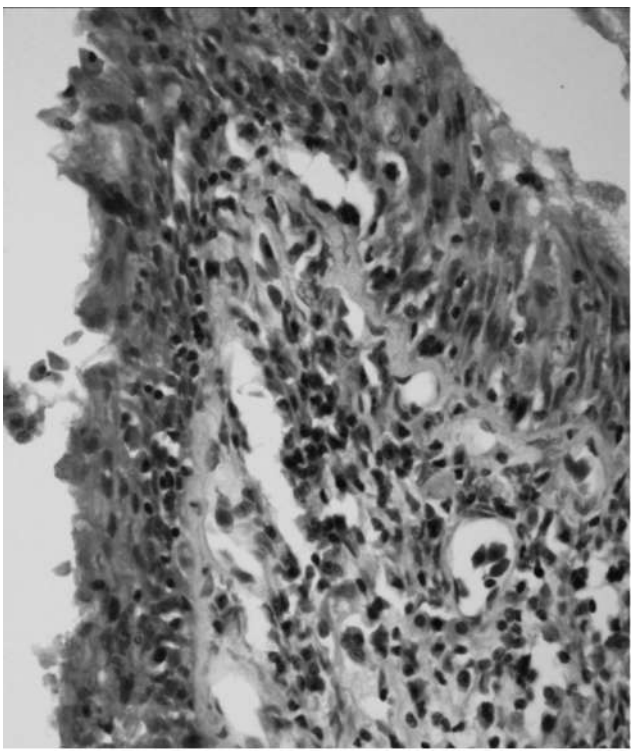

Figure 9 -Cloaca

METHODS AND RESULTS

Laboratory tests performed:

Tissue PCR +ve
(16S rRNA gene, Condon and Oakey, 2007)

Conjunctiva – 14 from 14 samples tested positive for Chlamydia
Pharynx – six from six samples tested positive for Chlamydia

Antigen ELISA (Anti LPS) +ve

Conjunctiva – Three out of six tested positive for Chlamydia
Pharynx was not tested as it was discovered later after the ELISA test.

Mycoplasma PCR (tissue) +ve

Conjunctiva – one out of six tested positive for Chlamydia
Pharynx – nil samples tested positive

Viruses - Thin section EM +ve

No samples tested positive. However more work is needed. These results are from the early stages of testing. Crocodilian cell lines are being established and this will allow more virus work to be performed.

Survey work was also done in relation to the laboratory work to see if related factors could be detected.

Farms were surveyed late 2006 for any factors that could have influenced the Chlamydia outbreak.

Heron birds were considered as disease carriers and extended weeks of cold temperatures were also considered as an influence.

Herons were not carriers and the temperature influence needs more detailed research. No other related factors between farms could be discovered.

Gene sequencing of the crocodile Chlamydia isolated is as follows:

16S rRNA- 98% to 99% similarity to C Psittaci, C abortus and C rostinovo. Omp 2 – 91% similarity to C caviae and C psittaci..

Therefore the crocodile Chlamydia species is new and placed between C psittaci and C caviae.

Outcomes:

Questions to answer:

What is the prevalence (reservoir) of Chlamydia infection in various age groups in the normal farmed population?

What species/strains of Chlamydia are present and are these unique to crocodiles?

Is the infection common in the wild population and is the infection vertically transmitted?

To answer these questions, funding was sought and granted for a one year project. The project consists of two parts.

1 year project:

Part one-

- Introduce and validate molecular techniques for Chlamydial detection and identification

Detection:

- PCR for the omp 2 gene – primary detection method.

Identification of positives:

- RFLP of the omp 2 PCR product
- Sequencing of the omp2 PCR product
- PCR and sequencing of the 16S ribosomal RNA gene
- PCR and sequencing of the 23S ribosomal RNA gene

Part two-

Epidemiological investigation of Chlamydial infection in crocodiles.

Prevalence and strains of Chlamydial infection in farmed animals (ocular and pharyngeal swabs):

- Hatchlings – 2 farms: <1week, 1-4 weeks, 4-8 weeks, 8-12 weeks
- Grower animals – 2 year old animals - 4 farms in the NT, 2 farms in Qld, 1 farm in WA

Occurrence of chlamydial infection in the wild population:

- Ocular and cloacal swabs from trapped animals

Transmission of Chlamydia on or within eggs (shell and embryo swabs):

- Eggs collected from nests in the wild (2 per clutch, 30 clutches

CONCLUSIONS

Early Conclusion discovered in 2007:

- No positives detected in hatchlings pre-emergence from the egg – no vertical transmission could be detected.
- No positives in hatchlings under 40 days of age.
- Most positives detected in animals between 60-80 days of age.
- Number of positive animals varies in older age groups.
- Animals sampled from the wild, had positive detections from cloacal swabs.
- Animals sampled from farms, had positive detections from the ocular and pharyngeal swabs
- Infection of Chlamydia and clinical disease is rare under the age of 40 days.
- Clinical eye and throat disease is almost always associated with the presence of Chlamydia.
- Chlamydia is present in normal farmed animals but its prevalence varies widely between age groups and between farms.

Related results to date:

- A bio security plan for the NT crocodile Industry has been developed. It outlines the bio-security measures to be taken in normal routine work procedures as well the measures to be taken in the event of a disease occurrence or outbreak.
- Finalization of a three year minor use permit through APVMA for the antibiotic Baytril; in the event of another Chlamydia outbreak.
- Crocodilian cell line cultures are being established as part of RIRDC/NTRIB funding, additional antibiotic testing can be performed.

(APVMA - Australian Pesticide Veterinary Medicine Authority)

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Experimental induction of vitamin deficiency with diet in captive alligators.

James P. Ross & Dale Honeyfield,

ABSTRACT: Previous studies show that mass mortality of American alligators (*Alligator mississipiensis*) in Lake Griffin in central Florida between 1998 and 2003 was due to neurological pathology and this pathology was associated with reduced levels of tissue thiamine (vitamin B1). Similar thiamine deficiency pathology is reported from captive marine mammals and free ranging salmonid fish that eat fish containing high levels of thiaminase. Gizzard shad (*Dorasoma cepedianum*), an abundant filter feeding fish, are common in alligator diets in Lake Griffin. We investigated whether gizzard shad have high levels of thiaminase, if feeding alligators gizzard shad would cause changes in alligator thiamine status and if thiamine deficiencies could be reversed by vitamin therapy and diet. We tested gizzard shad for thiaminase and demonstrated mean levels of 16,000 pmol/g/min which exceeds levels in alewife and smelt that cause thiamine deficiency in salmon that eat them. We held seven wild caught alligators in captivity and fed them only gizzard shad for 9-15 months. All seven showed significant declines in blood and muscle thiamine and three animals died showing symptoms similar to those seen in the field mortality event. Five of the seven alligators also showed diagnostic neural pathology at post mortem examination. Two alligators received thiamine therapy (injection and in the diet) starting in the 11th month of the experiment. These two alligators, which previously showed thiamine declines, restored their blood and tissue thiamine to normal levels and one of these did not show neuropathology, although the other did. We speculate on the relationship of lake eutrophication, gizzard shad abundance, blue green algal blooms and thiaminase levels in shad that might explain the observed field mortality of alligators as an end result of complex ecosystem interactions.

American alligator growth: Determinate or indeterminate?

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ABSTRACT: American alligators (*Alligator mississippiensis*) have been suggested to exhibit indeterminate growth, i. e. they continue to grow throughout their entire lives. The objective of this study was to address the issue of indeterminate versus determinate growth in alligators from measurements taken over long term capture to recapture intervals. Capture-recapture data from 1980 to 2007 (27 years) were used to determine if alligators continued to grow after reaching adult size. Capture crews caught 49 adult alligators on the Yawkey Wildlife Center in coastal South Carolina (2005 – 2007), of which twenty-two were long-term recaptures. Six had not stopped growing since last captured (5 < 12, 1 < 25 years) but were not exceptions to growth parameters found in this study. Sixteen (6 males > 3.25m, 10 females > 2.36m TL) recaptures had no discernable growth in TL since previous capture (11 – 27 years). I conclude alligator growth is determinate. Alligators in this habitat showed strong site fidelity. Eleven females were recaptured at < 100m of their capture site over a period of 11 to 26 years. Three others were recaptured at locations 300m to 2km from previous capture sites. Individual males were recovered at or near their original capture sites over this same time period. Incidental to this study, three females were observed to have nested at intervals over a period of 24 to 26 years.

Key words: *Alligator mississippiensis*, American alligator, determinate growth, life history, site fidelity, movements, nesting longevity.

RESUMEN: Se ha sugerido que el caimán norteamericano (*Alligator mississippiensis*) muestra un crecimiento indefinido i.e. continúa creciendo durante toda su vida. El objetivo de este estudio fue tratar el tema del crecimiento indefinido de los cocodrilos vs. el definido a través de mediciones que se tomaron después de intervalos de larga duración entre captura y recaptura. Para determinar si los cocodrilos continuaban creciendo después de alcanzar su tamaño adulto, se utilizó información captura-recaptura de 1980 al 2007 (27 años). Los grupos de captura atraparon 49 cocodrilos adultos en el "Yawkey Wildlife Center" en las costas de Carolina del Sur (2005-2007), de los cuales 22 fueron recapturas de largo período. Seis no habían dejado de crecer desde la última captura (5<12, 1<25 años) pero no eran excepciones a los parámetros de crecimiento que se encuentran en este estudio. La recaptura de 16 (6 machos >3,25 m, 10 hembras >2,36m LT) no experimentaron un crecimiento perceptible en el LT desde la captura anterior (11-27 años). Mi conclusión es que el crecimiento de los cocodrilos es definido. Los cocodrilos en este hábitat mostraron una fuerte fidelidad con el lugar. Once hembras fueron recapturadas a < 100 m de su sitio de captura original durante un período de 11 a 26 años. Otras tres fueron recapturadas en lugares de 300m a 2 Km de los anteriores lugares de captura. Los machos individualmente fueron recuperados en su sitio original de captura o cerca durante este mismo período de tiempo. En forma incidental a este estudio, se observó que tres hembras habían anidado en intervalos durante un período de 24 a 26 años

Palabras claves: *Alligator mississippiensis*, caimán norteamericano, crecimiento definido, historia de vida, fidelidad con el lugar, desplazamientos, longevidad de anidamiento.

INTRODUCTION

The American alligator inhabits various wetland habitats throughout the southeastern United States and west into Texas. Growth rate variability has been demonstrated in several states, including Florida (Jacobsen and Kushlan 1989), Georgia (Hunt 1990), Louisiana (Elsey *et. al.* 1992), North Carolina (Fuller 1981), and South Carolina (Wilkinson and Rhodes 1997). These studies demonstrated that growth varied in relation to alligator size, and thus age, between sexes, and among locations.

The relation between size and age was quantified for alligators in coastal South Carolina using mark-recapture data (Wilkinson and Rhodes 1997). Wilkinson and Rhodes (1997) developed growth curves by sex, of total length (TL) using the von Bertalanffy growth curve model (von Bertalanffy 1960, Fabens 1965, Kirkwood 1983). They found a mean of 34 years (3.46 m TL) for males and 24 years (2.51m TL) for females to reach asymptote size, which represents the mean size at which growth essentially stops.

Crocodilians have been suggested to exhibit indeterminate growth, i.e. they continue to grow throughout their entire life (Jacobsen and Kushlan 1989). However, Wilkinson and Rhodes (1997) had eight alligators among recaptures (2 M > 3.63m TL, 6F > 2.50m TL) that demonstrated no measurable growth for a period of > 10 years. This suggested alligator growth in length is determinate. According to the von Bertalanffy model, growth that approaches an asymptote and theoretically will continues to increase slowly throughout an individual's lifetime (Brisbin 1990). The curve will not reach zero growth. In reality this may not occur. The objective of this study was to address the issue of indeterminate versus determinate growth in alligators from measurements taken over long term intervals of captured and recaptured alligators.

METHODS

The study was conducted on the South and Cat Island portion (6033 ha) of the Thomas A. Yawkey Wildlife Center, a South Carolina Department of Natural Resources managed wildlife refuge, located on the north central coast of the state. These lands are located between the Winyah Bay and North Santee River estuaries (33 degrees N). Mean tide range is 1.16m at the Yawkey Wildlife Center with a spring tide range of 1.34m (National Ocean Service 2006). The dominant vegetation in the surrounding tidal marsh (2524 ha) is smooth cordgrass (*Spartina alterniflora*). Managed impounded ponds (1012 ha) were typically maintained at water levels < 0.6 m depth and were vegetated with widgeon grass (*Ruppia maritima*), a submergent aquatic plant interspersed with emergent tall cord grass (*Spartina cynosuriodes*), salt marsh bulrush (*Scirpus robustus*) and smooth cord grass. Water salinity in impoundments ranged from 0 to > 35 ppt. Historically the Yawkey Wildlife Center has been maintained, both privately and by the state as a wildlife sanctuary. Alligators have been protected there from hunting for nearly 100 years.

As part of statewide alligator research projects, alligators were captured on this study area during 1977 – 1983 and 1993 with modified baited trip snares (Murphy *et. al.* 1983), snare

pole, snatch hooks, (Cherkiss *et. al*. 2004), and walk-through snares (Wilkinson 1994). Measurements to the nearest 0.1cm were taken of dorsal total length (TL) and ventral snout vent length to the posterior of vent (SVL), snout, tail, hindfoot length, (HF), neck, chest and tail girth. Where practical, alligators were weighed. Sex was determined and individuals were marked by toe clipping and notching dorsal tail scutes (Charbeck 1963). Alligators were also marked individually during early studies using colored, numbered tags affixed to nuchal and tail scutes and with a numbered monel fish tag placed in the webbing between the toes of the hindfoot. In all instances, capture method, location and date were recorded, and alligators were released at their capture sites.

During 2005 – 2007, alligator capture was undertaken using volunteer assistance on the Yawkey Wildlife Center with emphasis on recapturing previously marked alligators located while basking. The marking sequence was observable while the animals basked and indicated the approximate time when animals were first captured. Traps were situated to recapture animals with a long interval since last capture (> 12 years). When captured, unmarked alligators were sexed, weighed, measured, marked and released. Recaptures were individually identified, and their measurements and capture locations were compared with earlier records. Since long-time intervals were involved, time interval between capture and recapture were calculated in years, months and days. Distance between capture locations were calculated using 1” = 2000’ scale maps.

RESULTS

Of 49 alligators captured during this study, 24 (10M, 14F) were recaptures of which twenty-two had intervals of > 11 to 27 years between captures. Alligator TL was compared between initial capture and subsequent captures to determine growth. Sixteen (6M, 10F) displayed no measurable growth for a period of > 11 to 26 years (6M > 3.25m, 10F > 2.36m TL) between initial capture and recapture during this study. There were six alligators (2M > 3.10m and 4F > 2.32m TL) that had grown since their previous capture (> 12 to 26 Years). The remaining two recaptures were first captured during this project and were not used in these calculations.

Distance between capture and recapture sites varied from 0 to 2 km. Eleven females were captured and recaptured at nearly the same site over a period of > 11 to 26 years while three others were recaptured at locations 300m to 2 km from their initial capture sites. Individual large males were captured-recaptured in relatively the same locations over this time period.

Incidental to this study are three females, two of which were observed to have nested at least three times over a period of 24 to 26 years. The other was observed to have nested twice over 25 years.

DISCUSSION

Elements that contributed to the feasibility of this study were: (1) the study area has been maintained free from alligator hunting for a period of at least 95 years; (2) the alligator population on the area has been subject to scientific study during periods over 31 years: (3) individual alligators were permanently marked using a continuous standardized marking system which facilitated identification of individual alligators while basking; and (4) earlier

telemetry studies included data on alligator denning, basking and general feeding areas which identified parts of individual alligator home-ranges .

Of 22 recaptures, 16 (6 males 10 females) had no discernable growth in 11 to 26 years. These had reached maximum growth upon previous capture. Six alligators (2 males, 4 females) had not reached average asymptotic size at previous capture, but four were thought to have done so between previous and final capture (12 to 26 years). One male continued to grow throughout the study. It was first captured as a hatchling at the nest, and recaptured 26 years later (3.10m TL). Its length age relationship was eight years less than the average asymptotic age from previous models (34 years) (Wilkinson and Rhodes 1997). A second male was captured three times over a period of 25 years. At first capture it was 2.77m TL, an average length-age estimate of 18 years. At second capture, 13 years later, it had increased to 3.35m TL, a length-age estimate below male asymptote (34 years). It had increased to 3.70m TL 12 years later upon final capture, a length age relationship indicating it had reached asymptotic size between its second and final capture. However, affirmation of this would require future capture. One female in this group was first captured at 88.6cm TL and at second capture was 2.32m TL (12 years). This alligator was smaller than any other female in the recapture data set. An alligator this size would be expected to continue growth. Three females were small adult size females when first captured: 2.24m TL, 2.27m TL and 1.27m SVL (tail missing). These animals grew 0.1m TL, 0.09m TL and 0.04m SVL respectively (12 years). This growth would not be an exception to growth parameters in this study. I therefore conclude that alligator growth is determinate.

Terminal growth was variable for both sexes. Terminal growth for males in this study varied from 3.25 – 3.84m TL (range 0.61m), while terminal growth for females varied from 2.36 – 2.94m TL, a greater relative range than for males (0.58m).

Recaptured alligators displayed high site fidelity, 82 percent were recaptured <100m of their capture sites. This may be attributable to the habitat in the study area. There are 1012 ha of tidally controlled marsh impoundments (N=25) in the study area ranging from 5 – 170 ha and an estimated 20 additional freshwater rain-catches < .05 – 156 ha. These impoundments and freshwater rain-catches are the primary habitat used by alligators in the study area. Finfish and crustaceans are abundant in these impoundments including: striped mullet (*Mugil cephalus*), atlantic croaker (*Micropogonias undulates*), atlantic menhaden (*Brevoortia tyrannus*), spot (*Leiostomus xanthurus*), ladyfish (*Elops saurus*) and blue crab (*Callinectes sapidus*). These species tend to congregate at impoundment water control gates on the study area (N=68), especially during the high tides cycle when gates allow water seepage into impoundments. Alligators make periodic feeding forays to these fish and crab concentrations, where marked individuals may be located. Alligators also habitually use the freshwater rain-catches as haul-outs for basking and denning, especially during periods of drought when impoundment salinities exceed 12 ppt. Basking and denning locations of larger alligators are predictable, and the same location may be used by some individuals for years. Marked individuals can be predictably located at these areas. Additionally, travel routes between denning-basking sites and feeding locations are traditional which makes walk-through snares highly efficient. Walk-through snares were the most frequently used capture method (63 percent). This passive capture method is designed to snare an alligator as it moves normally from one location to another and was not thought to influence alligator habitat use. Our use of baited trip snares (27 percent) and snare pole (8 percent) was similarly not thought to

influence habitat use. Both methods were employed at sites where alligators were visually located during daylight reconnaissance.

Data were not collected relative to alligator home range during this study. Information gathered during earlier telemetry studies (Wilkinson 1983) was used to help locate specific alligators. Display of high site fidelity by recaptured alligators in this study is reflective of familiarity with their activities in specific portions of what may have been a larger home range. In undisturbed conditions, the data demonstrate that large, dominant alligators become behaviorally habituated and predictable, sometimes for years.

Continuous monitoring of alligator nesting was not conducted on the study area. Incidental to this study, three of the female recaptures were observed nesting over a span of 24 – 26 years. At initial capture one female (2.03m TL) was associated with nesting and later a crèche of hatchlings by means of radio telemetry and blood plasma analysis (Wilkinson 1983). Thirteen years later, it was recaptured at the same location and was 2.47m TL. It was observed later that season, associated with a crèche of hatchlings. Offspring genotypes are consistent with maternity by the female guarding the nest being the mother of the clutch (Davis, *et. al*. 2001). Upon final recapture totaling a 26-year span, it was again found associated with a crèche of hatchlings. The second female (2.64m TL), at first capture, was similarly associated with nesting and a crèche of hatchlings, and again upon final capture 25 years later. The third female (2.94m TL) was captured four times, and was the largest female alligator ever caught on the study area. This female was similarly associated with nesting when first captured, and has been associated twice over a span of 24 years with hatchling crèches. Growth studies of alligators in coastal South Carolina showed that it required, on average, 24 years (2.51m TL) for female alligators to reach asymptotic size (Wilkinson and Rhodes 1997). Nesting may occur as much as nine years earlier. The size of this female (2.94m TL), 0.43m TL above asymptotic size, indicates it had reached asymptote and was perhaps older when first captured. The additional years of known nesting suggest this female has continued to produce viable young at an age > 50 years.

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Competing risk analysis of survival traits in *Crocodylus porosus*

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ABSTRACT: The heritability for overall survival in juvenile saltwater crocodiles has previously been estimated as 0.15 (SE 0.04). However, this heritability estimate was based only on whether an animal lived or died and not based on why the animal died. Thus, the objective of this study was to determine the heritability for various reasons for juvenile mortality in *Crocodylus porosus*. Data were collected from all juvenile crocodiles in the 2005, 2006 and 2007 cohorts at Darwin Crocodile Farm (n = 2,171) of known-parentage. The data were collected in a categorical manner as either congenital (hatchling abnormality), disease-related (confirmed by pathology), stress-related, runtism, no visible ailments (NVA; no obvious husbandry reason for death) or miscellaneous. Using a pair model, the heritability was 0.71 (SE 0.08) for all traits, whilst using an animal model, heritability estimates ranged from 0.39 (SE 0.03; Overall survival, congenital and stress) to 0.56 (SE 0.04; runtism). These estimates are higher compared to the previous published crocodile estimate and other livestock species. Further data is required to remove the confounding present in the current models.

INTRODUCTION

Juvenile crocodile deaths still remains an issue of concern for Australian crocodile producers. Webb (1989) commented that producers should aim for 95% survival in the first year after hatch, but in reality, survival rates are more likely between 85-90% (Isberg et al. 2004). However, grouping all deaths into an overall category does not assist in our understanding of the predominant causes of death. The overall purpose of this study was to collect mortality data in a categorical fashion to overcome this deficiency. Herein are the results from the genetic analysis of this data.

METHODS AND MATERIALS

Mortality records from 2,171 juvenile saltwater crocodiles of known-parentage from Darwin Crocodile Farm (Northern Territory, Australia) were collected from the 2005, 2006 and 2007 cohorts. Progeny records were from 67 “pair” families (53 sire families). After hatching, crocodiles were scute cut for individual animal identification.

Mortality records were collected on a daily basis by recording the animal’s unique scute cuts, and recording the reason for death using six categories as follows:
1. Congenital defects including unabsorbed yolk sacs, jaw deformities such as cleft palate and under-/over-shot jaws, spinal deformities, tail deformities such as no tail, partial tail, “curly” tails and any other physical defect.
2. Runtism was defined by an emaciated, non-thriving animal in comparison to others of similar age.

3. Disease-related was determined after pathology at Berrimah Veterinary Laboratory (BVL; Northern Territory Department of Primary Industries, Fisheries and Mines) and defined as independent to a management-induced stress. In most cases, subsequent administration of antibiotics was warranted.
4. Stress-related is defined whereby deaths occurred within a short time after a management-induced stress event. These include minimising size variation within pens (grading), moving animals between pens, hot water services failing or pens left without water.
5. No visible ailments (NVA) was used when no disease outbreaks were identified nor a stress incident noted. These deaths usually occur in random pens with no distinct trend in mortalities.
6. Miscellaneous is any other event that does not fit into the above categories. Animals that had not died (n = 1,764) and were still in the production system when the trial period ended (31st December, 2007) were right censored and coded zero (0). Table 1 shows the number of deaths in each category.

Table 1. Number of deaths in each category used in the survival analyses from 2,171 animals.

Category	No. deaths	Overall deaths (%)	% of overall deaths
Overall	407	14.96	
Congenital defect	7	0.26	1.72
Runt	201	7.39	49.39
Disease-related	37	1.36	9.09
Stress-related	62	2.28	15.23
NVA	93	3.42	22.85
Miscellaneous	10	0.37	2.46

Data were analysed using a Cox's Proportional Hazards Model in Survival Kit V3.12 (Ducrocq and Sölkner 1994; 1998) using two models.

1. Pair model

$$\ln[h_{ijk}(t)] = \ln[h_0(t)] + (ß_{HD}HDays_{jk} + ß_{No}NoFarm_{jk} + Year_k + Pair_j + Clutch_{jk})$$

2. Animal model

$$\ln[h_{ijk}(t)] = \ln[h_0(t)] + (ß_{HD}HDays_{jk} + ß_{No}NoFarm_{jk} + Year_k + Animal_j)$$

where $h_{ijk}(t)$ is the hazard function for the ith individual from the jth pair in the kth year at time t, $h_0(t)$ is the unspecified baseline hazard function, $HDays_{jk}$ is the number of days between hatching date and the 1st of January in that particular year for an individual from the jth pair in the kth year; $ß_{HD}$ is the regression coefficient for HDays; $NoFarm_{jk}$ is the number of live hatchlings in a particular clutch from the jth pair in the kth year; $ß_{No}$ is the regression coefficient for NoFarm; $Year_k$ is the fixed effect of the kth year (k = 2005, 2006, 2007); $Pair_j$ is the random effect of pair (assumed $N(0,\sigma^2Pair)$); $Clutch_{jk}$ is the common environment (random) effect of a clutch produced by the jth pair in the kth year (assumed $N(0,\sigma^2Clutch)$); and Animalj is the random effect of the jth individual (assumed $N(0,\sigma^2Animal)$). A 5% significance level was chosen to evaluate explanatory variables by backward elimination. Pair model log-survival heritability estimates were calculated as in Isberg et al. (2004), whilst the animal model estimates were calculated as

$$h^2_{log} = \frac{\sigma^2_{Animal}}{\sigma^2_{Animal} + \frac{\pi^2}{6}}$$

using the estimates of the variance component, σ^2_{Animal}.

RESULTS AND DISCUSSION

The pair model baseline survival function for crocodiles between hatch and 1000 days is shown in Figure 1. This plot shows the probability of a crocodile surviving to any given day, and it demonstrates a high mortality rate over the first approximately 400 days. Isberg et al. (2004) reported the probability of an animal surviving to day 400 was 56% after removing genetic and non-genetic effects. This probability has been increased using the current data to 89% for overall survival. For the other traits, the probability of an animal surviving to day 400 are 100%, 93%, 100%, 99% and 97% for congenital defects, runt, disease-related, stress-related and NVA, respectively.

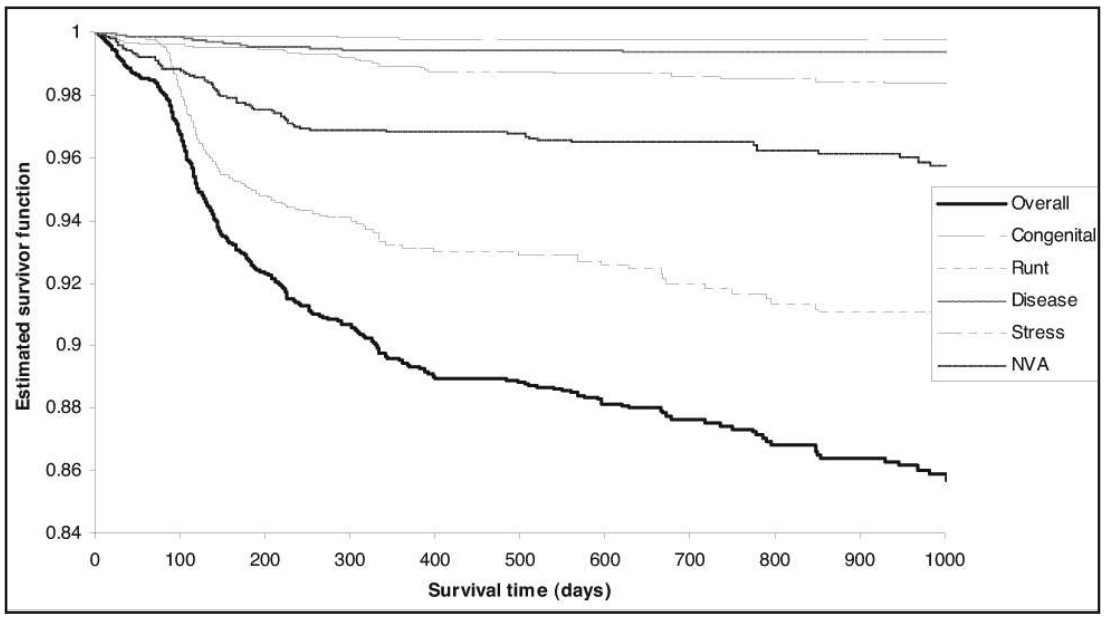

Figure 1. Baseline survivor function after removing all significant genetic and non-genetic effects for all survival categories between hatch and 1000 days.

Using the pair model, the number of live hatchlings produced in each clutch (NoFarm) was not significant for any of the survival categories, whilst using the animal model, NoFarm was significant for the runt, disease-related, stress-related and NVA categories. The date of hatch (Hdays) was found to be significant for the runt, disease-related and stress-related categories using the both the pair and animal model. Year was also significant for the runt pair model as well as overall, runt, stress-related and NVA animal models.

Using the pair model, the log-survival heritability estimates were all unexpectedly 0.71 (SE 0.08; Table 2), despite different models being significant and differences in the estimated variance components for pair and clutch. With exception, no significant random effects were found for the NVA survival category indicating that these are truly random events. However, using the animal model, the heritability estimates varied from 0.39 (SE 0.03) to 0.56 (0.04; Table 2).

Table 2. Heritability estimates (SE) for the survival categories using the pair and animal model. n.s. is where no random effects were fond to be significant, and thus heritability could not be estimated.

Category	Pair model	Animal model
Overall	0.71 (0.08)	0.39 (0.03)
Congenital defects	0.71 (0.08)	0.39 (0.03)
Runt	0.71 (0.08)	0.56 (0.04)
Disease-related	0.71 (0.08)	0.49 (0.04)
Stress-related	0.71 (0.08)	0.39 (0.03)
NVA	n.s.	0.42 (0.03)

Overall, these heritability estimates are extremely large in comparison to the overall heritability estimate published by Isberg et al. (2004; h^2 0.15 (SE 0.04)) and those for other livestock industries (Ducrocq et al. 2000; Knol et al. 2002; Southey et al. 2001). The similarity and magnitude of the pair model estimates may indicate confounding in the data set since there are only three years of data and clutch was modelled as an interaction between pair and clutch. Data will continue to be collected in this manner for future analysis. The animal model heritability estimates show differences between the different traits which was expected.

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Early growth of Black caimans (*Melanosuchus niger*) in Bolivia

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ABSTRACT: One hundred and five Black caimans (*Melanosuchus niger*) were captured and marked between 1992 and 1996 at Laguna Cedral, within the Biosphere Reserve, Estación Biológica Beni, Bolivia. Thirty caimans were recaptured at least once, five were recaptured twice and two caimans were recaptured three times. Longest periods between the first and last captures were between 1445 and 1470 days. Smallest caimans were 19 cm long (body length) at first capture and largest recaptured caimans reached 53 cm in body length, at about 4.5 years of age. Growth rates ranged between 0.28 to 0.47 mm/day for about a year, for those caimans captured before their first year of age; while growth decreased to as low as 0.14 mm/day later in life. Distances between capture sites ranged between about 300 to 1500 m for caimans captured with a four-year interval. All caimans captured before their first year of age were recaptured at < 700 m from their initial capture sites within the next year and most of them were recaptured at < 500 m of their initial capture site. Only one caiman captured at another location, about 3 km from the primary study site, was captured four years later at Laguna Cedral.

Hypoxia: Does it affect embryo differentiation rate or just growth?

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ABSTRACT: In crocodilians, the rate of embryonic development and consequently the duration of the incubation period are affected by temperature. Since incubation temperature has strong influences on embryo development by altering metabolism rate, we manipulated oxygen concentration in order to uncouple the effects of developmental rate from the direct effects of temperature. Here we consider whether oxygen concentration has influence on differentiation rate (or progression from one stage to the next) and growth (body mass and total length). Thus, we incubated *Caiman latirostris* eggs at two different temperatures (31ºC, 100% female-producing temperature, and 33ºC, 100% male-producing temperature) and at two O2 concentrations (15% and 21%). We monitored the developmental stages of these embryos within the thermosensitive period (stages 20-24). Incubation under hypoxia reduced embryonic growth, but it had no effect on differentiation rate. Our results suggest that both, temperature and oxygen concentration, affect yolk-to-tissue conversion rate (and thus embryo size), and differentiation rate is affected only by incubation temperature.

Relationship between size of reproductive females and size and mass of eggs and hatchlings of Babilla (*Caiman crocodilus fuscus*) in Colombian Croco farm LTDA, Municipio Barranco de Loba, Bolivar, Colombia

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ABSTRACT: The Colombian Croco farm classifies its reproducers in homogenous groups according to size. For the nesting season in 2005 we collected data on 104 nests from females of different size groups.

The size rank of each group were: Group 1: small females with average 66 cm (SVL); Group 2: females with average 76 cm (SVL) and Group 3: large females with average 84.5 cm (SVL).

The first group (small females) 40 nests were selected; the second group 37 and the third (large females) 27 nests. For each group the following aspects were evaluated: eggs length, width and weight of each clutch, also hatchling length and weight.

The information was related to female size of the three reproductive groups. The data collected for each variable were statistically analyzed. Analysis of variance revealed that females size does not affect the egg length, but width and weight do show a statistically significant relationship. Larger females have eggs that are wider and heavier than smaller females. These results also show a similar relationship with hatchling length and mass.

Physiological diagnostic and a comparison of growth and mortality induced by the effect of medicinal products on *Caiman yacare* hatchlings in Crocoland farm, Santa Cruz, Bolivia

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ABSTRACT: Mortality under captivity is often directly linked to conditions on the farm, where the effect of stress, high density levels, and bad sanitary cleaning and disinfection practices are further common sources of diseases that have to be treated with preventive handling actions to bring about an improvement on hatchlings and finally cure them. We analyze the effect of medicinal products and fluctuating temperatures over the development and mortality on hatchlings that, after 6 months of been born, still show a low growth rate level. We worked with 720 hatchlings, divided into 4 groups of 180, which were placed in 4 husbandry pools with different temperature degrees. Each one of the 4 groups were also subdivided and placed into 6 compartments with 30 hatchling, and supplying them with: G1: Anabolics, G2: Injectable B Complex, G3: Oral B Complex, G4: Suppressor, G5: Combination of the 4 medicines y G6: Standard group (without supplies). The preliminary results of the development were: 0.9 cm per month in G1 of Compartment 1, 3.7 cm per month in G2 of Compartment 2, 3.3 cm per month in G1 of Compartment 3 and 1.5 cm per month in G2 of Compartment 4. The optimum growth temperatures degrees fluctuated between 33ºC and 38 ºC, and the anabolics turned out to be the best encouraging medicinal product.

RESUMEN: La mortandad de cocodrilos en zoocriaderos se debe generalmente a condiciones específicas del criadero, donde el efecto del estrés, densidades elevadas y malas prácticas higiénico-sanitarias pueden desencadenar diversas patologías, ante las cuales se deben desarrollar alternativas y medidas de prevención, y en el mejor de los casos, mejoría y/o curación de los especímenes.

En este trabajo analizamos de los efectos que ejercen los medicamentos y temperatura sobre el crecimiento y mortandad en neonatos que, después de los primeros 6 meses, presentan un desarrollo deficiente. Se trabajó con 720 neonatos, separados en grupos de 180, y colocados en 4 bandejas con temperaturas diferentes. Cada uno de los 4 grupos, fue dividido en 6 subgrupos de 30 neonatos, suministrándoles: G1: Anabólico, G2: Complejo B inyectable, G3: Complejo B oral, G4: Antiparasitario, G5: Combinación de los 4 medicamentos anteriores, y G6: Patrón (sin medicamentos).

Los mejores crecimientos, en base a resultados preliminares, fueron de 0.9 cm/mes en el G1 de la Bandeja 1, de 3,7 cm/mes en el G2 de la Bandeja 2, de 3,3 cm/mes en el G1 de la Bandeja 3 y 1,5 cm/mes en el G2 de la Bandeja 4. Las temperaturas entre los 33 y 38 ºC son las más óptimas para el desarrollo y los anabólicos estimulan el crecimiento.

Efficiency of Freeze - Dried Crocodile Blood in Iron Deficiency Anemia Male Rats

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ABSTRACT: Male weanling Sprague-Dawley rats were divided into AIN93G^{+Fe}, AIN93G^{-Fe} and AIN93G^{-Fe} + FzCB groups. After 4, 8 and 24 weeks, animals were fasted for 24 h prior to the experiments. The hematological values that indicated anemia status were evaluated. After 4 weeks, hemoglobin (5.59 + 0.25, and 5.80 + 0.29 g/dl) and hematocrit (26.46 + 6.45 and 17.10 + 0.83 %) values of AIN93^{-Fe} and AIN93G^{-Fe}+FzCB groups respectively were significantly different (P<0.05) from AIN93G^{+Fe} (15.14 + 0.43 g/dl and 41.52 + 1.09 %) group. Consequently, after 8 and 24 weeks, hemoglobin (15.67 + 0.49, 16.32 + 0.17; 13.7 + 1.65, 15.44 + 0.55 g/dl) and hematocrit values (43.45 + 1.31, 45.44 + 0.44; 38.38 + 4.29, 40.08 + 2.15%) of AIN93G^{+Fe} and AIN93G^{-Fe}+FzCB groups respectively were differ (P<0.05) from AIN93G^{-Fe} (8.88 + 2.52 g/dl and 26.46 + 6.45) group. The freeze-dried crocodile blood had no detrimental effect on histological change in intestine kidney and liver after 24-week. These data suggest the freeze-dried crocodile blood has efficiency for promoting hemoglobin and hematocrit values on iron deficiency rat that may be used as food supplement in anemia patient.

INTRODUCTION

Iron deficiency anemia is the most prevalent nutritional deficiency and the most common cause of anemia in Thailand (Pattanee 2002). It is the most common micronutrient deficiency in the world today and impacts the lives of millions of women and children contributing to poor cognitive development, increased maternal mortality and decreased work capacity. It is characterized by a defect in hemoglobin synthesis, resulting in red blood cells that are abnormally small (microcytic) and contain a decreased amount of hemoglobin (hypochromic) (Provan 1999). The capacity of the blood to deliver oxygen to body cells and tissues is thus reduced. Iron is essential to all cells. Functions of iron include involvement in energy metabolism, gene regulation, cell growth and differentiation, oxygen binding and transport, muscle oxygen use and storage, enzyme reactions, neurotransmitter synthesis, and protein synthesis (Beard 2001). Measurement of hemoglobin or hematocrit is the most cost efficient and commonly used method to screen for anemia (Cook 1999). Iron therapy, in combination with dietary strategies to increase iron and vitamin C intakes, effectively treats iron deficiency anemia by raising the hemoglobin level and replacing iron stores.

Freeze dried crocodile blood is a natural product and can served as medicines for curing illness such as allergy and asthma, and may also prolong their life. It has been widely

consumed not only for its nutritious composition, but also for its claimed medicinal value (Siruntawineti *et al*. 2004). The practice of consuming crocodile blood for improving human health is found in the traditions of many Asian cultures. Recently, the Freeze dried crocodile blood production process has been development and the safety for crocodile blood consumption has been reported (Chaeychomsri *et al*. 2004, 2006). Our study aimed to determine whether the efficiency of freeze dried crocodile blood on iron deficiency male rat, Spraque-Dawley, to use as human food supplement by observing hemoglobin and hematocrit values in the rats.

METHODOLOGY

Preparation of Freeze-dried Crocodile Blood: Crocodile blood was collected from Siamese crocodiles (*Crocodylus siamensis*) rose at Sriracha crocodile farm, Chonburi, Thailand using sterile technique. Fresh crocodile blood was weekly taken and kept at 4ºC in sterile containers. The freeze-dried blood was prepared in sterile conditions and stored at 4ºC until use.

Laboratory animals: The Animal Ethics Committee of Kasetsart University, Thailand approved the use of laboratory animals in this study. Fifteen male Spraque-Dawley were purchased from The National Laboratory Animal Center, Mahidol University, Salaya, Thailand. They aged 3-4 weeks with weight ranging from 45 to 60 g. The rats were randomly divided into 3 groups. Group 1 (AIN93G^{+Fe}) received high fat corn starch (HFCS) base on AIN93G^{+Fe} (Reeves *et al*. 1993) diet (Table 1). Group 2 (AIN93G^{-Fe}) received HFCS base on AIN93G^{-Fe} diet. Group 3 (AIN93G^{-Fe}+FzCB) received HFCS base on AIN93G^{-Fe} diet for 30 days and followed by HFCS base on AIN93G^{-Fe}+Freeze dried crocodile blood 1000 mg/kg body weight. Rats were housed individually in hanging wire-mesh cages in a room with a controlled temperature of 25-29ºC and a 12:12-h light-dark cycle with 30-70% relative humidity. Animals were allowed unlimited access to food and distilled water. Daily food intake were recorded and body weights were recorded weekly

Table 1. Composition of diet

Dry Matter Ingredient (g/kg)	**High fat corn oil (HFCS)1**	
	AIN93G^{+Fe}	**AIN93G^{-Fe}**
Casein[2]	200.0	200.0
L-Cystine[3]	3.0	3.0
Corn starch[2]	529.5	529.5
Sucrose[2]	100.0	100.0
Cellulose[2]	50.0	50.0
Soybean[2]	70.0	70.0
AIN-93G mineral mixture[2]	35.0	35.04
AIN-93G vitamin mixture[2]	10.0	10.0
Choline Chloride[3]	2.5	2.5

1 Based on the AIN-93G diet. 2 Purchased from Diet (USA).
3 Purchased from Wako Pure Chemical Col., (Osaka, Japan). 4 Ferric citrate was omitted.

Experimental procedure: Beginning at 4 weeks of age, rats were fed the experimental diets for 24 weeks. After 4, 8 and 24 weeks, animals were fasted for 24-h prior to the experiments.

Rat blood was sampled at 4, 8 and 24 weeks. The blood sample was withdrawn from tail vein using ethylene diamine tetraacetic acid (EDTA) as anticoagulant. The hematological values of rat blood, complete blood count (CBC), white blood cell count (WBC), red blood cell count (RBC), Hematocrit (Hct), hemoglobin (Hb) concentration were performed by an automate hematology analyzer (Sysmex K-1000, Diamond Diagnostics, USA). All values were compared to control group at the same time of treatment and to the standard range for rats.

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

Statistical Analysis: The data were analysed by one-way ANOVA. The significant differences between the experimental groups, at $P<0.05$, were compared by Duncan multiple range test. Each value represents Mean + SE.

RESULTS AND DISCUSSION

Throughout the experiment AIN93G^{+Fe} and AIN93G^{-Fe}+FzCB groups appeared healthy, inquisitive and active. No illness or death occurred. However, AIN93G^{-Fe} appeared bad health and inactive. The body weight of AIN93G^{-Fe}+FzCB and AIN93G^{-Fe} groups were significant difference ($P<0.05$) from AIN93G^{+Fe} after 4 weeks of diet until the end of the study. These results indicated that AIN93G-Fe+FzCB and AIN93G^{+Fe} groups had higher growth rates after fed freeze-dried crocodile blood than AIN93G-Fe group that had Iron deficiency anemia.

The hematological parameters specially in hematocrit and hemoglobin values of AIN93G^{-Fe} and AIN93G^{-Fe}+FzCB treated groups revealed that after 4 weeks hemoglobin (5.59 + 0.25, and 5.80 + 0.29 g/dl) and hematocrit (26.46+ 6.45 and 17.10 + 0.83 %) values of AIN93^{-Fe} and AIN93G^{-Fe}+FzCB respectively were significantly different ($P<0.05$) from AIN93G^{+Fe} (15.14 + 0.43 g/dl and 41.52 + 1.09 %) group. After 8 and 24 weeks, hemoglobin (15.67 + 0.49, 16.32 + 0.17 and 13.7 + 1.65, 15.44 + 0.55 g/dl) and hematocrit (43.45 + 1.31, 45.44 + 0.44 and 38.38 + 4.29, 40.08 + 2.15%) values of AIN93G^{+Fe} and AIN93G-$^{-Fe}$+FzCB respectively were significantly different ($P<0.05$) from AIN93G^{-Fe} (8.88 + 2.52 g/dl and 26.46 + 6.45) group (Table 2). These results indicated that administration of the freeze-dried crocodile blood as food supplements had effects on hematological values. Moreover, our previous studies confirmed that the crocodile blood was free from parasites. Therefore crocodile blood should be safe for consumption as food supplement.

Treated rats of AIN93G^{-Fe}+FzCB group exhibited no alteration of intestine, liver and kidney after 24-week of daily feeding freeze-dried crocodile blood. These results indicated that freeze-dried crocodile blood had no detrimental effect on histological change in intestine kidney and liver in all treatments.

These data showed that freeze-dried crocodile blood had effect in hematological values especially in hemoglobin and hematocrit values on iron deficiency rat. Moreover, treated rats exhibited no alteration of intestine, liver and kidney after 24 week of daily feeding with freeze dry crocodile blood (Fig. 1).

Table 2 Mean hematological values of 5 Sprague-Dawley rats in each group after feeding 4, 8 and 24 weeks of experiment.

Hematological	After 4 weeks			After 8 weeks			After 24 weeks		
Value	AIN93 $^{+Fe}$	AIN93 $^{-Fe}$	AIN93^{-Fe}+FzCB	AIN93 $^{+Fe}$	AIN93 $^{-Fe}$	AIN93^{-Fe}+FzCB	AIN93 $^{+Fe}$	AIN93 $^{-Fe}$	AIN93^{-Fe}+FzCB
RBC (10^6/ml)	7.55 ± 0.10	4.69± 0.08*	4.80± 0.15*	8.26 ± 0.20	7.05 ±0.64	9.81 ± 0.31*	8.65 ± 0.11	6.00 ± 0.92	9.14 ± 0.91
HGB (g/dl)	15.14 ± 0.19	5.58 ± 0.14*	5.80 ± 0.14*	15.67 ± 0.24	7.57 ±1.11*	13.7±0.74	16.32 ± 0.17	9.69 ± 0.05*	15.44 ± 0.55
Hct (%)	41.52 ± 0.48	16.90 ± 0.43*	17.10 ± 0.41*	43.45± 0.65	23.15 ± 2.95*	38.38± 1.91	45.44 ± 0.44	21.65 ± 2.30*	40.08 ± 2.15
MCV (fl)	55.00 ± 0.41	36.00 ± 0.35*	35.70 ± 0.40*	52.57 ± 0.55	32.75 ± 1.25*	39.3 ±2.65*	52.52 ± 0.34	35.80 ± 0.50*	44.02 ± 2.34
MCH (pg)	20.02 ± 0.12	11.90 ± 0.10*	12.10 ± 0.12*	18.97± 0.23	10.70 ± 0.60*	14.04 ± 0.97*	18.86 ± 0.14	11.6 ± 0.46*	17.02 ± 1.03
MCHC (g/dl)	36.42 ± 0.10	33.03± 0.27*	33.90± 0.29*	36.15 ± 0.18	32.65 ± 0.65*	35.66 ± 0.25	35.88 ± 0.08	32.38 ± 1.20	38.70 ± 1.27
Plt (10^3/ml)	815.00 ± 74.25	1815.67 ± 72.45*	1811.50 ± 68.38*	738.00 ± 109.20	1394.50 ± 5.50*	1126.00 ± 100.93*	793.40 ± 76.62	1856.50 ± 152.50*	1070.40 ± 110.34
MPV (fl)	8.4 ± 0.21	9.39 ± 0.12	9.73 ± 0.40*	8.59 ± 0.28	11.90 ±0.38	8.90 ± 0.26	8.80 ± 0.36	14.18 ± 1.64	12.60 ± 0.37
WBC (10^3/ml)	12.50 ± 0.98	14.13± 3.96	17.05 ± 1.75	9.50 ± 1.14	13.90 ± 1.10*	13.4 ± 0.80*	8.78 ±0.87	5.42 ± 2.5*	8.12 ± 1.09
Neu (%)	7.55 ± 0.89	20.03 ± 6.3*0	14.10 ± 1.4 0	8.53 ± 1.00	13.57± 3.80	8.31± 0.84	13.2 ± 3.50	9.93 ± 1.09	14.06 ± 3.08
Lym (%)	85.38 ± 1.40	66.10 ± 8.10*	67.53 ± 5.10*	86.37 ± 1.97	79.30 ± 5.20	80.74 ± 2.10	76.6 ± 9.56	76.95 ± 17.30	53.50 ± 14.06
Eo (%)	1.43 ± 0.24	1.56 ± 0.47	1.37 ± 0.29	2.02 ±0.19	1.78 ± 0.40	2.03 ± 0.69	1.93 ± 0.23	3.49 ± 0.03	2.54 ± 1.63
Ba (%)	1.16 ± 0.18	1.12 ± 0.56	1.60 ± 0.58	0.63 ± 0.18	0.65 ± 0.25	2.06 ± 0.31	3.09 ± 1.43	3.35 ± 1.76	1.30 ± 0.37
Mo (%)	1.16 ± 0.50	11.16 ± 1.45	15.40 ± 3.79*	2.44 ± 0.97	4.67 ± 1.52	6.84 ± 1.19	5.12 ± 1.29	5.15 ± 1.65	2.83 ± .0.67

*Significant different between group at the same time (P<0.05)
RBC= red blood cell, HGB= hemoglobin, Hct= hematocrit, MCV= mean corpuscle volume, MCH= mean corpuscle hemoglobin,
MCHC= mean corpuscle hemoglobin concentration, Plt= platelet, MPV= mean platelet volume, WBC= white blood cell,
Neu= neutrophil, Lym= lymphocyte, Eo= eosinophil, Ba= basophil, Mo= monocyte

In conclusion, the results in this study revealed that freeze-dried crocodile blood has efficiency for promoting hemoglobin and hematocrit values on iron deficiency rat in at least 4 weeks of and very useful for use as food supplement in anemia patient.

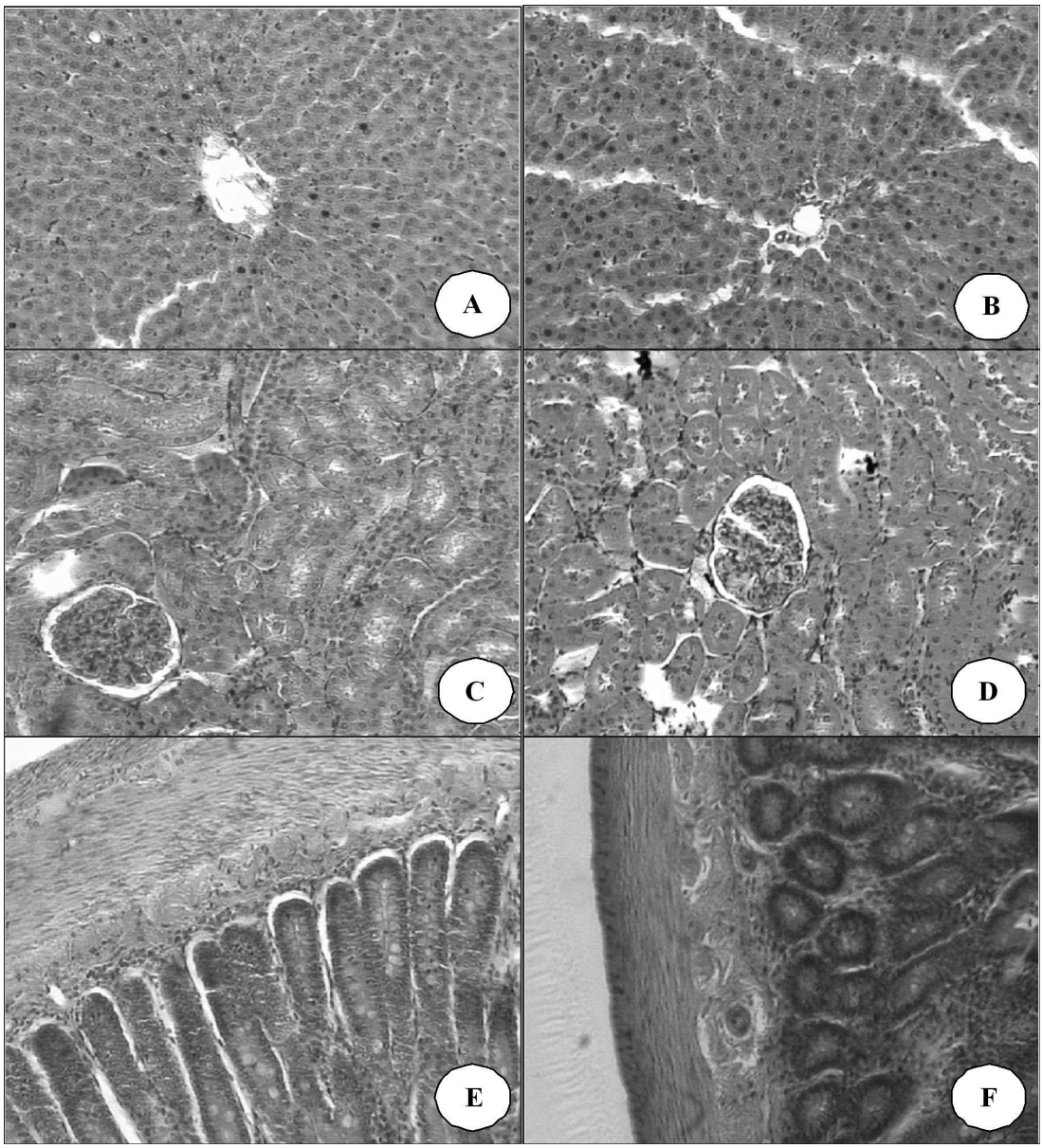

Figure 1. Histopathological examination of liver, kidney and intestinal of Sprague-Dawley rats after 24 weeks of freeze-dried crocodile blood consumption.

(A) Liver cell of control group (B) Normal sign of liver cell from freeze-dried crocodile blood consumption.
(C) Kidney cell of control group (D) Normal signs of kidney cells from freeze-dried crocodile blood consumption.
(E) Intestinal cell of control group (F) Normal signs of intestinal cells from freeze-dried crocodile blood consumption.

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Key words: Anemia; Crocodile blood; Rat; Iron deficiency anemia

How populations of the Australian Saltwater Crocodile (*Crocodylus porosus*) have recovered: Baseline analysis of four major tidal rivers within Kakadu National Park, Australia.

Britton, A.R.C., Lindner, G., Winderlich, S. (2008).

ABSTRACT: The Australian Saltwater Crocodile (*Crocodylus porosus*) was protected in the Northern Territory of Australia in 1971.Since then its recovery has been dramatic, and was accompanied by extensive, replicable surveys across many significant tidal river habitats. Various aspects of this recovery have been presented over the years, and it has since become clear that recovering population trends not only follow similar patterns but also take many years to become fully apparent. This paper presents up-to-date results on the near-complete population recovery of *C. porosus* within major tidal rivers, and is particularly relevant because it concentrates primarily on rivers within Kakadu National Park that have not been exposed to significant post-protection harvest of either eggs or adults. At least one tidal river appears to have now reached carrying capacity, with others close behind it, and the resulting similarities in density changes and population structure may represent an idealised baseline trend for crocodile population recovery in such habitats.

Ligawasan Marsh Wild Crocodile: Status of *Crocodylus mindorensis*

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ABSTRACT: Ligawasan marsh is strategically located at the central Mindanao river basin. Its physical characteristics and geographic location suggest a high potential to support wild populations of crocodiles particularly *Crocodylus mindorensis*.
Strategic survey, photo documentary and actual count captured their existence using equipment provided through a research fund by the Crocodylus Porosus Philippines, Inc. (CPPI). The presence of poachers, fishermen, farmers and local inhabitants inside and around the marsh are instrumental in describing habitats, volunteering live samples, locating nests and counting individual crocodiles.
The habitats were found in Sadsalan (the deepest part of the marsh), entering Cuyapon, Kabacan, North Cotabato, Talitay and Buliok at Rajah Muda side of Pikit, North Cotabato and Pagalungan, Maguidanao and tributaries.
The two largest crocodiles found before the study were *C. porosus* in Pagalungan side of the marsh. There were 265 *C. mindorensis* counted and 13 in captivity at the vicinity of the marsh from late 2007 and early 2008. A regular catch of foot long juveniles has been reported. Cultural myths, beliefs and environment have important role in the conservation and protection of their dwindling population in the marsh.

Keywords: Ligawasan marsh, crocodile, North Cotabato, Philippines, *Crocodylus mindorensis*

INTRODUCTION

Crocodile industry in the Philippines

The crocodile industry in the Philippines is a very lucrative industry due to the growing demand for skin, as raw material for quality handbags, boots, belts, briefcases and luggages in developed countries for their fashion industry.

Further, hotels and restaurants also include in their menu the exotic meat of these reptiles in their dining tables. Rapid commercialization of crocodiles can be seen on the growing numbers of crocodile farms in the provinces of Rizal, Palawan, Davao del Norte and the cities of Davao and Cagayan De Oro.

Though this actual scenario is good for the economic side of the Philippines but the conservation of these crocodiles in the wild is neglected and hence, there is greater likelihood that in the future these crocodiles particularly, the *Crocodylus mindorensis* will only be read

in books. If there is no action taken by both the government and the private sectors, these reptiles will no longer be seen in the wild. The present situation of these crocodiles in the wild is considered at very high risk of extinction due to the destruction of habitats caused by rapid urbanization, farming, negative local attitudes and ineffective management.

Crocodiles in Mindanao

The two species of crocodiles namely *Crocodylus mindorensis* and the *Crocodylus porosus* are both found in the island of Mindanao in the Southern Philippines. *C. porosus* for instance are mostly raised captive in the provinces of Davao del Norte and city of Davao for future commercial purposes while these are raised as pets in Bukidnon, Lanao del Norte and other provinces.

Information on *C. mindorensis* is quite silent or limited on its present situation although, it is believed to be in the wild particularly in the marshes of Agusan and Ligawasan and tributaries.

One proof that crocodiles exist in the wild particularly in Ligawasan marsh and its tributaries was documented in the national newspapers, the Philippines Daily Inquirer on May 15, 1994 (Maulana, 1994) and May 30, 1994 (Alconaba & Maulana, 1994) and also in the local newspaper Daily Express on May 23, 1994 (Duque, 1994). This wild wounded crocodile (believed to be *C. porosus*) measured 19 feet and 6 inches long and 3 feet wide with approximate weight of 800 kilograms. The fishermen who captured the crocodile witnessed fighting with another crocodile having an estimated length of 25 feet. This reptile is still roaming the Ligawasan marsh basin.

The Ligawasan Marsh

The Ligawasan Marsh has been identified as a distinct and unique region among the 15 bio-geographic regions of the Philippines (Wetlands in Asia). It covers about 288,000 hectares of which 43,900 hectares were declared a Game Refuge and Bird Sanctuary under the Forestry Administrative Order No.19 of December 26, 1940 (effective January 1, 1941). The Ligawasan Marsh Development Master Plan (1999-2025), prepared by the Region XII Office of the National Economic and Development Authority (NEDA) in November 1998, recommends designation of the marsh as a protected area under the National Integrated Protected Areas System (NIPAS) Act (Republic ACT No. 7586 of 1992).

Ligawasan Marsh is strategically located at the central Mindanao river basin covering 3 provinces such as: North Cotabato, Sultan Kudarat, and Maguindanao. It is within 19 municipalities and one city (or 190 barangays). It is the countrys' largest wetlands. It drains the rivers coming from the mountain ranges in the east – the Kidapawan and mount Apo ranges; north – the Carmen, Libungan, Bukidnon mountain ranges; and south – the Sultan Kudarat mountain ranges.

Potential food source

The migratory and endemic birds could be among the list of prey for the crocodiles. Tilapia, eels, mudfish, catfish and carp are also abundant in the marsh. Domesticated dogs and cats were listed to be attacked and eaten by the crocodiles. Reptiles like snakes and small lizards,

wild rodents, monkeys and other non-volant mammals could also be a part of their diet. Other dead animals may be driven to the marsh thru the tributary rivers.

Habitat

A game refuge and bird sanctuary was established in 1941. Meandering rivers provide sanctuary for the shy crocodiles. Mangroves, sedges water lilies, and grasses may increase the stealth ability of crocodiles to make them more effective predator. The margins of the marsh is being cultivated and planted with rice, corn, root crops, coconut, tobacco, oil palm, and banana. The margins of the marsh swell during rainy seasons. The highest rainfall (over 200 millimeters) comes during the month of July (based on the rainfall data of the past 4 years, USM). The rains during December also help in impounding water in the marsh. It supports a significant variety of wild plants and animals. But there is no solid scientific and statistical information on the marsh's biodiversity to strengthen *in-situ* conservation, and for appropriate water management to supply the water needed for the survival of its biodiversity.

This joint undertaking aims to enable the locals, farmers, barangay officials, and stakeholders to develop positive attitude towards self-reliance, appreciate their roles in conserving ecological resources through sustainable farming practices, upgrade their knowledge and skills in agro-livestock-fishery technology focused on crocodile farming system management and rural entrepreneurship.

Goals:

The purpose of this research is to verify if both *C. porosus* and *C. mindorensis* species co-exist in the marsh and its surrounding environs. Both species are still under pressure from poaching for commercial purposes, indiscriminate killing (in some areas), predated as a food source, and accidentally killed. It is believed that the Ligawasan Marsh still houses the largest wild population of *C. mindorensis* in the Philippines and it is the only remaining area where the interactive ecology of the two crocodiles in the Philippines can be studied.

Methodology:

I. Expected Results of this Project (First Year)

Through a proposed 50 days field survey work and 10 days extension work in the marshlands funded by CPPI:

1. Obtain baseline data on distribution and abundance of crocodiles in the marsh.
a. Field surveys
b. Questionnaire
2. Obtain baseline data on cultural beliefs about crocodiles and potential effect on conservation and/or sustainability. These are characterized by indigenous beliefs (IB) and indigenous knowledge (IK).
3. Collect biological information on crocodiles in the marsh.

II. Tentative Long Term Results – depending on first year activity and subsequent funding:

A. Development of a *C. mindorensis* rescue and rehabilitation center at USM.
   i. Potential of release back into the wild.
   ii. Release to the local hog industry for rearing.

B. Create a permanent study area/sanctuary in the marsh for *C. mindorensis*.
   i. Participation of indigenous inhabitants.

C. Investigate ranching strategies for *C. mindorensis* in protected areas.
   i. Livelihood and conservation activity through sustainability.

D. Commercial utilization of *C. mindorensis.*
   i. F2 progeny from farms
   ii. Sustained support for USM program.

RESULTS AND DISCUSSION

Ligawasan Marsh, potential haven of wild crocodiles

Ligawasan Marsh is a vast complex of river channels, fresh water, lakes, ponds and extensive marshes are the areas' main features. Its physical characteristics and geographic location suggest a high potential to support crocodiles. The marsh receives water from Libungan river, Malmar river, Pulangi river, Buluan river, Paglas river and Allah valley river. The water in the marsh is drained to the sea via the Rio Grande de Mindanao that empties into the Illana bay of Cotabato City.

It contains fresh water marshes with an abundant growth of *Eicharvia crassipes*, *Nymphaea tetregan* (water lilies), *Ipomoea aquatica (*kangkong), water hyacinths, swamp cabbages and redges. It also supports a great variety of wildlife including species of fish, reptiles, birds and mammals.

It produces a huge quantity of fresh water fishes like mud fish (locally known as Dalag), tilapia, cat fish (native and hybrid Hito), carps, freshwater eels, crabs and shrimps that are delivered daily in the cities of Cotabato, Kidapawan, Koronadal and Tacurong, Digos and Davao and the provinces of Sultan Kudarat, Maguindanao, South Cotabato, North Cotabato and Lanao del Sur. During the period of heavy rains, when the water level is high due to the swelling of its tributaries, most of inhabitants temporarily migrate to neighboring highland areas in search for alternative livelihood such as upland farming and daily labor in some commercial farms and businesses.

Majority of the inhabitants within the marsh are Maguindanaoan muslims although due to migrations some people particularly Ilocano, Cebuano and Ilongo Christian groups are also found in the villages surrounding the marsh.

The agricultural activities along these river tributaries decrease the volume of water that goes into the marsh. There are no precise data on the conditions and proportions of area that are permanently under water. But it is certain that the Ligawasan marsh swells during the

rainy season submerging some crops planted near the margins. The inhabitants were able to live with the periodic flooding by diverting their source of food and livelihood into fishing.

The Marsh is also home to some allegedly rebel factions who demand for an independent Islamic country in the Southern Philippines, the feared criminal groups, and the kidnapping gangs. While their presence, on one hand, is an opportunity for the conservation directions because poaching, collecting and trade of crocodiles from the marsh will not be physically pursued. Seemingly, on the other hand, bombs and explosives as war effects will be detrimental to habitat, food chain and ecological balance.

Crocodiles

The presence of crocodiles in the Ligawasan marsh has been noted during the Second World War. At the present time, there were captive crocodiles treated as pet near the marsh. Some poachers are also selling juvenile *C. mindorensis* around the municipalities near the marsh, these indicates that the *C. mindorensis* is actively reproducing in the wild.

It has been fairly documented that the biggest crocodile (*C. porosus*) was captured sold and died under the management of one resort in Pres. Roxas municipality and that this including another crocodile has been fighting when the other one was captured.

Ecological issues and threats in the marshland for crocodiles

- Plans and prospecting for natural gas exploitation
- Agriculture
- Siltation and eutrophication
- War (explosives, bombs, and bullets destroy the habitat)

There are other form of threats by which crocodiles in Ligawasan Marsh are exposed (Figure 1). Flooding from the municipalities that surround the marsh alters the ecological habitat of the crocodiles due to siltation and makes the marsh shallow.

Drought on the other hand provides opportunity for the locals for farming, while it is beneficial to the human populace it dries-off the marsh and when flood waters overcome the crops, the habitat for the crocodiles is altered. It also endanger the crocodiles because the farmed portions have been planted with oil palm and other permanent crops. The other threats are: alleged gas exploitation, wars around and inside the marsh where bombs are dropped the habitats and food chain are destroyed.

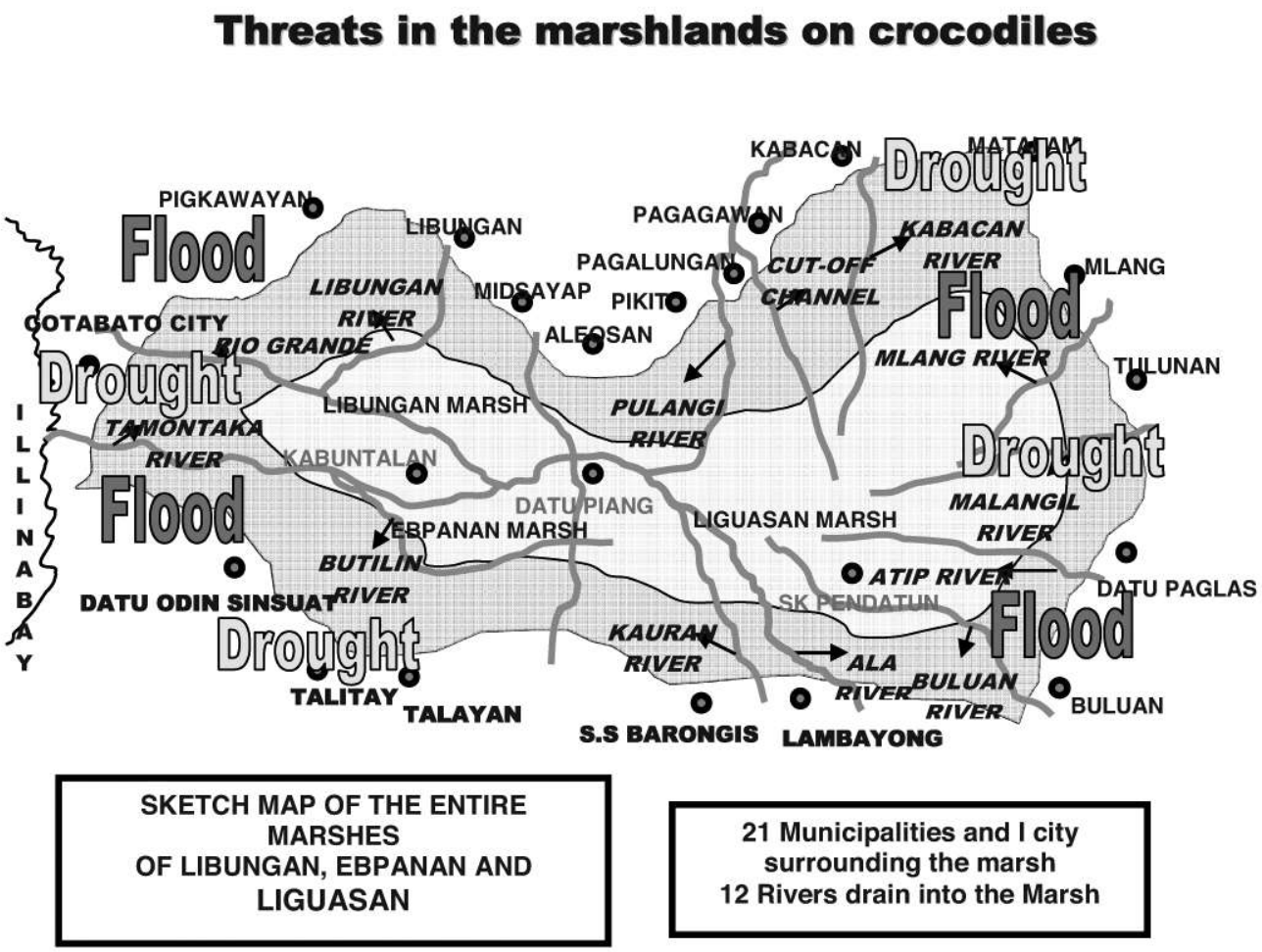


Figure 1. Sketch map of the marshes of Libungan, Ebpanan and Ligawasan by which wild crocodiles has been sighted and potential threats viewed.

Survey results on sightings and attitudes of locals.

The study focuses on the two species that are present in the area, *Crocodylus mindorensis* also known as the Philippine crocodile and the *Crocodylus porosus. C. porosus* is common in the crocodile industry for its meat and skin. The species is spread not only in the Philippines but also in other areas of the Asia-Pacific region. On the other hand, *C. mindorensis* is endemic in the Philippines and it is believed that its number is decreasing due to the destruction of its natural habitat and being captured for sale as pets. Further, the actual number of these crocodiles in the wild is unknown. There are claims of their presence in some areas in the wild but are unverified. In Mindanao, *C. mindorensis* are mostly found in Ligawasan marsh and its tributary rivers, although baseline information about their presence is limited due to the location and the political situation of the area.

Table 1 presents the situation of the crocodiles based on the actual sightings of people who are resident in the area and their attitude towards the crocodiles.

Respondents that actually sighted crocodiles in the area of Ligawasan marsh and its tributaries as well as respondents who owned crocodiles in captivity were randomly selected on location.

Table 1. Status of wild crocodiles in Ligawasan marsh and selected tributaries indicating the number, sizes and type as perceived by randomly selected respondents. (Note: Size in length – unless measured, approximated as small = 1 foot; medium = 1-2 feet; large = 2-3 feet; extra large = 3-4 feet; jumbo= 4-5 feet; very very large = 5 feet and above, unless specified the crocodiles counted are *C. mindorensis*)

LOCATION	SIZE OF CROCODILE	NUMBER SIGHTED
Ligawasan Marsh		**n=191**
- Cuyapon	Small to large	29
- Kabacan	Small to medium	5
- Sadsalan	Small to very large	117
- Talitay	Small to very large	16
- Buliok	Small to very large	22
- Pagalungan	Very very large	*C. porosus*= 2
Tributary		**n=74**
- Pres. Roxas	Medium to very large	5
- Omonay	Very large	25
- Tambad	Medium to very large	21
	Medium to very large	*C. porosus*=5
- Matalam	Small to large	8
- Pulangi	Medium to large	15
Total		**N= 265**

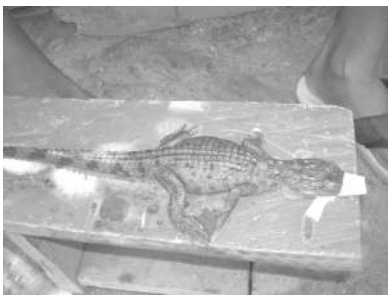
This survey was done in the following places: Barangay Cuyapon, Kabacan which is an entrance barangay of the Ligawasan Marsh, President Roxas town and barangay Tambad, Carmen and Pagalungan. Kabacan, President Roxas and Carmen are all towns of Cotabato province and Pagalungan in Maguindanao Province.

Pres. Roxas and Carmen were surveyed as part of the tributary (Pulangi river) of the Ligawasan Marsh. The survey was also done in barangay Omonay of Damulog, Bukidnon which is just a neighboring barangay of Tambad, Carmen which share Muleta river, a tributary of Pulangi river and where crocodiles have been sighted with nests.

The result of the survey showed that there were 265 sightings of the crocodiles, 252 are found in the wild and 13 under captivity. Most appeared in the afternoon as well as noon time and mostly were alone. The size of the crocodiles ranges from 1 foot to 19.5 feet (small to very very large). Most of the crocodiles diet were found in the fresh water particularly fish, which are in abundance in the Ligawasan Marsh.

The sighted wild crocodiles were confirmed as *C. mindorensis* (n=258) and *C. porosus* (n=7). Some eggs were collected by the locals and one clutch in a nest was allowed to hatch under the supervision of the researchers. These results were collected and recorded during the night and day surveys for at least 10 expeditions in the site of study.

These crocodiles were given approximate sizes from the actual measurements under captivity. The respondents gave their estimate of the size of the crocodiles. These were transformed into the proximate values prepared by the team. The sizes of *C. mindorensis* classified ranged from small to large while *C. porosus* were medium to very very large.



It was observed by 'Mr. B' (oldest poacher, collector for more than 30 years) that two different crocodiles were found in the marsh the black/yellow (friendly, with mythological connotation as reincarnate of humans), white (ferocious, shy, huge). This observation was confirmed by him after the visit at Crocodile Park in Davao as: *C. mindorensis* for black yellow while white as *C. porosus*. Another "Mr. T' was born twin to a male crocodile who is still in contact with him. During the full moon, the twin crocodile will be offered with live chicken and cooked rice and 'Mr. T' will observe the twin crocodile to appear and they have connections again. The twin crocodile always watches over him and his family around the Pulangi river, even when they go fishing, the crocodile leads them to where the big catch is.

Most of the small sizes (juveniles – one foot long) has been regularly caught and put in a screen cage lowered in the canal waterway leading to the entrance of Ligawasan via Cuyapon side until a buyer pays the catch.

These juveniles are usually sold to pet shops and collectors around Kabacan. The large to very large were caught only when orders are posed by a middleman. A large number of these sizes were delivered to operators of parks.

Table 2. Summary on the occupation and tribal affiliation crocodiles in the wild.

OCCUPATION OF RESPONDENTS	Number of respondents	TRIBAL AFFILIATIONS
Students	7	Maguindanao (n= 31)
Farmers	9	Igorot (n = 2)
Mayor	2	Ilonggo (n = 9)
Fishermen	8	Ilocano (n = 15)
Businessmen	2	Cebuano (n = 3)
Barangay official	2	
Soldier	1	
Agriculturist	1	
MILF	28	
	N = 60	

The respondents were classified according to their occupation and tribal affiliation (Table 2). It showed nine varied occupational groupings of the respondents who are mostly Ilocanoes followed by Maguindanaons who are related to their cultural identifications. Ilocanoes are industrious farmers and Maguindanaons establish houses in banks of water bodies and basically use fishing as source of livelihood. The rest of the respondents are residents in the area, traders, and family members of settlers or government officials.

In Barangay Cuyapon and Poblacion, Kabacan

Some captured crocodiles are caught by the local poachers ('Mr. B' and son) in Barangay (village) Cuyapon, Kabacan, Cotabato (which is one of the entrance to the Ligawasan Marsh) and were sold in the town Poblacion area for a price from Php 750 (US$15) to Php1500 (US$30) per piece for a 12-inche size crocodile. All of these captured crocodiles were *C. mindorensis*. Middlemen of poachers are selling these crocodiles (size=12 inches) in the cities and provinces to crocodile farms and pet lovers and shops for a price of Php 3500 (US$71). A *C. mindorensis* was found as pet in Poblacion, Kabacan about 3 years old, 7 feet long which was captured in the Malmar area (Malitubog-Maridagao rivers), a tributary of the Ligawasan marsh.

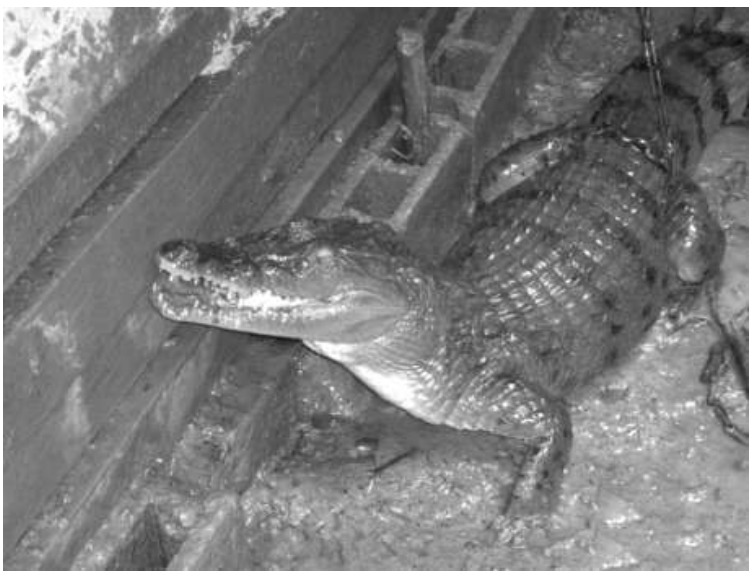
Entrance to the marsh

'Mr. B' and sons of Cuyapon, Kabacan

'Mr. B' illustrates how crocodile lay eggs and how many in a clutch . According to him, eggs are arranged by layers, the top most layer indicates the number in the clutch. If 2 eggs are on top, 20 eggs are laid; if 3 eggs on top, 30 eggs are laid. He collects eggs as well if ordered, it costs 20 pesos per piece.

discussions and lectures about crocodile conservation, the respondents were given a tour to the Davao Crocodile Park for exposure and confirmation about the looks and sizes of the crocodiles sighted, counted and collected,

(especially on species identification). This proved to be a good measure to confirm the volunteered answers to the questionnaires and focus group discussions. Information, Education, Communication (IEC) materials were provided to the participants for advocacy and complementation. The children in the foreground are young students who witness frequently the presence of the crocodile in Tambad every time they bring their carabaos to pasture along the bank of Muleta river.

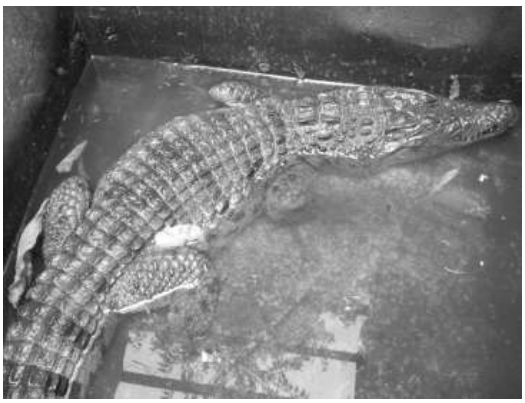


In Barangay Pisan, Kabacan Cotabato, a chained male *C. mindorensis*, caught using electrocution. This guy together with another (escaped) was caught close to a duckery project during a big flood. He was believed to have swam upstream via the Pulangi river. He was placed in a mini park zoo but due to the method of restraining and catching, he did not survived long

In Sitio Sadsalan, Cuyapon, Kabacan

Sitio Sadsalan is located in the mid-point of Ligawasan marsh and believed to be the deepest part of the marsh. This served as the breeding habitat of crocodiles and a 'holy' place for the locals. Occasional visit by locals from the MILF camp has proved that crocodiles of the black/yellow (*C. mindorensis*) and white (*C. porosus*) used the place for their nest. It has thick floating vegetation that formed into islets. The crocodiles used the rotting plant parts as nests. The locals stressed that the place should be vacated before 4:00 o'clock in the afternoon because the water become turbulent and only few can manage to get out safely from the place. They believed that the very very large crocodile will appear and make the water turbulent with huge waves when they fight. But logically, this is so because the islets move due to strong wind velocity and waterways close up where you can not retrace your passage. Much more, security is not guaranteed at any time. There were 15 bancas of full security force that accompanied the research team to the area in case an encounter happens. The largest number of sightings of wild crocodiles was recorded in this place.

In Kabacan, North Cotabato



Four *C. mindorensis* crocodiles were bought from hunters in Maridagao river area. They measured 3-4 feet long. Two males died due to fighting while one female was kept in an enclosure in the farm. The other male crocodile was placed in a cement water tank that served as cage and fed with refused from the food store. The owner is willing to donate to the University if there is a need. He got a license from DENR to keep the crocodiles. This is where trading of juveniles and mature crocodiles take place.

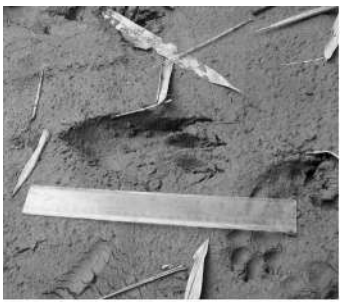
In President Roxas, North Cotabato

In President Roxas, two captured *C. mindorinses* are found under the custody of the local government unit. The lengths of these two crocodiles are around 7 feet. We also interviewed the former mayor who bought the biggest crocodiles (*C. porosus*) in the Philippines

so far being reported whose length is 19 feet and 6 inches and 3 feet wide and weighed 800 kilograms. This crocodile died in 1994 due to gunshot wound (Alconaba & Maulana, 1994). The only remaining part of this huge reptile is the skull (measures almost 2 feet) and 2 teeth.

In Tambad, Carmen and Omonay, Damulog

In the boundary between barangay Omonay and Tambad along Muleta River, it was reported that a man (one of our respondents) was attacked while in the river and was bitten in the right leg in the year 2005. One respondent also reported that they shot a 200 kilogram, 9 feet black crocodile (allegedly, *C. porosus*) in September 2006. This croc was slaughtered and was eaten. In Tambad area, along the Muleta River which was surrounded by bamboo trees and corn fields, a couple of nests was seen by the researchers. Crocodile marks were seen near the banks of the river. It was reported that the 22 eggs of this crocodile was taken by one of our respondents (a crocodile poacher). He sold those eggs to the local people for 20 pesos (0.45 cents in US dollars) each. We recovered two eggs from one of the locals (our respondent) who said he wanted to hatch it but he is not successful. The eggs measured almost 3 inches (7 centimeters). The other nest was allowed to hatch and 10 juveniles were monitored from the nest while the mother crocs watch nearby. Footprints of the mother crocodile was observed in the shoreline of the river.



The army detachment in barangay Omonay also reported that crocodiles were seen in the vicinity of the camp. The commanding officer said that in daytime they saw crocodiles in the Muleta River. During the night at around 10 p.m. and at dawn around 2 a.m., crocodiles he said were seen crawling in the slope of the hill where the detachment is located. The army's response is to drive them away by shooting them with their guns.

In Talitay, Rajah Mudah, Maguindanao

Two separate day-surveys were conducted at Talitay, Rajah Mudah with the support of the local barangay officials (Barangay Capt., Odin Abubakar) and residents on board a 8-sitter banca (small wooden boat). The respondents in barangay Talitay showed the habitat and locations by which crocodiles were caught, captured, and sometimes killed when they attacked ducks farms. However, these crocodiles have been victims of air bombings in the area during the clean-up procedures

by the military where alleged kidnap gangs and rebels were suspected to be hiding. The floating vegetations and islets were totally destroyed. The crocs were forcibly driven towards SK Pendatun, Maguindanao side of the marsh. The team was not allowed to visit due to security reasons, big waves and turbulent waters impassable to small boats.

In Buliok, Rajah Mudah, Maguindanao

A day survey was conducted in Buliok, Rajah Mudah. Negotiations took place with MILF leaders. The visit was organized with the troop leaders as guide. The hunting grounds for crocodiles were shown. Fishing is the source of livelihood of the locals. The guide showed how crocodiles and juveniles were trapped in the fishing gears. There is a sustained fish catch that proves abundance of fish food and food chain. An occasional catch of juveniles entrapped in the fishing gears was observed and these juveniles were sold together with the fishes caught.

In Matalam, North Cotabato

An owner of a resort housed a large male and medium size female in a mini zoo captured from the Pulangi river. There were four crocs (*C. mindorensis)* at the start but sold the other two to pet collectors. The collection is one of the attractions in the resort. This also attracts poachers and hunters to bring more catch but due to the small space the owner refused the other crocs, it cost ranging from five to ten thousand pesos a crocodile.

Myths, legends and other telltales surrounds the wild crocodile

There were several myths and legends noted during the interviews with the people in Ligawasan marsh and the Pulangi (Camp Mantawil), these are:

- The crocodiles could be the “real crocodile” or “pagali”. The pagalis are men that shifted to a crocodile form. They are supernatural that guard the natural environment.
- Crocodiles are kept for “good luck”.
- The reproductive organ of the male crocodile is used as aphrodisiac, it makes the penis erect for days. Men put this in the side pocket before sex to enhance sexual performance.
- The crocodile tooth is gathered and used as necklace, it serves as amulet.
- Every turn of the Pulangi river is a territory of a crocodile family.
- There was a large crocodile with a length of 28 -30 feet, and its upper arm is as big as a sack of rice.
- Never kill or harm the crocodile because crocodiles will come and attack you for vengeance.
- There is a “holy” place in the water as territory of the largest crocodile in the marsh where they gather at 4 pm, so leave the place before that time because if not, big waves and the turbulence of the water will consume you.
- A man was born twin to a male crocodile. The crocodile become buddy of the

man, they lived together, the man can command other crocodiles to do errand for him, every harvest time and full moon an offering of rice and a chicken will be killed for the crocodile, the crocodile knows it is for him and he will come out of the water during that ritual. No one person was attacked by crocodile in the area ever.

- No artifacts of crocodile should be carried in a boat or "banca", crocodiles will attack the vessel.
- Crocodiles are ferocious and will eat humans, humans feared the crocodiles, they are not touched hence.
- The mother crocodile eat the eggs and hatchlings when the eggs hatch and only those who escaped survived. This controls the crocodile population.
- The number of the topmost layer of eggs in the nest is the corresponding count of eggs in the clutch. If 2 eggs are found on top, the total count is 20, if three, 30 eggs, and if 4 , 40 eggs.

Myths and beliefs record from local people in the sanctuaries or habitats of crocodiles are contributory to their survival. Some myths and beliefs are good but some are considered threat to crocodiles. The Maguindanaoan people for instance do not want to harm the crocodiles since they argued that the spirit of the crocodiles sometimes becomes human. Others said that they want to capture crocodiles and raise them as pets since they will give good luck in terms of financial prosperity to the family. Others said crocodiles protect human from any sickness and diseases since crocodiles absorbed all those sickness and diseases in their body while other just leave them alone since crocodiles they said will not harm if they are not harmed. Further, some respondents said the sexual organ of the male crocodile if eaten can give then more vigor in their sex life while others said that if they kept the sexual organ as an amulet will make them more attractive to women. A respondent also said that crocodiles have some sort of center teeth whose function he said will tear humans. Finally, one of our respondents said that crocodiles are friends since they help by eating pests.

Extension Works

Advocacy on conservation and creation of volunteer teams to provide locals information about the crocodiles and why they should be conserved and protected were conducted in four areas of the survey sites.

A series of community immersion and seminars were conducted by the team to introduce the research project and to involve the locals that surround the marsh and immediate tributary for massive campaign on conservation of wild crocodiles. The research team used radio broadcast for awareness and focal group discussions after a schedule is established in the barangays. The barangays involved were Cuyapon, Omonay, Tambad and Ugalingan. These have been mostly identified as habitat and places where crocodiles has been sighted, collected, trapped and sold. It is also the residence of identified poachers, collectors and sellers of live crocodiles.

Added as an attraction for the locals is giving trainings in handling their livestock for deworming, medications, feeds, and feeding of livestock and poultry. The team gave also consultations for the farming activities of the settlers.

Posters on conservation and protection of the wild crocodiles were developed in consultation with the locals. These were reproduced in tarpaulins and hung in strategic places in the barangay.

Figure1. Samples posters in tarpaulin on crocodile conservation and protection for advocacy in Ligawasan Marsh, tributaries and barangay surrounding the marsh.

CONCLUSION AND RECOMMENDATIONS

The result of this survey gave us baseline information that indeed *C. porosus* and *C. mindorensis* are in the wild in the Ligawasan Marsh and its tributaries in Mindanao. The official recorded count of 191 wild crocodiles in Ligawasan marsh and 74 wild crocodiles in its tributaries are limited only to 6 sites in the marsh and 5 in the tributaries. It is also limited to 60 individuals who were approached by the researchers at the time of day and night surveys.

It is recommend that a sanctuary or conservation area and a rescue center will be established in the vicinity with the University of Southern Mindanao in Kabacan, Cotabato that will serve as frontline area for research, conservation, protection and education for this endangered but unique crocodile species in the Philippines.

Further, the long term research activity for the wild crocodile research should be funded and conducted to be able to sustain the conservation of the wild crocodiles in the largest marshland in the country.

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Status of *Caiman latirostris* and *Caiman yacare* populations in North Argentina

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ABSTRACT: In past years, caiman populations were utilized without a solid basis of biological knowledge, nor the status of the populations. Fortunately, this situation has changed, and today, studies are necessary in order to access to wildlife to undertake a sustainable use program. In Argentina, it is a requirement for Ranching programs that monitoring of wild populations in each Province be undertaken; so available information about the status of both caiman species distributed in Argentina (*Caiman latirostris* and *C. yacare*) have increased. In this work we present surveys results, done during 2007 in Formosa and Salta Provinces, and in 2008 in Corrientes Province, Argentina. In the three Provinces, wild populations look healthy, presenting higher densities in Formosa (up to 144 ind. km^{-1}). In Salta Province, we found principally *C. latirostris*. In Formosa, results were more variable, existing places with abundant populations of *C. latirostris* and some others presenting higher densities of *C. yacare*. In Corrientes Province, *C. latirostris* was found in the southwest portion, Yacare caiman was found in the northeast of Corrientes Province, and both species share distribution in the northwest part.

Distribution and population status of spectacled caiman (*Caiman yacare*) and black caiman (*Melanosuchus niger*) in the Mamoré and Iténez river basins, Bolivia.

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ABSTRACT: There are five species of caimans registered for the Bolivian territory. The spectacled caiman (*Caiman yacare*) and the black caiman (*Melanosuchus niger*) are sympatric species which have generated special interest in Bolivia, due to their potential for their sustainable use. At the same time, both species are the most affected because of the illegal hunt. Populations of *C. yacare* and *M. niger* have been evaluated during the dry season in aquatic habitats of the up basin of the Mamoré river an in the mid basin of the Itenez river. The different types of habitats were classified for both areas. In the Mamoré basin, 89% of the caiman population belonged to the specie *C. yacare* and 11% to *M. niger*, meanwhile in the Itenez river 95% of the population belonged to the specie *C. yacare* and 5% to *M. niger*. In both basins a remarkable inter-specific segregation was observed. We discuss the environmental and geomorphological factors that might influence in the differences observed between both basins and in the habitat selection of both species.

Key words: Distribution, *Caiman yacare*, *Melanosuchus niger* , Mamoré river, Iténez river.

RESUMEN: En el territorio boliviano se han registrado cinco especies de caimanes. El lagarto (*Caiman yacare*) y el caimán negro (*Melanosuchus niger*) son especies simpátricas que en los últimos años han generado interés en Bolivia, debido a su alto valor de conservación y el potencial de realizar un aprovechamiento sostenible. Al mismo tiempo, son las dos especies más afectadas por la caza legal e ilegal. Se evaluó las poblaciones de *C. yacare* y *M. niger* en hábitats acuáticos durante la época seca en la cuenca alta del río Mamoré y en la cuenca media del río Iténez. Se realizó una tipificación de hábitats en las dos zonas. En la cuenca del río Mamoré, el 89 % de la población de caimanes pertenece a la especie *C. yacare* y 11% a *M. niger*; mientras que en el río Iténez, el 95% de la población pertenece a *C. yacare* y 5% a *M. niger*. En ambas cuencas se observó una segregación inter-específica notoria. Se discuten los factores ambientales y geomorfológicos que influyen en las diferencias observadas entre ambas cuencas y en la selección de hábitats por ambas especies.

Palabras clave: Distribución, *Caiman yacare*, *Melanosuchus niger*, río Mamoré, río Iténez.

Preliminary information about distribution and abundance of the Black Caiman *Melanosuchus niger* in Beni, Bolivia

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ABSTRACT: Among the crocodile species present in the low lands Bolivia, its possible to find *Melanosuchus niger*, evenly distributed, with populations that are severely diminished due to excessive pressure between 1950 and 1970, entering the Red List of the UICN under the category of Endangered in 1982. In Bolivia, since 1980 the specie was already considered rare, and was even included in the Red Book of Vertebrates. As a result of new rules of protection, and their inclusion in the CITES appendix I in 1975, the population of Black Caiman is slowly coming back to his natural distribution and natural habitats. They were then classified at the low risk level by the UICN, even though for Bolivia detailed information doesn't exist yet. The results of abundance and distribution studies obtained during the crocodile surveys, during 2006 and 2007, in 324 sample points in Beni department, show a total of 3052 Black Caimans in 2369.454 km of shoreline and at 43% of the surveyed sites, had an estimated density between 0.02 and 63.97 ind/km. This suggests that the populations are recovering, but they are not abundant in all their original geographic range.

INTRODUCTION

Widely distributed, the black caiman populations (*Melanosuchus niger*) were under great hunting pressure during 1950's to 1970's due to the leather commerce. In consequence, the populations were greatly reduced in most of its original distribution range (Asanza 1992), becoming one of the species included in1982 in the IUCN Red List with the category of "Endangered".

In Bolivia, where the species was historically abundant in the north and east of the country (Ross 1998), the commercial hunting was intensified since 1942 (Aparicio y Ríos 2006). According with these authors, an estimate of 781 leathers of lagarto (*C. yacare*) and black caiman were extracted daily until 1950, from the Beni provinces. For *M. niger*, these numbers were decreased between 1956 to 1973 to about 12 caimans per day; meanwhile, between 1974 to 1977 the collected data point a number of 152 caimans per day.

The harvest of wildlife animals of M. niger was allowed in Bolivia until 1979 (D.S. 08063, 1967), establishing a minimal size of 2,5 m of total length and forbidding the hunting between December and July. Nevertheless, these regulations had minimal or none effect controlling the intense exploitation that the species was suffering (Ross 1998). In the present days, the black caiman is completely protected by the Supreme Decree 16606 (1979), and posteriors, becoming the species part of the Red Book of Bolivian Vertebrates in 1980.

Besides some small scale poaching continued (King y Videz-Roca 1989) and still continues today (CPIB *com. per.*), in a general way, and as a result of the protectionist measures

applied and the incorporation of the species in the 1975 CITES I appendix, the black caiman populations started recovering and returned to some of their original distribution range (Da Silveira 2002), becoming in 2000 into the "low risk" category of the UICN.

In Bolivia, the information related with the *M. niger's* population status is scare and is in part supported by qualitative reports. The census performed between 1986 –1987 showed that the species was still in its historical area of distribution, but in very low numbers, dominating the population young sub-adult individuals (King y Videz Roca 1989). Posterior counting showed the presence of local abundant populations in specific areas of Beni and Santa Cruz Department lowlands. But, these surveillances were performed in protected areas: Estación Biologica del Beni (Pacheco 1993), Reserva de Vida Silvestre Ríos Blanco y Negro (FAN y WCS 1994), y Reserva Inmovilizada Iténez (Liceaga *et al*. 2001). Besides other reports that suggest the presence of localized populations in some flood lagoons of the Iténez river, inside the Noel Kempff Mercado National Park (Ross, 1998) and in the Isiboro - Sécure Indigenous Territory and National Park (TIPNIS) (FAUNAGUA *et al.* 2005). We can also include the data collected in the North of La Paz, inside the Tacana I TCO (Llobet 2005).

In order to update and increase the knowledge about the conservation status of this species in Bolivia, the results for abundance and distribution of the *M. niger* are presented here, from the surveillances performed during 2006-2007 in the Beni Department. Information that belongs to crocodilian studies performed to establish the 11 different Lagarto's (*Caiman yacare*) Management Plans in this department, the studies correspond to: Municipio de Loreto and the Original Communitarian Lands (TCO for *Tierras Comunitarias de Origen* in Spanish) Sirionó, Itonama, Baure, Cayubaba, Canichana, Movima I, Movima II, Tacana III, Joaquiniano and Moré.

Study Area

Located in the northeast of Bolivia and being part of the Amazon Basin, the Beni Department is part of a large system of flood plains with periodical floods from the overflow of rivers that run through it. The study area is located inside this department, including the Municipio of Loreto, and the Original Communitarian Lands (TCO) Sirionó, Itonama, Baure, Cayubaba, Canichana, Movima I, Movima II, Tacana III, Joaquiniano y Moré. For the TCO's besides its territorial extension the bodies of water traditionally used to harvest *C. yacare* were also considered (Fig. 1).

In a general way, the Bolivian Amazonian plains have a tropical climate, with an intense rainy season in the summer. About 60 – 80% of the rains occur between December and March, and at the same time the temperatures are the highest (Navarro y Maldonado 2002). The highest water levels are generally registered between January and March, as a result of the runoff of the rains produced in los Andes.

METHODOLOGY

The field work was performed in the low water season, during the months of July and September of the years 2006 (Municipio de Loreto) and 2007 (TCOs). The samplings

consisted in nocturnal surveys in row guided canoes using dazzling methods, following all the recommendations for this kind of studies (Woodward y Marion 1978, Woodward 1987, Coutinho y Campos 1996, Pacheco 1996), avoiding high wind-wave days and one week wait after cold weather fronts. This standardization of the surveys minimized the methodological bias (Pacheco 1994).

At the same time, the following classification for the bodies of water was used: a) rivers or continuous water courses; b) streams; c) fluvial lagoons, very close related with important water courses, belong to old river streambeds or cut meanders; d) tectonic lagoons, with large surface but with an homogenous deep, these lagoons are in contact with the superficial freatic layer that is between 0,5 – 2 m deep, that assures a stable water level throughout the year, besides the seasonal precipitation (Poully et al. 2004); and e) small lagoons, lentic bodies of water with a perimeter less than 1 km independently its origin. This classification corresponds to the one used by the Natural History Museum Noel Kempff Mercado (lowlands scientific authority) in the process of designing monitoring tools for the *Caiman yacare* (Museo de Historia Natural Noel Kempff Mercado 2005).

Inside this classification some modifications were added: a) white-water rivers, rivers that contain great amounts of load from the runoff of rains in the high Andes, and with lots of sediments (Mamoré and Beni river basins); b) clear-water rivers with low levels of load (Iténez river basin); and c) black-water rivers, originated in streams in the plains and richer in humus' acids.

The method used to enumerate the caimans was the incomplete counting or relative abundance index (ind/km). For the totality of the places with black caiman presence, the factors included in the statistics were the type of water (basin), type of water body and the history of usage of crocodilian species in the area (administrative unit), because the relative abundance data didn't follow a normal distribution, it was calculated through non-parametric statistics (Kruskal-Wallis, Spearman correlation coefficient).

To determine the population structure categories of size of 60 cm. were used. The population size structures obtained were compared without considering young individuals, because this group is under a high mortality that produces great fluctuations among months (Velasco y Ayarzagüena 1995). Those caimans that weren't close enough to allow correct size estimation, were included in the category "eyes only" (King *et al*. 1990, Pacheco 1996), and were considered in the total density estimations of each place.

At the same time, during the counting the presence of *C. yacare* was considered, this species has an overlapping distribution range with *M. niger* in the study area. Both species can be easily differentiated in the field, and considering other crocodilian species in the study assures not to overestimate the black caiman for this species (CITES 2007), and allow us evaluate the relationship between both, calculating the proportion of species for each survey. The comparing between relative observed densities were performed without considering class I individuals (individuals with TL < 59 cm. for *M. niger* and TL< 50 cm for *C. yacare*) because the aim was to find potential competence relationships between the two species (Dueñas 2007).

RESULTS

For the population studies of *M. niger* and *C. yacare* a total of 2.369,45 km of shore were surveyed in the different bodies of water, spread around 324 sampling points (fig. 1). In the Table 1, the obtained results are summarized.

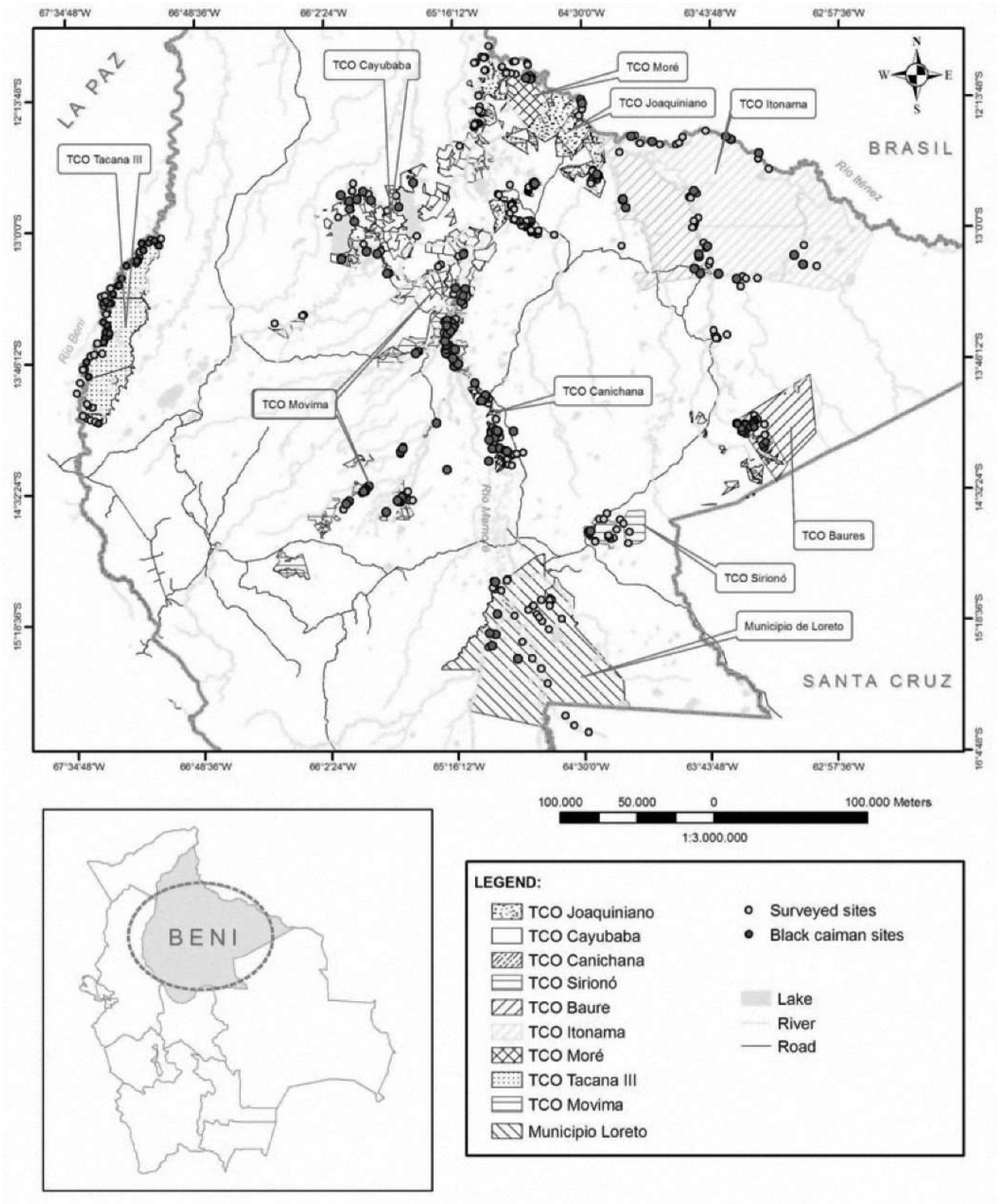


Figure 1. Observed distribution of *Melanosuchus niger* in the Beni Department.

Table 1. Relative abundance indexes for *Melanosuchus niger* related according to basin and study area.

Study area	Basin	Sample (km)	Sampling points	Places with caimans	Nº Caimans	Density range (ind*km^{-1})	Ind*km^{-1}	Clases II-V*km^{-1}
Tacana III	Beni	447.72	59	28 (47.46%)	165	0.08-4.58	0.63	0.62
Sirionó	Mamoré	68.954	13	1 (7.69%)	1	0 -1.21	1.21	1.21
Joaquiniano	Iténez	83.22	21	4 (19.05%)	27	0.6-4.90	0.80	0.71
Moré	Iténez	67.29	20	2 (10%)	7	0.29-0.50	0.41	0.41
Baures	Iténez	122	31	10 (32.26%)	1212	9.77-63.97	31.64	12.01
Itonama	Iténez	419	38	24 (63.16%)	230	0.13-15.75	0.81	0.63
Cayubaba	Mamoré	343	24	19 (79.17%)	754	0.02-25.00	0.71	0.68
Movima	Mamoré	479.93	57	34 (59.65%)	557	0.1-34.20	1.47	1.38
Canichana	Mamoré	183.24	33	12 (36.36%)	92	0.1-14.60	0.97	--
Loreto	Mamoré	155.1	28	5 (17.86%)	7	0.18-10.00	0.38	0.38
TOTAL		2369.454	324	139 (42.90%)	3052	0.02-63.97	2.14	1.46

Abundance and distribution

A total of 3052 black caimans were counted, with a presence in 43% of the places studied. The relative abundance indexes are between 0,02 and 63,97 ind/km.

The observed distribution was not uniform among variables nor inside them. The media of relative abundance for the 139 sampling points with presence of black caiman was 4,21±9,50 ind/km. High population densities were found in the Iténez basin (63.97 ind/km in the tectonic lagoon La Porfía, TCO Baures; 15.75 ind/km in the fluvial lagoon Bahía Puerto Chávez, TCO Itonama) and in Mamoré basin (34.20 ind/km in the fluvial lagoon Laguna Bella, TCO Movima; 25.00 ind/km in the tectonic lagoon El Triunfo, TCO Cayubaba), but the registers of low population densities were larger: in 75 surveys less than 1 ind/km were counted, meanwhile in other 21 surveys moderate densities were observed (1.0 – 2.0 caimans/km) (figures 2 & 3).

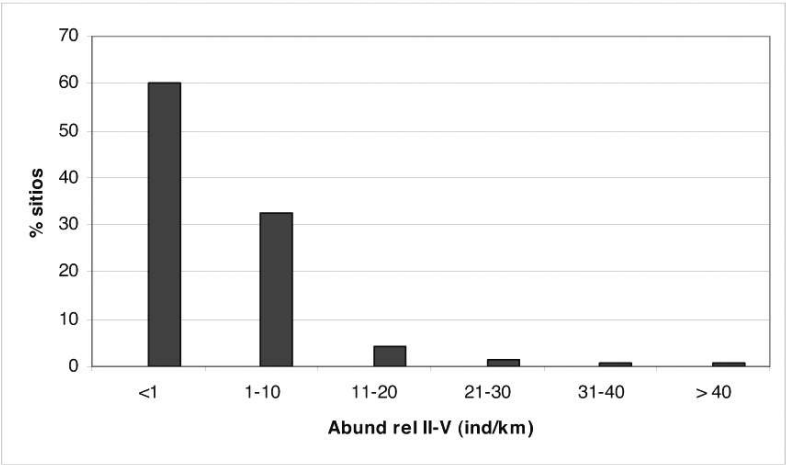


Figure 2. Observed percentage of relative abundance of *M. niger.*

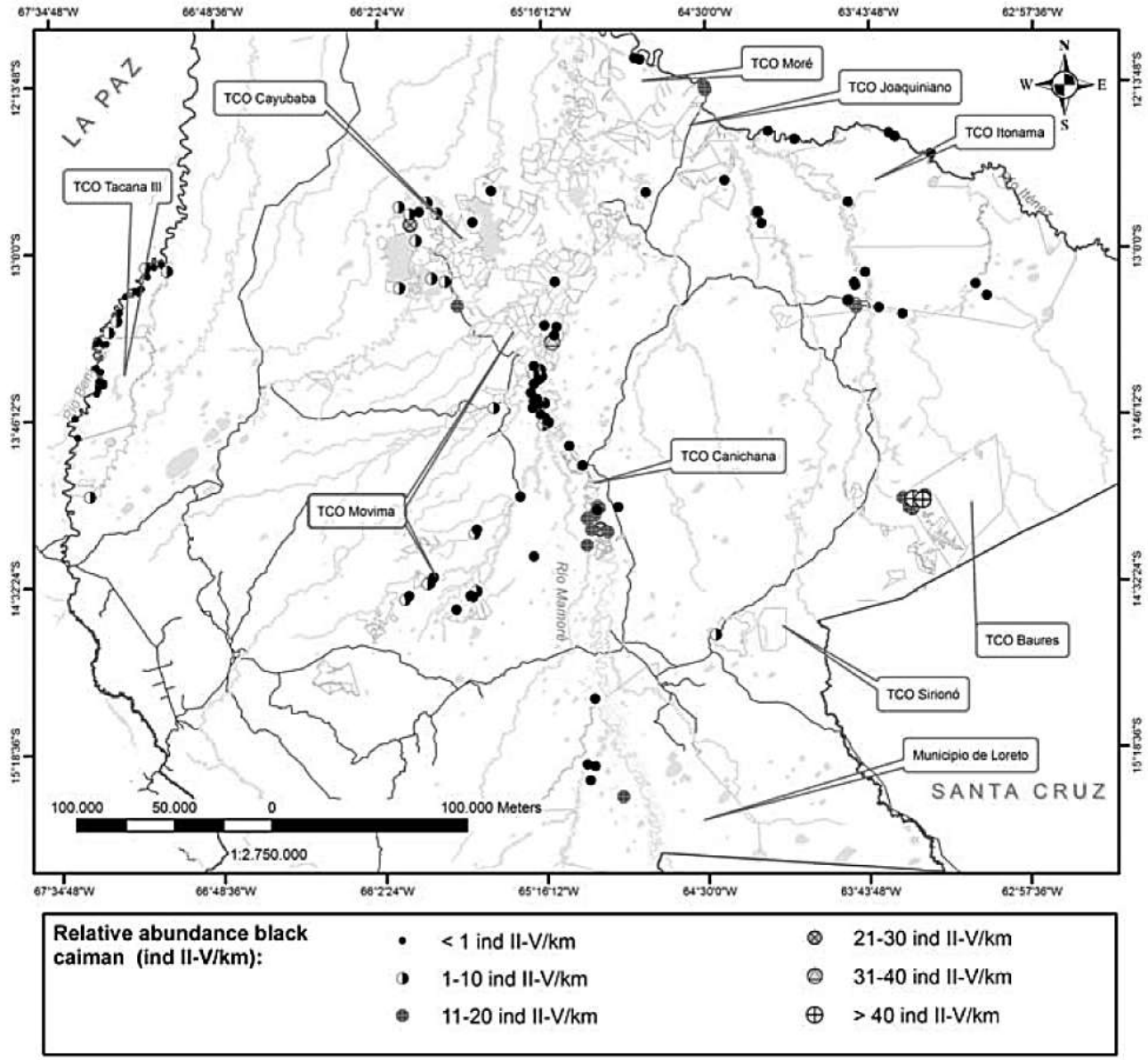


Figure 3. Observed distribution of relative abundance of *Melanosuchus niger* in the Beni Department.

The spatial variation of estimated relative abundance of *M. niger* was analyzed for each studied TCO or Municipio, among bodies of water and among basins (Fig. 4).

Highly significant differences were observed for the administrative units and for the types of bodies of water, the first is related with the second, because the 578 classes II to V caimans registered in the Baures TCO were registered in tectonic lagoons. In this kind of body of water the highest relative abundances were registered (8.14±11.52 caimans/km), exceeding in 71% of the observations 3 caimans/km. The relative abundances were similar among fluvial lagoons (2.15±4.80 caimans/km) and streams (2.80±0.95 caimans/km) and lower in rivers (1.06±4.58 caimans/km). The small lagoons weren't considered because there was only one register for black caiman for them.

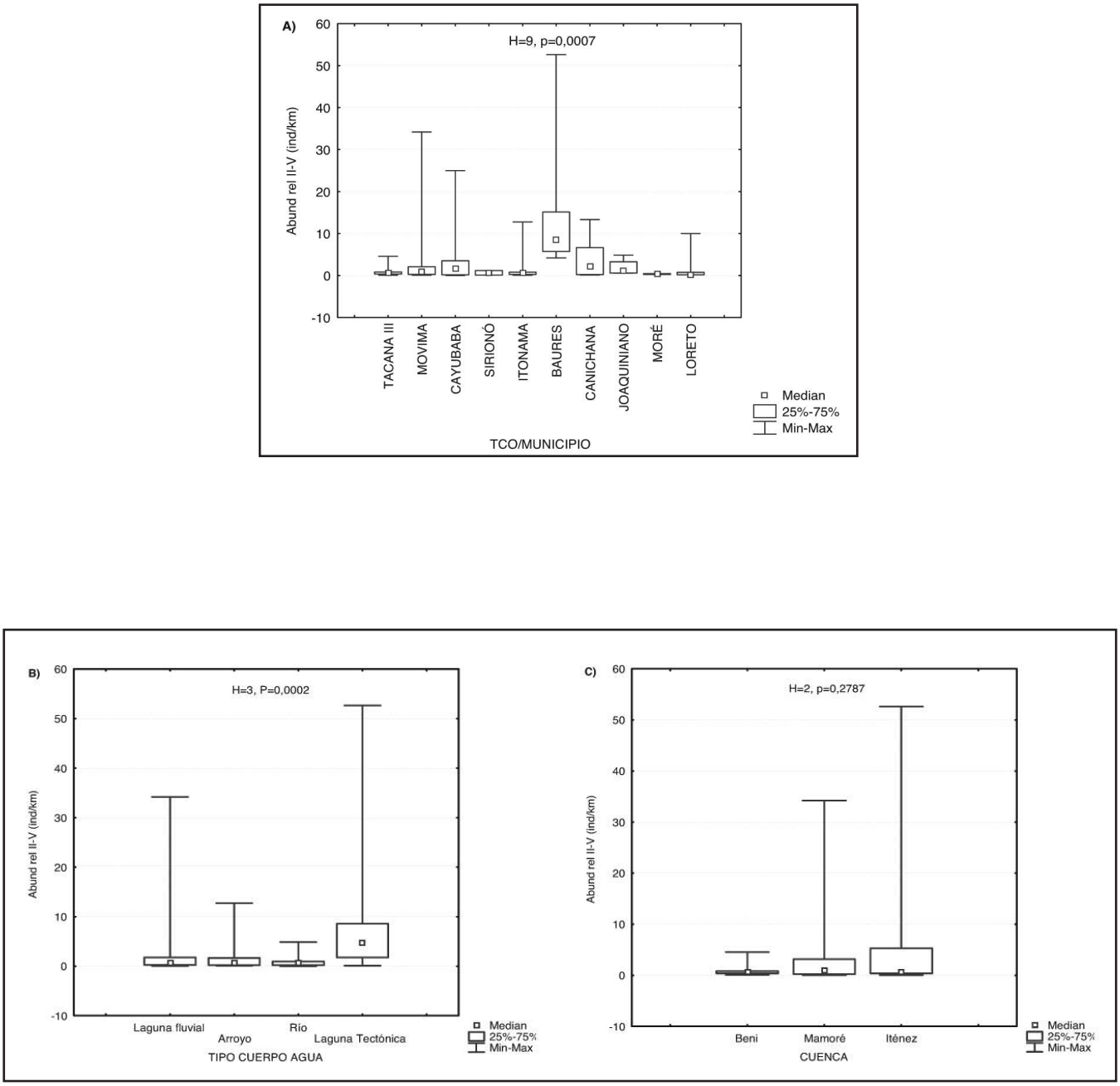


Figure 4. Variation of the general relative abundance estimated for *M. niger* for: A) administrative unit; B) type of bodies of water; and C) basin.

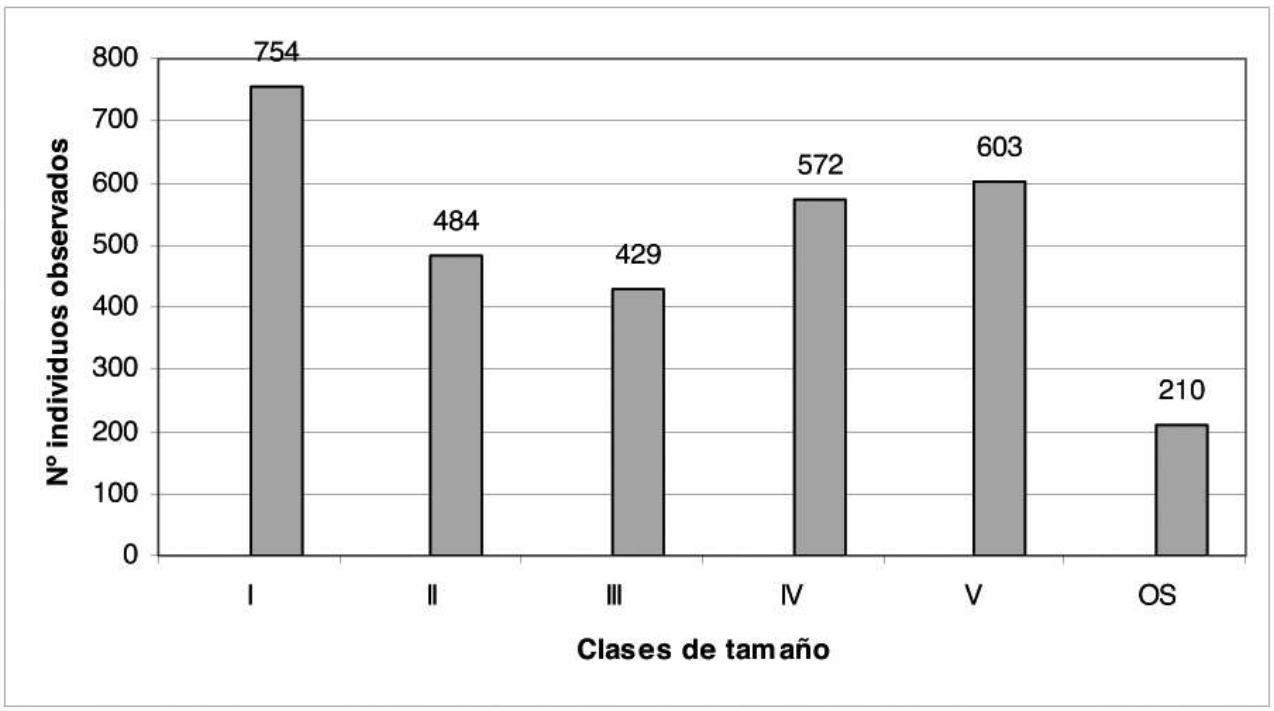
The correlation analysis establishes statistically significant correlation only among relative abundance classes II-V and type of body of water (p = 0.048). However, the presence or absence of black caiman, according to the same analysis carried out considering the entirety of the developed samplings, it establishes highly significant correlation between the presence of black caiman and basin type (p = 0.0016), like between presence of black caiman and type of body of water (p =0.005). When excluding the tectonic lagoons of the analysis, present in the basins Mamoré and Iténez, this correlation disappears. While the developed

same analysis excluding the class individuals I would show highly significant correlation between occupation and half basin of the river Mamoré (p =0.000023).

Population structure

The estimate of the population structure was based on obtained data of 2842 black caimans on the 3052 sighted (93%). Remaining 210 *M. niger* was counted as "eyes only".

The 5 considered size classes were observed in the three basins and the different types of bodies of water, but not in the 10 administrative studied units. The most variable and abundant class (26.53%) were the neonates (class I), continued by the individuals of more size, classes V and IV (Fig. 5).



Figures 5. General population structure of *M. niger* for Beni department.

The population structure without keeping in mind neonates varied among spaces, bodies of water and basins (Fig. 6).

In the different types of bodies of water the population is composed mainly for individuals of great size. However, in the whole basin of Iténez, as well as in TCOs Itonama, Joaquiniano and Baures located in this basin, prevalence of sub-adults or smaller individuals is observed. Except for Baures's TCO, in those that relative low densities of *M. niger* were also observed.

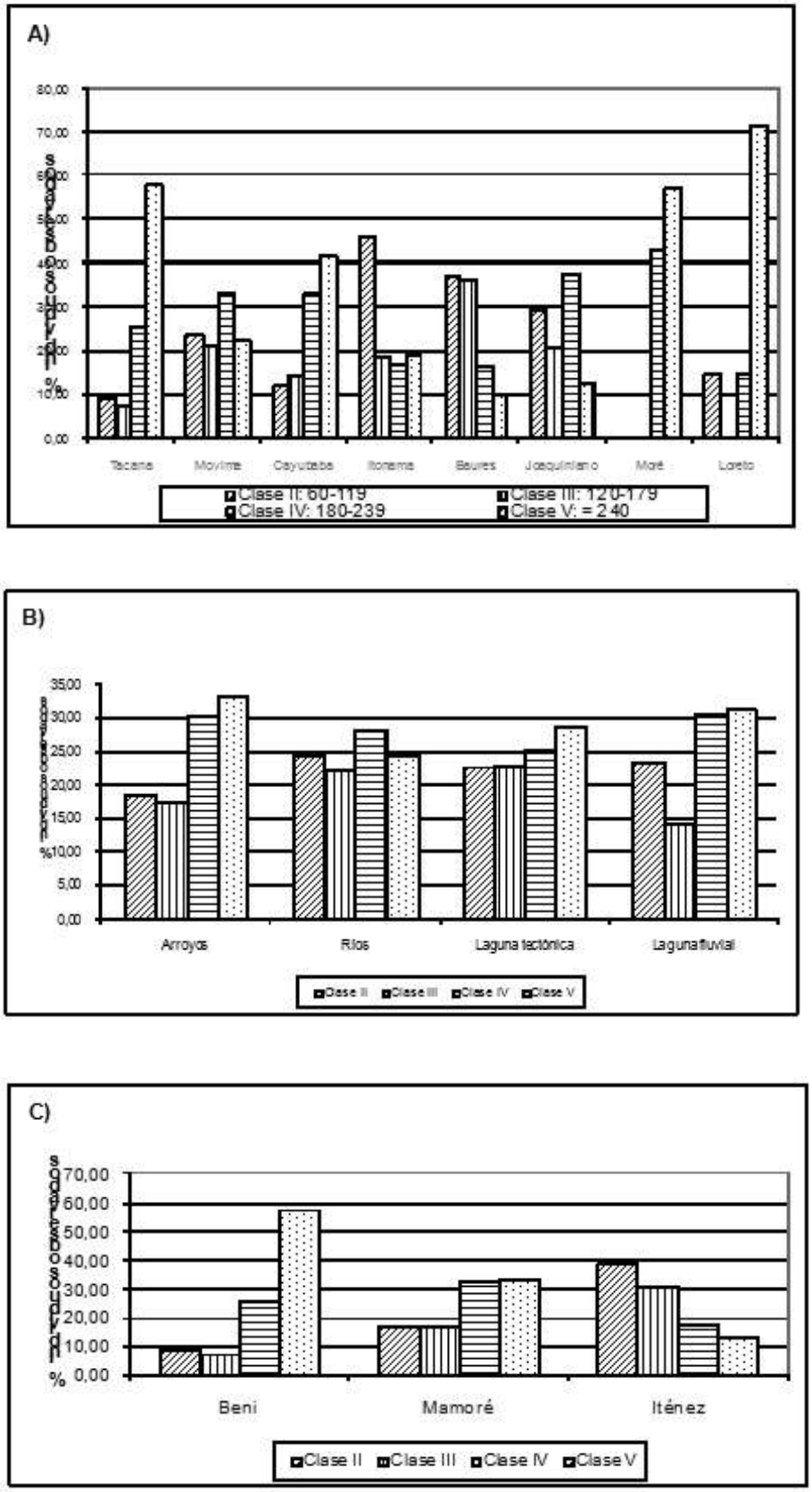


Figure 6. Presence of the different population strata of *M. niger* according to: A) administrative unit; B) type of body of water; and C) basin.

Relationship with *Caiman yacare*

In the area of study two gregarious species share lakes, rivers and streams: *M. niger* and *C. yacare*. No other crocodilian species has been detected during the works. A total of 81672 individuals of both species were identified during the counts. Their distribution and abundance was not continuous throughout the whole study area. *C. yacare* was observed (97%) species and the most abundant (abundance average 45±104.24 individuals II-IV/km). *M. niger* was observed in 43% of the counts (2.94±4.47 individuals II-V/km) (Fig. 7, Table 2).

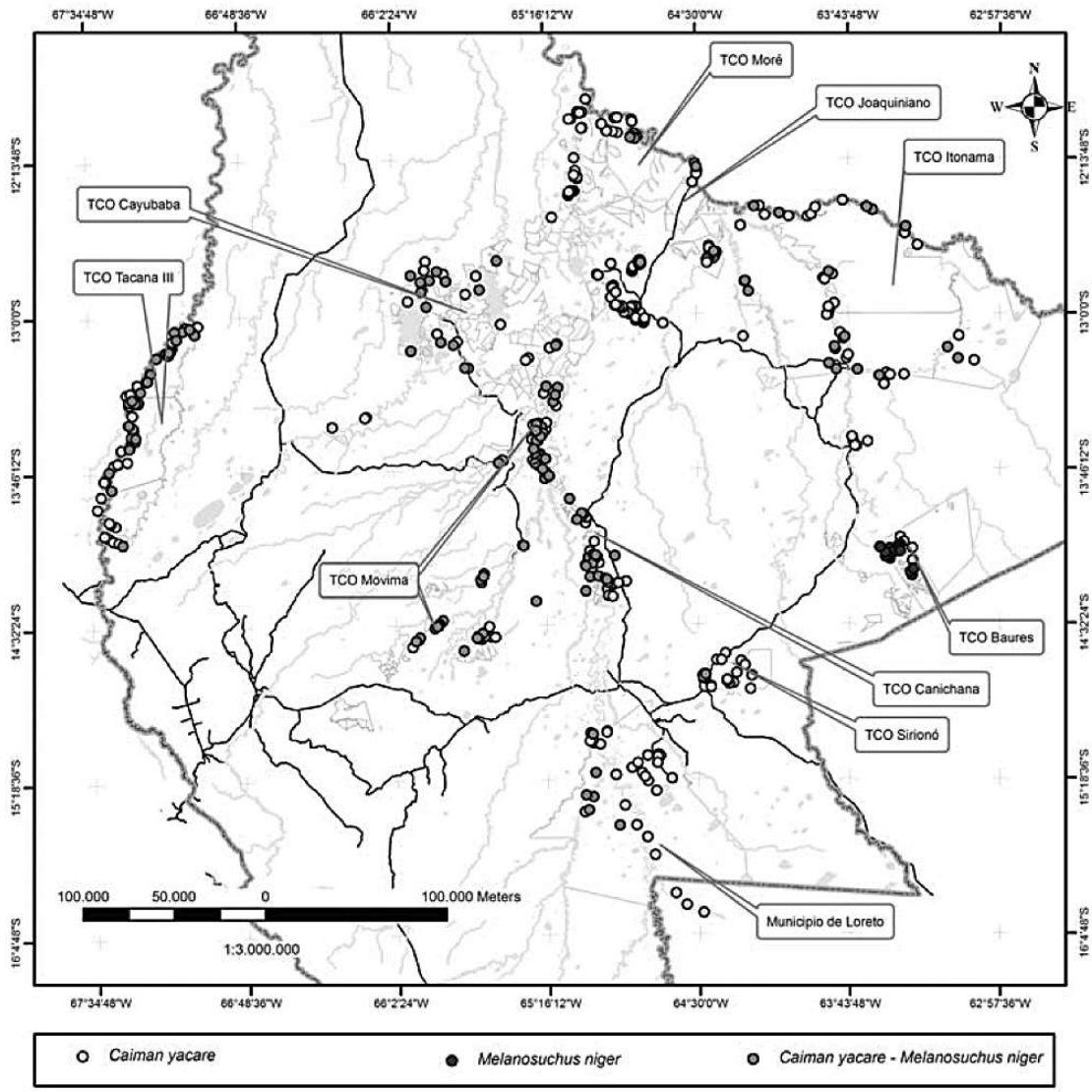


Figure 7. Space relationship between *C. yacare* and *M. niger.*

When comparing the composition of species, it was found that *C. yacare* and *M. niger* was only sympatric in 39.51% of the studied places, meanwhile that in the 57.41% of the studied places *C. yacare* was the only found species and only in 3.09% of the places *M. niger* appeared as only species, settling down an association coefficient of 0.44. No other crocodilians species were observed during the fieldworks (Fig. 7).

Table 2. Relationship of proportions observed among *M. niger* and *C. yacare*.

		Abund rel (ind/km)		%		
TCO	**Bodies water**	**Lagartos**	**Caimanes**	**Lagartos**	**Caimanes**	**Proportion among species**
Tacana III	Fluvial lagoons	61.46	0.29	99.18	0.82	0.008:1
	Streams	50.39	0	100	0.00	0:1
	Rivers	41.38	0.34	99.21	0.80	0.008:1
Movima	Fluvial lagoons	14.68	0.22	91.89	8.11	0.09:1
	Small lagoons	13.33	0	100	0.00	0:1
	Streams	1.26	0.47	96.19	3.91	0.04:1
	Rivers	2.25	0.82	94.46	5.54	0.59:1
Cayubaba	Fluvial lagoons	56.01	0.2	99.62	0.38	0.04:1
	Tectonic lagoons	7.43	2.58	69.94	30.06	0.43:1
	Small lagoons	119.44	0	100	0.00	0:1
	Streams	37.25	12.75	74.5	25.50	0.34:1
	Rivers	27.16	0.11	98.42	1.58	0.02:1
Sirionó	Fluvial lagoons	3.82	1.21	99.93	0.07	0:1
	Streams	30.18	0	100	0.00	0:1
	Rivers	34.95	0	100	0.00	0:1
Cayubaba	Fluvial lagoons	56.01	0.2	99.62	0.38	0.04:1
	Tectonic lagoons	7.43	2.58	69.94	30.06	0.43:1
	Small lagoons	119.44	0	100	0.00	0:1
	Streams	37.25	12.75	74.5	25.50	0.34:1
	Rivers	27.16	0.11	98.42	1.58	0.02:1
Itonama	Fluvial lagoons	16.92	0.8	98.51	1.49	0.02:1
	Streams	17.02	0.31	98.2	1.80	0.02:1
	Rivers	15.47	0.25	98.51	1.49	0.02:1
Baures	Fluvial lagoons	0.33	8.59	2.75	97.25	0.03:1
	Streams	6.67	0	100	0.00	0:1
	Rivers	17.63	0	100	0.00	0:1
Canichana	Fluvial lagoons	47.73	1.02	98.12	1.91	0.02:1
	Small lagoons	82.21	0	100	0.00	0:1
	Streams	9.86	0	100	0.00	0:1
	Rivers	13.22	0	100	0.00	0:1
Joaquiniano	Fluvial lagoons	73.75	0	100	0.00	0:1
	Tectonic lagoons	7.35	0	100	0.00	0:1
	Small lagoons	1643.41	0	100	0.00	0:1
	Streams	2.17	0.2	97.24	2.75	0.03:1
	Rivers	10.08	0.3	95.51	4.49	0.05:1
Moré	Fluvial lagoons	39.14	0.04	99.82	0.08	0.002:1
	Tectonic lagoons	78.67	0	100	0.00	0:1
	Small lagoons	50.4	0	100	0.00	0:1
	Streams	36.6	0	100	0.00	0:1
	Rivers	10.1	0.5	95.28	7.72	0.05:1
Loreto	Fluvial lagoons	16.59	0.08	99.62	0.38	0.004:1
	Tectonic lagoons	10.58	0.2	97.92	2.08	0.02:1
	Small lagoons	190	10	96.61	0.00	0:1
	Streams	36.6	0	100	0.00	0:1
	Rivers	10.1	0.5	96.61	3.39	0.04:1

A relationship among both species cannot be determined, neither to establish an association pattern for type of body of water and basin, due to the variation in the composition of species among bodies of water, basins and studied areas (Fig. 8), and due to the reduced populations of *M. niger* detected.

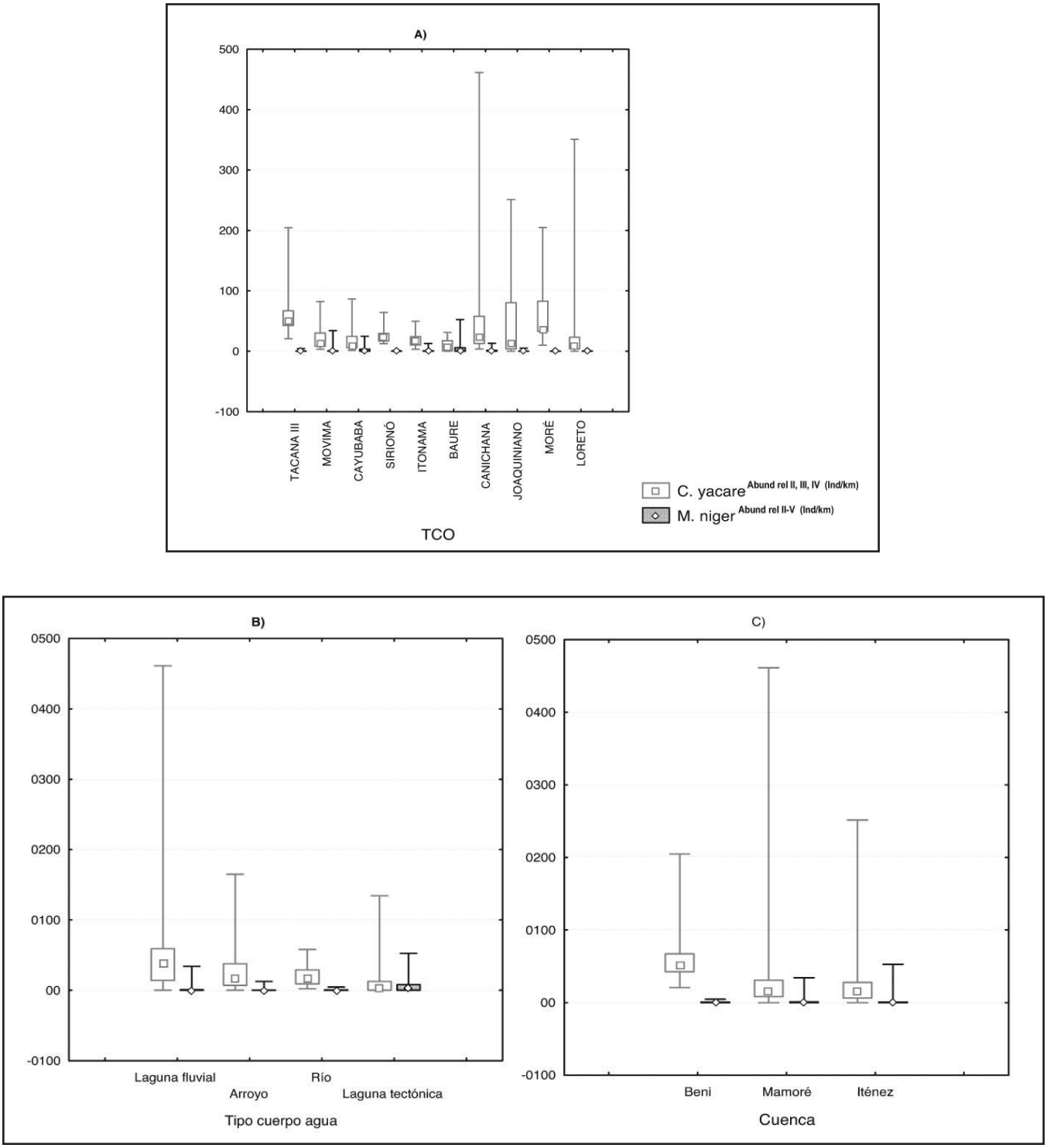


Figure 8. Variation of the estimated relative abundance by species in: A) different studied administrative units; B) different bodies of water; and C) the three sampled basins.

DISCUSSION

Distribution and relative abundance

M. niger turned out to be moderately a common species in the study area (43% of the sampling places), spreading to occupy relatively not very accessible areas, associated mainly with lagoon-like bodies of water, especially tectonic lagoons. It was also observed that in certain areas with intense harvest of *C. yacare*, the species is common (half-tributary system of the Mamoré river). Another factor to consider in the distribution of this species is the type of water. The largest tendency of occupancy observed in the basins of rivers of white waters (46.3% of the studied areas in the Beni and Mamoré basins instead of the 36.4% of the places of the basin of Iténez river) it has already been presented in other works (ex. Rebêlo and Lugli 2001, CITES 2007). The aquatic ecosystems formed by rivers and streams of black waters, poor in nutrients, are considered unable to maintain big populations as those reported for the ecosystems of white waters. According to these authors, the caimans would be limited by the productivity of the habitats that they occupy and, therefore, the rivers of white waters, rich in nutrients, would not be limiting the development of their populations.

The estimated relative abundance without considering juvenile (0 -52.64 caimans / km) with an average of 1.27 caimans / km (2.94 ind / km considering only the places with caiman presence), compared with other populations where the species is distributed, goes from abundant to low.

For the Beni department, the results presented by Pacheco (1993) in the Biological Station of Beni indicate densities in lagoons of 0.47-19.5 caimans / km, while in rivers they turned out to be smaller to 1.4 caimans / km. For the Wildlife Reservation Ríos Blanco y Rio Negro in Santa Cruz, the densities obtained in the Blanco and Negro river there were 1.4 caimans / km and 0.9 caimans / km respectively (FAN and WCS 1994). Meanwhile other works in the Itonama TCO (Liceaga et al.2001) obtained a range of 0.06-6.67 caimans / km (average 1.51±2.68), with presence of *M. niger* in 45.5% of the studied places.

These results contrast with those recently obtained in other areas of their distribution range. The night counts performed in five Brazilian states during 2004 and 2005 (CITES 2007) showed presence of *M. niger* in 94% of the studied places, estimated density between 2.1 and 466.5 ind / km and an average of 48.2 caimans / km. For Ecuador, the described range of densities was of 8.27 - 4.09 ind / km (Villamarín-Jurado 2006).

We should remember that the population's estimation of *M. niger* presented doesn't constitute a complete population census, but an indicator of the minimum number of caimans that are in the area. The methodological deficiencies for the nocturnal surveys (Magnusson 1982b, Larriera *et al.*1993, Abercrombie and Verdade 1995, Pacheco 1994, Pacheco 1996), added to problems of accessibility for the investigators to reach the habitats, it implies that part of the caimans will remain without being detected. Tendency to underestimate the population that is also seen in cases of populations with very low densities, since it greatly decrease the probability of observing an individual. Therefore, we can suppose that the presented densities are conservative, being difficult to establish the relationship between the index of abundance and the real density present in the area (Hutton and Woolhouse 1989).

The indexes of relative abundance of caimans offer a limited data, if the distribution of frequencies of classes of sizes of the population under study is unknown (Magnusson 1983). For a group of animals in which the reproductive event is strongly related with the size / age, the estimate for the population structure allows us to obtain an approach to its conservation state (Hines 1992, Pacheco and Llobet 1998, Dueñas 2007), to detect the reproduction occurrence (Magnusson 1982b), to study the effects of the poaching (Cintra 1989, Mourão *et al.*1996), to determine the differences of use of habitat for populations of different strata (Campos *et al*.1994) and to make precise decisions about the handling of these species (Borteiro 2005). On the other hand, the estimates of curves of population are an indirect indicative of the fluctuations in the abundance of a certain crocodilians populations and are of difficult interpretation (Bayliss 1987).

The curves of *M. niger* in the different types of studied bodies of water are seemingly healthy, the same for the Tacana III, Cayubaba and Movima TCOs. For Moré TCO I and the Loreto Municipality, although the population structure appears healthy, the size of the sample is small (n =7). While the distribution for sizes observed in the Joaquiniano, Itonama and Baures TCOs could be interpreted as populations under some level of exploitation or in recovery.

If we analyze the distribution of sizes for basins, the abundance of caimans of big sizes present in the Beni and Mamoré basins suggest populations with good conservation state. However, if we consider the population structure in the Iténez basin, where the Joaquiniano, Itonama and Baures TCOs would be located, next to Moré I TCO, this would be dominated by individuals of smaller size. Now then, in spite of the potential existence of a small use of black caiman at local level, this species, in Bolivia, is protected, being illegal its commercial use.

The same as observed in other towns of Amazonia (Rebêlo and Lugli 2001), the factors that limit the populations of *M. niger* can be independent of the human exploitation. Mentioned TCOs, without big habitat alterations neither hunt pressure on the species, neither present evidences of a wide recovery of the populations of black caiman, what could suggest that in atmospheres of black waters their recovery can be slow.

Another aspect to consider, according with Dueñas (2007), a healthy crocodilians population's curve is characterized by the presence of a bigger frequency of small sizes, continued by a gradual decrease of the largest sizes. According with this, the population structure observed in the Iténez basin would be showing a population with exponential growth, 85% represented by the small and medium size classes (classes I, II and III).

However, it is understood that habitually the drop of observed small-sizes caimans could reflect a bias due to the visibility or as a result of the behavior of this size class. The individuals of Class I are in isolated areas of low depth and with dense vegetation; and not in open areas where the sampling is carried out, reason for which this size class is not habitually considered in the evaluations of population structures, in fact, for the case of Baures TCO, where 81% of the caimans of the basin were located, it was possible to carry out complete and detailed counts of the three tectonic lagoons where these showed up, included the vegetated banks. The caimans observed in the Beni and Mamoré basins,

correspond to more than 56% of the observations carried out in rivers, streams and fluvial lagoons, with numerous lagoons and annexed small lagoon to the main streambed and areas covered by vegetation, favorable habitats for individuals of smaller size.

On the other hand, the most accessible habitats, are marginal habitats for caimans of intermediate sizes (Dueñas 2007). In accordance with Thorbjarnarson and Da Silveira (2000), the dominant males and the reproductive females for this species would be in flooded areas of difficult access and with certain independence of the hydrologic fluctuations of the rivers, with more presence of males in habitats of open waters, while the females would be located in areas embraced by aquatic vegetation (Da Silveira 2001). This can be the case of the tectonic lagoons, located in poorly communicated areas and with smaller tradition of harvesting crocodilians (Baure TCO and Cayubaba-higher area) a population of *M. niger* has been maintained protected for several years in this area. In these lagoons the 51.23% of the individuals class IV and V were detected.

Finally, considering the high percentage of bigger classes registered, together to the observation of nests of *M. niger* in the reproductive epoch of 2006-07 in all the studied TCOs, except for the Moré and Itonama TCOs, would be indicators that the species is reproducing with success. (Asociación Boliviana de Conservación and Central de Pueblos Indígenas del Beni 2008),

Relationship *M. niger* and *Caiman yacare*

The interactions of crocodilians species in Amazonia are barely known and the studies that examine the patterns of the communities have provided controversial conclusions (Medem 1971, Magnusson 1985).

The importance of the inter-specific competition in the crocodilians communities organization is of great interest, but difficult to establish by simple presence of differences in the use of resources among species, this is not a competition evidence, and if factors like predation, food, climate or others maintain the densities in low levels, the competition factor would be insignificant (Rebêlo and Lugli 2001).

Nevertheless, the same as it has been observed in other studies (Magnusson 1982a, Brazaitis *et al.*1988), where the ecological competition with a more common and smaller size *C. crocodiles*, that could be playing an important role in the natural slow recovery of *M. niger*; in the studied area *C. yacare* could be filling this paper. In accordance with available information (Rebêlo and Lugli 2001), numerous *C. crocodilus* next to few "surviving" *M. niger* from the commercial hunting they were subjected, could be contributing (as predator or competitor) to block the recovery of the populations of *M. niger*. In the present work, the similar species *C. yacare*, that was abundantly observed in all the administrative units studied, could be exercising this competition, impeding the recovery of bodies of water in those that *M. niger* should be abundant, according to these same authors, it is considered that reduced populations of *M. niger* are unable to affect the distribution of *C. crocodilus* (in our case *C. yacare*), although we cannot confirm this.

This could explain the observed tendencies of bigger presence of *M. niger* in areas of current intense hunt of *C. yacare* inside the mark of the National Program of Sustainable Use of

Lagarto, like it is the case of the central area of the river Mamoré, an area of historical importance for the hunting of both species and, at the moment, for the harvest of *C. yacare*.

However, since there are not enough evidences on the relationship among both species, the differences of distribution between these sympatric populations should be attributed to habitat preferences (Magnusson 1985). Similar studies (Rebêlo and Lugli 2001) establish that a micro-habitat analysis could suggest certain tendency to a partition of the habitat among both species. The preference of *C. yacare* for low depth and slow waters habitats and the preference of *M. niger* for deep waters, would imply that, in spite of sharing the same bodies of water in several counts, *M. niger* and *C. yacare* would not be sharing the same micro-habitats. This differences in use of micro-habitats and the difference of the adults' sizes could reduce the effects of sharing the habitats and of feeding of similar preys.

CONCLUSIONS

It’s ignored the level of risk that the black caimans experienced in the past in the department of Beni. The information about the population situation of *M. niger* is scarce and most of it is sustained by qualitative type reports.

The presented data, although it’s preliminary and requires of more research, provide a first detailed vision of the community of *M. niger* in Beni. A dispersed population in the flood plain but apparently not abundant, except some local areas whose abundance varies in association with different habitats and it can be affected by other species, as *C. yacare*.

The results suggest that, although the populations are recovering, the species is not still abundant in all its distribution range, but it is locally. However, facing the results of studies developed among 1986-1987, to the present time, even though the population stays reduced, larger prevalence of mature individuals is observed. On the other hand, the presence of nests and/or neonates of *M. niger* in 6 of 8 studied TCOs, suggests that the species is reproducing with success in these areas.

We can also consider that, without imminent threats of habitat destruction, large areas of pristine habitats of difficult access and with a minimum threat of poaching, could have a favorable situation for the recovery of this species that is staying in the far away habitats of difficult access. However, it is also important to remember that the presence of small dispersed populations throughout the department, probably result of the overexploitation that *M. niger* suffered in the past, doesn't imply that the species has recovered in all its range of historical distribution.

The objective of this type of surveys carried out is to estimate the abundance and to make surveillance through time. It is necessary to incorporate this species to the general considerations of the management plan of crocodilians of the Beni department and of the entire country, and to increase the knowledge about the species. The population's surveillance should be increased in area and time to have a wider understanding about the status of the species.

The above-mentioned recovers special importance in a department in which, the evidences of growing populations in some located areas, increase the interest of incorporate this species

into the commercial use. For this reason, since *C. yacare* and *M. niger* are sympatric species and both have commercial value, the National Program of Sustainable Use of *Lagarto*, should be redirected to at least consider both species. This consideration would facilitate controlling the harvested *M. niger* that is illegally sold as big leathers of *C. yacare* by some specific leather-rescuers, situation that might also be affecting the recovery of the species.

The absence of information about the population state throughout the whole range of distribution of the species is the biggest obstacle for the development of a management and conservation program. For this reason, the departmental interest in developing a management program based on the commercial controlled use, should be sustained with appropriate information about the population state of *M. niger* in the region. The information provided in this article should be complemented and incorporated into the political framework to be developed for the use of crocodilian species in Bolivia.

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Wicked Problems with Wicked Crocodiles

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ABSTRACT: The CSG and its members are involved with solving crocodilian conservation problems around the world. Humans generally attribute negative values to crocodiles (*wicked crocodiles*), which favour eradication, and so incentives to value crocodiles positively, favouring conservation, are often needed. The successful management of crocodilians typically involves dealing with an array of interacting variables (social, economic, biological), all subject to risk and uncertainty. These complex, dynamic and ever-changing problems can be defined as *wicked problems* (Rittel and Webber 1973). Yet the CSG and it members have met with considerable problem-solving success Relative to the 1960s, 13 of 23 species have increased in abundance and 19 species are not considered threatened with extinction within the next 50 years. With 4 other species, such optimism may not be justified. The main lesson learned from conserving and managing crocodilians is that the human variables associated with conservation are much more problematic than the biological variables.

INTRODUCTION

The theme of the 19th Working Meeting of the IUCN-SSC Crocodile Specialist Group (Santa Cruz, Bolivia, 2-7 June 2008) is "*Lessons Learned on Conservation and Management of Crocodiles*". The CSG and its members have played a pioneering role in generating new knowledge and learning lessons about the conservation and management of crocodilians, and are the major international "institution" involved with crocodilians. So it is a pleasure to address this issue here, and highlight some of the key issues I think are important. The most important lessons we have learned is that the biological variables, although challenging, can often be quantified in a way that allows accurate prediction. The human variables in contrast, are much more unstable and vulnerable to spontaneous change.

The CSG

The IUCN-SSC Crocodile Specialist Group (CSG) has evolved into a problem-solving organisation, focused on conserving the world's crocodilians. The membership of the CSG involves an array of people (337 members from 52 countries in May 2008) from the private and public sectors, from one or more of a series of primary disciplines (biologists, wildlife managers, NGOs, consultants, crocodile keepers, zoological park staff, crocodile farmers, tanners, manufacturers, educators, lawyers). All are problem-solvers - sometimes problem creators - in their own right.

The CSG was formed under the auspices of the Species Survival Commission (SSC) of the International Union for the Conservation of Nature (IUCN), as a loose and informal group, mainly of biologists, with expertise on crocodilians. The idea was that the CSG could provide the SSC and IUCN, on a voluntary basis, with credible scientific information about the status

of crocodilians, particularly for the IUCN Red Data Book – now the IUCN Red List of Threatened Species. However, creating the CSG had unforseen consequences. There were no NGOs with specialist conservation credentials nor interest in crocodilians in the late 1960's, and so the CSG, as a consortium of like-minded individuals, deeply concerned about crocodilian conservation, informally assumed that role. With many of the more charismatic wildlife species, NGO interest was already established, and so the role played by SSC Specialist Groups was perhaps not so broad.

The SSC and IUCN benefited from the scientific information the CSG provided and welcomed onservation action undertaken by CSG members. The CSG benefited from the credentials implicit in operating what was essentially a specialist NGO under the auspices of the SSC and IUCN. It is an unusual but effective alliance, the strength of which, from a CSG perspective, lies in: the governance freedom extended to the CSG by the SSC; the diversity of CSG membership; the camaraderie which now exists between CSG members; the dedication of CSG members to crocodilian conservation; their pride in association with the SSC and IUCN; their willingness to assist *gratis*; the free and open exchange of information that takes place between most CSG members; and, the transparency with which the CSG conducts its business.

Both the formal function of the CSG (providing scientific information to the SSC and IUCN) and the informal function (pursuing conservation action), clearly assists the SSC and IUCN to fulfil their Missions with regard to world crocodilians, in an efficient and cost-effective manner.

Conservation and Changing Values

For the CSG to pursue conservation, and solve conservation problems, it is clearly important they have a clear view of what conservation is and what it is not. This is of course subject to strong and variable personal views, within and outside the CSG. My own opinions, which I believe are widely shared by CSG members, is that *conservation action* is directly to human *values*. Throughout history people have never conserved anything that they did not value positively, and they have destroyed and eradicated many items that had negative values or no recognised value (neutral values). So on this basis, conservation can be defined as: *the sum total of actions taken to preserve and maintain items which are valued positively.* It does not really matter if the values are *utility* values (use values), or intrinsic values - what matters is that the net values are positive and can drive conservation action. If the values are negative they drive eradication.

The values people attribute to crocodilians vary from culture to culture and have evolved and changed over time. The earliest hunter-gathers apparently coexisted with crocodiles, but this does not mean they were motivated by conservation ideals to do so - they had no other option. The crocodiles were incapable of catching and eating all the people, and the people, with the technology of the day, were incapable of catching and eating all the crocodiles. An uneasy alliance, constrained by technology, in which both sides received benefits (occasionally eating each other), which came at a cost (occasionally being eaten). The problem that people from bygone years faced, which still exists today, was essentially: *how do we coexist with crocodiles?* The solution was: *with caution, skill and knowledge built on experience.*

The era of colonisation brought with it improved technologies for killing crocodiles over time, increasing popularity of sport-hunting, increased effectiveness of pest eradication programs and even the use of crocodile skins for leather in the 19th Century. It reduced crocodilian populations in many areas, but from a population viewpoint, the numbers killed were largely sustainable by the wild populations. Not so with large-scale commercial exploitation fuelled by international trade in the 20th Century, particularly after World War II. Wild populations plummeted around the world and by the early 1960s, when the IUCN Red Data Book was launched (1963), crocodiles were all considered vulnerable to extinction.

In terms of values, prior to the 1960s the *positive* values attributed to crocodilians by people were based on utility (= use) values. Crocodiles were a source of protein (meat and eggs) and products (mainly skins). These values could only be obtained by killing crocodilians. The consequences of unrestricted killing of crocodilians (extinction) was not generally appreciated before the 1960's. The *negative* values were that crocodilians preyed on people and domestic livestock, competed for food resources, restricted access to wetlands, and were generally a dangerous nuisance: values which could also only be avoided by killing crocodilians. The relationship between crocodilians and the values people attributed to them thus revolved around people killing crocodiles.

The public awakening about *extinction* in the 1960s resulted in *intrinsic* values being added to the list of positive values. People may not have particularly liked crocodiles, but neither did they like the idea of them going extinct and being lost to the world forever. In addition, with depleted crocodile populations everywhere, the negative values were decidedly reduced: less crocodiles, less problems. The rebalancing of net values meant that after the 1960s, increasing efforts to “save” crocodiles from extinction were possible - the era of conservation had begun.

The high *intrinsic* values associated with avoiding the extinction of wildlife spawned movements such as animal rights and animal liberation, and greatly increased interest in animal welfare. It led to many more organisations pursuing conservation, but with members often united through sharing a particular *intrinsic* value (little “c” conservation organisations) rather than through sharing a primary commitment to pragmatic conservation goals (big “C” conservation organisations).

This difference in conservation focus was to become very important to the CSG, because when conservation efforts with crocodilians succeeded, and depleted wild populations did recover, the positive values were eroded (extinction was no longer a possibility), but the negative values increased (more crocodiles more problems). That is, net values declined, favouring eradication rather than conservation. This led to the promotion of *sustainable use* programs, where crocodiles could once again be killed for trade, adding new positive values. It required a commitment to sustaining the uses, which was a technical challenge overcome in different ways in different programs.

The reintroduction of killing crocodiles to provide incentives to conserve crocodiles, was supported by big “C” conservation organisations, but strongly opposed by little “c” organisations. Their moral and ethical positions were the priority and they did not sanction the killing of animals for any reason, including improved conservation. It led to significant conflict within what is generally considered the conservation community, which was

essentially conflict about competing values rather than conservation itself. That conflict continues today. Every proposal to CITES involving the consumptive use of crocodiles is formally opposed by consortiums of little “c” conservation NGOs.

Wicked Crocodiles

In terms of implementing conservation programs for crocodilians in the field, CSG experience and common sense both dictate that it is critically important to understand the values local people attribute to crocodilians. These will mostly be negative ones. People do not have to view many crocodile attacks on people, nor discuss the frustrations and dangers crocodiles cause farmers and fishermen, to realise why. That crocodiles are normally viewed as *wicked crocodiles* by the majority of people is a matter of accepting reality.

Accordingly, despite most CSG members holding the *intrinsic* values of crocodilians highly, they often need to exploit *utility* values to make crocodile conservation programs work, particularly in areas where the people coexisting with crocodilians live in poverty. The two sets of values are not mutually exclusive and never have been. Hunters tend to hold their prey in high esteem.

Wicked Problems

Protecting severely depleted crocodile populations has sometimes led to rapid population recoveries, in which case more sophisticated management programs incorporating sustainable use have usually been implemented. But legal protection of highly depleted wild populations does not always result in a recovery. Where the human populations are high, where wetland habitats are restricted and heavily used by people, where crocodile populations were depleted long ago, the challenges of making protection work can be extreme. Regardless of whether trying to promote population recovery, or manage recovered populations, it soon becomes apparent that conserving crocodiles involves suites of different variables (social, cultural, legal, economic, political, biological), all interacting in often unknown but dynamic ways, all subject to risk (known low probability events occurring) and uncertainty (the “wild cards” - new variables not previously recognised as being important). These types of problems with crocodile conservation are identical to those encountered in the field of urban planning, where plans made for the future are invariably confounded by key variables (assumptions) not lasting the test of time. They have been aptly termed “wicked problems” (Rittel and Webber 1973). Most of the problems the CSG has had to deal with are thus *wicked problems with wicked crocodiles.*

The challenge with wicked problems is to accept that they cannot be solved by a classical reductionist (bottom up) approach to problem-solving, in which it is assumed that if you know all the component parts you will be able to predict how the program as a whole will operate. This type of highly dynamic problem, with different dimensions of the problem changing continually, is best approached through scenario planning. Deriving different management scenarios, and then subjecting them to detailed scrutiny from the top down. When a scenario is selected and implemented, it should be with full knowledge that circumstances will change and flexibility and adaptability will ultimately determine whether the goals of management are sustained over time. What this means in practice is that a precautionary approach is more about having protocols in place to detected and respond to

change, rather than a highly prescriptive way forward, implying (completely erroneously), that all key variables are known and understood.

Based on CSG experience, the single key ingredient for successful conservation programs for crocodiles is usually the presence of an individual champion with vision and leadership skills, who can both keep the original conservation objectives in sharp focus and retain institutional memory - a person rather than a position. Institutional memory of how a program responded to perturbations caused by risk and uncertainty in the past is a major safeguard for achieving long-term sustainability in the future. There are also some general rules born of CSG experience:

1. You can only become skilled at managing wildlife by managing wildlife, rather than planning to manage it.

2. You cannot avoid making mistakes, and nor will you be able to avoid being criticised for making them. If you cannot tolerate criticism, get out of the crocodile conservation game.

3. The game rules for any conservation or management program will change continually.

The political variables impacting on a crocodilian management program are but one set of variables vulnerable to change. Within forums such as CITES, decisions affecting local management programs can be made to achieve other political goals, with those voting on whether to support or reject a proposal often having only a rudimentary knowledge of the real substance of the issue. Little “c” conservation organisations opposed to killing animals for any reason are often more effective in such forums than big “C” organisations trying to promote management programs that include some controlled killing. Even at national and local levels, political support for a program can wax and wane depending on the passing parade of political players and the degree to which decisions are based on political opportunism, even jealousies, rather than conservation *per se*. The resources provided to establish a program, which often includes a large commitment to monitoring initially, will often be withdrawn or reduced when the program is operating. The vagaries of politics are arguably a much more important “threat” to conservation programs than the risk of overharvest. The ability to sustain a management program will ultimately be linked to the ability to fight against some political changes and adapt to others. However, the political variables are only one of many sets of variable subject to continual change.

Indicators of Conservation Success

In the 1960s the global wild populations of almost all crocodilians of commercial value for their skins were depleted, many dramatically so, relative to their status in the 1940s. This is clearly reflected in the proceedings of the 1st Working Meeting of the CSG in 1971. In the 40 years since the 1960s, despite significant variability between countries, there have been significant changes in status with most species (Table 1).

Table 1. Probable changes in global population size since the 1960s for 23 species of crocodilians. “Secure?” refers to whether the global population is considered secure against extinction within the next 50 years.

Species	Probable Trend	Secure?
A. mississippiensis	Improved	Yes
A. sinensis	declined (now improving)	No
C. crocodilus	improved	Yes
C. latirostris	improved	Yes
C. yacare	improved	Yes
P. palpebrosus	declined (?)	Yes
P. trigonatus	declined (?)	Yes
M. niger	improved (SU)	Yes
G. gangeticus	improved (now declining)	No
T. schlegelii	declined	Yes
C. acutus	improved	Yes
C. cataphractus	declined (?)	Yes
C. intermedius	improved	Yes
C. johnstoni	improved	Yes
C. mindorensis	declined (now improving)	No
C. moreletii	improved	Yes
C. niloticus	improved	Yes
C. novaeguineae	declined (stable)	Yes
C. palustris	improved	Yes
C. porosus	improved	Yes
C. rhombifer	declined (?)	Yes
C. siamensis	seriously declined	No
O. tetrapsis	declined (?)	Yes

By 2008 13 of the 23 species of crocodilians (57%) have probably increased in abundance relative to population levels in the 1960s and 10 (43%) have probably decreased. However, 19 species (83%), regardless of whether increased or decreased relative to 40 years ago, for a variety of reasons, are still considered secure - not threatened with extinction globally in the next 50 years. Four (4) species (17%) remain problematic (Table 2).

They *may* be secure given the conservation programs now in place, but they remain CSG priority species for action (Table 2).

Table 2. Crocodilian species that may not be buffered against extinction within 50 years, that are priorities for CSG conservation action. CSG assessment in the IUCN Red List is "critically endangered" (CR) for all four.

Species	Problem	Action
A. sinensis	Seriously depleted in wild, remnant habitat remaining, public opposition to reintroductions (CR)	Encourage existing programs; More habitat dedicated, more releases to wild, more incentives to public, increased public education
C. mindorensis	Seriously depleted in wild, remnant habitat remaining, public opposition to reintroductions (CR)	Encourage existing programs; More habitat dedicated, more releases to wild, more incentives to public, increased public education
G. gangeticus	Seriously declining wild population, restricted range (CR)	Encourage existing efforts to determine reasons for decline, more basic ecological research, encourage population increase, repopulation in other parts of range.
C. siamensis	Serious population decline in Cambodia; wild crocs to village farms in Kalimantan (CR)	Boost wild population in Cambodia with captive-raised juveniles marked to distinguish in trade; Dialogue between SE Asian countries re trade; initiate research in Kalimantan to quantify status.

DISCUSSION

The CSG currently has 337 members, from 52 countries, who on average have more than 10-years experience with the conservation, management and sustainable use of world crocodilians. This means at least 3370 years of experience, which even if valued at $10,000 per person per year, provides a knowledge base that has conservatively cost more than $30 billion dollars to assemble, and may cost $3 billion each year to sustain and grow. It is the CSG members and their staff, students and operational budgets, spread throughout the world, that are at the coal-face of conserving and managing the world's crocodilians - the front-line of dealing with *wicked problems with wicked crocodiles*. They are the people providing the new knowledge and new lessons about how to conserve crocodilians.

The CSG assists its members, by facilitating the exchange of information between them, providing a forum through which members can learn from each other, and addressing problems that individual members cannot deal with effectively: for example “CSG National Reviews with Recommendations”. The CSG provides the SSC and the IUCN with a unique opportunity to source knowledge on crocodilians for use within the international forums in which they operate, well-distanced from the ground roots “problems” which many CSG members have to deal with.

Those CSG members dealing directly with management programs, especially programs incorporating sustainable use, have the skills needed to evaluate management scenarios realistically. They have a practical understanding of the strengths and weaknesses of different approaches, the types of mistakes that can and will be made, the most likely roadmaps to success, and the critical role that social, cultural, economic and political variables can and will play. The biological variables, although important, usually prove to be the least problematic in sustaining a management program.

It is now clear that long-lived, late-maturing crocodiles are as amenable to sustainable use as any other species, *if* the rate of harvest can be controlled. This is clearly a challenge in some national contexts because of a range of capacity problems, many of which cannot be rectified simply in order to make crocodilian management more successful. The same capacity problems effect education, health, infrastructure development, etc. Hence the types of management applied in different national contexts need to be tailored to local circumstances. There is no single "ideal" program.

From a CSG perspective, it is frustrating that we still have species of crocodilians that were *critically* endangered in the 1960s and remain so today. These species are all now being assisted by dedicated conservation programs, which was not the case in the 1960s, so advances have been made. But bold, new and innovative approaches may be needed if significant changes in status are to be achieved and sustained in the future. The main practical issues that need to be investigated if new conservation scenarios are to be identified and implemented have little to do with biology:

1. Who benefits financially, in direct and indirect ways, from maintaining the *status quo* and resisting change?
2. Are the beneficiaries the ones that need to benefit in terms of the incentives required to enhance a population recovery?
3. Is there a “legal assumption” involved, in the sense of laws restricting conservation program options that can be applied?
4. To what extent do intrinsic versus utility values exist in the community?
5. Is the flawed approach based on a strong philosophical or religious commitment to particular types of solutions?
6. Is the maintenance of a flawed solution implicit in fund-raising?
7. Is the issue a politically sensitive one for local politicians?
8. Is the issue an important or trivial one for local people?
9. Are there commercial industry ramifications?
10. Is the management capacity present to undertake different approaches?
11. Is gratuity involved in decision-making?
12. To what extent does poverty influence the actions of people?

13. Are there any cultural links with the species?
14. Are land tenure issues involved?
15. Is illegal trade involved?
16. To what extent is trade (illegal or legal) the primary or secondary cause of the population's *failure to thrive?*
17. Are the reasons for failure being allocated objectively or are convenient *public enemies* being used to divert responsibility?
18. Does the legal system have the capacity to achieve compliance with the laws?
19. Are cultural sensitivities to problems so great that they cannot be addressed objectively?
20. Are local people educated?
21. To what extent can concerns about wildlife be prioritised relative to other basic humanitarian needs such as health, education and food security?
22. Is there sufficient genuine interest by those required to conserve the species to negotiate increased involvement from communities?
23. Do the authorities understand the difference between population dynamics and dynamic populations?

The ability to implement new approaches to conservation, even if urgently needed to avoid the extinction of a critically endangered species, may be far more constrained by social, cultural, economic and philosophical barriers than by biological ones. This is the main lesson I have learnt about the conservation and management of crocodilians. It is people who usually create conservation problems, but it is also people who usually solve them, and people who prevent potential solutions even being tested. The problems are truly *wicked.*

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A New Orinoco Crocodile (*Crocodylus intermedius*) Population in the Apure Llanos. Venezuela.

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ABSTRACT: The Orinoco crocodiles introduced at El Frío Biological Station, Caño Guaritico Wildlife Refuge and surrounding areas have formed a "new population". These crocodiles come from wild eggs, wild hatchlings and hatchlings from captive adults. At the beginning of the Venezuelan Conservation Program the number of crocodiles in the area was almost zero. 2,282 juvenile crocodiles were introduced at the study area between 1990 and 2006. We define a population of this species as a group of 300-500 individuals older than one year, which includes at least 25-30 breeding females. The introduction Program was evaluated through night and day surveys along 476 km of water courses between October 2006 and January 2007. The minimum population size is estimated as 400 crocodiles with at least 31 breeding females. The estimated introduction rate is 17,8 %. In Venezuela occur three Orinoco crocodile populations: Cojedes, Capanaparo and Guaritico (new), which shows a fast increasing in individuals and geographic expansion. El Frío Biological Station develops a "ranching" of eggs from the new population, with exclusive conservation purposes. This is the first case in the world where a wild crocodile population is made up from captive individuals.

INTRODUCTION

Crocodylus intermedius is the great crocodile of the Orinoco basin. Its historic distribution is restricted to the huge plains below 200 m over the sea level typical of this river, although exist some records of its presence up to 400 m. According to naturalists from 18th and 19th centuries the species was very abundant both in Venezuela and Colombia. From 1929 to the early 60's an uncontrolled commercial hunting depleted the species in most of its habitat; just two important populations survived in Venezuela (Cojedes-Sarare and Capanaparo) and some small groups or isolated individuals in different places like Tucupido, Camatagua or Manapire (Ayarzagüena 1987; Thorbjarnarson and Hernández 1992; Seijas et al. 2002).

The conservation activities started in Venezuela in the late 70's, along the 80's four captive-breeding centres were established, and in 1989 Caño Guaritico Wildlife Refuge (CGWR) was designed as a specific area for the Orinoco crocodile conservation. Most of the restocking efforts have been taken in CGWR and in adjacent areas like El Frío Biological Station (EFBS). In this area the species was almost extinguished 20 years before (there are three unconfirmed reports of crocodiles from local people). 2.282 juveniles have been introduced between 1990 and 2006 (Velasco pers. comm.).

The study objective is to show up the results obtained by means of the restocking program in CGWR and surrounding areas and, on the basis of that, demonstrate the existence of a new population for this species.

Previous census (Lugo 1998; Chávez 2002) evaluated the success of the introduction program in CGWR and EFBS. The present study is more extensive in time and space, and it is actualized, which is really important in a population that is continuously growing since the restocking program started.

STUDY AREA

The study was carried out in the southwest of Venezuela, into the Flooded Llanos region (Velasco and Ayarzagüena 1995), in an area around 5.000 km^2, which includes CGWR and EFBS (Fig. 1).

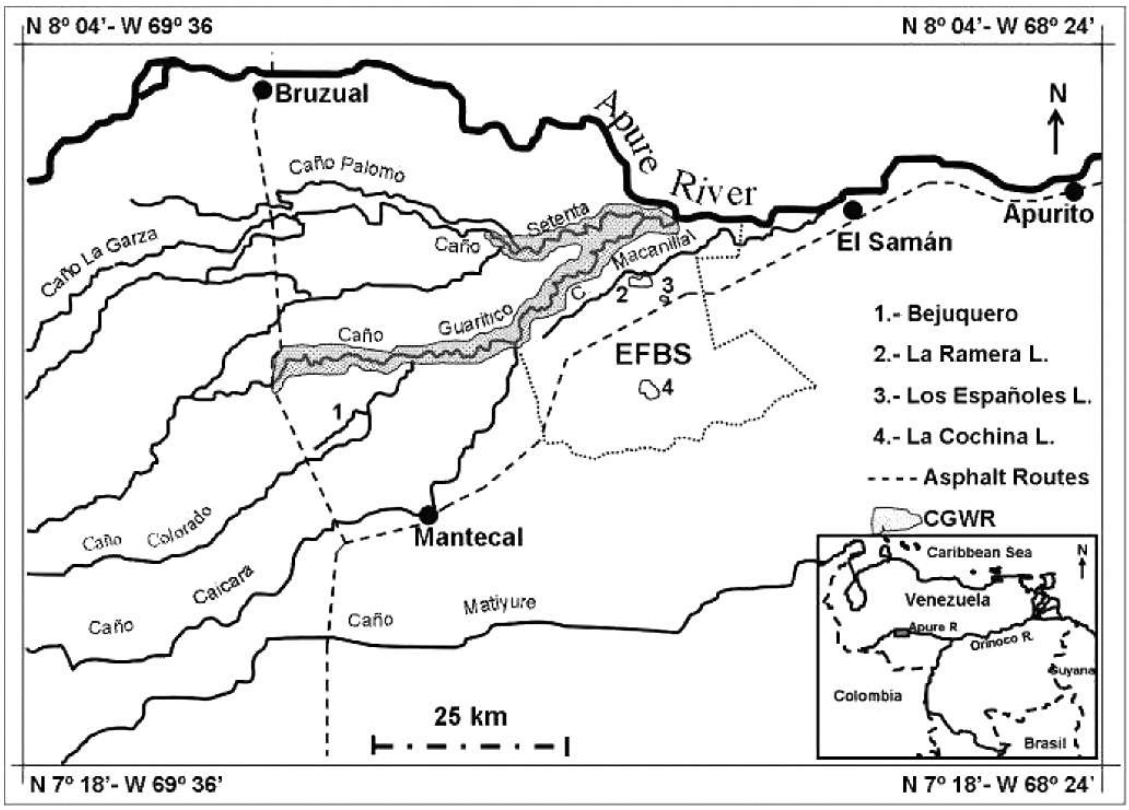

Figure 1. Map of the study area, includes CGWR, EFBS and other surveyed sectors. The water flows from west to east.

There are two clearly-defined seasons in the region, a dry season between December and April, and a rainy season between May and November. The almost flat relief and the rich clay substrates promote that, during the rainfall peak (July-August), 80 % of the territory is flooded up to one meter by the rainfalls water and the overflow of main rivers and *caños*.

Caño is a water course characteristic of the huge plains, with seasonal flow that canalizes the waters from rivers and lagoons overflows.

The savannah vegetation is typically herbaceous, but rivers and caños are flanked by gallery forest, mangle (*Coccoloba obtusifolia*) grows over the banks and some *caños* and lagoons present floating vegetation (*Eichhornia sp.*).

The surveyed *caños* in this study flow across or between private cattle ranches (*Hatos*).

MATERIAL AND METHODS

From October 2006 to January 2007 nocturnal spotlights surveys were carried out from aluminium or wooden boats powered by 30 or 40 hp outboard engine. Crocodiles were detected and differenced from caimans (*Caiman crocodilus*) with the help of a 1.000.000 candles torch connected to a 12V battery. The observed crocodiles were recorded on a GPS Garmin E-Trex, which was also used to measure distances, speed, and time employed. The in-navigable sectors of Caño Macanillal and Los Españoles lagoon were surveyed by foot or by horse. La Cochina lagoon was surveyed from the shore by 4WD vehicle.

The census team was composed of the investigator and local people (except in EFBS) like fishermen, tourist guides and/or security employers, who know the area and the exact points where the crocodiles used to be. In the results, "observed crocodiles" are those that were already sighted. "Reported crocodiles" are those that were not seen for us, but are usually observed by local people. The preference of this species for concrete points during the dry season supports the reliability of this information.

The crocodile density is expressed in Individuals/km (Ind./km), except in the lagoons where is not possible to express density, because of its highly variable perimeter. The census was carried out looking for the minimum level water that allows the navigation. As is well-known, water level has great influence in crocodile detection (Woodward and Marion 1978; Hutton and Woolhouse 1989; Da Silveira *et al* 1997; Ron *et al* 1999; Da Silveira *et al* 2008).

The population size estimation is calculated by two methods: a) Assigning the average density obtained in the census to sectors which we were informed that contain crocodiles but could not be surveyed, b) Estimating the survival rate of introduced crocodiles in small well-known areas, and considering that rate for the total number of introduced crocodiles at the whole study area.

RESULTS

Population Size

115 crocodiles over 80 cm total length were observed along 476 km surveyed; if we add 96 "Reported crocodiles" that were not observed, we obtain 211 "registered crocodiles" (Table 1).

Table 1. Observed, Reported and registered (observed + reported) crocodiles during the census at different body waters.

Date	Surveyed Area	km	Observed	Reported	Registered	Ind./km
10/10/2006	C. Terecay	33	0	0	0	0,00
10/10/2006	C. La Aguada	6,9	1	1	2	0,29
11/10/2006	C. Palomo (Section A)	21,1	0	0	0	0,00
02/11/2006	C. Garza (Section A)	11,4	1	3	4	0,35
03/11/2006	C. Palomo (Section B)	8	0	0	0	0,00
07/11/2006	C. Setenta	6	2	6	8	1,33
15/11/2006	C. Garza (Section B)	42,2	3	15	18	0,43
18/11/2006	C. Matiyure	17,3	6	4	10	0,58
19/11/2006	C. Molino Mocho	9,6	1	2	3	0,31
24/11/2006	C Bejuquero/C. Colorado	26,1	3	2	5	0,19
27/11/2006	CGWR C. Setenta	39,5	5	7	12	0,30
01/12/2006	CGWR C. Guaritico	128	27	36	63	0,49
31/01/2007	R. Apure (Section A)	61,2	3	7	10	0,16
28/01/2007	R. Apure (Section B)	50,3	7	13	20	0,40
18/01/2007	C. Macanillal	15,3	30	-	30	1,96
03/01/2007	La Cochina L.	-	6	-	6	-
15/01/2007	La Ramera L.	-	16	-	16	-
20/01/2007	Los Españoles L.	-	4	-	4	-
Total		**475,9**	**115**	**96**	**211**	

We observed crocodiles in all the surveyed areas, except in Caño Terecay and Caño Palomo, which both are narrow, shallow and do not represent an appropriate habitat for the species. If these *caños* and the crocodiles observed in the lagoons are removed from the analysis, the average density obtained in the study area is 0,45 Ind./km. The highest density was observed in Caño Macanillal (1,96 Ind./km).

-Size population estimation based on potential habitat and census.

We consider that in the study area there are around 648 km of river courses that are potential habitat for the species. 234 km (34%) of several sections of the *caños* Caicara, Setenta, Bejuquero, Guaritico and La Aguada could not be surveyed because they were inaccessible or because they become dry before than expected. These *caños* were surveyed for us in other accessible sections and in all of them we observed crocodiles; in addition, reports from local people confirm the presence of crocodiles at these not surveyed sections. If we apply the average density obtained in the census (0,45 Ind./km) to the not-surveyed sections, we obtained 105 estimated crocodiles, that added to the 211 “registered crocodiles”, resulted in a population size of 316 crocodiles.

- Size population estimation based on survival rate of introduced crocodiles.

As we mentioned at the Introduction, the whole crocodile population comes from individuals raised in captive- breeding centres; if we estimate the survival rate of the introduced

crocodiles, we can have a good estimation of the real population size. Some areas allow a quite good estimation because few crocodiles have been released in them and, in addition, are monitored constantly (Table 2).

Table 2. Estimated survival rate in small and well-defined areas.

Area	Introduced crocodiles	Observed crocodiles	Survival Rate (%)	Estimated Crocodiles	Estimated Survival Rate (%)
C. Garza	67	6	9	21	31,3
La Cochina L.	16	4	25	6	37,5
C. Matiyure and C. Caicara	69	5	7,2	15	21,7
La Ramera L.	72	14	19,4	16	22,2

In the four areas the survival rates oscillate between 21,7 and 37,5 %. Using the lowest value (21,7 %) as indicative of the survival rate for the 2.282introduced crocodiles, the population size estimation will be 495 crocodiles; if we use the highest one (37,5 %), the theoretical population size will be 856 crocodiles.

Breeding females

Between 2005 and 2006 at least 22 different females breed in EFBS and CGWR, added to nine nests referred to us for fishermen and local people. 21 nests were observed at EFBS and the rest in other parts of the study area (Table 3).

Table 3. Observed, referred and estimated (observed + reported) nests in the study area between 2005 and 2006.

Area	Observed Nests	Reported Nests	Estimated Nests
C. Terecay	0	0	0
C. La Aguada	0	0	0
C. Palomo	0	0	0
C. Garza	0	1	1
C. Matiyure	0	4	4
C. Bejuquero and C. Colorado	0	0	0
C. Setenta	0	0	0
C. Guaritico	1	2	3
Apure R.	0	2	2
C. Macanillal (EFBS)	10	0	10
La Cochina L. (EFBS)	0	0	0
La Ramera L. (EFBS)	10	0	10
La Entrada L. (EFBS)	1	0	1
Total	**22**	**9**	**31**

Some of the eggs founds in EFBS nests are collected to continue with the captive-breeding program.

CONCLUSIONS

The values showed by the different estimation methods oscillate between 316 and 856 crocodiles. With this in mind, we estimate the population size present in CGWR and EFBS in, at least, 400 non-hatchling crocodiles, which includes around 30 breeding females.

This new population is comparable to the other two described ones for Venezuela, Cojedes – 547 crocodiles- (Seijas and Chávez, 2000) and Capanaparo -536 crocodiles-(Llobet and Seijas, 2002).

400 crocodiles is equivalent to 17,8 % survival rate of the introduced crocodiles, three times more than the estimated rate of survival of wild ones (Antelo in prep), which clearly shows the importance of the captive breeding conservation program.

The new population represents the successful introduction of a man-eater species in the wild, being, possibly, the first case around the world in which a new crocodile population is made up exclusively by individuals raised in captivity.

According to previous census (Lugo 1998; Chávez 2002), the information from fishermen and our observations, this population shows a fast increasing in individuals and geographic expansion.

We finally conclude that this success, which highlight at international level, has only been possible because of the substantial collaboration of several public and private institutions: Venezuelan Ministry of Popular Power for the Environment, FUDENA, FUDECI, FLASA, WWF-USA, AECI, GECV, and of course the four captive-breeding centres: Fundo Masaguaral, UNELLEZ, Agropecuaria Puerto Miranda and EFBS.

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Population Status and Evaluation of the releasing program of Orinoco's caiman, (*Crocodylus intermedius*) in the Cojedes River, Venezuela.

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SUMMARY: In order to continue with the management strategies aimed to conserve and recover the populations of Orinoco crocodile in the Cojedes River, we estimated the abundance and population structure including spatial and temporal variations. Twenty five nocturnal surveys were performed in five different segments of the river (43 Km) between December 2005 and May 2006. The abundance indexes show intervals of 0.35 to 5 individuals/km, with a media of 2,9 ind/km for the most representative segments. There were no significant differences in the population structure between segments, and in all the cases the Class V adults, and Class II juveniles dominate the populations. From 61 different captured animals 5% belong to the reintroduction program, representing a 1,5% of the 207 animals reintroduced in may 2005. The dispersion of juvenile crocodiles (as wild as freed) shows that these animals use a relative small area of action. The growth rate of the freed crocodiles in the Cojedes river is between 2,8 and 11,4 cm/year. The development of the juvenile crocodiles in the Cojedes river seems to be very slow, and far below the potential growth shown by the species, therefore, the reintroduction of more animals in this area should be reviewed and/or refocus.

RESUMEN: Para continuar con las estrategias de manejo orientadas a la conservación y recuperación de las poblaciones del caimán del Orinoco en el río Cojedes se estimó la abundancia y estructura poblacional incluyendo variaciones espaciales y temporales. 25 muestreos nocturnos fueron realizados en 5 sectores diferentes (43 km) del río entre diciembre de 2005 y mayo de 2006. Se encontraron índices de abundancia entre 0,35 y 5 individuos/km, con un valor medio de 2,9 ind/km para los sectores más representativos. No se observaron diferencias en la estructura poblacional en los diferentes sectores y en todos los casos la población estuvo dominada por individuos adultos Clase V, y juveniles Clase II. De los 61 caimanes distintos capturados el 5% correspondieron a individuos provenientes del programa de liberación, se calculó una fracción de permanencia de 1,5% de 207 individuos liberados en mayo de 2005. La dispersión de caimanes juveniles (silvestres y liberados) demuestra que tienden a permanecer en un área de acción relativamente reducida. La tasa de crecimiento en cm/año de los caimanes liberados en el río Cojedes están entre 2,8 y 11,14, el crecimiento de los caimanes juveniles del río Cojedes parece ser muy lento, y muy por debajo del potencial mostrado por la especie, por lo que la liberación de animales en esta localidad debe ser revisada y/o reorientada.

INTRODUCTION

The Orinoco's caiman is one of the most seriously endangered crocodilian species of the world, the commercial overexploitation since 1930's until the end of 1950's decimate the population all over the distribution area (Thorbjarnarson 1992, Ross 1998, Seijas 1998). Besides the legal efforts taken up to date, the population recovery has been too slow (Seijas 1998) and the species is still endangered for a factors combination as the habitat destruction, egg harvest, poaching, intentional deaths and other incidents (Thorbjarnarson y Hernández 1992).

In the Cojedes river system of Venezuela, the largest known reproductive population is found, making it the key place for the recovery of the species (Seijas 1998).

Several evaluations had been performed in the Cojedes river, providing valuable data about the most important wild population of the country (Godshalk 1978, Ayarzagüena 1987, 1990, Thorbjarnarson y Hernández 1992, 1993a, 1993b, Seijas 1993, 1998, Seijas y Chávez 2000).

In the Cojedes river system, historically, some special characteristics were present that lead to the residence of the most important caiman population, as the poor communication systems from important commercial roads of the country to the river, the constant riverbed changes with a complex meander system, navigation channels and old meanders, after a flood period. Another important factor that helps with the residence of the caiman in the Cojedes river, is that the Cojedes State remains as one of the least populated places of Venezuela (Seijas 1998).

Actually, the Cojedes river is under constant human pressure, caused specially by important intensive-agriculture areas close to the river, and large urban and industrial locations (Godshalk 1978, 1982, Ayarzagüena 1987, 1990, Seijas 1998). In the last 50 years, the human activities had changed the habitat characteristics of the Orinoco's caiman in the Cojedes river. Some changes modified the water quality of the river, meanwhile others altered the physical characteristics of the river by channels, deviations, dams, and dredges (Seijas 1998, Seijas y Chávez 2002, Mendoza y Seijas 2007).

The actual population status of the Orinoco's caiman in the Cojedes river is probably a consequence of the historical factors mentioned before, and the interactions of the species with the new factors directly or indirectly related to the human presence and activities. (Seijas 1998). Today, the Cojedes river isn't under any protective or special administrative regimen, even after several years of studies and the development of proposals, the protected area declaration for this location hadn't been achieved yet, determining the necessity of the project to achieve the creation of this area.

The present work, developed with the economical support of the Wildlife Conservation Society (WCS) and FUDECI, was made aiming to establish the population status of the Orinoco's caiman (*Crocodylus intermedius*) in the Cojedes river, with the objective to obtain necessary actualized information, in order to build a better vision about the conservation status, as to evaluate the population restoration efforts in the area helping to support technically the continuity of the work or to refocus it in order to increase its success.

STUDY AREA

The Cojedes river belongs to the Turbion-Cojedes river system, that extends through several regions and flows into different relieves, ecosystems, canopy structures and types of human activity. The study area is placed south Lagunitas(Libertad)-El Amparo- Santa Cruz road, south to San Rafael de Otono National Road, part of the Cojedes river known as Caño de Agua, from the referencing point of La Batea, to the south passing a divide called Caño Amarillo, takes part of the Sarare river, that runs parallel to Caño de Agua and to a section of Caño Amarillo.

Most of the Cojedes river belongs to an area known as Tropical Dry Forest (Ewel y Madriz 1968). In the study area we find station homogeneity, with two well defined weather stations, as is common in the Venezuela plains. The rain station, which extends from May to October, and the dry station that takes place from December to March, being April and November transitional months between stations. According with the information obtained from the Environment Ministry, the average rain fall of the area is 1328.1 to 1335 mm (1967 to 2004).

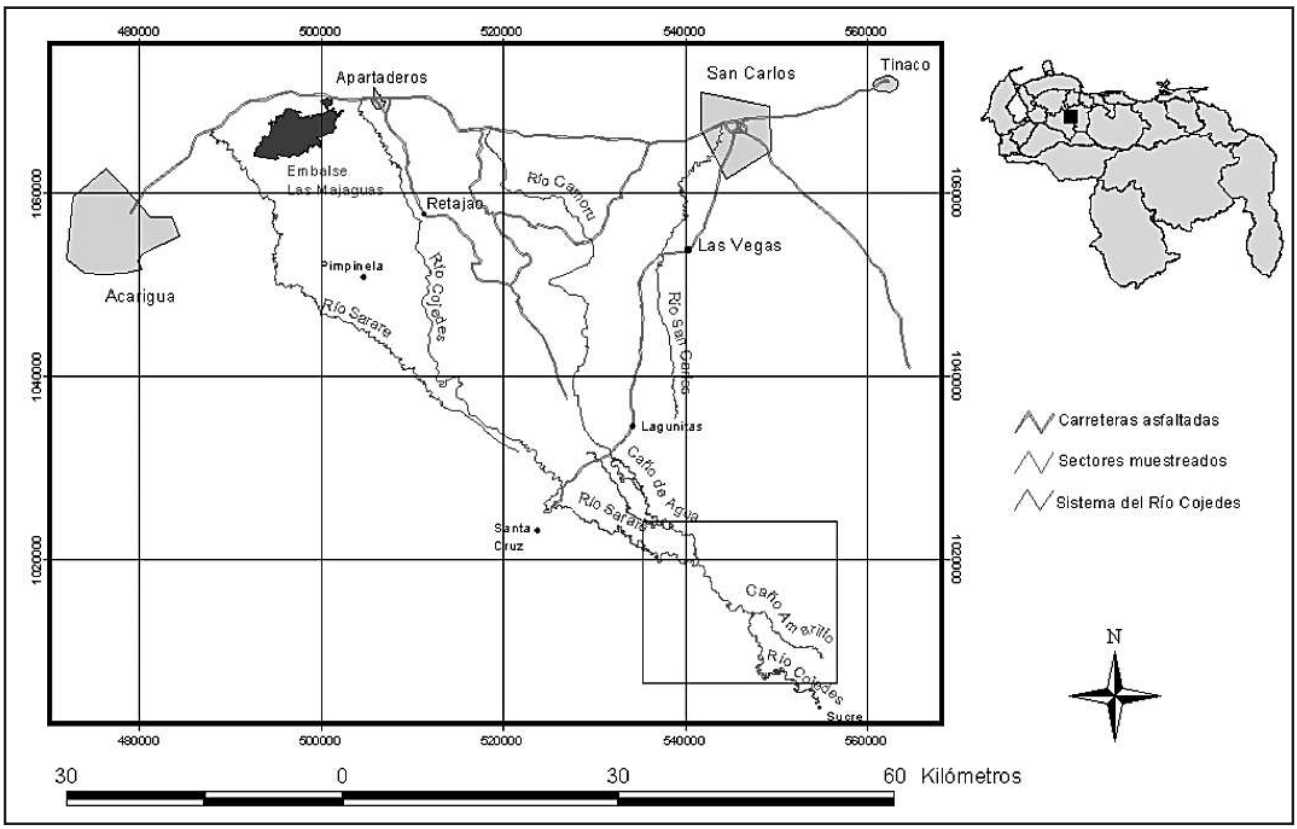

Figure 1. Study area relative location in Cojedes river System (Portuguesa and Cojedes limits estados, Venezuela).

METHODOLOGY

Study Area Delimitation

For this study five sections were selected: 1) La Batea – Confluencia, in which 5,5 km of river were sampled, from La Batea point to the confluence of the Sarare river and Caño Amarillo, downward the river; 2) Sarare. In this section 3,1 and 3,8 km were sampled, from the confluence of the Caño de Agua and Sarare river, upward the river; 3) Merecure-Caño Amarillo, in this section 12,3 km were sampled, from the confluence of Caño de Agua and Caño Amarillo, downward the river; 4) Caño Amarillo, in this section 7,5 km were sampled from the divide of Caño Amarillo and Caño de Agua, downward the river; 5) South Cojedes, in this section 14 km were sampled, part of the Cojedes river from the divide of Caño Amarillo and Caño de Agua downwards the river. (Figure 2)

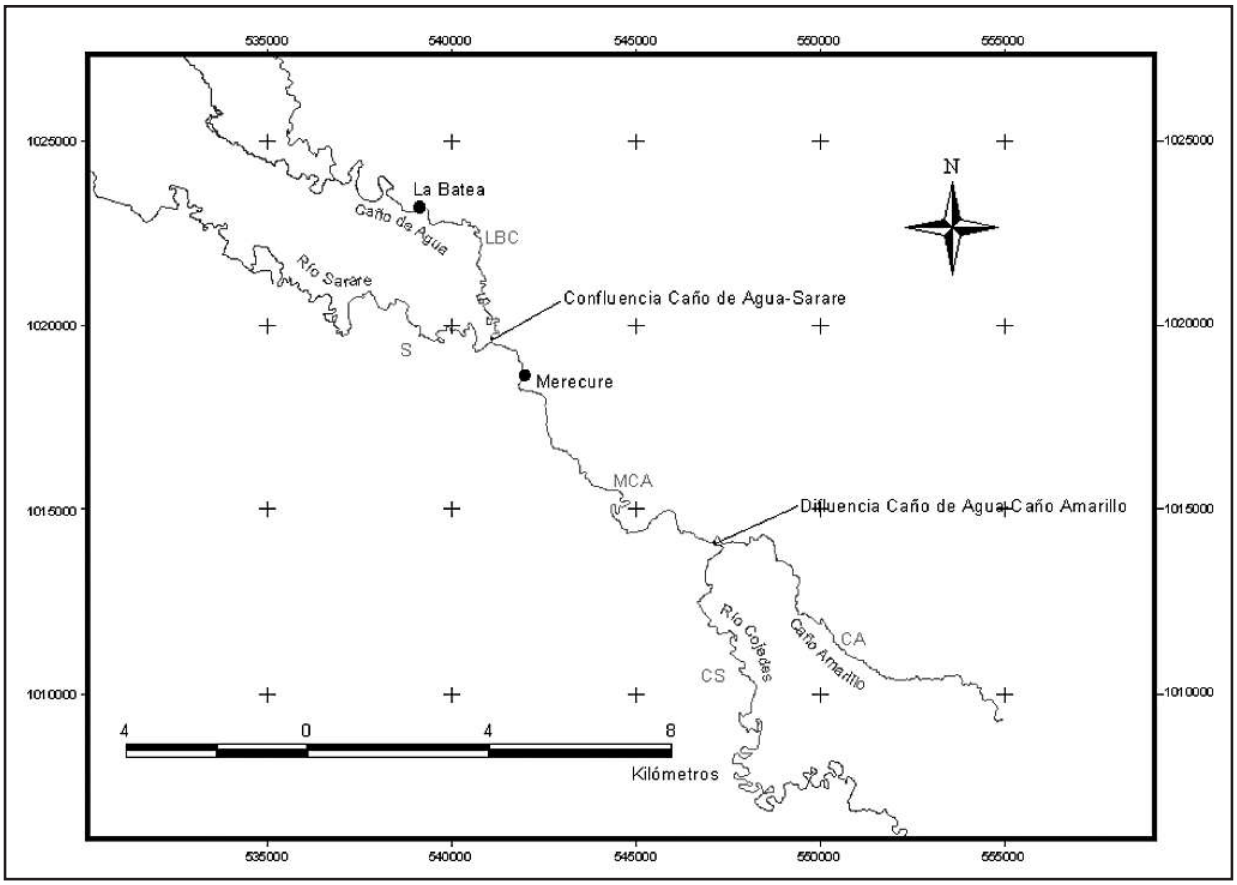

Figure 2. Study area. There appear the principal points of reference indicated in the text. The sampled sectors are indicated by initials: LBC, La Batea-Confluencia; MCA, Merecure-Caño Amarillo; S, río Sarare; CA, Caño Amarillo; CS, río Cojedes Sur.

Crocodilian Counting

Nocturnal counts were performed to determine the population status of C. intermedius in the Cojedes river, since December 2005 to May 2006. Monthly repetitions were performed, sampling each night sections of about 15 km of river. The counting of caimans was made sampling both river beaches. Most of the samplings were made alongside the current flow.

In the counting, the maximal approach to each individual was intended in order to have a positive identification of the species (*Crocodylus intermedius, Caiman crocodilus*) and to estimate the size of the animal (total length, LT). In the field the size of the animals was estimated in intervals of 30 cm, but for the analysis intervals of size of 60 cm were used (Seijas 1998, Seijas y Chávez 2000):

- Class I: Individuals below 60 cm of LT
- Class II: Individuals between 60 to 119 cm of LT
- Class III: Individuals between 120 to 179 cm of LT.
- Class IV: Individuals between 180 to 239 cm of LT
- Class V: Individuals equal or above 240 cm of LT.

The neonate individuals (Class I or younger than 6 months of age) were counted but not considered for the abundance estimate. The individuals were also grouped in size categories, as described by Seijas (1998) and Seijas and Chávez (2000), the individuals between 60 cm to 180 cm of LT were considered young, the animals between 180 to 240 cm of LT were classified as sub-adults and those bigger than 240 cm as adults.

The caimans' index of abundance was calculated by dividing the number of animals registered by the kilometres of river crossed. The abundance values obtained in each sampling (inv/km) were expressed as percentages of the values obtained at the beginning of May (considered as 100 %) in the same section of the river, in order to analyze the abundance variation as the dry station pass by. A correlation analysis was made to describe the relationship between these percentages and the days after January 17th (the first day of sampling considered for the analysis), as an indirect measurement of the water level (Seijas 1998, Seijas y Chávez 2000).

The spatial variation of the abundance was analyzed by comparing the obtained values (ind/km) among the different sections of the river and among the different sections that compose each section, with a Kruskal-Wallis test.

The average values of the density combined with capture-recapture analysis and the individual dispersal for each studied section were used to calculate the minimal size of the *C. intermedus* population in the study area.

The caimans' population structure for all the river, and for each one of the sections of it, were calculated using the maximal number of individuals registered for a particular size class, independently the month of sampling, as the minimal number of animals of that class present in the river (Messel *et al*. 1981). The structure among sections was compared by a Chi-Square test (X^2) using contingency tables. The values for the Class I group were not considered in the analysis to avoid bias in the results, because the high death indexes the neonate individuals of this class have.

Meanwhile the samplings, young caiman captures were performed in different sections of the Cojedes river. The captures were made by hand or using metallic laces.

Releasing program evaluation and performed captures

In order to evaluate the reintroduction program of the year 2005, the study area's freed individual rate of residence was calculated, obtaining percentages for the number of freed animals captured from the total number of freed animals of the study area. For this purpose young animals no longer than 1,5 m of total length were captured.

For each captured animal the following data was registered: total length (LT) from the tip of the snout to the end of the tail, body length (LC) from the tip of the snout to the back part of the cloaca, head length (Lcab), snout length (Lhoc) from the tip of the nose to the front border of the eye's orbit, tail width (GC), the maximal width of the tail just after the cloaca, and weight (P) in grams for individuals less than 10 kg. The measurements of LT and LC were made with metric tape and a 5 millimetres precision; the Lcab and Lhoc measurements were made with a Vernier and a 1 millimeter precision. The weight was measured with a 5 g precision in individuals less than 1 kg, 50 g precision for individuals between 1 and 5 kg, and 100 g precision for individuals above 5 kg, with precision pesolas of 1, 5 and 10 kg.

In addition sex and scaly-related data was collected from the captured animals; disposition of the nape, post – occipital and dorsal scales, number of scales in the simple caudal crest and double caudal crest, and ventral scales. Besides this the geographical coordinates, habitat and animal disposition were recorded.

Each captured individual was carefully checked to detect wounds, scars or mutilations. The presence of marks of *Paratrichosoma*, a parasite that makes holes in the skin (King y Brazaitis 1971, Ashford y Muller 1978), and ecto-parasites (leeches), was in the same way registered.

The relative fatness of the captured individuals was established (physical condition measurement), condition indexes developed for Seijas (1998) for Cojedes river caimans were used, where length measurements are related with the weight of the animals. The length measurements that best fits for this caiman's condition index is the snout length (Lhoc) (Seijas 1998). The formula for calculating the condition index (IC) is:

$$IC = 441,3 * P * Lhoc^{-2,982}$$

According with the formula, the individuals with an IC below one are considered relatively thin, and those that have an IC above one are considered relatively fat, in addition the IC values obtained were compared with the ones found by Seijas (1998) in the Cojedes river, assuming that the values for the caimans would be around 1.

The recaptured young caiman growth rate was calculated. Because many of the individuals had part of the tail missing, the growth rate was calculated with the LT and LC (Seijas 1998). Only the data referring to recaptures of more than 60 days were used to calculate the rate of growth.

By the other hand, the growth of the captured caimans was compared with earlier data of the Cojedes river of the past years, by a model developed by Seijas (1998) starting with the

equation of the growth model of Von Bertalanffy, which represents the maximal grow of a species in a given time (t). In order to apply the model, the body length (LC) of the animals was used, in this way the bias from the animals that lose part of the tail was eliminated.

$$LC = 1{,}136 * (1 - 0{,}8768 * e^{-0{,}1407 * t})$$

In addition, as we have the reintroduced caiman freeing locations, the dispersal of the individuals was also analyzed with the Geographic Information System.

RESULTS

Since December 2005 till May 2006, 25 nocturnal samplings were performed in the five defined sections of the Cojedes river, monthly repetitions were accomplished for most of the sections, except for Caño Amarillo and South Cojedes in which only one survey was possible. The results obtained during December were not included in the analysis due to the level of water of the river was still too high, therefore, the crocodilian populations would still remain dispersed because of the flood dynamics of the river and the adjacent savannah.

The sections with more number of surveys and therefore the most representative ones are La Batea – Confluencia and Merecure – Caño Amarillo.

Abundance

The lowest abundance indexes (ind/km) of caimans, was found in the South Cojedes and Caño Amarillo sections with values of 0,35 and 0,66 ind/km, in the months of April and May respectively, is important to notice that there was lower sampling effort in these sections compared with sections with more repetitions. Meanwhile the higher indexes were reported in La Batea – Confluencia with values of 5 ind/km for February and 4,8 ind/km for May; in Merecure – Caño Amarillo 4 ind/km for February, and 3,9 and 3,6 ind/km for March and May respectively. (Table 1)

Table 1. Caiman abundance in different sections of the Cojedes river. The values are expressed in individuals by kilometer of river ridden (ind/km). CA, Caño Amarillo, CS, Cojedes Sur, LBC, La Batea-Confluencia, MCA, Merecure-Caño Amarillo and Sarare.

FECHA	CA	CS	LBC	MCA	S
17/01/06	---	---	2,6	2,4	---
18/01/06	---	---	---	2,3	0,9
01/02/06	---	---	5	2,3	---
02/02/06	---	---	---	3,4	2,4
20/02/06	---	---	3,15	4	---
21/02/06	---	---	---	3	---
28/03/06	---	---	4,8	3,9	---
29/03/06	---	---	---	3,7	2,7
18/04/06	---	0,35	---	---	---
19/04/06	---	---	3,3	2,9	---
02/05/06	---	---	---	3,2	---
03/05/06	---	---	---	3,6	---
16/05/06	---	---	3	2,3	---
17/05/06	0,66	---	---	---	---

A tendency was observed related to the increase the number of observed individuals as the dry season get stronger, this by the analysis of the temporal change of the fraction individuals by kilometer of river during the sampled months (including young, sub-adults and adult caimans), even though the values remain relatively constant through all the samples. The resulting correlation between the fraction of observed individuals and the days passed since January 17th (determined as the first day of sampling) resulted positive but not statically significant (R = 0,317, P = 0,173). It must be noticed that for this analysis the values of abundance for May were excluded, because the rain season had already started.

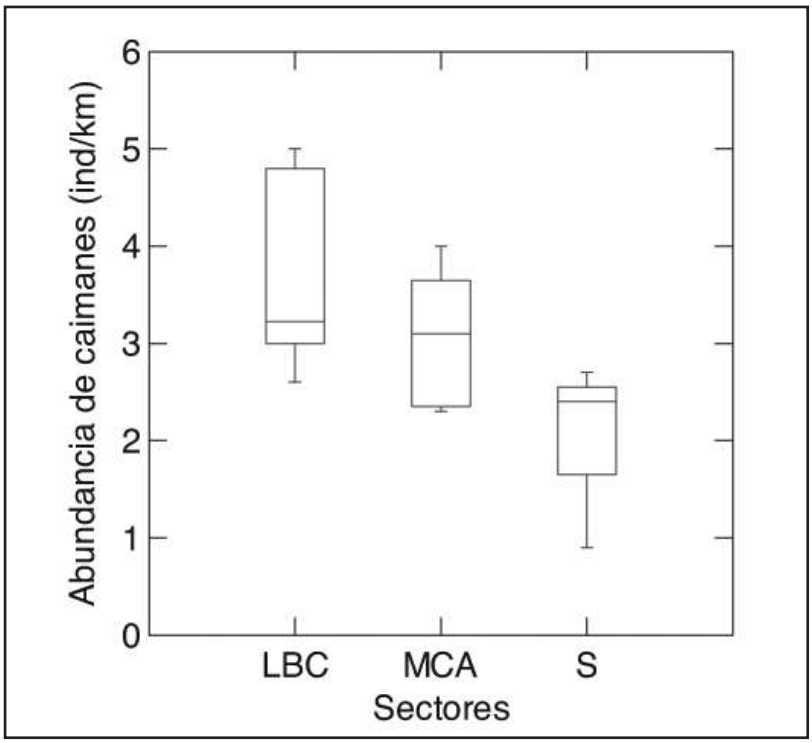

Figure 3. Caiman abundance values variation among the more representative sampled sections of the Cojedes river: LBC = La Batea - Confluencia, MCA = Merecure-Caño Amarillo and S = Sarare.

A Kruskal-Wallis test was made to compare the abundance values among the different sections of the river and no statically significant differences were found (H = 4.462, P =0,107), South Cojedes and Caño Amarillo were excluded from the analysis due to the small size of the sample (Figure 3).

In the study area a caiman population was estimated with a minimal size of 78 individuals without counting the neonate animals, using the average values of the abundance index for the most representative sectors and with the surveys in the South Cojedes and Caño Amarillo sections (Table 2). This number is based in abundance indexes below the maximal abundance indexes obtained in the different sections of the river. If we use the maximal values, the population estimation would be 100 individuals, that means a 22% higher population. It's important to notice that in the following paragraphs the minimal population estimate will be readjusted with the help of the capture-recapture and individuals' dispersal analysis.

Table 2. Minimal size of the caiman population based on the abundance indexes in the different sections of the Cojedes river.

Section	Length (km)	Number of samples	Density (ind/km)	Estimated number	Maximal density (ind/km)	Estimated number
Caño Amarillo	7,5	1	0,66	5	0,66	5
Cojedes Sur	14	1	0,35	5	0,35	5
La Batea – Confluencia	5,8	6	3,6	21	5	29
Merecure – Caño Amarillo	12,3	12	3,08	38	4	49
Sarare	4,4	3	2	9	2,7	12
Totals	**44**	**23**		**78**		**100**

The calculations were made for the Cojedes river from La Batea, through the mouth of Caño Amarillo to the South Cojedes, and in effluents as a section of Caño Amarillo and a section of the Sarare river.

Nevertheless, if we use the same criteria used by Ayarzagüeña(1987), Seijas (1998) and Seijas y Chávez (2000), for estimating the caiman populations in all the Cojedes river system we would also need to consider: 1) Caño de Agua Norte, 2) North Cojedes, 3) Caño Culebra, and 4) other parts of the sections of the study area not sampled. Besides -that, in this study we will only estimate the size of the caiman population in the sampled sections, because the characteristics of the not sampled Cojedes river system sections may be variable and thus the caiman abundance values.

Besides all, some comparisons were made related to the abundances found in the different sections of the Cojedes river of this study, and the previous studies performed with the Cojedes river caimans. (Ayarzagüena 1987, Seijas 1998 y Seijas y Chávez 2000, Chávez 2000).

The indexes of abundance were compared for the 1991-1996 seasons (Seijas 1998) and 1997-1999 (Chávez 2000), and the present study, by a Kruskal – Wallis test. The results show slight differences between the numbers, but these are not statically significant differences (H = 8, P = 0,127). (Table 3).

Table 3. Caiman abundance indexes through the years for the sampled sections of the Cojedes river.

Section	Length in km	Abundance Ind/km (1991-1996)	Estimated number (*)	Abundance Ind/km (1997-1999)	Estimated number (*)	Abundance Ind/km 2006	Estimated number 2006
La Batea– Confluencia	5,8	7,26	42,10	8	46,4	5	29
Merecure– Caño Amarillo	13,1	4,88*	64	6	78,6	4	53
Total	**19**		**106**		**125**		**82**

* The estimated number for each sector comes from the product of the abundance found for Seijas (1998) y Chávez (2000) and the length of the sections determined in the study.

Population Structure

In the most representative sampled sections, the caiman populations were integrated by a major proportion of adult individuals Class V: in the La Batea-Confluencia section there were a predominant presence of Class V individuals (52%), followed by Classes II, IV and III (20, 16, and 12 respectively); In the Merecure-Caño Amarillo section we found the same thing, a major percentage of individuals Class V (39,68%) followed by Class II (31,74%) and in a less proportion Classes III and IV (17,46 % and 11,11 % respectively).

In the Sarare section the larger proportion observed were Class II individuals, with 60 %, followed by Classes III and V individuals (27,27% each one of them). Finally in the section with lesser samples, Caño Amarillo, the major proportion of individuals belongs to Class V animals (60%) followed by 20% of each one of the Classes II and III. It must be noticed that South Cojedes was not considered for this analysis because there were not enough observations to infer the population structure in that section (Figure 4).

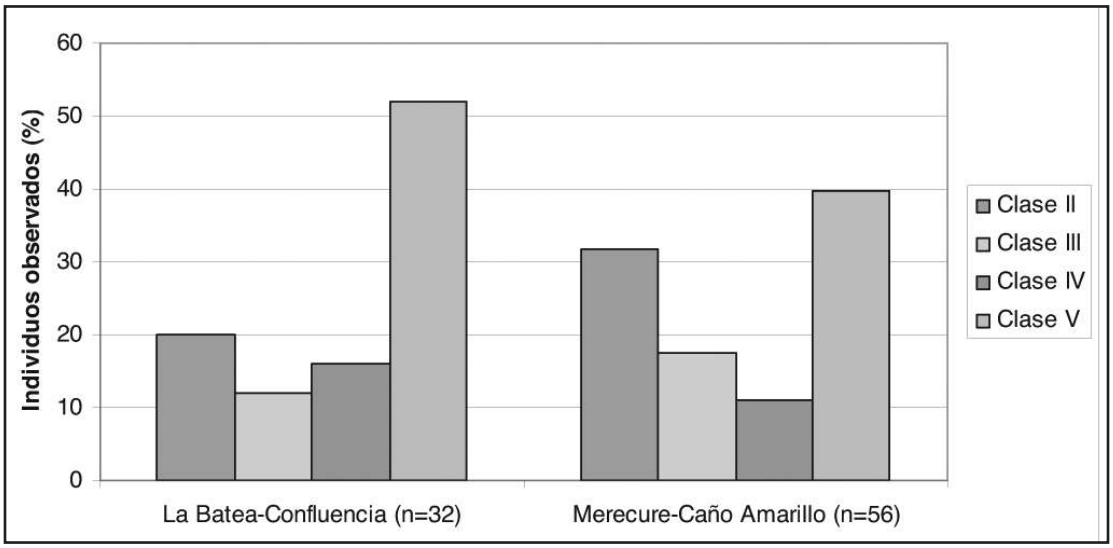

Figure 4. Caiman population structure for the section with more number of samples of the Cojedes river. The size classes are related to the total body length (LT).

The different size structures were compared through contingency tables, using the maximal observed values for each one the size classes in each one of the sampled sections, thus the obtained differences were not statically significant (X^2 = 12,454, P = 0,410). In addition only the two most representative sections, for the number of samples, were considered for the structures comparison, likewise no statically significant differences were found (X^2 = 2,176 P = 0,537).

As in the abundance, the caiman's size structure found in this study was compared with the population structure of previous studies. For this reason the two most sampled and representative sections of the study, La Batea-Confluencia and Merecure-Caño Amarillo, were compared.

Comparing the surveys performed by Seijas (1998) during 1996 and 1997, and the present study (2006), in La Batea-Merecure section, we notice that the population structure suffered variations, although these are not statically significant (X^2 = 15.656, P = 0,001). None the less, its important to point that in this lapse of time La Batea-Merecure section increase the proportion of sub-adult and adult individuals (Class IV and V) and the number of young Class II individuals reduced, by the other hand the proportion of Class III individuals remain relatively constant. In the Merecure–Caño Amarillo section, in this lapse of time the number of adult Class V individuals increase significantly, and the young Class III and II individuals reduce to a lower proportion (Figure 5 and 6).

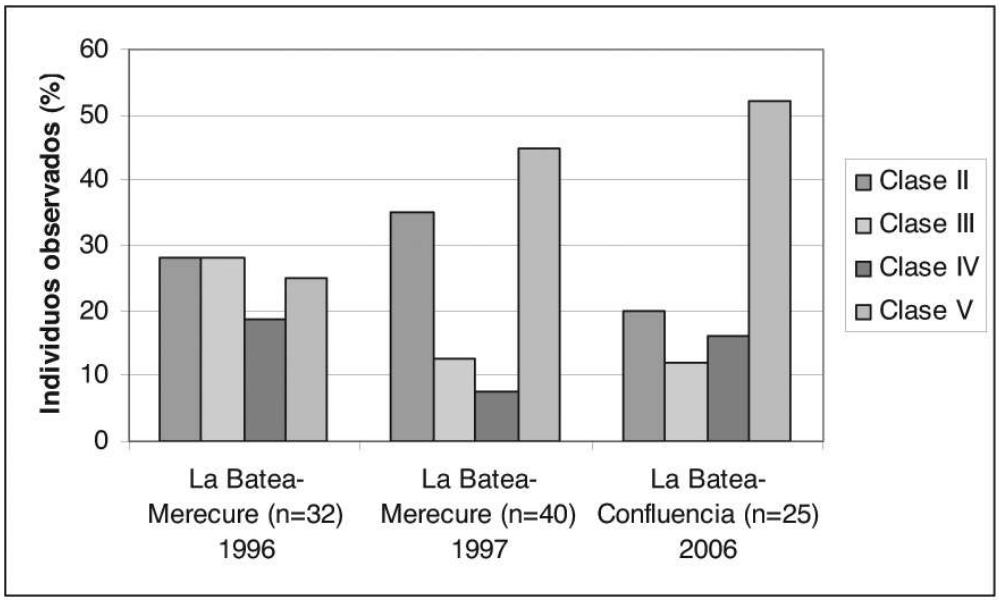

Figure 5. Caiman population structure variation in La Batea-Merecure section, since the surveys performed in 1996-1997 (Seijas 1998, Seijas y Chávez 2000) till the samples of the present study 2006.

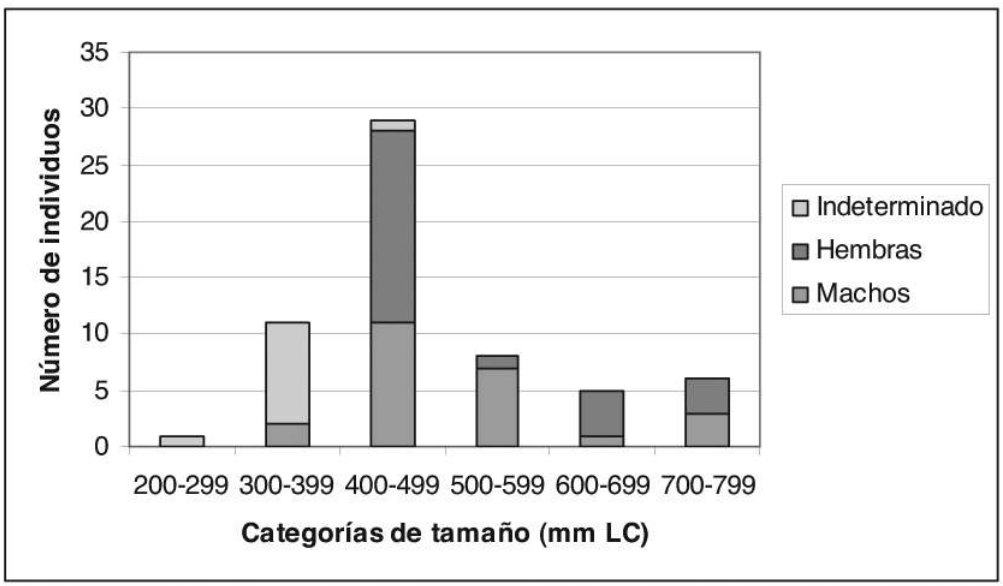

Figure 6. Caiman population structure variation in the Merecure-Caño Amarillo section, since the surverys performed in 1997 (Seijas 1998, Seijas y Chávez 2000) till the samples of the present study 2006.

Cojedes river releasing program evaluation

Since January to May 2006 81 young caiman were captured in the Cojedes river. There were captures in all the sampled sections, although, most of the samples (86,5%) came from the Merecure-Caño Amarillo section (75,3%) and La Batea-Confluencia section (11,11%) (Figure 7).

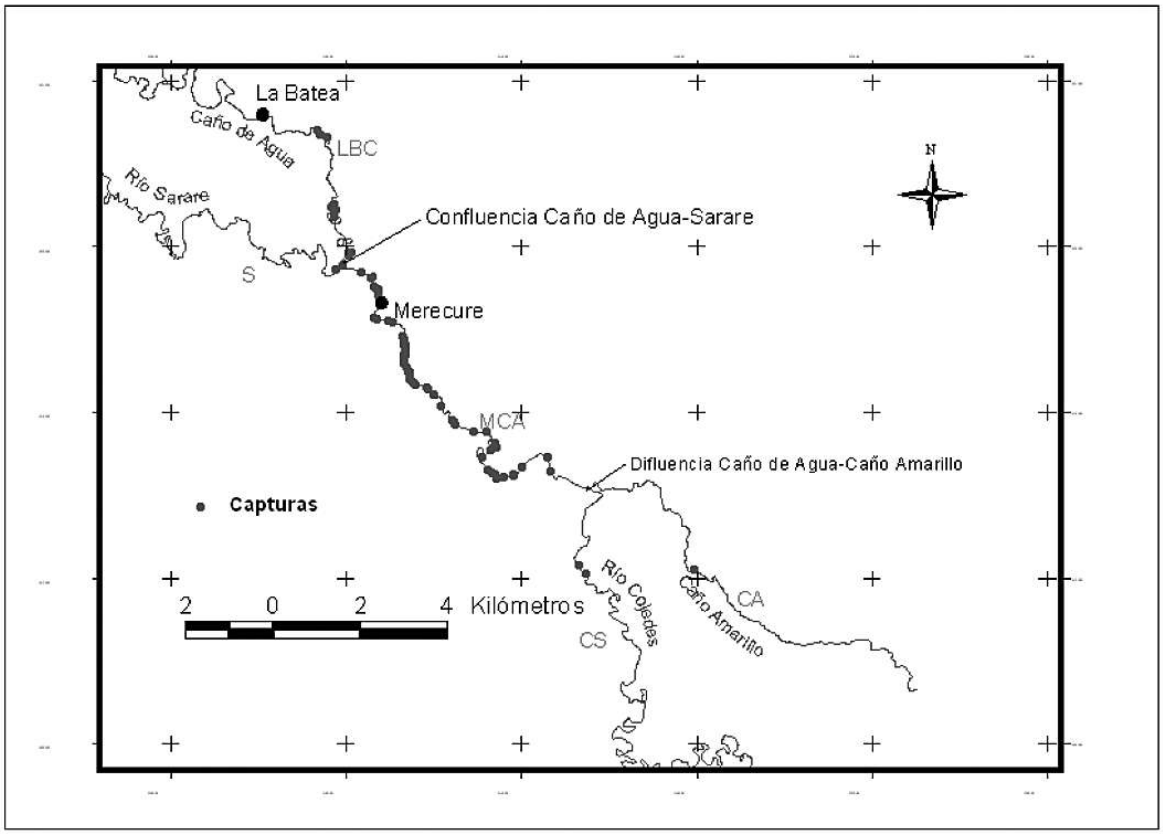

Figure 7. Detail of the study area showing the reference points that limit the river sections were most of the caimans were captured. LBC, La Batea-Confluencia, MCA, Merecure-Caño Amarillo, S, Sarare, CS, South Cojedes and CA, Caño Amarillo.

From the 81 captures, 61 individuals were captured at least one time, the rest of the animals were recaptured and in many cases a single animal was recaptured more than once. From the 61 different captures during the nocturnal surveys, 90% belong to wild individuals (55 animals), meanwhile the other 10% was composed by marked animals, that means wild animals recaptured from different earlier studies. Besides, only three of these captured animals (5%) belong to the releasing of 2005, and the other 3 individuals presented metallic plates of animals of other studies not related with 2005 releasing.

With base in these results the rate of residence of the 2005 released individuals was calculated, for the study area is 1,5% after one year of the release (in total 207 animals were released).

Most of the captured individuals (wild and released), 52 individuals were in sizes between 600 and 1200 mm of LT, and between 300 and 800 mm of LC. Seven individuals belong to Class III, and two to Class I. The data about the captured animals are presented in the annexes.

The captured individuals were grouped in size categories, with intervals of 100 mm of LC (Seijas 1998) (Fig. 8). From all the captured individuals, without considering Class I individuals, we found 24 male and 25 female, giving us a relationship of sexes of 1:1, we couldn't determine the sex of the other animals.

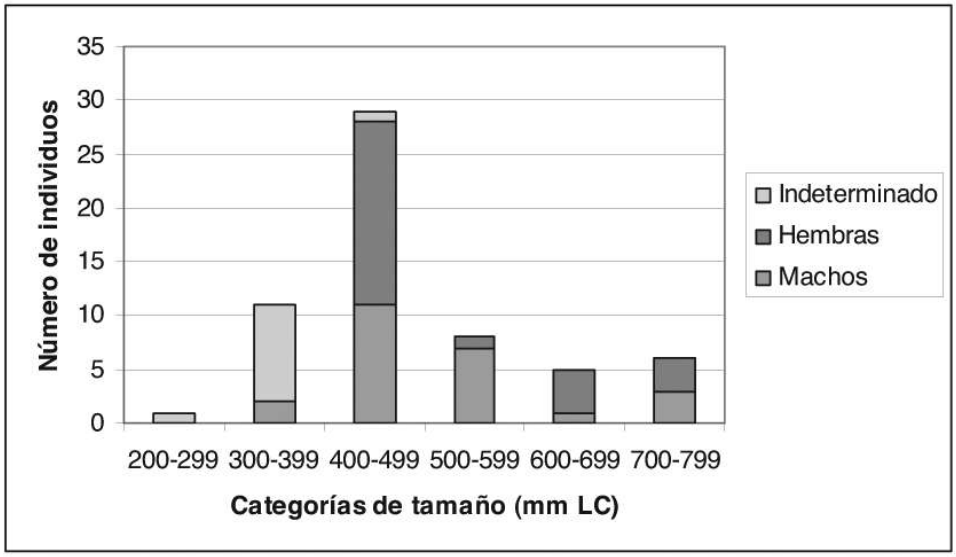

Figure 8. Size and sex of the Orinoco caimans of the Cojedes river.

Applying the model developed for Seijas (1998) for calculating the condition index of the captured caimans of the Cojedes river, we get values from 0,52 to 1,43, with an average value of 0,83 (± 0,15).. The correlation of the condition indexes and the different measurements found in the captures (LT, LC, Lcab, Lhoc and GC), give us in all cases positive highly significant correlations (Table 4). This situation suggest that the animals as bigger they get the fatter they are.

Table 4. Results of the correlation between the condition index and the measurements obtained in the caiman captures (LT, LC, Lcab, Lhoc, GC, weight).

Variables	R of Pearson	Probability
Total length	0,390	0,054
Body length	0,484	0,000
Head length	0,362	0,005
Snout length	0,430	0,001
Tail width	0,578	0,000
Weight	0,584	0,000

The condition index of the released individuals recaptured in the present study was between 0,67 and 0,97 and it was directly related with the size of the animal, individuals of higher size shown indexes closer to 1, meanwhile in the smallest ones the index was lower. The condition index of the captured animals in the different sections of the Cojedes river was relatively constant and no significant differences were found (H = 2,174, P = 0,825). Although, the higher condition indexes were found in Sarare and South Cojedes, this may be caused by the small size of the sample in these sections (Table 5).

Table 5. Caiman condition indexes (IC) from the different sections of the Cojedes river.

Sections	Number of individuals	Average condition index	Standar deviation
Caño Amarillo	1	0,808	---
South Cojedes	2	0,864	0,19
La Batea-Confluencia	8	0,852	0,16
Merecure-Caño Amarillo	47	0,832	0,15
Sarare	2	0,907	0,11

A correlation was also calculated, between the condition indexes of all the captured animals and the days that passed since January 17th (the first day of sampling), as a indirect measurement of the effect of the dry season. A negative correlation was found (R = -0,089), but not significant (P = 0,497). We couldn't find neither differences between males and females (H = 0,192, P = 0,909). In addition the incidence of wounds, mutilations and parasites was analyzed. Forty of the captured animals show wounds (66,6%), the individuals with more incidence of wounds were between 300 and 500 mm of LC (Figure 9).

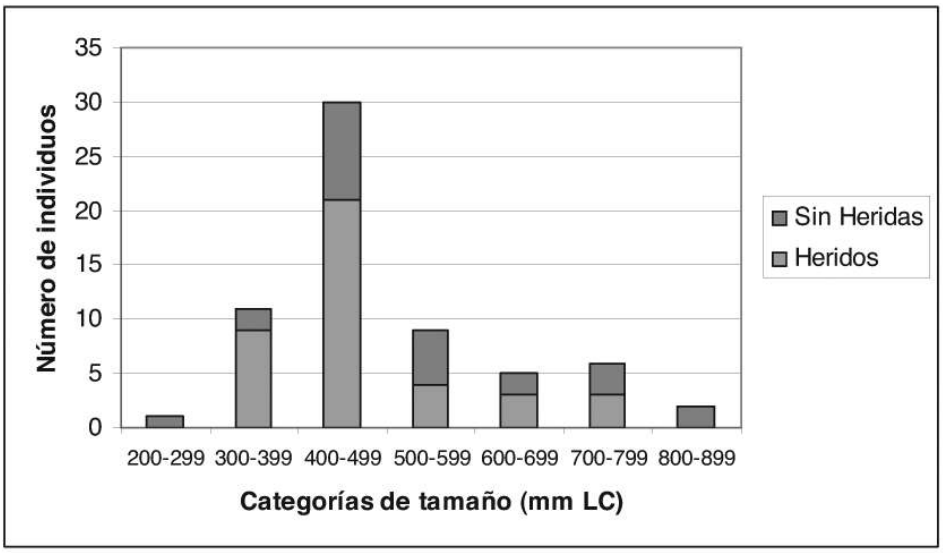

Figure 9. Frequency of animals with or without wounds in the captured samples of the Cojedes river.

The individuals with wounds or mutilations weren't distributed evenly between the samples of different sections, and were related with the number of captures performed in each section. Most of the wounded caimans (47,54%) came from Merecure-Caño Amarillo. All the captured animals from all the river sections show a high incidence of wounds (Table 6). The differences between sections were not significant (X^2= 5,135, P = 0,4).

Table 6. Proportion of wounded and healthy captured caimans in the different sections of the Cojedes river.

	Captured caimans				
Sections	**Healthy**	**Proportion (%)**	**Wounded mutilated**	**Proportion (%)**	**Total**
Caño Amarillo	1	100	0	0	1
South Cojedes	0	0	3	100	3
La Batea-Confluencia	22	5	6	75	8
Merecure-Caño Amarillo	17	35,5	30	64,5	47
Sarare	0	0	2	100	2
Total	**20**		**41**		**61**

Among the wounded animals, nine (20%) had a limb missing; two (4,44%) had the jaw broken or out of place, 15 (33,3%) had bites and/or scars in the body, and 14 (31,1%) had lost some fingers. The 44,4% of the individuals presented more than one type of wound or mutilation. The most frequent wound, although, was represented for the lost of one part of the tail (44.4%). This fact is easily appreciated when the number of rows of the simple caudal crest (CCS) scales are counted, as shown in Figure 10. Two of the captured individuals also had parasites, one of them *Paratrichosoma* in the ventral scales and the second one leeches in the mouth. Two individuals were captured outside the water, one of them completely healthy (released), and the second one almost dead with very severe wounds in the neck, it possibly get out of the water to die. The average condition index of the recently wounded caimans was 0,7968 ± 0,1664 and some of them looked quite thin, this could be also produced for the presence of important mutilations that can affect their weight. Although, no statistical significant differences were found between healthy and mutilated animals. (Mann-Whitney Test = U = 391,5, P = 0,894).

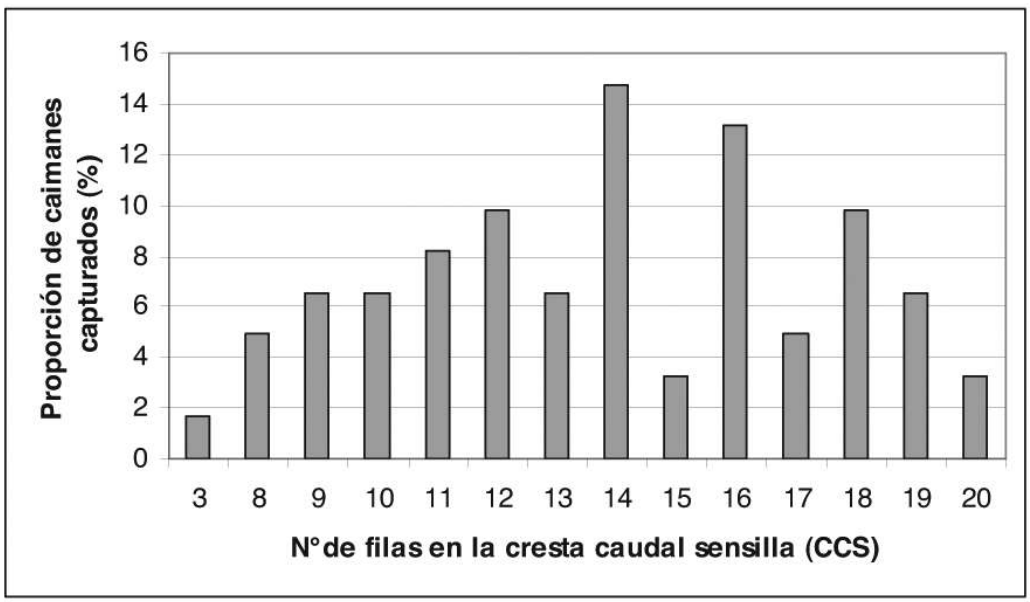

Figure 10. Percentage of captured caimans in the Cojedes river according with the number of scales rows in the simple caudal crest.

The incidence of wounds in the released caimans coming from the reintroduction program was 50%, three of them did not show wounds at the moment of the capture and were complete,

the other three show different types of wounds, one had parasites in the mouth (leeches), another one had a piece of the tail missing and the last one was about to lose the right hand, that was inflamed and losing parts of the skin.

The growth model developed by Seijas (1998) for the caimans of the Cojedes river, was applied only in four wild animals previously captured during this study, three that came from the releasing, and to three marked individuals from earlier studies. Although 15 individuals were captured more than once, most of them were recaptured in periods of time shorter than the required to perform the model of growth rate, only the animals that were recaptured with a lapse of time higher than 60 days were considered for the analysis.

The body length values (LC) obtained in the equation were compared with the values observed in the field through the Wilcoxon sings test; where significant differences were found (Z = 2,701, P = 0,007). In most of the cases the observed sizes were greater than the expected ones, this may suggest that the captured animals of the study show a greater growth than the animals captured by Seijas in 1998 in the same river (Table 7).

Table 7. LC values expected and observed in the captured and recaptured caimans, to which the growth rate was calculated.

	LC Values	
Individual	**Expected**	**Observed**
ZOO-213140	252,31	341
UZ-1648, 234408	265,85	400
UZ-1687, ZOO213174	270,73	414
UZ-1613	181,19	450
UZ-1694	174,42	740
UZ-1692	300,62	612
234353-234354	490,26	490
UZ1171-UZ1172	375,72	425
UZ1669	273,12	510
UZ1547-UZ1548	385,18	432

The annual growth of the recaptured individuals in the Cojedes river show values between 5,2 cm/year and 36,46 cm/year, with a media value of 19,83 cm/year, and values between 4,33 mm/month and 30,38 mm/month, with a media value of 16,52 mm/month. These values show a growth tendency similar the ones reported for Caño Guaritico, and Capanaparo river, where Chávez (2002) and Llobet (2002), presented growth values between 19,4 and 27,1 cm/year, and values between 15,18 mm/month and 17,25 mm/month respectively.

The annual growth in the recaptured individuals of the Cojedes river show values between 5,44 cm/year and 19,42 cm/year, and values between 4,53 mm/month and 16,19 mm/month, using the body length measurement (Table 8). In the same way these values can reflect a similar growth tendency than the one shown by Seijas (1998), with values between 1,05 and 14,2 mm/month.

It's important to notice that in the Cojedes river as long as the captured animals become bigger and in consequence older, they show higher annual growth rates. To make sure of this, the annual growth rates and the lapse of time between the capture and recapture events were correlated, as a measurement of the survival in the environment. Also the annual growth rates and the total length (LT) of the last capture event were correlated. In both cases positive sadistically significant correlations were found: LT vs. Growth rate (R = 0,725, P = 0,018) and Lapse of time vs. Growth rate (R = 0,641, P = 0,046). This situation points that, possibly after a year of survival, the animals show a better adaptability to the environment.

With the existing data base of the Crocodilian Specialist Group of Venezuela, the releasing points of the released caimans of the Cojedes river were located. Then the dispersion distance of the three captured animals that came from those releasing processes was calculated, two of them were captured more than once. The individual ZOO 213140 released on May 21st 2005 moved about 2,3 km from the releasing point Via Caño Amarillo until the capture place, this animal was captured two more times, from about 250 m away from the first capturing point, in both occasions. The individuals UZ-1648-234408 and UZ-1646-ZOO 213174, released on May 3rd 2005, they moved 1,1 km and 3,7 km respectively from the releasing point Confluencia Sarare – Caño de Agua to the capture location, the individual UZ-1648-234408 was captured two more times, moving about 100 m from the first capturing point. (Figure 11).

Table 8. Body length, annual and monthly growth in the recaptured individuals of the Cojedes river. The initial LC of the wild animals is from the first capture event, and for the released animals the size when they were released.

			Growth (LC)		
Individual	**Initial LC**	**Final LC**	**Lapse of time(days)**	**cm/year**	**Mm/month**
ZOO-213140*	341	390	311	5,44	4,53
UZ-1648, 234408*	400	455	350	5,73	4,77
UZ-1687, ZOO213174*	414	515	364	10,1	8,41
UZ-1613	450	470	106	6,67	5,55
UZ-1694	740	740	93	0	0
UZ-1692	612	720	456	8,64	7,2
234353-234354**	490	860	1126	12,01	10,01
UZ1171-UZ1172**	425	798	700	19,42	16,19
UZ1669	510	565	372	5,39	4,49
UZ1547-UZ1548**	432	798	733	18,22	15,19

*Caimans from the reintroduction program

** Caimans marked in previous studies.

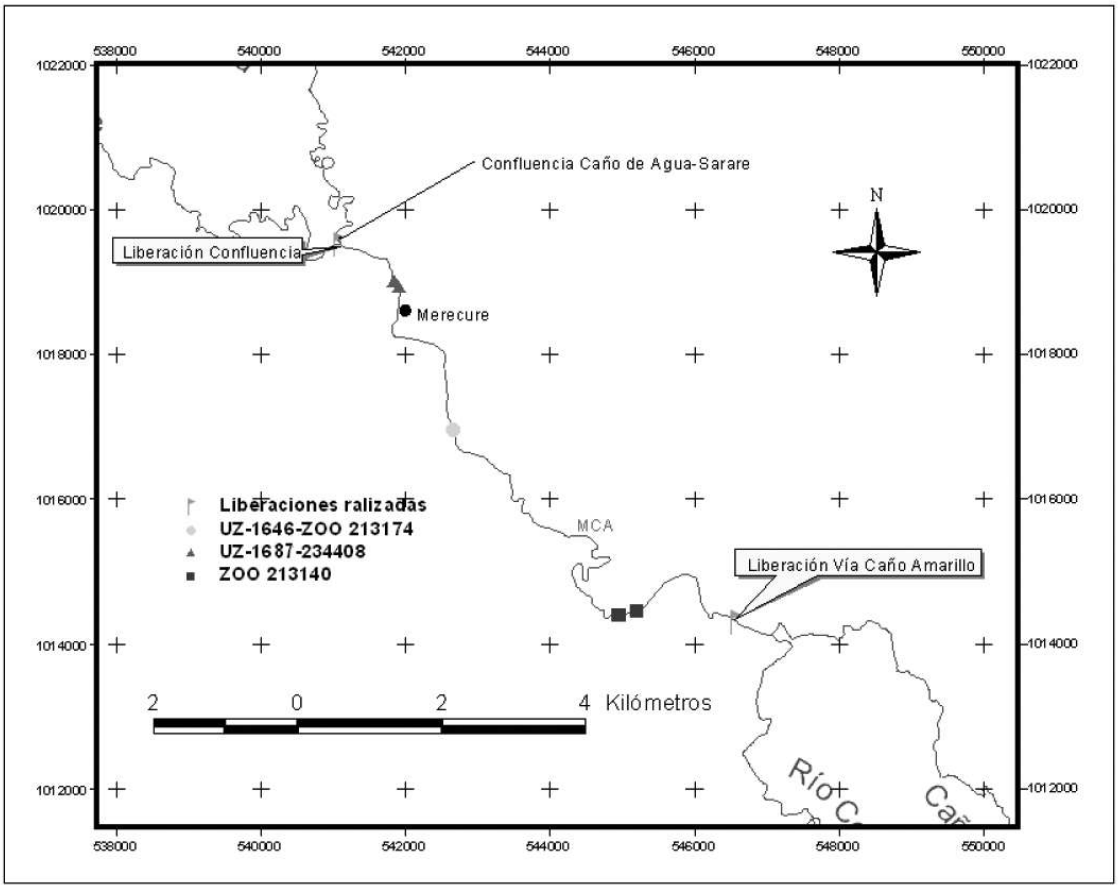

Figure 11. Dispersal of the released animals in Cojedes river in the year 2005 (Via Caño Amarillo 177 released individuals and Confluencia Caño de Agua-Sarare river 30 individuals released) and captured in the present study in 2006.

In addition, the dispersal distance of the wild captured and recaptured animals of the present study was calculated, taking as the initial point of the individual the first capture, two wild animals were recaptured more than once. It was observed that most of the individuals had a relatively small dispersal from the first point of capture to the recapture point (in a lapse of time of three months), two individuals moved between 1 and 1,2 km (UZ-1694 y UZ-1613), five of them moved between 15 to 100 m, and the individual UZ-1601 moved 210 m between captures, nevertheless, in a fifth capture the animal was in a very close position to its initial point. Besides that the dispersal distance of the marked individuals from previous studies was calculated, and from an individual that was captured in the present study and that was recaptured in the year 2007 by other study in the area, two of the three individuals marked in previous studies show a dispersal distance of 1,6 and 1,5 km (234353-234354, UZ-1547-UZ-1548) from its first capture to the recapture point (in a lapse of time of three years one month and two years respectively), the third individual moved only 9 m (UZ-1171-UZ-1172) between capture and recapture in a two years lapse. Finally the individual UZ-1669 marked in the present study moved 166 m in a lapse of one year (Figure 12).

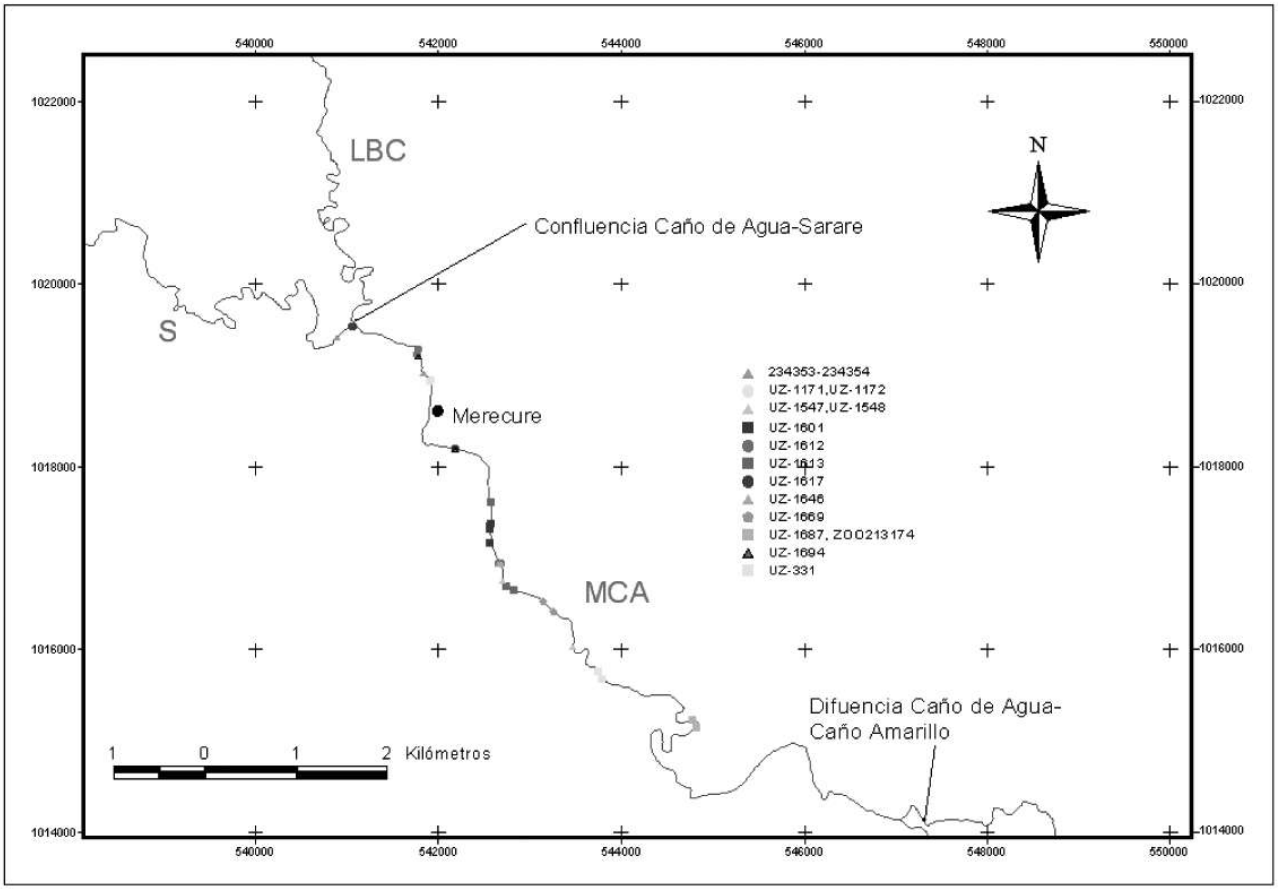

Figure 12. Dispersal of the wild individuals captured – recaptured in the present study.

DISCUSSION

Abundance

In previous studies performed in previous years, is pointed that the best populations of the Orinoco's caiman is found in the Cojedes river (Godshalk 1978, 1982, Ayarzagüena 1987). Seijas (1998) presented results of the population status of the Orinoco's caiman since 1991 to 1997, in the Cojedes river system, the river sections that can be properly compared with this study are La Batea-Confluencia and Merecure-Caño Amarillo. The number of animals estimated by Seijas (1998) in all the Cojedes river system was of 540 individuals. If we only take the two highly representative sections of this study, the estimated number would be 106 individuals, being the population found in the previous study (1991-1997) higher in a 23% than in the present one. Chavez (2000) presented population status results of the Cojedes river from the years 1997-1999, and found that in a general way the population size of the Cojedes rivers tends to be relatively stable between these years; 287 individuals (without neonates) in almost 50 km surveyed in year 1997; 228 individuals in 46,7 km surveyed in year 1998; and 289 individuals in 58,8 km surveyed in year 1999. In the same way, if we only compare the two similar sections of this study, in the 19 total km surveyed, the number estimated by Chávez (2000) would be of 125 individuals, that means that the population of the lapse 1997-1999 is higher in a 34% than the one found in the present study (82 individuals). It seems that the actual caiman population estimate in the sampled sections is below the previous year estimations.

An important factor to be considered is the fact that in 2005, 207 individuals of *C. intermedius* were released in the Cojedes river. And thus it was expected to find higher population indexes than those found in previous years, at least in the areas close to the releasing points, but in the other hand, the population indexes of the sections closer to the releasing points were below or relatively constant to the ones found in previous studies.

The monitoring of crocodilians represents some problems, specially controlling the biological variabilities as the carefulness of the animals and the population density (Pacheco 1994, 1996). In the same way, the tendency is to underestimate the populations when the population densities are too low. Finally, the relative abundance indexes are going to underestimate the real size of the population, because part of this population will be usually remain undetected and its very hard to establish a relationship between the relative abundance index and the real density of the area (Hutton y Woolhouse 1989). In the present study we evidenced that the abundance indexes can change from one nocturnal survey to the other.

Is important to consider the methodology used for estimating the caiman populations, because there are a lot of factors that can affect the visibility of the caimans during the nocturnal counting. The water level is the most important one (Seijas 1998). The differences in the visibility of the caimans and the water levels of the river, have important implications for the population status monitoring. Seijas in 2000, points that the best period to conduct the sampling is between November to January, because during this lapse not only a larger fraction of caimans can be observed, besides, the number of babas is low, which reduces the sampling time and avoids the investigators fatigue. Nevertheless, specially for the present study (2005-2006) the water level on these moths was too high and thus a lower fraction of caimans were visible, besides the chance of navigating in more sections of the river because of the high level of the water, this water level floods the near lowlands and savannahs to the study area and thus the caimans have more space to disperse. The major caiman fraction was observed in May (advanced drought period), but the low river level make the accessibility to some sections of the river difficult.

The caiman population in the Cojedes river was not evenly distributed. There were differences among sections as in abundance as in size structure. The higher densities were detected in the La Batea-Confluencia and Merecure-Caño Amarillo sections, river sections that keep the meanders and are still surrounded by forests. La Batea – Confluencia results are below the ones estimated by Ayarzagüena (1987), the same that are relatively constant to the ones reported by Seijas y Chávez (2000). The caiman density decreased down waters Merecure – Caño de Agua, values that were also below numbers found in previous studies, these places have been progressively affected by deforestation and human presence.

The results for the Sarare, Caño Amarillo and South Cojedes, was insufficiently sampled and compared to the results of previous studies they are also below the estimates, it is strongly recommended to focus more efforts in these sections in order to have better estimates for the caiman populations.

Population structure

The caiman population structure didn’t show significant statistic differences among the different sections of the river, in La Batea-Confluencia, Merecure-Caño Amarillo and Caño

Amarillo sections, the caiman population was structured by a higher proportion of adult Class V individuals (52%, 39,68%, 60% respectively). In the other hand, in the Sarare and South Cojedes sections there was a higher proportion of young Class II individuals, with values of 60% and 45,45% respectively.

In 1990 Sijas, found that the population of Caño de Agua Sur (La Batea-Confluencia) was particularly composed of sub-adult and adult individuals (>1,8 m LT), and the Merecure-Caño Amarillo section show an mixed population structure, with a higher proportion of young Class II and III individuals.

In La Batea-Confluencia and Merecure-Caño Amarillo sections, through the years, besides the populations seem to be relatively constant, the size structure show an increase in the proportion of Class V adult individuals and a decrease in the Class II and III young individuals. It seems that the population structure in this place in the last 9 years (1997 – 2006), could have been influenced by: 1) a replacement process from young individuals to adults; 2) a change in the distribution and dispersal of the individuals, responding to a change in the habitat quality among the river section, because the main nesting beaches of the Cojedes river are found in Caño Amarillo Sur (La Batea – Confluencia) (Seijas 1998); and 3) by differences in the death rates among the individuals of different sizes in the different sections of the river.

As Seijas pointed in 2001, maybe the most logical answer is that the differences shown in the abundance and population structure, are produced by the human activity over the caiman populations. This situation, added to the bad perception of the local people about the caimans, can clearly and definitely affect the population structure. Another factor that can influence the population size structure is the existing relationship between the animals carefulness and the human pressure in a given area (Pacheco 1996, Llobet 2002). In the river sections far from human activities, as Caño de Agua Sur (Seijas y Chávez 2000), the big caimans tend to have a higher chance of survival and establishment, making in this way, a higher fraction of the population.

Releasing Program Evaluation

There was no previous studies in the Cojedes river about the population restoration program before the present study. In the rest of the country, most of the releasing processes had had a continuous tracking, except for the study performed by Muñoz and Thorbjarnarson in 2000, where eight caimans where constantly radio-telemetry tracked for eleven months for experimental purposes. Besides that other two studies with a relatively high sampling effort were performed in the Refugio de Fauna Silvestre Caño Guaritico and in El Frio ranch surroundings (Lugo 1998, Chávez 2000).

Seijas (2003) pointed that the success indicators for the releasings can be obtained from the fraction of individuals that survive or stays in the releasing area, by the body growth rates that the individuals show in their new environment, and by the eventual reproduction of the released caimans.

Inside the population restoration program, in the RFS Caño Guaritico, in survival-residence terms, Lugo (1998), using diurnal and nocturnal countings, calculated residence rates for the released individuals between 8,9 and 12,2% for the number of released individuals of previous years, Chávez (2000), using a similar methodology, calculated a residence rate of 7 and 16% for the caimans released two years eight months and six years eight months previous to his study. In the Cojedes river, in the present study, the calculated residence rate is 1,5% from 207 released caimans in May 2005. Then, the residence rate for the released individuals of 2005, one year after the releasing, is far below the values found for Lugo (1998) and Chávez (2000) in the RFS Caño Guaritico. Its necessary to point that, we are talking about residence and not about survival, because it's possible that some of the released animals may have completely left the study area, or that besides they have stayed in the area they hadn't been captured (Seijas 2003). Some of the authors agree that the survival data are based in casual observations (Neill 1971) or in a small sample size (Modha 1967, Webb y Messel 1977). The residence values found in this study could be underestimated because of the crocodilian monitoring problems earlier mentioned.

It must be noticed that the nocturnal counting, and the capture-recapture method, are less efficient that the radio-telemetry one used by Muñoz y Thorbjarnarson (2000) and because of this it may probably show underestimates (Seijas 2003)

In the other hand, it is not discarded the chance that some of the released individuals could not survive in their new environment, possibly because intra or inter- specific interactions, as, for instance, the anecdotic data collected by Seijas (com pers) in other areas of the country where releasings take place, in which the just released caimans were predated by adult babas.

The body growth as al physical condition shown by the caimans in their new environment, constitutes another way to evaluate the releasing success, and at the same time it may show the habitat quality where the releasing took place. (Seijas 2003).

The media growth rate of the released caimans in the Capanaparo river (0,079 cm LT/day) was similar to the wild animals (Muñoz y Thorbjarnarson 2000). The growth data of the released animals in a new environment reported by Lugo (1998) and Chávez (2000) in the RFS Caño Guaritico, show values between 28,1 and 32,7 cm/year, and between 19,3 and 46,5 cm/year, respectively. In the present study, the caiman growth rate in cm/year for the released animals in the Cojedes river are between 2,8 and 11,14. In any way, compared to the growth rate of the caimans of previous studies, the growth rate of the caimans in the Cojedes river seems to be too slow, and clearly far below the potential shown by the species.

In the other hand, in the Cojedes river, the growth rate of the wild individuals measured in the study, was very similar to the calculated values of the released individuals that came from the releasing. But the wild marked animas from previous studies show growth rates highly superior to the wild and released individuals with lower sizes, therefore, the growth rate of the wild caimans in 2006, was relatively similar to the monthly growth reported by Seijas (1998), for wild caimans in the same study area.

In the Cojedes river system, massive fish deaths are frequently reported, at the end of the dry season and the beginning of the rain season, caused by the high levels of pollution in

the water, this pollution comes from discharges of effluents, agrochemicals and other specific pollutants that come from cities and towns that are in course of the river (Seijas 1998, 2001, Mendoza 2003, Elorga 2007 (en prensa)). This situation may slightly affect the abundance of food resources for the caimans, but, through the years this may represent an important decrease in the availability of food resources. The direct consequences these changes can have in the availability of food resources and in the growth of the caimans, cannot be determined by the available data.

Seijas (2003) points that in most of the localities where releasing processes took place till date (Caño Matiyure del hato Cedral and Caño Guaritico-Macanillal),the growth of the released caimans has been correct, with very close values to the ones obtained in the zoocriadero, this means that these localities are the most favorable for the development of the individuals of the specie. In contrary, the same author points that some environments are of low quality for *C. intermedius*, and that the releasing of individuals in this kind of localities should be revised; as in an specific place as Tucupido dam, where the growth rates registered were extremely low for the two released caimans (-0,2 and 12,7 cm/year), numbers relatively similar to the ones found in the present study.

The values of the physical condition index calculated for the Cojedes river caimans, in the present study were relatively lower that the ones obtained by Seijas (1998) and by Llobet (2002) in the Capanaparo river.

The released individuals captured show condition indexes similar to the wild captured animals. Although, several factors might affect the relationship between the seasonal changes and the physical condition index of the animals in natural conditions (lower IC as the dry season becomes stronger), as the availability of food resources and the temperature changes between seasons (Chabreck y Joanen 1979, Hutton 1987, Jacobsen y Kushlan 1989).

About the dispersal of the released animals, Muñoz y Thorbjarnarson (2000), reported a maximal distance of dispersion of 12 km for released animals in a lapse of one year after the releasing. Llobet (2002) found an even higher distance of dispersal, of 21,86 km for an individual, in a lapse of time higher than 7 years after the releasing until the recapture. This behavior matches with the one described by Messel et al. (1981) for *Crocodylus porosus*, which he names as an animal that travel long distances. Muñoz y Thorbjarnarson (2000) also point that the Orinoco's caiman tends to move moderately upwards the river (3 to 8 km) and just a little downwards the river (1 to 2 km). In the Cojedes river the dispersion of the individuals was lower than the reported by Llobet (2002), the maximal distance that was registered for the released animals of the place was of 3,7 km downward the river in a year lapse of time from the releasing, and the lowest dispersion distance was of 1,1 km downward the river. In addition, the dispersal of wild animals captured and recaptured in this study was lower (in a lapse of time of one and three months) being the highest dispersal distance of 1,2 km and the lowest of 15 m. As it was pointed earlier many individuals were captured more than once, in most of the situations the capture points were relatively close one to the other (about 100 m). It seems, that the young caimans of the Cojedes river tends to stay in a reduced action area.

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Long-term population data of the Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes River System, Venezuela

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ABSTRACT: Since 1991, at least 145 nocturnal spotlight counts of Orinoco crocodiles have been conducted in several segments of the Cojedes River System (CRS), which amounts to a total of 1396 km of river surveyed. The effort, however, has not been uniformly distributed; rivers segments such as Cojedes Norte (CON), 28 times, Confluencia-Caño Amarillo (CAM), 35 times and La Batea-Confluencia (LBC), 28 times, are the ones that have been visited more frequently, precisely those easier to visit for logistic reasons. Other river sections has been surveyed fewer times. These do not allow reliable analyses of population trends. In all river sections the abundance of crocodile population have decline. Population structures have also changed, but no clear pattern is apparent. The population decline is worrisome. The Ministry of Environment should be in charge of a systematic monitoring program in accordance with universities and ONGs involved in the conservation of the species.

RESUMEN: Desde el año 1991 se han realizado al menos 145 conteos nocturnos de caimanes del Orinoco en el Sistema del Río Cojedes (SRC) los cuales suman un total de 1396 km de río muestreados. El esfuerzo, sin embargo, no ha estado uniformemente distribuido. Algunos segmentos de río, como Cojedes-Norte (CON), 28 veces, Confluencia-Caño Amarillo (CAM), 35 veces y La Batea-Confluencia (LBC), 28 veces, son los que han sido visitados con mayor frecuencia, que son, precisamente aquellos más fáciles de visitar por razones logísticas. Otros segmentos han sido recorridos en muy pocas oportunidades como para permitir análisis de tendencias confiables. En todos los segmentos analizados ha quedado en evidencia un declive en la abundancia poblacional. La estructura de la población también ha cambiado, pero no se hace evidente la existencia de algún patrón. La disminución de la población es preocupante. El Ministerio del Ambiente debería responsabilizarse del desarrollo de un programa de monitoreo, en acuerdo con las universidades y ONG que trabajan por la conservación de esta especie.

INTRODUCTION

The best known population of the Orinoco crocodile (*Crocodylus intermedius*) is found in the Cojedes River System (CRS, the Cojedes River plus its branches and tributaries), in central Venezuela. Several investigations have been conducted in the CRS in the last twenty years (Ayarzagüena 1987, Seijas y Chávez 2000, Chávez 2000, Mendoza 2003, Navarro 2007, Ávila-Manjón in prep.). All these studies, however, have been somehow disconnected or have covered different river sections. In this paper we try to put together the available information regarding population numbers and size-class structure to see if there is any

evidence of trends. This analysis will be useful for the design of a monitoring program for the species.

MATERIALS AND METHODS

We analyzed published and unpublished results of nocturnal spotlight counts of crocodiles in the CSR. All these surveys were conducted in similar way, i.e., from a 3.7 m boat powered by 10 or 15 hp outboard engines. Crocodilians sighted were approached as close as possible to allow positive identification of the species (the spectacled caiman is also present in the river) and to estimate total length (TL). In this paper we only deal with the results for *C. intermedius*. For the present analysis four size categories were recognized (Seijas and Chávez 2000):

Category	Regarded as
Less than 1,2 m TL (excluding hatchlings)	Smalls
TL ≥ 1,2 y <1,8 m	Juveniles
TL ≥ 1,8 y <2,4 m	Sub-adults
TL ≥ 2,4 m	Adults

In surveys prior to 1996, the length of river sections were calculated on the maps, or estimated according to the time taken in travelling them. After that year, the use of Global Possitioning Systems (GPS) permitted a much more accurate determination of the length of each sections. The Index of relative population abundance (PI) was expressed as number of individulas observed per kilometer (Ind/km). For river sections, PI were plotted against survey date to see if any population trend emerged.

For a particular year, population structure of crocodiles for sections with more than one survey was calculated using the maximum number of individuals in a size category, regardless of the survey in which they were observed. That was assumed to be the best estimate for that particular size class and for that year (Messel *et al*. 1981, Seijas y Chávez 2000). Comparisons of population structure among river sections were made using contingency tables.

RESULTS AND DISCUSSION

Population abundance: Since 1991, at least 133 nocturnal spotlight counts have been conducted in several sections of the CRS (Fig. 1). The total effort amounts to 1396 km of river surveyed. The effort, however, has not been uniformly distributed. Some rivers sections have been surveyed 15 or more times, whereas others have been studied in only a few occasions (Table 1). For the analyses, surveys conducted under conditions that compromise their reliability (for example, after a heavy rain or in dates too advanced into the rainy season) were excluded for analyses.

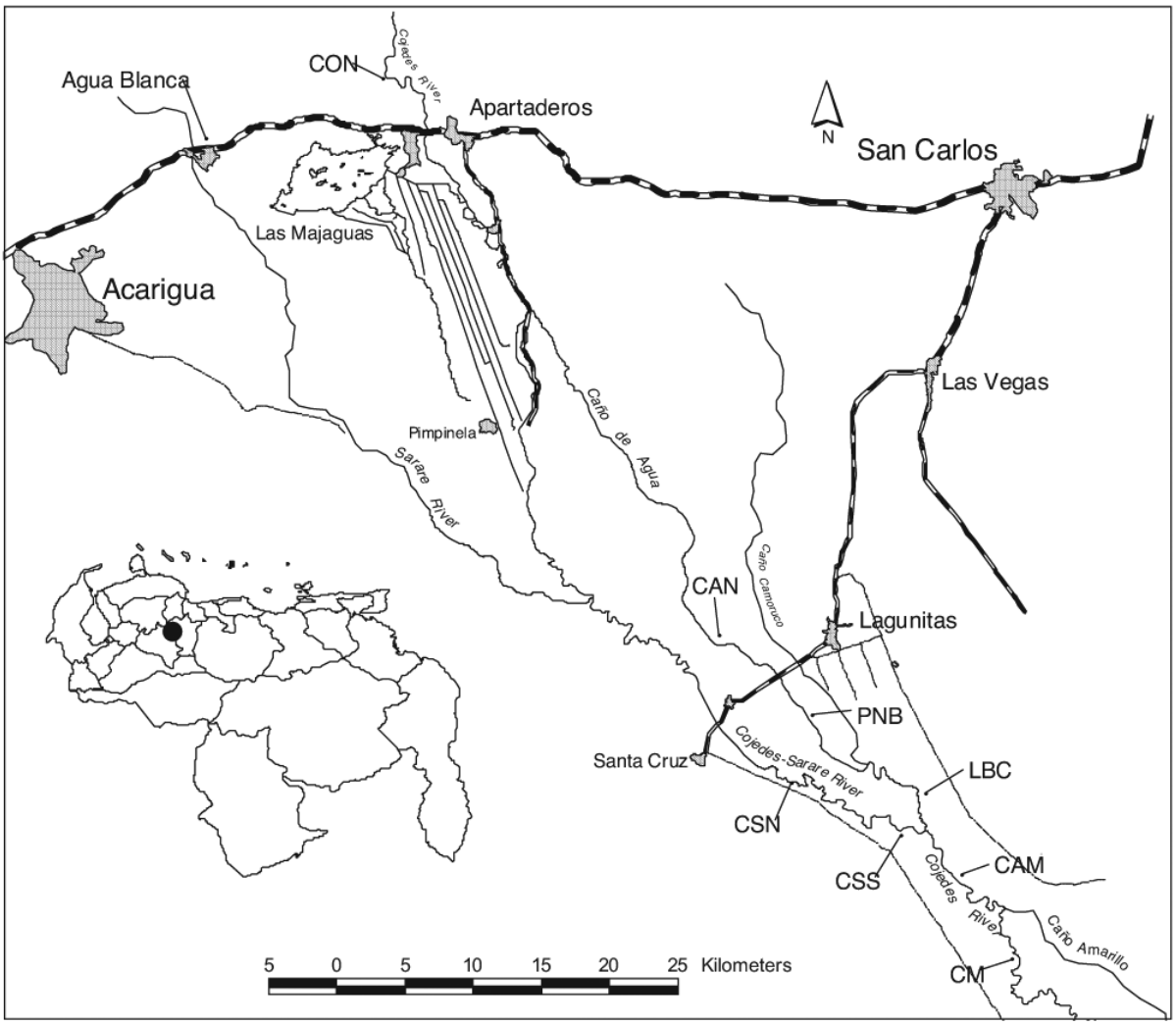

Figure 1. Rivers sections of the CRS: Cojedes Norte (CON), Caño de Agua Norte (CAN), Puente Nuevo-La Batea (PNB), La Batea-Confluencia (LBC), Confluencia-Caño Amarillo, Cojedes Medio (CM), Cojedes-Sarare Sur (CSS), and Cojedes Sarare Norte (CSN). Two others river sections, Cojedes Sur and La Culebra are not shown in the map.

Table 1. Number of times each river section has been surveyed.

River segment	N° of surveys	First date	Last date	Elapsed time (years)
Cojedes Norte (CON)	28	19-Jan-93	23-Feb-02	9,10
Caño de Agua Norte (CAN)	15	03-Jul-93	07-Feb-08	14,61
CA-Puente Nuevo-La Batea (PNB)	19	12-Feb-92	16-May-02	10,26
CA- La Batea-Confluencia (LBC)	28	14-Jun-91	16-May-06	14,93
Confluencia-Caño Amarillo (CAM)	35	13-Jun-91	28-Feb-08	16,71
Cojedes medio (CM)	5	25-Feb-98	18-Apr-06	8,15
Cojedes Sur (CS)	4	19-Mar-94	18-Apr-97	3,08
La Culebra	3	11-Apr-96	17-Aprr-97	1,02
Cojedes-Sarare Norte (CSN)	4	04-May-93	29-Apr-99	5,99
Cojedes- Sarare Sur (CSS)	4	03-May-01	29-Mar-06	4,91

Cojedes Norte (CON), river section located north to the road “troncal 5”, has been surveyed 28 times. A plot of population index vs date of surveys clearly indicates a sustained decline of the number of crocodiles seen (Fig. 2). From 1993 to 1997, PIs were around 3 ind/km. In the latest surveys (Mendoza 2003) PIs have not reached 1 ind/km. The low variability of surveys for 2001 and 2002 assign a high confidence to these results. This river section is the most deteriorated of all considered in this study, due to its proximity to agriculture and other human related activities (Mendoza y Seijas 2007).

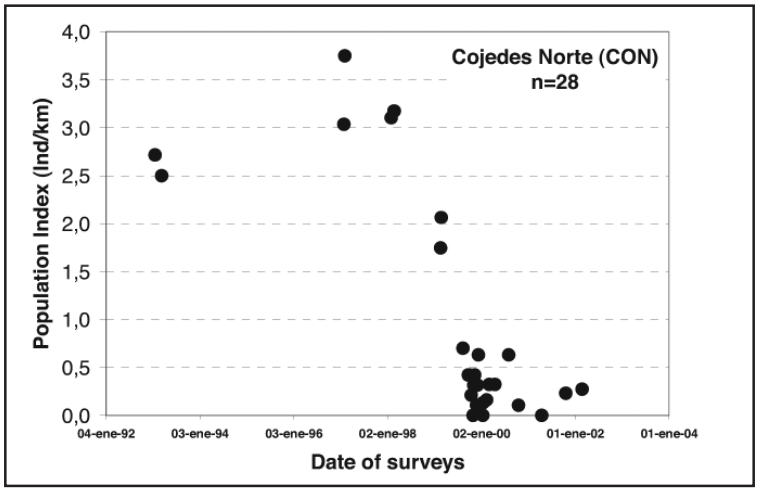

Figure 2. Plot of population indices (PI) vs date of surveys for Orinoco crocodiles in CON. Population abundance has clearly declined well below the levels of 3 ind/km or more shown in years 1997 and 1998.

The last survey in Caño de Agua Norte (CAN), conducted in February 2008, produced a PI of 2.6 ind/km, which is the lowest ever obtained in that river section (Fig. 3). That figure is very low if compared with PIs obtained from 1993 to 1999 which were around 4.6 ind/km. However, it is necessary to conduct new evaluations in the short run to determine if the most recent figure is truly an indicative of a declining tendency.

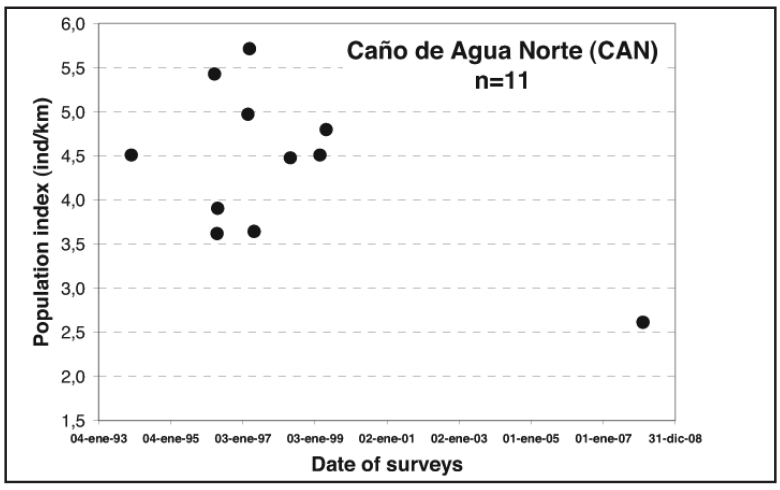

Figure 3. Plot of population index (PI) vs date of surveys for Orinoco crocodiles in CAN. According to the latest survey, population abundance has clearly decline from the levels above 3 ind/km shown in 1997-1998.

The decline of the Orinoco crocodile population is also apparent in La Batea-Confluencia (LBC) (Fig. 4). The PIs observed there during 1996 and 1997 varied from 3.3 to 8.7 ind/km,

with an average of 5.5 ind/km. More recently, and particularly after 2002, PIs have never reached 3 ind/km, with an average of 2.3 ind/km. The differences between the PIs for these two groups of years is significant (Wilcoxon 1 way test, X^2=10.6; *P*=0.001).

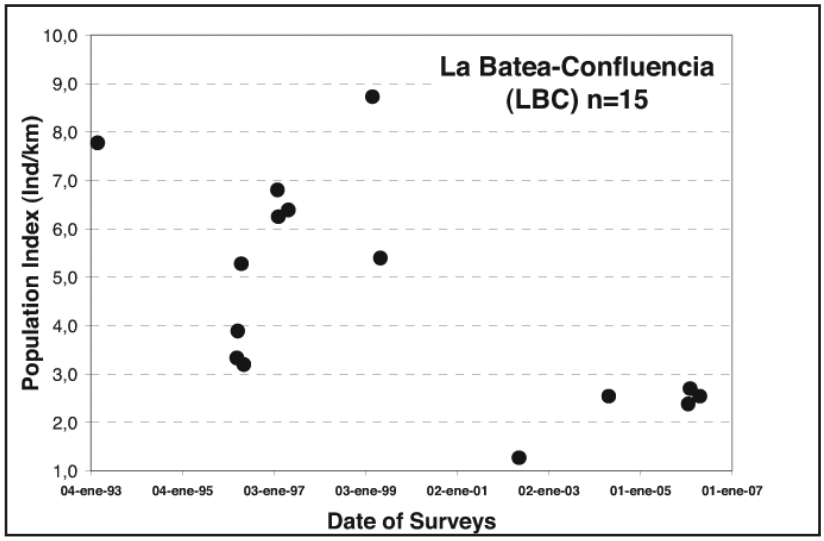

Figure 4. Plot of population indices (PI) vs date of surveys for Orinoco crocodiles in La Batea-Confluencia (LBC). Although data show a high dispersion, population decline is apparent.

The situation in CAM is a little bit more complex (Fig. 5). As occurred in river sections already analyzed, PIs show relatively high values from 1996 to 1999. The three surveys for 2003 and 2004 indicate a substantial decline of PIs, with values less than half the average of previous years. More recently, however, population data indicate an increase, probably due to the fact that 360 captive reared juvenile crocodiles have been released in this river section or in its proximities.

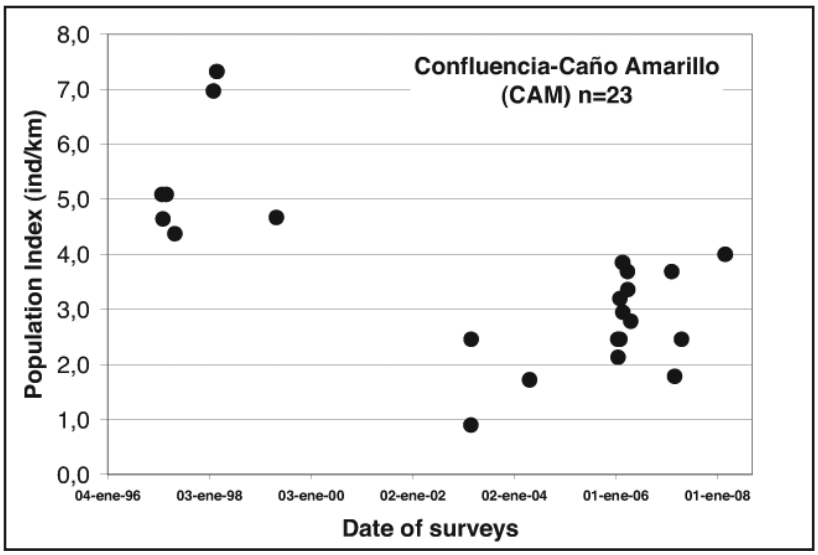

Figure 5. Plot of population indices (PI) vs date of surveys for Orinoco crocodiles in CAM. Two trends are shown: a declining one from 1993 to 2004, and an increasing one after that year.

Population structure: In some river sections of the CRS population structure of crocodiles has also changed, but in some cases is difficult to distinguish trends. The following graphs show only population structures for those river sections that have enough data to attempt comparative analyses.

There are data for five non continuous years in CAN. The first survey is for 1993. In that year, even though the population was dominated by small crocodiles, adults represented an important fraction (32%) of it. Population structure for 1996, 1997, and 1999 were essentially the same. If we take data from 1996 as the most representative of those years (based in higher number of surveys), and compare it to the one from 1993, the differences are significant (X^2=7,7; *P*=0,05). Results for year 2008 are based on one survey that covered 8 of the 17 km of the segment (Fig. 6).

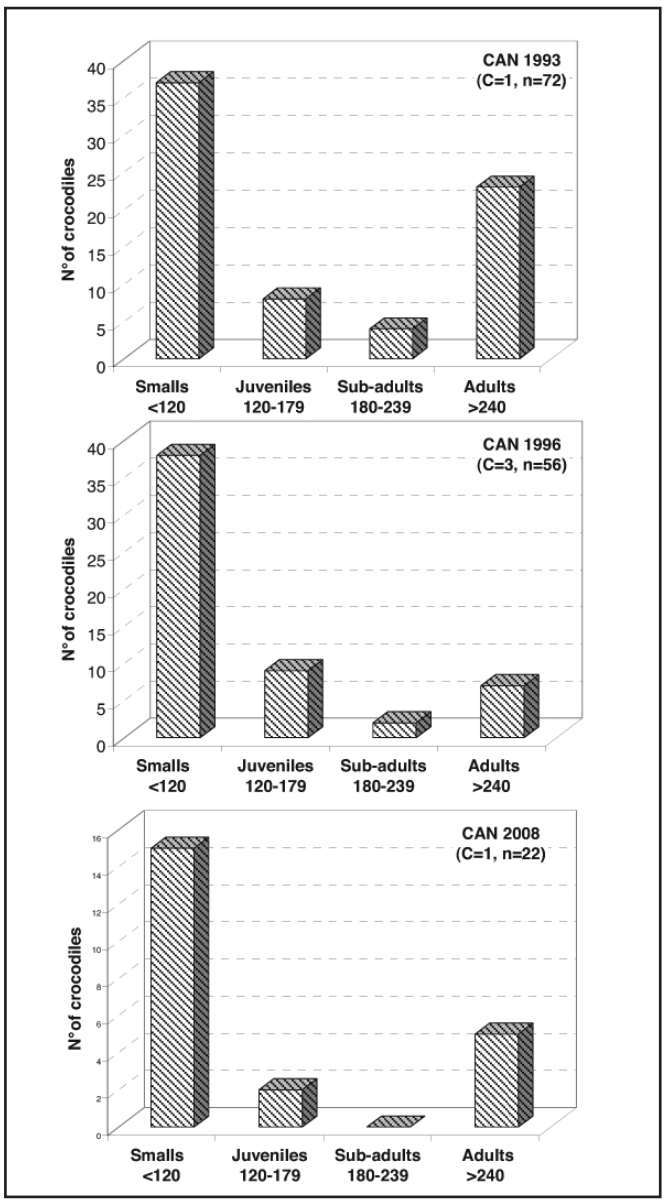

Figure 6. Population structure of crocodiles from CAN. Results for 1997 and 1999 (not shown) are essentially equal to the ones for 1996. C, number of counts; n, number of crocodiles. Size categories in cm.

In the case of LBC, population structures have shown a high variability, but no trend is apparent (Fig. 7). The proportion of adults in this section has always been important, to the point that this class was the dominant one for 1997 and 2006. LBC is a river segment of Caño de Agua where every year takes place the majority of nesting events in the entire CRS (Ayarzagüena 1987, Seijas and Chávez 2002). Conditions for nesting in Caño de Agua may change from one year to another depending on the severity of the dry season and the

availability of deep pools and nesting beaches, which may cause that adults enter or leave this river section. This could partially explain variations in population structure from year to year. Another source of variation is that visibility of different size classes of crocodiles varies according to changes in the river as the dry season progresses (Seijas y Chávez 2000) adding noise to the results.

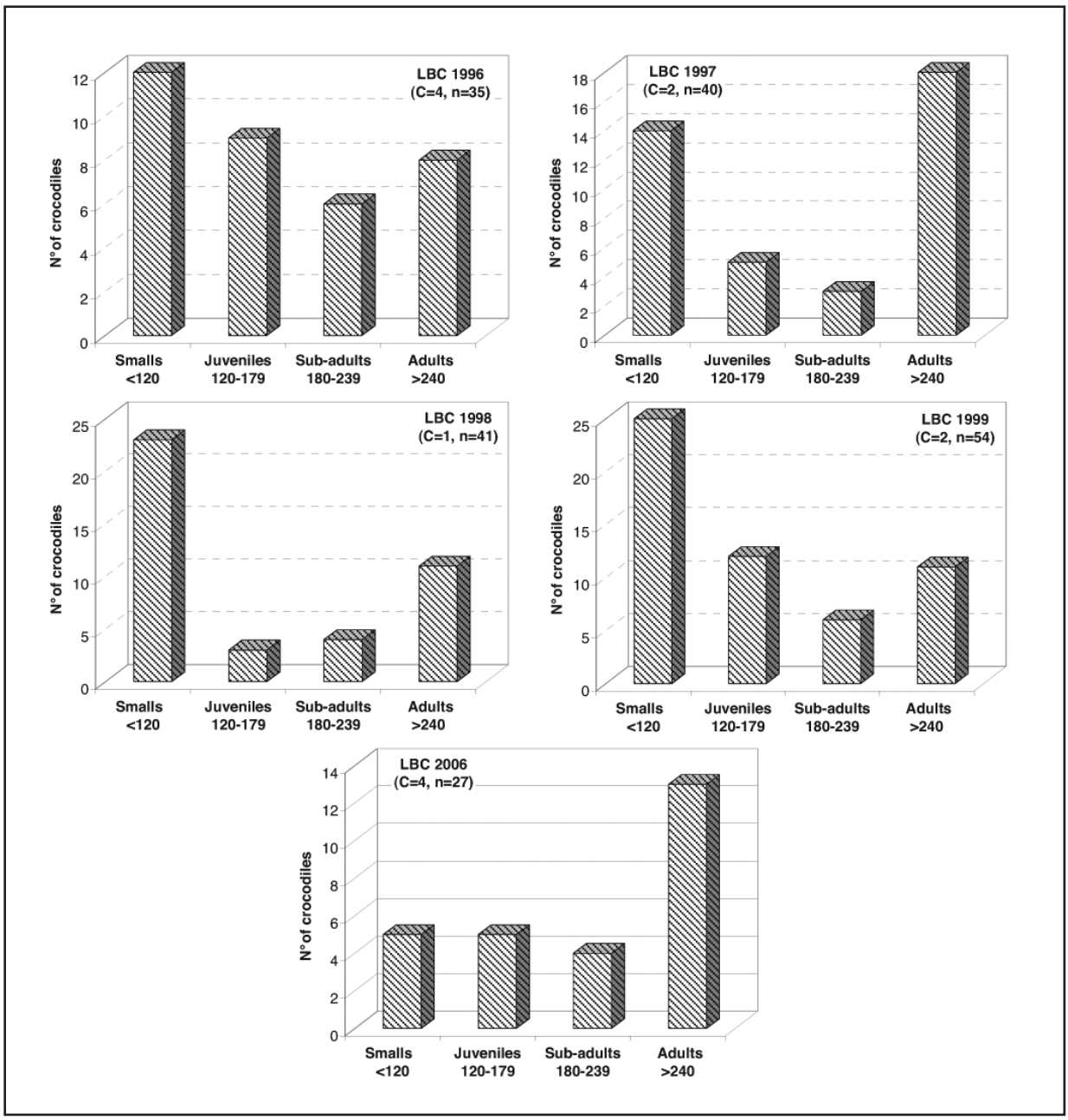

Figure 7. Population structure of crocodiles in LBC. C, number of counts; n, number of crocodiles. Size categories in cm.

In CAM population structure has also changed, somehow, in an erratic form (Fig. 8). The importance of juveniles seems to have declined, whereas the proportion of adults has increased. Changes in proportion of small crocodiles from 2006 to 2007 could be explained by the release into the river of captive reared individuals.

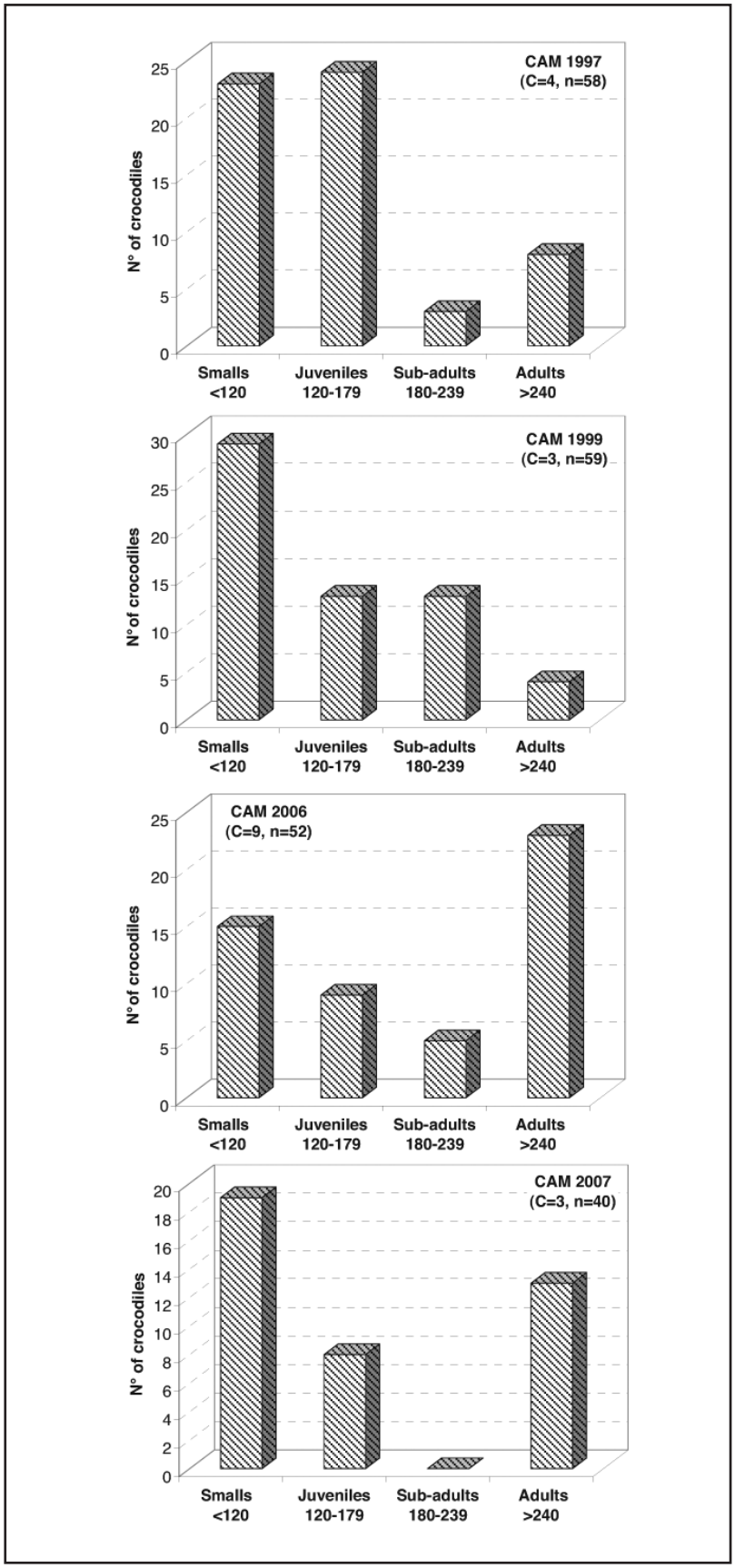

Figure 8. Population structure of crocodiles in Confluencia-Caño Amarillo (CAM). C, number of counts; n, number of crocodiles. Size categories in cm.

CONCLUSIONS AND RECOMMENDATIONS

There are unequivocal signals that the population of Orinoco crocodiles, in different river sections of the CRS, has declined in recent years. The reasons of the decline have not been carefully investigated, but our observations indicate that human presence in the river has increase in recent years. The CRS is not legally protected, but there is a proposal to declare a portion of it as a Wildlife Reserve. Legal protection is not enough, and a rigorous law enforcement plan to protect against illegal killing of this protected species must be implemented immediately. Monitoring of crocodile population in the CRS should continue, but sources of variations should be reduced to increase the accuracy of results. The establishment of a precise monitoring program is a priority, such as it has been recognized in the "National Strategy for the Conservation of the Orinoco Crocodile and its Action Plan" (ENCCOPA 2007). This program must be under the responsibility of the Ministry of the Environment, in coordination with universities and ONGs involved in the conservation of the species.

ACKNOWLEDGEMENTS

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Double clutching in a captive female Orinoco Crocodile *Crocodylus intermedius* at The Dallas World Aquarium, TX.

Luis Sigler

ABSTRACT: The Dallas World Aquarium imported a pair of adult Orinoco crocodiles *Crocodylus intermedius* from Venezuela in 1998. The 25 year old female had previously laid three clutches in captivity. The pair mated in Dallas and laid an unproductive clutch December, 1998. The female was inactive until 2002 when modifications were made to the nesting area. In April, 2003 the first Orinoco crocodiles born outside their natural distribution, hatched. Each year, from 2003-2007, a successful clutch has been laid producing 83 hatchlings. In April 2007, 40 days following the hatching of a clutch laid in December 2006, the female laid a second clutch, which appeared to contain only two eggs, found in the water. It was later discovered that another 29 had been laid in the nesting area. These were not detected until December 2007 when they were uncovered during another nesting event. Of two eggs discovered in the water, one was fertile and incubated artificially. It developed an embryo that died at day 60 due to low humidity in the incubator. The 29 eggs left in the nest were infertile despite the fact that conditions were optimal. Further studies must be done to understand this unusual behavior. American alligators have been known to retain sperm. It is suspected that this may also be true in crocodiles. Sperm may be retained from one mating and used to fertilize a second clutch of eggs. This double clutching event may be the first of its kind reported in the Americas. It has been reported previously for two Asian species- the Mugger crocodile, *Crocodylus palustris*, in India, and the Siamese crocodile, *Crocodylus siamensis,* in Cambodia.

INTRODUCTION

The Dallas World aquarium (DWA) located in downtown Dallas, TX, USA, imported a pair of Orinoco crocodiles *Crocodylus intermedius* from Venezuela in 1997 for display in an indoor exhibit at the second level of the Rainforest building. The male was 18 years of age and the female 25 years old. The exhibit consists of 64,000 liter fresh water divided in two ponds and with a land-water ratio of 40:60. To provide heat we installed two 60 watts Flood UV lamps (Mega ray Zoo Reptile UV®) and four heat stripes (1500 watts) over the nesting area. The water is maintained at 80° F (26.6 °C) and is constantly filtered into the system.

The crocodiles are fed every Saturday with eviscerated rainbow trout *Oncorhynchus mykiss* + vitamins (Mazuri® Zu Bird tablets) at an approximate amount of 10 pounds a week. Some days they are trained and rewarded with chicken drummets (no more than 10 pieces a week). They shared their exhibit with Black Pacus *Piractus brachypomus* and Red belly piranhas *Pygocentrus nattereri* and with free flight birds upon which they occasionally prey.

Orinoco crocodile's courtship and breed in the wild during September and October and females deposit eggs in early January to early February (Medem 1981). The breeding activities from 2003 to 2007 were closely followed at the DWA, and despite the latitude difference between Colombia-Venezuela and Dallas, TX, the breeding season for our Orinoco crocodiles under artificial/captive conditions is quite similar (October – November). Nesting was

recorded in December and January, and hatching time under artificial incubation in March and April after an average of 92 days (Sigler 2007).

Double clutching must be defined as an additional clutch of well developed eggs between two normal nesting events; with enough time to realize it is different in the ovo genesis from the first one and not affecting the characteristics of the third one.

The first clutch from the 2007 season was laid on December 20th 2006, and was composed of 45 eggs buried on the sand bank where the female usually nests. After 90 - 95 days of artificial incubation, 30 crocodiles hatched between March 18th and 23rd 2007.

The second clutch was composed of 31 eggs: two were laid in the shallow pond of the exhibit around 12:00 pm on April 26th 2007, and the remaining 29 were buried in the nesting area (Fig. 1) but were not discovered until December 26th 2007. The two eggs laid in the pond were collected in less than an hour with an extendible net (Fig. 2) and moved to the incubation area in a plastic bucket with sand and leaves.

The incubator was set at the normal temperature and humidity (30.0 °C and 96% RH). After that, the eggs were measured (Table 1) and the mucus coats were removed. The mucus coats were clear and appeared normal. When the incubator was stabilized, a plastic container filled with vermiculite saturated with water was used for the eggs (Fig. 3). A thermo – hygrometer was placed inside the container to make the parameters visible from the outside. The two eggs showed a kind of band the following days after the incubation started, but only one appeared normal.

When the humidity was lower than 92% a misting bottle was used to spray water over the eggs in the vermiculite. The eggs were candled with a flashlight and only one showed a kind of yellow reddish content and the other showed an air bubble instead (Fig. 4).

In early June, after 41 days of incubation, the rains were so heavy over Dallas, and the DWA showed some leaking areas close to the incubator. We supposed the humidity will be kept high but it dropped some days to lower 80's %. Many days the egg container inside the incubator had been misted heavily but after 3 days the humidity decreased again.

On June 30th (65 days of incubation), I opened both eggs after candled and noticed a dead embryo 70 mm long in the fertile egg (Fig. 5), and a whitish yolk in the other egg witch has an air bubble (Fig. 6). The embryo showed a little autolysis which suggested it died tree weeks before.

The other part of the clutch was found on December 26th while the female was digging for her usually December clutch (2008 season). We saw on the TV closed circuit when she dug out some eggs from the underneath of the nesting area. When we approached the nest, the odor of decomposing tissues suggested those eggs were not from this season and must be part of the clutch deposited on April 26th 2007. The eggs were together and buried in 3 layers 30 cm into the sand, as a normal clutch (Fig. 7). All but four of the eggs were broken and their content revealed no evidence of fertility. The unbroken eggs were measured and opened, they had whitish yolks and the albumin had no blood vessels (Fig. 8).

Double clutching was only reported in Asia for two species of crocodiles. The Mugger (*Crocodylus palustris*) held at the Madras Crocodile Bank in India, and it is showed in some females from different generations (MCBTCH 2008). Double clutching has also been seen in Siamese crocodiles (*Crocodylus siamensis*) in Cambodia in three different facilities in at least four females longer than 2.25 meters and around 25 years old. 80% of the time the first clutch was larger than the second. In at least 20% of the cases the second clutch produced hatchlings but the success rate of the other clutches is unknown, as the eggs (possibly fertile) were not collected for artificial incubation (Nao 1995).

It is possible that the combination of enough food offered to the crocodiles at the DWA (Mc Mahan *pers. comm*.) and the lack of environmental signals as water level and ambient temperature confused the reproductive system of the crocodiles (Thorbjarnarson *pers. comm.*)

American alligators have been known to storage sperm (Gist *et al* 2007). It is suspected that this may also be true in crocodiles. Sperm may be retained from one mating and used to fertilize a second clutch of eggs.

To my knowledge this is the first report of double clutching in *Crocodylus intermedius* where a clutch of 31 eggs was laid on April 26, in between two normal clutches laid on December 20th 2006 and December 27th 2007. One egg of the second (April) clutch was fertile and developed normally but died from incubation problems on an estimated age of 45 days. Main comparison data among first (n=45) and second clutch (n=6) are showed on Table 2.

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Table 1: Egg measurements from the second clutch.

Egg #	Fertility	Length	Width	Weight
1	Positive	86 mm	52 mm	125.3 g
2	Negative	82 mm	47 mm	119.4 g
3	Negative	80 mm	48 mm	Non registered
4	Negative	81 mm	50 mm	Non registered
5	Negative	81 mm	48 mm	Non registered
6	Negative	80 mm	48 mm	Non registered

Table 2: Resumed information about the reproductive events cited in this document.

	Normal clutch 2006 – 2007	Double clutch 2007	Normal clutch 2007 – 2008
Date of laying	Dec 20th 2006	April 26th2007	Dec 27th 2007
Clutch size	45	31	47
Egg mass	5 243.4 g	3 792.5 g	5 228.7 g
Egg size (average)	79.9 x 49.4 mm	81.6 x 48.8 mm	79.4 x 48.7 mm
Fertility	100 %	3 %	72.34 %
Incubation time	90 – 95 days	Failure at day 45	89 – 92 days
Date of hatching	March 18 – 23 2007	----	March 22 – 25 2008
Hatchlings produced	30	1 dead embryo	31

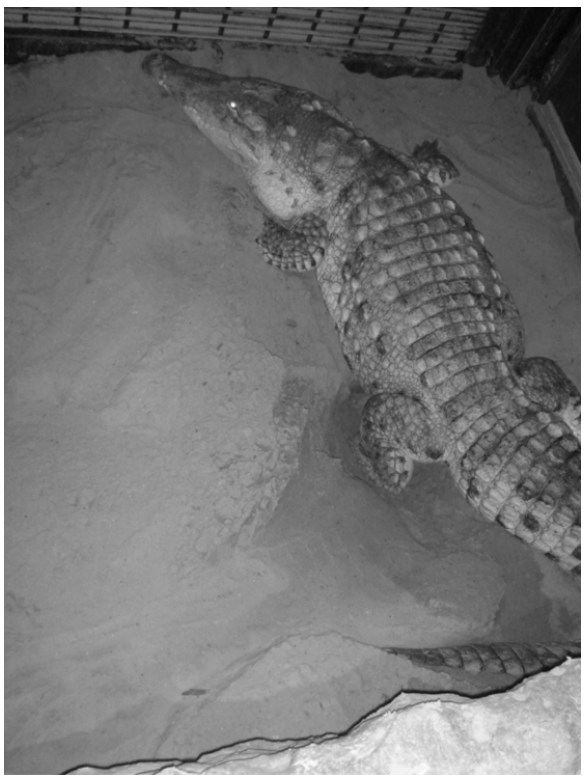

Figure 1. Female Orinoco crocodile *Crocodylus intermedius* digging a hole in the sand. Two hours after, she laid two eggs in the exhibit pond.

Figure 2. Position of the two eggs laid in the water and before removed with an extensible net.

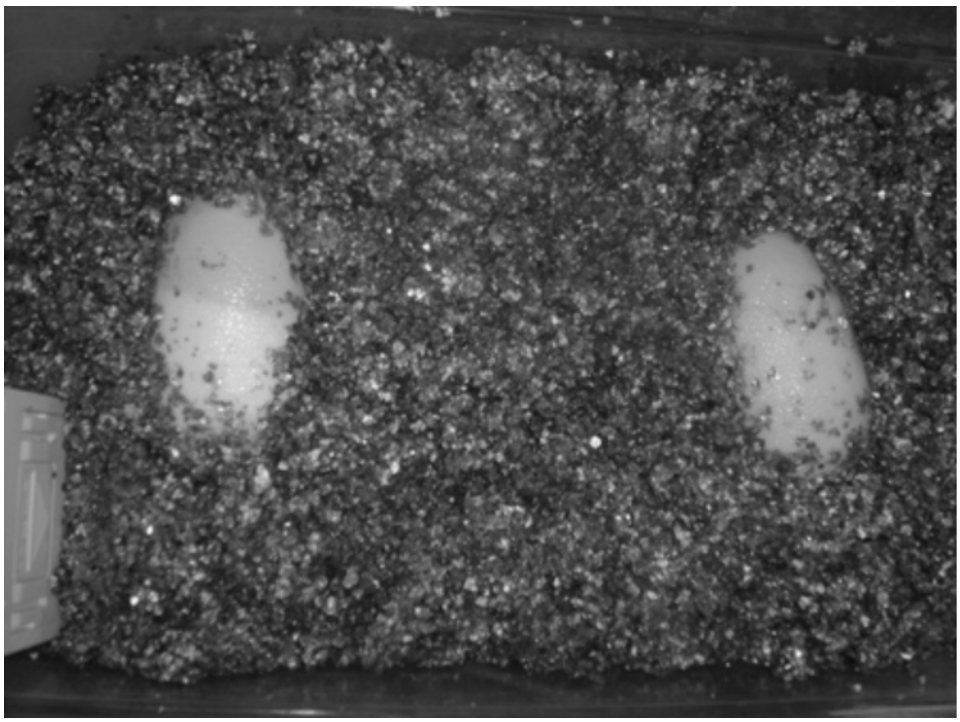

Figure 3. The two eggs were deposited in a plastic container with vermiculite saturated with water.

Figure 4. Candling the eggs to check their status (top is fertile and bottom is not).

Figure 5. Embryo development in the fertile egg.

Figure 6. Infertile egg content.

Figure 7. Disposition of the buried eggs.

Figure 8. Four of the non broken eggs buried in the nest.

Tomistoma schlegelii: results of a Workshop, and development of an Action Plan for its Conservation.

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ABSTRACT: We present the results of the first International Workshop dedicated to the conservation of *Tomistoma schlegelii*, held in Thailand in March 2008. The primary aim of the Workshop was to develop a Conservation Action Plan for the species. The current status of Tomistoma throughout its range is described, along with major threats and management issues. This leads into the key issues within the Action Plan. We also briefly discuss recent work in Tomistoma biology and management (including captive breeding), as well as TTF activities that have enabled and supported this work.

Born to be wild: conservation and re-enforcement of Philippine crocodile populations in San Mariano, Isabela, Philippines

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ABSTRACT: A reproducing population of the critically endangered Philippine crocodile *Crocodylus mindorensis* was discovered in the municipality of San Mariano, Isabela Province, in 1999. A community-based conservation strategy here has addressed the direct threats to crocodiles in the wild: hunting, habitat conversion and destructive fishing practices have largely stopped in San Mariano. There is broad societal support for *in-situ* crocodile conservation and sustainable wetland management. Three core crocodile home-ranges are actively protected by communities and the local government. The crocodile population in San Mariano is slowly increasing but remains critically small. A full recovery of the crocodile population to viable levels depends on successful reproduction and survival of juvenile crocodiles. Crocodile nests are often lost to predators. Hatchling mortality in the wild is high, mainly because optimal wetland habitat for juvenile crocodiles is scarce. In 2005 a head-start program was set up aiming to reduce hatchling mortality. Crocodile nests are guarded. Hatchlings are collected from the wild and kept in controlled conditions. After 18 months the captive-raised juveniles are soft-released in artificial small ponds. A trial release in 2007 of 4 captive-raised juveniles has been successful: after one year all have survived and adapted to wild conditions. In 2008, 30 captive-raised juveniles have been released. The positive experiences with community-based crocodile conservation in San Mariano and the results of the re-enforcement program could serve as a basis to reintroduce captive-raised Philippine crocodiles in former parts of their range.

Actions for Gharial Conservation and Management in Teraï, Nepal

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ABSTRACT: Since 1978, thanks to Dr Tirtha Maskey a Conservation program has started in Nepal with the gharial breeding centre construction in Chitwan National Park, Teraï. Few years after, the first released sessions have started in the main Teraï Rivers. In spite of these actions, Nepalese gharial population decreased. In 2000, Nepalese government, via Dr Maskey in collaboration with Luc Fougeirol team, starts to increase the effort for gharial conservation. During 6 years, French biologists were gone in Nepal to support Department of National Park and Wildlife Conservation (DNPWC) in gharial survey and breeding centre development. But in September 2006, the program was affected by the death of Dr Maskey in tragic helicopter crash. WWF, WWG and Awely (French NGO) have decided to initiate a partnership and follow the mission with an ambitious project. With the agreement of DNPWC, the project argues for 5 mains goals: 1/continue increase in scientific knowledge on gharial and its habitats; 2/ integer favourable measures for gharial conservation in protected areas; 3/ Develop the ex situ conservation measures (breeding centres); 4/ continue population awareness on the protection of their environment through gharial conservation; 5/ contribute with Gharial Task Force in the reinforcement of gharial conservation for world biodiversity. With the strong affect of the Chambal sanctuary gharial population, (mass death in the end of 2007, more than 100 individuals), gharial conservation in Nepal gets more and more a priority because of the upstream situation of those population.

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

Context

Global context

Historically present in North part of Indian sub-continent, gharial is now mainly present in

Nepal and India. 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). During the 2006 CSG meeting organized in France, conclusions have been alarming: it had remains only 200 wild adult gharials.

This crocodile is the most endangered, it is why that it is classified in Annex 1 of CITES Convention and since April 2007, Critically Endangered Specie on IUCN red list.

Nepalese context

In Nepal we can find the second most important population in the world with approximately 60 adults. These populations are still living in Narayani and Rapti Rivers in Chitwan National Park, Babaï and Karnali Rivers in Bardia National Park and Koshi River in Koshi Tappu Wildlife Reserve.

There are numerous causes to the decline of the gharials populations. For a long time, the gharials have been victims of an intensive poaching because of different parts of their body were thought to have medicinal properties or to be linked to mystical practices. The big males, who are the only ones to have a ghara, were thus the favourite preys of the poachers. The setting up of National Parks and Wildlife Reserves in Teraï has considerably reduced this threat.

Today other disruptions have appeared:

- Human disturbance: there are too many fishermen who create important basking troubles and their fishing practices are very destructive.
- Deterioration of habitat quality: there are riverbank extraction and mainly water pollution. (factories upstream from the park rivers).
- Dams built down-river from Chitwan rivers constitute today an obstacle that cannot be crossed by the aquatic species (fishes, crocodiles, dolphins…) when they swim upstream. The gharials swept along by the strength of the current during the monsoon, and when they try to swim upstream when the low waters come back, they find themselves in front of a wall, and they cannot go back to the population of the park. The same problem applies to fishes, their preys.

Tragedies for gharial conservation

World gharial conservation has known the two last years, tragedies which have increased the difficulty and the emergency of the situation.

In September 2006, a tragic helicopter crash had caused Dr Thirtha Man Maskey’s death. Passionate by this reptile, he had made his thesis on Gharial Conservation and he has always been dedicated on gharial conservation (first during his work for DNPWC and finally for WWF Nepal). His death had implied a new start with different partners so reorganization for conservation project in Nepal.

In December 2007, Mass death of gharial had started in Chambal Sanctuary Rivers. Since that time more than hundred adults and subadults are dead. Starting the last week of January, specialists from India and all other the world have investigated the deaths. It is suspected

that a toxin caused the kidney damage and failure, though a toxin but its source has not yet been identified (GCA website).

Conservation initiatives in Nepal

In Nepal, within the Chitwan National Park, the specie has been prevented from extinction thanks to a captive rearing programme initiated in 1978: the Gharial Conservation Project in Kasara. It aims to breed gharials from a captive population but also from wild eggs (collected on Chitwan park river banks). Dr Maskey was the initiator of gharial released in the beginning of 80's when he was Director General of DNPWC. Since 1981, about 700 young gharials from the rearing centre, the Gharial Conservation Project, have been released. Dr TM Maskey was the first and the most committed person on gharial conservation in Nepal.

In this context, in 1999, Dr Maskey had requested help from French NGO to make survey of released gharials and increase breeding techniques and sanitary survey in Kasara Centre. Each year since 2001, French volunteers from SOS Crocodiles and now Awely come to make survey in National Parks Rivers and increase breeding centre capacity (Cadi *& al.* 2002, Cadi *& al.* 2005). The last action was the creation of a new nursery in 2006.

A new project for Nepalese conservation

Even if the increasing of ex situ conservation conditions (with breeding centre) in Nepal seems to be in favour of gharial, the future actions are numerous. Now with the partnership of WWF Nepal, WWG (Wildlife Watch Group) and the support of DNPWC (Department of National Parks and Wildlife Conservation) we wish to put into place a project to increase gharial conservation in Nepal. With the mass death in India, Nepalese conservation takes priority and legitimacy for populations upstream from Gangetic basin. Moreover, it is the responsibility of Nepal which possesses 30% of world population and finally because of our experiences permits us to have good analysis of the situation.

So we can and we have to save one of the last gharial populations, as it did for rhinoceros or tiger several years before.

To be effective this project has to be global. For that we have identified 5 components:

1. Continue increase in scientific knowledge on gharial and its habitats which is, for instance, too low,
2. Integer favourable measures for gharial conservation in the management of protected areas (Chitwan NP, Bardia NP, Koshi Tappu WR…),
3. Develop the ex situ conservation measures (breeding centres of Chitwan and Bardia) to increase gharial population in Nepal,
4. Continue population awareness on the protection of their environment through gharial conservation,
5. Contribute in the international context of Gharial Conservation Alliance, in reinforcement of gharial conservation for world biodiversity.

Increase scientific knowledge

As we made for 6 years in Chitwan NP Rivers, we have to continue survey in these rivers but also in Bardia NP and Koshi Tappu Wildlife Reserve. First to permit us data collections on individual number and population type and secondly to determinate favourable habitats.

Gharial is a good sign for river quality so more than gharial habitats; this survey will underline habitat quality of many aquatic species like dolphin and otter.

For released survey, our reports made during the 4 last years underline the necessity to release gharial in February and more upstream from river than possible. Moreover, long net fishing has to be banned, protected areas created and prospecting launched.

To make prospecting, we will use cattle mark for identification and telemetric system to know gharial behaviours. We know that wild population depend of released gharial so we have to increase survival rate.

Studies to develop conservation measures in protected areas

But gharial survey will not be useful for specie conservation if we do not study actual rivers management in protected areas. We have to study threats which press on rivers. Chemical pollution which implies bioaccumulation risks for aquatic species especially for gharial in top of aquatic ecosystem. Human disturbance which destructs favourable habitats for gharial: rivers level decreases each year because of intensive agriculture and Fishermen press fish stock in using long net, electricity or poison. All these threats will be responsible of aquatic ecosystem destruction without actions.

Make studies and after an action plan with strict rules in protected areas will permit to save gharials, aquatic ecosystem and also the only resource of numerous local people as Bothe or Musher (fishermen ethnos).

Gharial is one of the best indicators of rivers quality and working. So it will be useful to make rivers studies through gharial with the Freshwater program or our partner WWF Nepal.

Develop ex-situ conservation measures

But before favourable habitats come back, we have to protect and develop rearing population. In 2006, we have built (with the support of La Ferme aux Crocodiles, France) a new nursery in Kasara Breeding centre which has permitted increase survival rate of babies' gharial. Now, we have to increase reception capacity with new pools and food quality with a fishing farm to give its live fishes with good size.

To avoid extinction of breed specimens in case of diseases, we will create a second breed pole as productive as Chitwan pole in Bardia National Park. Chitwan will be a model; we have already made plans and estimation of these new constructions.

The results in Kasara breeding centre permit us to think about international breeding sites. A partnership with zoos which can provide adaptive structures will give us a solution to:

- increase world breed effective,
- find financial support for in-situ conservation,
- increase people awareness all other the world.

Finally to have efficient breeding centre, we will make rearing gharial survey with growth and sanitary check-up.

Increase people awareness

To take into place this entire program, we cannot work alone. Population awareness and participation will be very important for this project.

To have regular update on gharial status, we will work with Park rangers who will be able to make this work during their patrol. But for that we will teach them on gharial specie and prospecting techniques.

Buffer Zone Community participation is important. In one hand the community will work with us during construction as we had mad during for nursery and to manage these structures like fishing farm. In other hand they will be the mediator with villagers. Our survey had showed that villagers are afraid by gharials because they do not know that gharial is only fish eater and so non aggressive crocodile. Community will make easier our communication with villagers.

Children are Nepal future, it is important to involve them in our awareness program. We wish to work with school and orphanage to teach children on gharial but also rivers conservation. To increase their involvement, we will take into place expositions with children creation like draws, paints, poetries in public place but also hotels.

Using events will be an advantage. Events like local festival, Wildlife weeks or released sessions.

Even if they are in part responsible of bad gharial situation, fishermen have to be included in this project. With them with will create an alert network (for us and Parks authorities) if they see gharials in bad situation. They are always on rivers; they will be our best partners to check gharials regularly. Moreover they already help us for egg collection.

As we will make for rangers, we will teach guides on gharials and prospecting methods to update gharial status. More than this updating, hotels and guides will help us on international awareness in providing for example “Gharial boat safari”.

The partnership with WWG for Dr Maskey resources centre will permit us to propose report and give conferences on gharial and rivers conservation to Nepalese students who wish to work on Conservation and Environment.

Develop international awareness through international volunteers will permit to increase our work in Nepal during this project.

Gharial international survey

Created in June 2006 during CSG meeting, Gharial Conservation Alliance is the best way to develop international survey. Near 30 persons forms this group: specialist from CSG, gharial country representative or zoo curators.

But Nepal has another responsibility. With India, it is the only country which possesses real population and efficient breeding structures. To avoid genetic problems, we have to launch an exchange program with India. In Kasara, gharials are breaded since 1978 with the same group: 2 males and 11 females. So there is a risk of genetic impoverishment.

Project structure

It will be a four years project with an important partnership:

- Local, with rangers, community, villagers, children, fishermen, tourism actor,
- National, with WWF Nepal, WWG – Dr Maskey resources centre,
- International, with Gharial Conservation Alliance, international volunteers, zoos.

The project will be managed by Awely, WWG and WWF Nepal in partnership with the Department of National Parks and Wildlife Conservation. It will be Awely program officer who will apply action program in partnership with Nepalese local coordinator who will be resource person for gharial conservation in Nepal.

CONCLUSION

In conclusion, it is important to underline that gharial conservation is an international input in biodiversity conservation and Nepal is one of the last chances to save this species. But more than save the gharial, this project will imply local people with participative actions. As it had been made for tiger or rhino, it is time to push the gharial as an emblem for Nepal.

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Report on the investigation into gharial mortality in the Chambal river in India.

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ABSTRACT: In mid-December 2007 sub-adult and adult gharial (*Gavialis gangeticus*) started dying in the lower parts of the Chambal river in India and at first a protozoan infection or lead poisoning were suspected as causes. During an on site investigations by an international group of CSG veterinarians a number of postmortems were out in the field. The findings were visceral and particular gout with primary kidney failure. These findings could be reconciled with previously done postmortems and confirmed by histopathological examination. A toxic agent responsible for causing this mortality, still ongoing at the time of writing, has not yet been identified.

A puzzling feature of this event is that mugger (*Crocodylus palustris*) and river dolphins (*Platanista gangetica gangetica*) in the same river did not appear to be affected. Toxicological, ichthyological and hydrological investigations are ongoing at a local level. They fall outside the competency of the investigating CSG team.

An update on the *Crocodylus porosus* and *Crocodylus novaeguineae* Conservation and Management in Papua New Guinea (1982 – 2008)

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ABSTRACT: This paper presents the results from the ongoing monitoring program in the Sepik River System of PNG and provides an updated analysis from the 2006 France meeting. The *C. porosus* surveys are being conducted annually whilst the *C. novaeguineae* surveys are conducted biannually. Although there are notable missing data in the preceding years for both species it is assumed that this will not greatly affect the analysis of the data in any way. The data from all sets were updated with the recent March 2008 results indicating that the *C. porosus* population for N = 12 sites which has been surveyed consistently since 1982 showing 20% reduction from 2007 observations. This reflected an annual mean percentage reduction of .9% annually. Similarly the nesting effort for N = 29 sites also represented a reduction of nest observation of 6.2% nesting effort from 2007. Again this also reflected a mean percentage reduction of .4%. Generally it can be suggested that the unusual decline in nesting effort showed no significant difference in the trend for all sets of data. The raw data for the prior years indicated similar nesting effort with the only increases notable in 2007. The *C. novaeguineae* depicted an increase in nesting effort from the 2007 counts. N = 21 reflected 33% increase in nest numbers whilst the N = 45 reflected a 9.8% increase. Both sets indicated an increase of 1.8% annually. It can be suggested that the wild population densities are healthy rather than declining for both species. It can be suggested for both PNG species that the wild population densities are healthy rather than declining. This is consistent with our skin export figures from PNG which reflected the wild and ranched skins exports from Mainland Holdings for the last 10 years since 1997 at approximately 25 000 - 30 000 skins annually. Thus, the status of the PNG population level in terms of wild harvests is considered viable for the current dispensation to enable commercial exploitation to continue.

INTRODUCTION

This is about the 10th appearance from the Papua New Guinea (PNG) delegates that constitute the industry and the government since the 7th Meeting at Caracas – Venezuela in which the initial paper was presented (Hollands 1986). The current report provides an update to the results for the *Crocodylus porosus* for March 2007 and 2008 and *Crocodylus novaeguineae* for October 2007. As in the previous reports, the data used in this report have been consistently maintained over the years by the Department of Environment and Conservation (DEC) with additional data being added after surveys from each peak nesting seasons. This report is intended to update the recent survey results from the 2006 report presented at the 18th Working Meeting of the Crocodile Specialist Group (CSG) in Montelimar, France.

We have attempted to put together a budget that will facilitate for the expansion of the aerial survey program to other areas of PNG; unfortunately we were not able to get the support for the expansion program. The industry in itself although sustainable is very small and the costs involved carrying out the expansion together with the capacity within the current establishment of the Department is under staffed. A representative ground survey work has been carried out to three provinces. The surveys were conducted primarily to assess the trends in community use of the species from the wild and the hunting methods. These surveys are recommended to be conducted biannually to each area to enable some consistency especially for the long-term data usage and interpretation.

Hence, this paper will present in brief the information on the enforcement work and the skin trade in PNG. It will not discuss in detail the significance to implementation of the monitoring program, management and the commercial skin trade. This has been described in Solmu (2004) a report presented at the 2004, 17th CSG Working Meeting in Darwin, Australia.

METHODS

The application of the survey techniques for this highly technical component of the PNG program has been described in various reports (Hollands 1987, Cox *et al* 2006, Cox *et al* 1994b, Manolis 1995, Solmu & Kula 1996, Solmu 2003 & 2004) and is being consistently maintained throughout the years. The survey covers an area of approximately 70 – 100km in length of both sides of the Sepik (Figure. 1) over all the floating herbaceous vegetation including lake fringes, oxbows and overgrown channels.

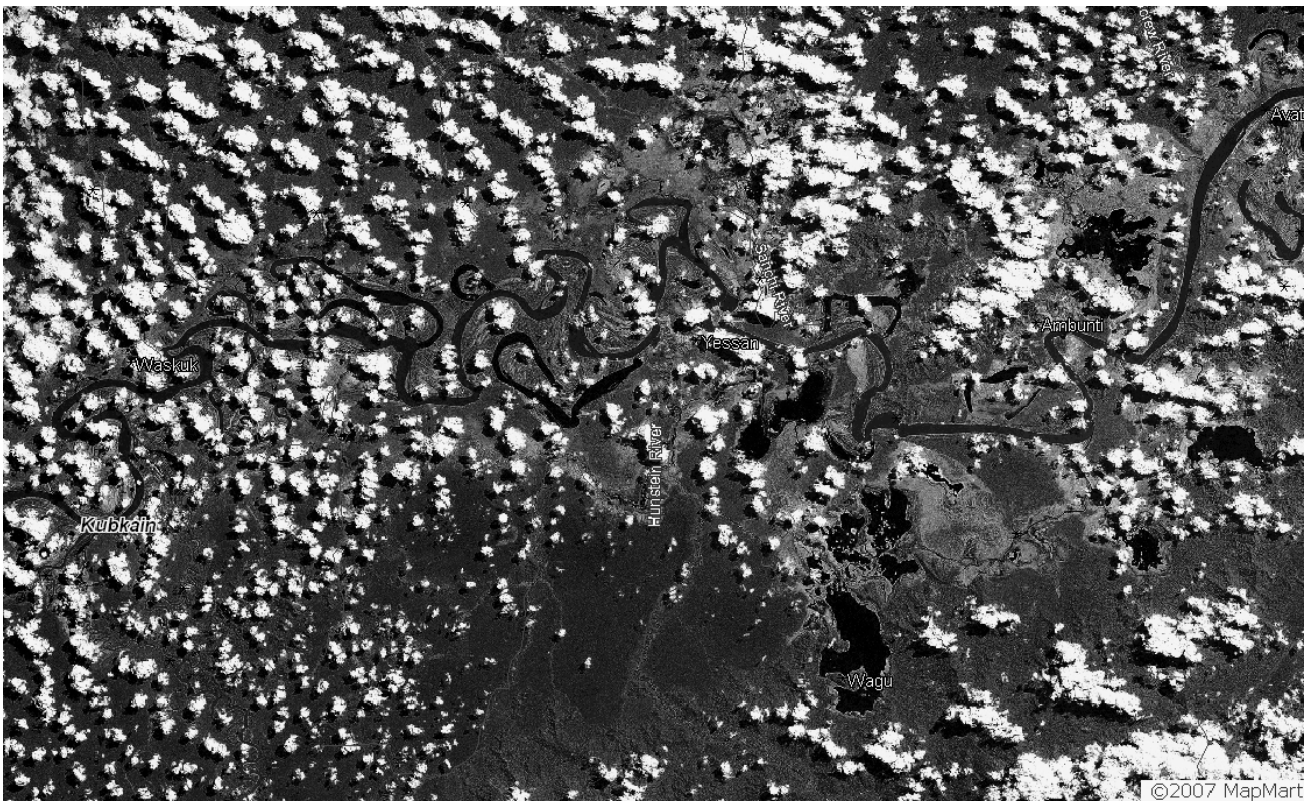


Figure 1. Sepik River wetlands and the survey areas.

The wetlands and the survey area covers about five (5) – ten (10) kilometers wide belt of active meanders that has created a active floodplain of up to 70 kilometers wide with extensive black water swamps (WWF 1999). Survey normally commences at around 8.00am and concludes at around 5.00pm depending on the weather and shadows, which are very important variables that affect visibility from the helicopter. Same dates are being maintained over the years for the conduct of this survey. The combined data especially from the N = 41 sites provides a wider coverage of all sites from the system and provides an index of adult abundance (Table 1).

RESULTS

Crocodylus porosus

The following tables presented the summarized data for the nesting efforts for each set of data. These data sets showed all survey years in which surveys are being conducted. The principle site N = 12, nests counts for 2008 (75) reflected a drop in nest counts from 2007 (90). This is evident through out all the sets e.g. N = 15, N = 29 and N = 41 (Table. 1).

With eye observations across Table 1 for the raw data, generally it can be assumed that there is an increase in nests observations from years 2003 – 2008 for sets N = 15, N = 29 and N = 41.

Table 1. The nesting index for all sets for the Sepik River System that reflects PNG.

SITES	N = 12	N = 15	N = 29	N = 41
1982	45			
1983	30	38		
1984	43	49		
1985	49	57		
1986	51	57		
1987	-	-	-	
1988	50	57	82	
1989	52	65	92	
1990	54	63	92	
1991	57	69	101	119
1992	63	75	103	123
1993	62	73	112	132
1994	46	57	97	111
1995	78	92	124	145
1996	61	73	115	137
1997	70	81	125	154
1998	37	45	63	77
2003	74	85	131	182
2004	72	82	129	161
2005	76	84	136	167
2006	74	87	142	184
2007	90	105	172	219
2008	75	89	162	209

The increases basically is assumed to be related to the community driven awareness for the value added incentives to the egg harvests program where adult females are being protected, not to say that we are also mindful of the current management plan for the legal size limits.

However, in observation of the data over the 23 year survey period, the trend indicates significant increases in the nests counts in 2007 counts. The increase is assumed to be partial in response to the egg harvest program; however that cannot be scientifically concluded. Generally the variability in the nests counts over the years is considered to be consistent with the exception of the 2007 where there is a higher nests observation.

The nesting effort for all years up to 2006 report at the 18th CSG is being updated with the recent March 2008 results, continued to reflect significant trends, (Figures. 3a and b), although there is a decline in the nest observations in 2008 which is considered insignificant.

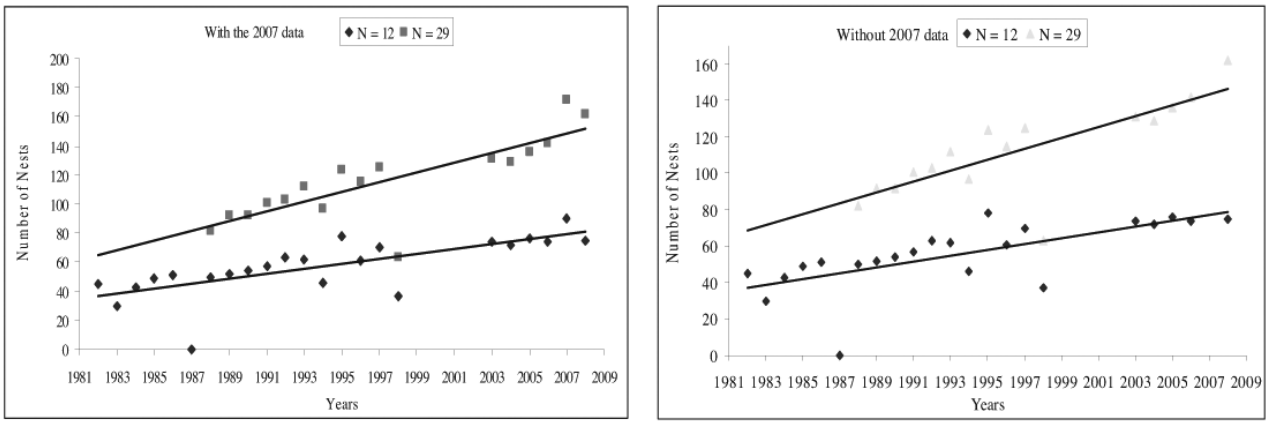


Figure 3. (a). With the 2007 data and, (b). Without the 2007 data. Total nests numbers observed during the survey as an index representing the PNG wild populations level for N = 12 and N = 29 for *Crocodylus porosus* survey years (1982 – 2008).

The equation for Figures 3. (a) With the 2007 data, being regressed with number of nests against years: N = 12 (-3349.6 + 1.7804Y), r^2 = 0.509, p = 0.0002; and N = 29 (-6589.22 + 3.357Y), r^2 = 0.6487, p = 0.0001. (**b**) Without the 2007 data, N = 12 (-3125.3 + 1.5956Y), r^2 = 0.469, p = 0.0005; and N = 29 (-5840.89 + 2.982Y), r^2 = 0.598, p = 0.005. Both sets maintained increases in nesting effort with or without the 2007 data despite the decline in 2008 observations.

Crocodylus novaeguineae.

Table 2. *Crocodylus novaeguineae* data sets indicating the index for PNG.

SITES	N = 21	N = 3	N = 7	N = 5	N = 12	N = 48
1981	75	5				80
1982	102	8				110
1983	107	14				121
1984	75	11				86
1985	110	7				117
1987	73	11	21			105
1988	103	10	26	16		155
1989	87	7	31	19	11	155
1990	89	4	14	16	12	155
1991	83	8	15	15	12	133
1992	71	3	12	6	8	100
1993	72	11	10	12	9	114
1995	91	12	15	11	19	148
1996	72	11	13	19	12	127
1999	74	12	5	9	4	104
2003	98	15	17	22	14	166
2005	99	21	19	31	14	184
2007	131	20	34	18	17	220

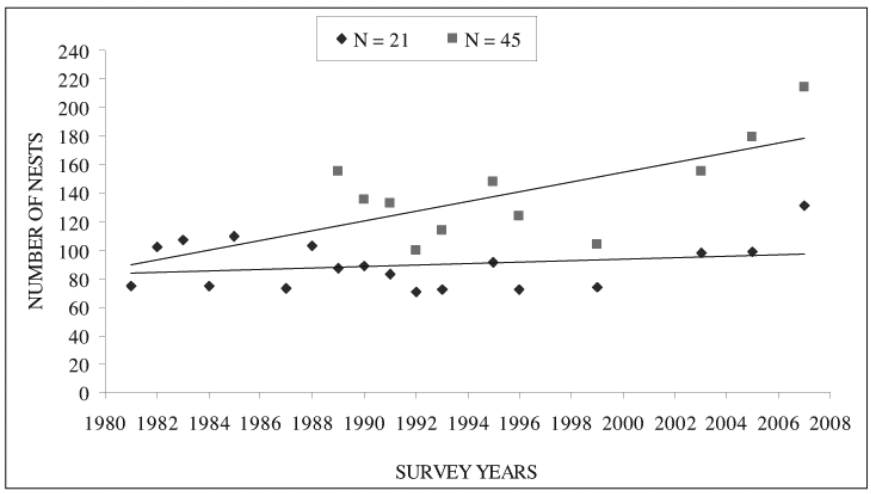
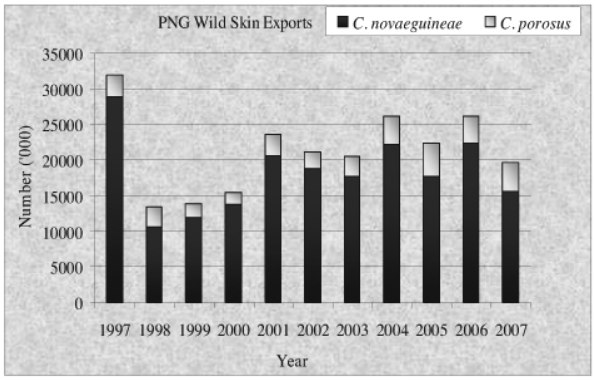


Figure 3. (c)**.** Results of the *C. novaeguineae* nesting trend from 1981 – 2007.

The regression equation for the *C.novaeguineae* populations (Figure 3c); N = 21 (-929.5 + 0.5117Y), r^2 = 0.056, p = 0.38; N = 45 (-6660.45 + 3.4074), r^2 = 0.403, p = 0.04. Both sets reflectd from the primary site N = 21 and the secondary set N = 45 had significant observations of nest counts and the regression line is considered significant however but stable for N = 21.

In general the overall results for the PNG population are considered stable and increasing although the is a significant threat in the habitat degradation from the exotic fish species.

The Country Export



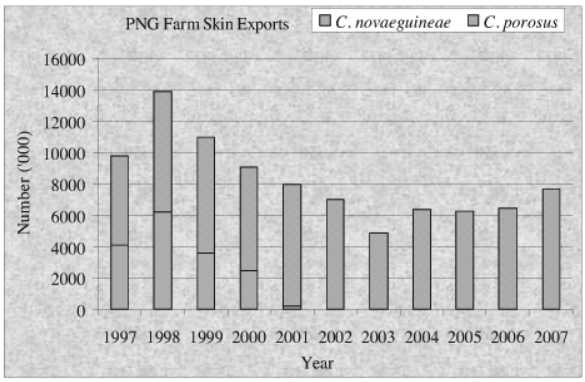


Figure 4a. Indication of wild skin exports. **Figure 4b.** Indication of farm skins exports.

The graphs in (Figures 4a and 4b) export from PNG reflects the annual shipment of whole wet salted skins. Most of the shipment of skins are exported to various small buyers around Europe, Asia and the Australian region. The component of the wild skins reflected a large number of *C. novaeguineae* and the balance of shipment the *C. porosus.*

This reflects that the *C. novaeguineae* is the most hunted wild population from all regions in PNG. It should also be noted that Figure 4c, reflected mostly the ranched whole skins from the Mainland Holdings. From the graph it can be assumed that the company has maintained its annual export figures at 6 – 7000 of *C. porosus* farmed skins since 1997, however has decided not to ranch the *C. novaeguineae* populations since 2001.

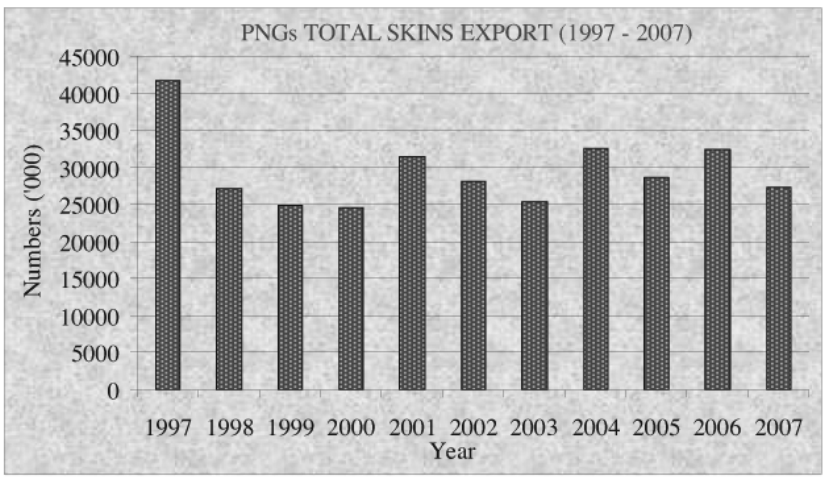
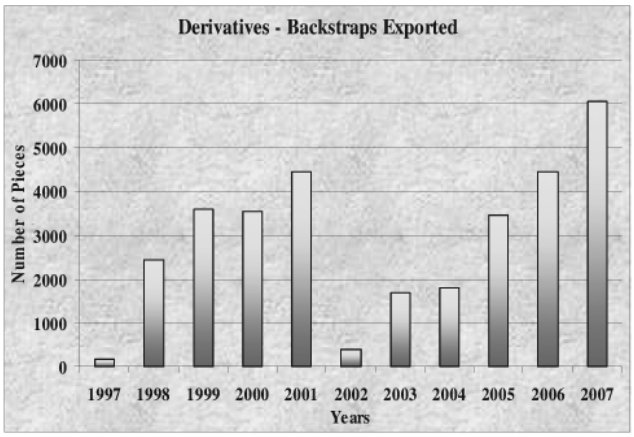


Figure 4c. The total skins exports both farm and wild from PNG.

Figure 4c, reflects the total aggregate skin exports from PNG that includes farm and ranched skins of both species. The graph reflects a consistent export market of raw hides from PNG by various exporters at 35 – 40000 skins annually. The export figures is consistent with average annual exports of total skins for the previous 10 years (1982 – 1993) (Solmu 1994) and (1997 – 2007).



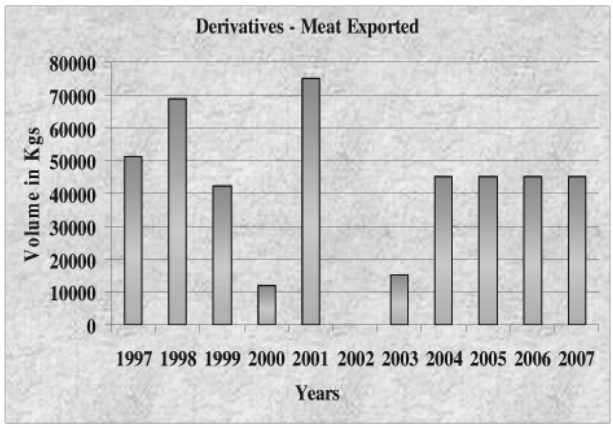


Figure 4d. Back-straps exports. **F**

Figures 4d and e, reflects value added incentives on the resource apart from the whole skin market. Note that the export of by-products is allowed under the current management plan from established and registered operation in PNG. Currently the only farm allowed to export by-products from its establishment in large volumes is Mainland Holdings Limited of Lae. With the exception of Mainland other small holding facilities are restricted from trade in by-product exports. This is basically to restrict uncontrollable harvesting of wild animals for by-products which is difficult to control and in contravention of the existing management plan.

Summary

The crocodile industry in PNG continues to strive successfully and play a major role in the conservation of both its species in the country. This is through community awareness and value added incentives directed towards the major land owners. Although there are set backs in many areas for instance logistics to support government implementation of many of its programs the industry has supported where need arises. One of the important issues is the consistent government funding for the major component of the aerial survey, which is considered the heart of the industry in extrapolation of the index from the Sepik. The funding has been consistent for the last five years including this year to enable consistent data collection for this important program. It is hoped that funding will continue to be maintained for the long term and in the near future so that increases can be requested for implementing supporting programs and logistical requirements bought.

An interesting occurrence in the northern population now is the introduction of the exotic fish species that requires interventions for the prevention of habitat degradation. Biological control for the species is not possible due to the extensiveness of the wetlands and investments for control per se…. is unviable. Community support and consultative arrangements is very much needed to support major initiatives for this program.

Thus the industry at the current stage is stable and increasing for both species as evident from our regression analysis results and wild skins export figures. Its is hoped that with collective support from the private industry and partners PNG can continue to be the major role model for sustainable use of endangered species, especially crocodiles for other countries to learn.

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