Community Participation in Conservation and Management of Crocodiles through the Egg Harvest Program in the Sepik Region of Papua New Guinea

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ABSTRACT: The core aspect of the crocodile management program in Papua New Guinea depends heavily on sustainable utilization of wild resources. Over the last 40 years the program has progressed through four distinct phases. Initially from direct wild harvest to controlled harvest of size limits, then came the capture of small juveniles for ranching operations, and lately the harvest of wild eggs. Therefore the wild harvest of skins, juveniles and egg increases the benefit to resources owners and add value to facilitate and strengthen the approaches to habitat conservation and management of wild crocodile resources. The current egg harvest program implemented by Mainland Holdings, Department of Environment and Conservation, and the Sepik Wetlands Management Initiative provides direct benefits to resource owners who realize the importance of crocodile habitat conservation.

INTRODUCTION

The vast wetland areas of Papua New Guinea is inhabited by two species of crocodiles, the New Guinea fresh water crocodile, *Crocodylus novaeguineae*, and *Crocodylus porosus* commonly known as the saltwater crocodile. *C. novaeguineae* is endemic to the mainland of New Guinea including Irian Jaya while *C. porosus* is found on both the mainland and the offshore surrounding island of Papua New Guinea. (Figure 1).

![Figure 1. Distribution of C.porosus and C.novaeguineae](image-url)
Background to Egg Harvest

The egg harvest program was launched in 1985 for *C.porosus* and 1988 for *C.novaeguineae* initially as a way to salvage eggs prone to flooding and human predation. Most of the eggs collected from wild in the Sepik all go to the Mainland Holdings hatchery in Lae, Morobe Province.

Eggs are collected during the aerial survey by the Department of Environment and Conservation - National Crocodile Monitoring Unit (NCMU) personnel due to the difficulties involved in handling of eggs thus ensuring good hatching success rate.

The program was suspended temporarily in 1994 after the *C.porosus* harvest due to mixed reactions by some land owners although with no biological evidence that the program was detrimental to recuperating of juvenile population in the wild.

After some consultation with the land owners, local politicians and the management authority it was agreed that the harvest should be conducted bi-annually for both species. Landowners were initially paid K 1.00 per viable egg, taken from the nest on their land, and in order to avoid loss in protein, a chicken egg was given to supplement the loss of eggs as payment. The price for the 1994 egg harvest increased to K 2.50 for *C.porosus* and K 2.00 for *C.novaeguineae*, including chicken eggs.

In 1996 *C.porosus* egg harvest saw an improvement in the prices of K3.00 for every single (viable) egg that includes giving away 2 chicken eggs (a 20% increase) an added value to the potential of saving eggs from human predation. Aerial surveys in 1996 confirmed a marked decline in human predation of nests.

From 1999-2001 no harvest was conducted because of funding problems the helicopter surveys were not been able to be carried out. Therefore, the canoe harvest started in 2002 and continued annually up to 2008. With the canoe harvest came the formation of the Sepik Wetlands Management Initiative (SWMI), a Community Based Organization (CBO) operating as the middle person between DEC, Mainland Holdings and the landowners. At the same time the price of eggs increased significantly from K7.00 in 2002-2004 to K10.00 in 2005 and there on, with the potential to increase further.

The egg harvest has been going on for 16 years now in Sepik Region with significant contributions to the socio-economic well being of the rural community whose land are usually inundated by floods and unfit for any other agricultural crops as source of income to sustain their livelihood. Both crocodile species are commercially utilized for their skins and this trade has been progressing for the past six decades. This long-term source of revenue and foreign earnings is significance and attention is drawn from both sectors of the Government and Industry to develop strategies for the long-term conservation and sustainable use of crocodiles.

The PNG crocodile management model has been considered a successful example of ‘sustainable utilization’ worldwide where mechanisms for both crocodilian species are utilized and developed through farming, ranching and captive breeding programs are combined with wild skin harvest.
Both populations are currently listed on Appendix II of CITES allowing a controlled export trade. The Management Program in Papua New Guinea has acquired from the start, a dual commitment for wildlife conservation and improvement of the well being of local communities in major wetland areas.

**Sustainable Crocodile Resource Management**

![Diagram of Sustainable Crocodile Resource Management](image)

**Figure 2. A simple model of sustainable use of crocodile resources in PNG.**

The current practice in PNG is an indicated in Figure 2 where the link between the three important stakeholders is working effectively in term of corporation, capacity building, enforcement, regulation, monitoring and habitat protection.

The governments role towards the Industry is more of a regulatory approach where the Department of Environment and Conservation (DEC) is the mandated agency in dealing with commercial use of wildlife resources regulates the industry and enforces wildlife laws.

To the local resource owners the government encourages them to use their resources sustainably. To achieve that the DEC carry out regular monitoring checks on the wild population and advises the local resources on the current status of wild population. In some cases quotas have imposed on egg harvest in some villages.

**EGG HARVEST AREA**

The egg harvest area covers the Middle-Upper Sepik (Figure 1) regions of Ambunti (04° 10. 445 E, 142° 40.445 S), in the East Sepik Province. Most of the sites fall inside the aerial survey route. The harvest area covers approximately 75-80 km of floating vegetation along both sides of the Sepik River.
The Upper Sepik river harvest sites include Hauna Levels, Oum Scrolls, Keipi, Bowami Lakes, North Bowami, Biaga scrolls and Kubkain Oxbows and scrolls. The Middle Sepik region includes sites in the vicinity of Ambunti, ranging upriver to sites in the vicinity of Hauna village and downriver to the Japandai village area and further down to Chambri Lakes. The harvest route stretches over a distance of 120 km. Crocodile nesting habitat identified includes: overgrown oxbows, fringing vegetation along lake margins, overgrown channels and scrolls.

In the harvest area, most villages are scattered along the Sepik riverbanks on dry ground however many of them are flooded during high water levels. Some villages are on higher grounds up in the Hunstein range and on the smaller hills where the river provides the only means of transport in these areas.
EGG HARVEST METHODS

Previous harvests (1985-1998) were carried out using the helicopter drop and retrieval method in which two personnel were dropped off at the nest and picked later when the eggs were collected (Hollands 1985, Cox et al. 1989, Genolgani et al. 1991, Cox and Genolagani 1992, 1994). This harvest method was replaced with ground harvest using canoes to in 2002. Nests located are opened up very carefully; all nesting materials are placed in a carton box. The eggs are placed in the cartons and carefully covered by the original nesting material and brought back to the camp.

Clutches are then unpacked and the data recorded on clutch size and viability (live, dead, and infertile). Non-viable eggs are discarded; remaining good eggs are marked with permanent ink to indicate the top position, and then repacked in boxes of decaying grass. Temperatures are monitored every few hours and the eggs ventilated as necessary to maintain 32°C until the harvest can be air freighted to the incubator.

RESULTS OF EGG HARVEST

<table>
<thead>
<tr>
<th>Year</th>
<th># of Nests</th>
<th>Total # of Eggs</th>
<th>Viable Eggs</th>
<th>Infertile &amp; Dead Eggs</th>
<th>% of Viable Eggs</th>
<th>Average Clutch Size</th>
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### NESTING EFFORT OF PRIMARY SITES

<table>
<thead>
<tr>
<th>Village</th>
<th>Name of Lagoon (Location)</th>
<th>Number of Nests (Year 2005)</th>
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<td>SWAGAP</td>
<td>WABOGWA</td>
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<td>KAMSI</td>
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<tr>
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<td></td>
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<tr>
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<td>DUABLO</td>
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<td><strong>Total</strong></td>
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<tr>
<td>KUBKAIN</td>
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<td></td>
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<td></td>
<td>NEBGUBOS</td>
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<tr>
<td></td>
<td>HUGNO</td>
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<td>GANGUEL</td>
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<td></td>
<td>WIDIHUK</td>
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<tr>
<td></td>
<td>BALUWE</td>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
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<td>BAKU</td>
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<td>GUMAMO</td>
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<tr>
<td></td>
<td>KERIBESIMO</td>
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<tr>
<td></td>
<td>YARAK</td>
<td>4</td>
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<tr>
<td></td>
<td>YANUK</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
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MODEL OF EGG HARVEST PROGRAM

Figure 1. Model of egg harvest program.

ACHIEVEMENTS FROM THE EGG HARVEST PROGRAM

1. Local communities
2. Habitat rehabilitation
3. Population enhancement
4. SWMI – United Nation’s Equatorial award

PNG GOVERNMENT STRATEGIC DIRECTIONS

• MTDS
• Amendment of International Trade Act

INTERNATIONAL OBLIGATIONS

• CITES
• CSG/IUCN
CURRENT EFFORTS TOWARDS WETLANDS HABITAT CONSERVATION

Sepik Wetlands Management Initiative (SWMI)

The current efforts by the Sepik Wetlands Management Initiative (SWMI), a Community Based Organization in Ambunti, to carry out public awareness campaigns with the major objective of protecting wetland habitats. A clear example is the construction of signboards at important primary survey sites to promote awareness on the habitat protection program. This initiative is very helpful and complements the current DEC crocodile monitoring program.

The SWMI in particular has emphasized and ensured the reduction in burning of nesting habitat in the survey areas. Burning is a cultural practice by locals in order to gain access to fishing and hunting areas. The awareness programme by SWMI, in recent years, has resulted in a reduction of burning in many of the primary nesting sites surveyed. It is evident that the public awareness programme has resulted in an increase in nesting activity in some sites.

Egg Harvest Program – A Conservation Tool

During the past two years, the nest owner’s conservation program of egg collection has been continued to be carried out by Mainland Holdings (Cox et al. 2006). As part of Mainland Holdings captive breeding program, the egg harvest program is particularly aimed at salvaging crocodile nests that are prone to flooding and other natural predation, which accounts for over 40-45% of egg losses in the wild (Cox and Solmu 1996).

The benefits of this program have played a significant role in the socio-economic development in these communities over the years. The egg harvest program provides financial incentives for the resource owners to protect nesting habitats from practices such as burning and predator nests from predation.

A primary aim of the egg harvest program is to promote habitat conservation, which offers nest owners an incentive for not burning nesting habitats thus substantially increasing the benefit derived from their resources. This over time has enabled resource owners to link habitat protection and the incentive through cash payments.

Future Approach - Community Development

- Infrastructure
- Tax Credit Scheme
- Prov & LLG support

CONCLUSION

The current management program for both CITES protected species (C. porosus and C. novaeguineae) although is effective, however, needs to be reviewed to look at a long term management plan, to cater for the growing demands of the export commodity taking into consideration the sustainability of the wild population.

Therefore, Papua New Guinea has a viable and probably increasing wild C. porosus population,
as indicated by the increasing nesting trend from the analysis of the survey results. Meanwhile, *C. novaeguineae* indicates positive signs of improved nesting effort.

The primary aim of the crocodile monitoring program is to determine if population trends are increasing, decreasing, or are stable. This should be achieved through analyzing raw nest counts from the same sites surveyed consistently over the same years. Maintaining the 41 sites surveyed since 1982 for *C. porosus* and 48 sites since 1981 for *C. novaeguineae* is crucial in determining this. It should be noted the additional sites surveyed between 1989 and 2005 should be maintained as these data could be useful in future analysis of other nesting trends.

The increase in nesting activity over the past two years is attributed to habitat conservation initiatives and protection of crocodile nesting habitat in most of the primary nesting sites.

**Recommendations**

- Although increasing to stable nesting trends are depicted for both crocodile species, it is critical the long term monitoring programme is maintained by DEC and ensure sufficient funds are available on an annual to biannual basis.
- Capacity building is critical to ensure new scientists and community based organizations are adequately trained through hands on experience to ensure sustainability of the program
- Support existing programs such SWMI and WWF etc.
- GIS of survey sites and production of aerial survey photographs as sites have changed over time (long term)
- Crocodile harvest data needs to be continued to be collated as a secondary monitoring exercise to the aerial surveys to indicate harvest levels and trends by provinces and size limits.
- Continue to stream line surveys through carrying out surveys on a biannual basis and erasing surveys routes which indicate zero nesting over time
- Promote preliminary research and surveys with international organizations, government agencies regarding impact of introduced fish on crocodile nesting habitats.

**ACKNOWLEDGEMENTS**

Firstly our thanks to the Department of Environment and Conservation, especially Dr. Wari Iamo, Secretary of the Department, for organizing funding for the conduct of the aerial surveys. We extend our appreciation to Benny Gowep for been part of the survey team for nearly two decades.

The support of the Crocodile Industry, Greg Mitch of Bush Development Corporation and Mainland Holdings is acknowledged. Without their continuous support this report would not have been presented at the CSG meeting in France.

All these persons and organizations have in one way or the other been instrumental in the crocodile program over the many years; John M. Genolagani, Godfrid C. Solmu, Jack Cox, David Wilkins, Juda Nundima, SWMI, and SIL Aviation,
REFERENCES


Report on the II National Workshop “Cuban Crocodile Status and Conservation Priorities”

Ramos Targarona, Roberto (Ed.)

Parque Nacional Ciénaga de Zapata, Cuba.

ABSTRACT: This will be a report on the forthcoming Workshop on Cuban Crocodile Status and Conservation Priorities (to be held May 12-17, 2008), an update of the one held in June 2006. This time, the discussions will include a more broad range of participants, including government representatives and decision makers at different levels, community members and guest specialists from different countries, who will discuss all issues related to Cuban crocodile status, present impacts and conservation strategy. Among the novelties that will be subject of discussion, are the preliminary results of ongoing research on Population Genetics and their implications for Cuban crocodile conservation. This report will be like hot, just baked bread. Obviously, we cannot forward an Abstract in advance.
ABSTRACT: The existing small population of Mugger crocodile inhabit in southeastern part of Iran near Pakistan Border. The small but scattered population occupies vast type of fresh water habitats in the area. The main habitats could be classified in two main natural and artificial habitats. The main natural habitats are the small and large ponds along the main rivers, Kaju, sarbaz and Bahukalat. Most of these ponds have similar characteristics providing suitable habitats for the crocodiles. Generally, crocodiles avoid from shallow and running parts of the rivers and prefer fairly deep and calm parts of the rivers with suitable vegetation and sandy banks. As the other main habitat type, artificial water bodies also play essential support for the crocodile population too. Small and large ponds nearby villages constructed for the rain water storage as well as the dams constructed along the rivers supposed to be important habitats for the crocodiles too (Mobaraki 2002). The main part of the crocodile range due to its importance as crocodile habitat designated as “Protected area” named “Gandou” (local name for the crocodiles), more over some parts of the area also have designated as 19th Ramsar site of the country which annually host large numbers of migratory birds. The movement of crocodiles between the habitats is a quite usual recorded behavior in the area. In most habitats the crocodiles have close contact with local people. Different fish, amphibian and bird species are the main food resources for the crocodiles in these habitats. Some ponds in border area are supposed to be as crocodile habitats too, and some reports from local people indicating movement between the habitats of Iran and Pakistan have reported. Constructed dams on the main rivers had important effects on the habitats too.
Recent Finds on mugger Crocodile study in Iran

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ABSTRACT: Mugger population was quite unstudied species in the country before. The main existing information was for the far years reported by Minton 1966, Kinunen 1970, Tuck 1975 and Anderson 1979. So in the past years field work and studies in order to collect information on biology and other different aspects of crocodile life cycle have been as a main activity. Reproduction of crocodiles was one of the important subjects that the gained information was as the first records in the country. Nesting season, location of the nests, eggs, hatchlings and their mortality rate were studied in this relation. Nesting season for Mugger crocodiles in Iran starts in April- May and the eggs hatch in June-July. We have records of 24 and 26 eggs with 8 cm length, 4.7 widths and 80-90 gr. Weight (Mobaraki 1998, 2002). The location of the different found nests indicates that in normal situation the crocodiles use fixed specific areas for the nesting. The results gained from collected hatchlings from 3 nursery sites show average length of 30.25 cm and 87.35 g body weight, N= 8 hatchlings, (Mobaraki and et all 2006). Relative to the number of eggs, the number of surviving hatchlings indicates a high mortality. The main feeding behaviors and resources of crocodiles through fecal sample collections also was identified which shows the crocodiles use different sources as food like insects, birds and fish species, but they are mainly dependant on fishes. Burrowing and movement between different habitats and water bodies were the most common recorded behaviors of crocodiles. The movement behavior seems to be a potential threat for the crocodiles too (Mobaraki and Abtin 2007).
Eggs harvest records versus night counts in *Caiman latirostris*: What do they really mean?

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\(^3\) Secretaria Estado de Medio Ambiente y Desarrollo Sustentable de la Provincia Santa Fe

**ABSTRACT:** Information on the situation of crocodilians population under management (i.e. ranching), is crucial in order to verify the sustainability of the program, but it seems very difficult to be achieved with the standard night counts monitoring techniques in species with cryptic behavior like *Caiman latirostris*; so we present and discuss the value of the information on 15 years of eggs harvesting in one of the most studied populations of the species, in a location where harvest effort was similar among years since the beginning of the project, and where the majority of the nests (90% to 95%) were always available for the eggs collection. We compared this information with our monitoring records in the same period and location. We found that nevertheless night counts showed an average recovery of the population of 50%, the number of nests and eggs harvested increased in 750%. On the other hand, we found that negative environmental conditions like droughts, affected positively the results of the night counts, with more animals counted per km. (9.2), but clearly, those years the egg harvest was lower than the ones with average environmental conditions, which produces 5 or 6 times more eggs, at the same time night counts were of 5 to 6 animals per km. Finally, we also found that the major increase in eggs harvesting, happened after the ninth year from the first releasing, which coincide with the published information on the age of sexual maturity of the species. We are proposing here to utilize the information on eggs harvest, combined with the night counts results, in order to be able to evaluate the population status of species with habitat preferences such as *C. latirostris*.

**INTRODUCTION**

Information on the situation of crocodilians population under management (i.e. ranching), is crucial in order to verify the sustainability of the program, but it seems very difficult to be achieved with the standard night counts monitoring techniques in species with cryptic behavior such as *Caiman latirostris*.

The Broad-Souted Caiman is one of the species that mostly uses heavily vegetated and shallow water environments, this makes really difficult to obtain reliable information on the populational situation because those places are often almost inaccessible for vehicles and people.
METHODOLOGY

Here we present information of 15 years of eggs harvests in one of the most studied populations of the species, in a location where harvest effort was similar among years since the beginning of the project, and where the majority of the nests (90% to 95%) were always available for the eggs collection, called Laguna El Fisco. We compared this information with our monitoring records in the same period and location.

RESULTS AND DISCUSSION

We found that night counts showed an average recovery of the population from less than 1 caiman per kilometer, up to almost 10 caimans per kilometer in 2000, then decreased to 4 caimans per kilometer in 2006 and 2007 (Fig no 1).

Figure 1. Night counts from 1992 to 2007.
Meantime, the number of nests and eggs harvested increased in 750%. (Fig. nº 2).

![Graph showing eggs harvest from 1992 to 2007.](image)

**Figure 2.** Eggs Harvest from 1992 to 2007.

Even thought that night counts seems to stabilize after year 2006 and 2007 at a level similar or even lower than in 1997 and 2000, the eggs harvest continued increasing, mostly after year 2001. This is actually coherent with the fact that at that time, most of the released caimans at the beginning of the 90’s, supposedly must start to breed, accordingly with the published information on the age of sexual maturity for the species (Larriera *et al.*, 2006). On the other hand, we found that negative environmental conditions like the drought in 2000, affected positively the results of the night counts, with more animals counted (9.2 ind. Km⁻¹), but clearly, those years the egg harvest was lower than the ones with average environmental conditions, which produced 5 or 6 times more eggs. We are proposing here to utilize the information on eggs harvest when possible, combined with the night counts results, in order to improve accuracy on the evaluation of the population status of species with habitat preferences such as *C. latirostris.*
Hatching success of black caiman (Melanosuchus niger) nests and spatial relations on egg collection by humans in the Mamirauá Sustainable Development Reserve, Brazil

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ABSTRACT: Predation and flooding have been identified as the main causes of egg mortality for many crocodilians species. Mortality could be due to egg consumption by humans, a common practice in the Mamirauá Sustainable Development Reserve (MSDR). This study is aimed to answer the question: is the egg collection by people related to nest proximity to human communities? We searched for black caiman nests walking on the shore of 41 water bodies. We visited all nests twice to determine nest fate. We found 148 black caiman nests in 21 of the 41 studied water bodies. The proportion of hatched nests was 15%, flooding was responsible for egg mortality in 13% of nests; 70% of nests were predated. Humans were responsible for 36% of all predated nests (about 1140 eggs). Tegu lizard (Tupinambis sp), jaguar (Panthera onca) and probably brown-capuchin monkey (Cebus apella) were responsible for 63.7% of all predated nests.

We developed a cost-distance model to find out if the egg collection is limited by the distance to the lakes. We related the cost-distance values of each lake with the proportions of eggs taken, through regression models. We did not find influences of the cost-distance values on the proportions of nests collected by people. This suggests that there are economic incentives that justify travel efforts to the interior lakes. Pirarucu (Arapaima gigas) fishing, which coincides spatially and temporally with black caiman nesting, could be the incentive indirectly associated with egg collection. Since black caiman sustainable harvesting programs are being developed in the MSDR, it is necessary to establish limits on the human consumption of eggs in order not to compromise potential earnings from managed caiman hunting and population dynamics.

RESUMO: Predação e inundação de ninhos têm sido identificadas como as principais causas de mortalidade de ovos de muitas espécies de crocodilianos. A mortalidade pode se dar por consumo humano de ovos, uma prática comum na RDS Mamirauá. Esse estudo pretende responder a pergunta: a coleta humana dos ovos de jacaré-açu está relacionada com a proximidade dos ninhos com as comunidades humanas locais? Percorremos a pé a margem de 41 corpos hídricos na procura de ninhos de jacaré-açu. Todos os ninhos foram visitados duas vezes para determinar seu destino. Encontramos 148 ninhos de jacaré-açu em 21 dos 41 corpos hídricos estudados. A proporção de ninhos eclodidos foi de 15%, inundações foram responsáveis pela mortalidade de ovos em 13% dos ninhos. 70% dos ninhos foram predados. O ser humano foi responsável pela predação de 36% dos ninhos (aproximadamente 1140 ovos). O jacurarú (Tupinambis sp.), a onça-pintada (Panthera onca) e provavelmente o macaco-prego (Cebus apella) foram responsáveis por 63.7% dos ninhos predados. Desenvolvemos um modelo custo-distância para saber se a coleta de ovos de jacaré-açu é
limitada pela distância e a dificuldade para chegar aos lagos. Relacionamos os valores custo-
distância de cada lago com as proporções de ninhos consumidos, a través de modelos de
regressões. Não houve influência do valor custo-distância dos lagos na proporção de ninhos
coletados por ribeirinhos. Isso sugere que existem incentivos econômicos que justifiquem
o esforço de deslocamento até os lagos. A pesca de pirarucú (Arapaima gigas), que coincide
espacial e temporalmente com a nidificação do jacaré-açu, poderia ser o incentivo associado
indiretamente à coleta de ovos de jacarés. Sendo que programas de aproveitamento sustentável
de jacaré-açu estão sendo desenvolvidos na RDSM, é necessário estabelecer limites no
consumo humano de ovos de jacarés através de discussões com as comunidades locais para
não comprometer a dinâmica populacional e os potenciais ingressos econômicos do programa
de manejo.

INTRODUCTION

The development of crocodilian sustainable-use programs requires the estimation of
reproductive and survivorship parameters as well as age and sexual structure of the population
(Webb and Smith 1987). Egg, hatchling and juvenile survival rates are considered to be
among the most important factors affecting population growth of Crocodylus niloticus and
C. johnsoni (Hutton 1984; Smith and Webb 1985 in Webb and Smith 1987). Predation (Deitz
and Hines 1980; Hussain 1999) and flooding (Webb et al. 1977; Kushlan and Jacobsen 1990;
Campos 1993; Allsteadt 1994) have been identified as major causes of egg mortality for
many crocodilian species.

The black caiman (Melanosuchus niger) is the largest alligatorid in South America (Ross
1998) and has the second heaviest average clutch mass in the order Crocodylia (Thorbjarnarson
1996). Although individual crocodilian eggs contain a small proportion of proteins and lipids
(Manolis et al. 1987), total clutch masses average 0.67 and 6.2 kg (Thorbjarnarson 1996),
and likely represent an important source of energy for nest predators. Although Amazonian
turtle eggs are frequently traded (Klemens and Thorbjarnarson 1995; Moll and Moll 2004),
there is no similar information on human use of crocodilian eggs. In the Mamirauá Sustainable
Development Reserve (MSDR) it is common to find caiman eggs being collected by local
people. Thus, the present study is aimed to determine if egg collection pressure is related
with the proximity to human local villages. The objectives of this study were to: 1. quantify
hatching success and mortality, 2. identify the causes of egg mortality and 3. examine the
spatial relationships of egg collection by humans in the Jarauá Sector of the MSDR, during
the 2007 nesting season.

METHODOLOGY

Study Area – The Mamirauá Sustainable Development Reserve (MDSR)

The MDSR is the largest protected Varzea (subject to flooding by high sediment load waters)
forest in the Amazon Basin, with an area of 1.124.000 ha. It is located at the confluence of
the Japurá and Solimões rivers, about 600 km west of Manaus, in the Central Amazon,
Brazil. This study was conducted in an area of 25,500 ha (about one half of the total area
of the Jarauá sector), located in the southeastern portion of the MSDR (Figure 1). The human
population of the MSDR consists of 5.087 inhabitants and users (Data: Demographic Survey
Mamirauá, 2006-MSDI), locally referred to as “ribeirinhos”. The MSDR is a protected area
where black caiman sustainable harvesting programs are being undertaken. Varzea forests in the Central Amazon are characterized by periodic flooding with mean amplitudes of 10 m (Junk et al. 1989). In the MSDR, the highest water levels occur between May and June, and the lowest water levels between September and November (Ayres 1993). Black caiman nesting season occurs during low water levels (from September to December).

During the low water period, large volumes of water leave a great portion of the MSDR and many interior water bodies lose physical connection with the main water course. These water bodies are referred to as interior lakes, and have been identified as preferred black caiman nesting areas (Da Silveira and Thorbjarnarson 1997). These lakes are also home to the commercially valuable pirarucu fish \textit{(Arapaima gigas)} (Castello 2008) which is traditionally captured during low-water periods.

Figure 1. Location of the Study area. Source: Mamirauá Sustainable Development Institute.

Data Collection – We studied black caiman nesting in 41 interior water bodies between September 2007 and January 2008. We located the nests walking on the shores around the perimeters of water bodies. For this study, the lake margins were defined as the terrestrial area up to 20 meters away from the edge of the water. To determine nest fate, we visited all the nests found at the beginning and at the end of the incubation period, with a 30 to 60 day-interval between each visit. Nest fate was determined observing marks and egg shells left around the nests. In about one third of the studied nests we collected data of clutch and egg size.

Spatial Modelling – We developed a cost-distance model using the IDRISI Kilimanjaro program to find spatial relationships of egg collection by the people from the São Raimundo de Jarauá community, the principal users of lakes in the study area, this methodology was adapted from Seijas (2001). The cost-distance model is a tool that integrates remote sensing data (Landsat TM5 satellite images) with geographic-information-system information, in order to quantify how difficult (\textit{i.e.} costly) it is for the \textit{ribeirinhos} to get from their community to any one of the studied lakes, moving through surfaces with different degrees of locomotion.
difficulties (i.e. friction values). This was accomplished by creating a map of land covers with different values of friction to represent the relative cost of moving through each land cover type. The main criterion used to calculate the friction values was the mean velocity in which a ribeirinho travels on water using a 5 hp boat (between 5 to 10 km/h) or walks on land through different types of várzea forests (between 0.2 to 1 km/h) (See Table 1 for details of this calculation). Using these friction values and the distance between the community and the lakes, the model calculates a cost-distance value for each lake. High cost-distance values represent lakes located far from the community with difficult access (lakes in which the ribeirinho have to walk great distances on land), whereas low cost-distance values represent more accessible lakes located close to the community. We excluded from the analyses lakes where nests were absent. Finally, cost-distance values were related through regression models to the proportion of nests collected by ribeirinhos in each lake.

Table 1. Criteria used to calculate friction values for each land cover type.

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Mean velocity (km/h)</th>
<th>Friction value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open water</td>
<td>10</td>
<td>1</td>
<td>The base cost, the easiest and most utilized way to travel by ribeirinhos in the varzea</td>
</tr>
<tr>
<td>Water with exposed soils and floating meadows</td>
<td>5</td>
<td>2</td>
<td>Floating meadows impose higher difficulties to go through</td>
</tr>
<tr>
<td>High varzea forest</td>
<td>1</td>
<td>10</td>
<td>Relatively easy to walk but ribeirinhos have to carry heavy things as paddle canoes and fish</td>
</tr>
<tr>
<td>Low varzea forest</td>
<td>1</td>
<td>10</td>
<td>Relatively easy to walk but ribeirinhos have to carry heavy things as paddle canoes and fish</td>
</tr>
<tr>
<td>Chavascal forest</td>
<td>0.2</td>
<td>50</td>
<td>Very difficult to walk, virtually a barrier. Ribeirinhos avoid to walk on these poorly-drained topographical depressions</td>
</tr>
</tbody>
</table>

RESULTS

We located 148 M. niger nests in 21 of the 41 water bodies. We documented successful hatching in only 15% of the nests. Flooding was responsible for egg mortality in 13% of the nests, and in 3.4% of nests it was not possible to determine the nest fate (the nests were not found on the second visit). Predation was the main cause of egg mortality, totaling 69% of all studied nests.

Ribeirinhos were responsible for 36.3% of all nest predation (37 nests with mean clutch size of 30.8 eggs, about 1140 eggs). Other predators as tegu lizards (Tupinambis sp.), jaguar (Panthera onca), and probably brown capuchin monkeys (Cebus apella) were responsible for 63.7% of nest predation.

The cost-distance model identified the “Urucuraninha do cedro grande I” lake as the most costly for the community members to reach, as opposed to “Cobra” lake, which was the least
costly (Figure 2). Egg collection was found in both most and least costly to reach lakes, the regression models did not find a relationship between the cost-distance value and the proportion of nests collected by *ribetinhos* ($R^2 = 0.002$, $P = 0.852$). (Figure 3).

**Figure 2.** Land cover types, studied lakes, and Jarauá community in the Jarauá sector, RSDM A= Cobra lake (the least costly); B= Urucuraninha do Cedro Grande lake (the most costly); and C= Jarauá community.

**Figure 3.** Plot showing the percentage of nests predated by humans in relation to the cost-distance values in each lake.
DISCUSSION

One of the few publications where black caiman hatching success in the wild is reported suggested that flooding of nests is the main cause of egg mortality, while predation is negligible in two localities of the Ecuadorian Amazon (Villamarin-Jurado and Suarez 2007). For other crocodilians, predation has been identified as the main cause of egg mortality, but in many studies (Cintra 1988; Hussain 1999) the proportion of eggs taken was not higher than the number of eggs that hatched. In this study we found that a very high proportion (~70%) of nests was depredated. The presence of researchers in nesting locations could increase the probability of nests being found by non-human predators as found in *Alligator mississippiensis* (Deitz and Hines 1980). Further analyses that take this into account may explain part of the high predation that we found.

Caiman eggs in the MSDR are collected by *ribeirinhos* in most and least costly to reach lakes. Research on black caiman poaching in the MSDR suggested that the high prices paid for caiman skins in the past acted as an economic incentive for ribeirinhos to reach interior lakes to illegally hunt caimans. Once the skin trade was banned and replaced by a less lucrative meat market (which was still illegal), ribeirinhos quit hunting caimans in interior lakes but did not stop visiting those lakes in order to fish pirarucu (*Arapaima gigas*) (Da Silveira and Thorbjarnarson 1999). This suggests that pirarucu fishing is lucrative enough and justifies the distances to travel to interior lakes.

Today, illegal caiman meat hunting no longer occurs in Jarauá and apparently, there is no egg market in the low Japura river. Consequently the main use for caiman eggs in Jarauá is subsistence human consumption which does not generate economic incentives that would justify, by itself, great distances to travel. Since pirarucu fishing coincides spatially and temporally (between September and November) with black caiman nesting, we suspect that pirarucu fishing might be related to caiman egg collection. During the three-month pirarucu fishing season, no fishing activities other than those for local consumption are allowed in the Jarauá sector. The sustainable use program of pirarucu generated about 500,000 US$ in 2007 in the MSDR (Amaral and Barbosa 2008) and this strong economic incentive explains why the *ribeirinhos* are traveling to interior lakes. Black caiman eggs are a much appreciated aggregate value during pirarucu fishing activities and are a high-energy resource relatively easy to obtain once the ribeirinho is already in the interior lakes. The cost-distance model in this study considered only egg collection by the people from São Raimundo de Jarauá community because they use most often the studied lakes. There exists the possibility that people from communities in other sectors are illegally using the same lakes (Pers. obs.). Since the Jaraua community is the closest village from these lakes, to get into them from other places would mean even higher travel costs. If people from other communities are collecting eggs in the studied lakes, it strongly supports the idea that economic incentives from fishing activities (illegal in this case) justify the travel costs.

Caiman egg consumption is probably a traditional practice in the MSDR that probably existed long before the creation of the reserve, perhaps traditionally associated with fishing activities. Nevertheless, black caiman sustainable-use programs are being implemented in the MSDR and the high levels of egg consumption found in this study may compromise potential earnings from managed caiman hunting and population dynamics. In this sense, it is important to undertake discussions with local communities to address limits for egg collection activities.
It is also important that a long-term nesting monitoring program be implemented in this and other sectors of the reserve where it is possible that the relationships between nest fate and human egg collection are different.

AKNOWLEDGEMENTS

This study was financed by the Wildlife Conservation Society. The Mamirauá Sustainable Development Institute provided logistic support; the Instituto Nacional de Pesquisas Espaciais (INPE) provided the Landsat images. Benor G. de Souza provided field assistance; the Jarauá community people were always helpful in the field. The floating stations guards (Eder and Moacir) help permanently with hydrologic data collection.

LITERATURE CITED


**Nesting Habits of the Black Caiman** (*Melanosuchus niger*)
**in the Rupununi Region of Guyana**

**Peter Taylor.**

**ABSTRACT:** As part of a collaborative ecological study conducted with local Macushi Amerindians we report on nesting habits of locally healthy populations of black caiman (*Melanosuchus niger*). Complete data sets of detailed information, collected over two seasons report on 29 intact nests. Continuing observations of predation events and environmental perturbations were made. Parameters described included habitat usage and nest density therein, nest dimensions and composition, proximity to water, clutch mass and egg biometrics, insolation of nests, incubation period, temperatures of nests, hatching success, and maternal presence. Where possible hatchlings were later recovered and examined (N = 159 from 11 clutches). Mean clutch size for Rupununi *Melanosuchus* nests is 32. Range is 22 to 39. Eggs are very large. Egg mass means in some clutches exceed 155 grams. More than 80% of nests are chiefly of leave and twig composition receiving little or no insolation. Most nests are observed in oxbow, lake or pond situations but also occur along rivers. Over 30% of nests are visited by tegu lizards (*Tupinambis teguixin*) usually resulting in complete predation events. Attending female caiman are observed near nests over 80% of the time. Evidence is strong that mother caiman assist hatching of nests. Strong aftercare of offspring is observed.
A simple method of incubating crocodilian eggs for conservation aims

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ABSTRACT: Incubation of crocodilian eggs has been developed through many years and several trial and error methods, beginning with the monitoring and control of wild nests (in situ) and subsequently with systems that utilize seminatural and artificial incubation techniques that involve the direct manipulation of eggs. Nevertheless, the two first methods do not allow for the achievement of a controlled environment in which large scale egg incubation can be attained which is a very valuable tool in commercial captive breeding programs in addition to other programs that are focused on restocking wild populations. Very often incubation chambers are of great complexity and this limits their use in rural areas where the management of several clutches is needed in order to accomplish objectives that go together with a crocodilian conservation program.

The construction and design of an incubation chamber that is both economical and functional is very important and more so being that it can be used as an important tool in the management of endangered species of crocodilians. These incubators can be used by those communities that live side by side with these reptiles and may want to benefit from the sustainable use of these species coupled with the available wetland biodiversity in general. This system has been in use for more than ten years and applied in several conservation programs that include industrial and communitarian efforts. These techniques offer an alternative and efficient option for the management of wild populations.

RESUMEN El manejo de la incubación de huevos de Crocodylia se ha desarrollado durante muchos años mediante diferentes métodos, iniciando con el control y monitoreo de las nidadas in situ, y posteriormente realizando métodos de incubación seminaturales y artificiales que involucran la manipulación de los huevos. Sin embargo los dos primeros métodos no permiten la realización de incubaciones controladas a gran escala lo cual es de gran utilidad en los programas comerciales y de conservación. Normalmente las cámaras de incubación son de gran complejidad y esto dificulta su instalación en áreas rurales en donde se requeriría el manejo de múltiples nidadas para lograr los objetivos de los programas de conservación de Crocodylia.

El diseño y construcción de una cámara de incubación de fácil elaboración se presenta como una sencilla alternativa económicamente viable y funcional sobre la cual se pueden basar ingeniosos programas de manejo de especies de cocodrílidos que estén en peligro o que quieran ser aprovechadas de manera sostenible in situ con la participación de las comunidades que viven de la biodiversidad de los humedales.

El sistema ha sido validado por más de 10 años en diversos programas tanto industriales como comunitarios y actualmente es una eficiente alternativa de manejo de las poblaciones naturales.
Sex Determination in Reptiles

In reptiles, there are numerous species in which sex is determined by differences in incubation temperature and not by genetic fixation. That is why it is probable that in times of increasing temperatures caused by global warming, crocodilians could be one of the most affected groups of vertebrates. In hypothetical cases, increases in temperature affecting a specific region (inland, wetland, beachfront or other) and where there are residing populations of reptiles in which sex determination is based on subtle temperature differences probably could be affected drastically and in a negative way by altering the natural sex proportions encountered in healthy populations.

It has been established that in 70 species belonging to 43 families of reptiles, sex is determined by TSD, (Temperature Sex Determination). In turtles there is wide variation, in *Chelidae*, *Trionchidae*, and *Staurotypidae* sex is determined genetically GSD (Genetic Sex Determination). Moreover TSD is prevalent in the rest of families of turtles even though there are species with GSD. Belonging to *Chelididae* there has been a report for the Alligator snapping turtle.

With respect to the studied reptiles the vast majority exhibit GSD while TSD has been described in *Agamidae*, *Eublepharidae*, *Gekkonidae* and *Lacertidae*, in addition to all Crocodilians and Tuatara (*Sphenodon punctatus*), while in *Anfisbaenidae*, there has not been any species found to exhibit TSD, in snakes studies have been few and results cited are not determinant so that one can prove the influence of temperature in their sexual development, even though there have been studies with members belonging to *Colubridae*, *Elapidae*, *Pythonidae* and *Viperidae*.

Sex determination caused by variations in incubation temperatures have shown to produce 100% females in the following cases:

- Production of 100% female offspring at lower incubation temperatures with a pivotal temperature in which both males and females are produced in the same proportions.
- Production of 100% females at higher incubation temperatures with a pivotal temperature in which males and females are produced in the same proportions.
- Production of 100% females at lower and higher temperatures in which two pivotal temperatures are present.

The consequences of global warming are more evident in reptiles that exhibit TSD, these variations are converted into potentially dangerous situations in which a given population could generate in different breeding seasons only males or only females with dire consequences to the survival of the species, only the species that exhibit double pivotal temperatures could have an additional alternative in cases of higher temperature exposure, in addition egg losses due to these variations could be of significant importance. It has also been noted that males belonging to the order *Crocodylia* that have been incubated at the fetal stage at temperatures close to those that give rise to females develop penises of smaller size than those whom were incubated at temperatures more towards those that give rise to males (Lance, *verbatim*). At the same time numerous authors have done tests with regards to the influence that incubation temperature has on the adaptability, growth, development, and behavior of these reptiles after hatching.

Techniques focused on the study and control on the factors present in the incubation process
of reptile eggs, especially those of crocodilians have been characterized by not being invasive permitting them to finish their due course in their development naturally. The only material present being cylindrical nets around the nests used to capture the emerging hatchlings. These techniques do not diminish losses in case of flooding, human predation or increased temperatures but exhibit certain benefits as to point to the area in which the nest is located.

In those cases in which a population of crocodilians or other species of reptiles are at high risk due to the loss of nests by way of human intervention like that of floods (Bad use of hydroelectric power), global warming, increased presence of predators due to the inadvertent creation of suitable conditions such as Monitor lizards or Tegus (*Varanidae, Teidae*) in an area, it would be convenient to evaluate the advantages and risks of manipulating wild nests with the purpose of diminishing egg loss and at the same time controlling the sex proportions that are necessary in order to keep a population at an adequate sex ratio.

If studies of this nature determine these factors then it would be possible to develop an incubation technique that is economical, efficient, and precise and that can be applied to the regions where these species are distributed.

**The Incubator**

The incubator is a chamber or closed area constructed for the purpose of maintaining live organisms (mainly eggs) in suitable environmental conditions for their adequate growth and development. Efficient incubators should maintain a temperature and humidity gradient that is constant. (Medrano, 2001).

Artificial incubation is a hydrothermic system utilized in order to control and stimulate the development of eggs by artificial methods. In conservation programs that involve the manipulation and monitoring of eggs as well as in production farms at an industrial level, incubation is a necessary link in the chain of knowledge and production. Success in incubation of these eggs permits the hatching and rearing of eggs obtained from captive breeding and egg ranching operations in natural nesting areas. (*op.cit*).

**History**

Incubation of crocodilian eggs is a common practice in those countries that can benefit from the use of this resource. These species are subject to commercial use and man has found a valuable use for these reptiles in the food and fashion industries.

In Colombia the need to establish an efficient technique in order to attain good results in the incubation of caiman eggs (*Caiman crocodilus fuscus*), favored the development of numerous systems and chambers with varying degrees of complexity and costs in which the priority was to achieve procedures that are simple and that allow the incubation of large quantities of eggs at the same time. This objective permitted the design of a vast number of systems and trials, some based on the scientific method and others not so much.

Very few of these systems functioned in an autonomic fashion during the long incubation process and success was attained more through discipline, observation and human effort than to the efficiency of the incubator itself. (Medrano 2001).
The use of previous methods such as water jackets\(^2\) such as those developed in Australia were useless in the sense that these systems were developed for holding a few hundred eggs and not thousands as those encountered in Colombian breeding operations that soared above (20,000) per farm. This was a puzzle that had to be solved being that the humidity and temperature gradients were very hard to stabilize in the large chambers utilized to accommodate the large number of eggs produced year after year. The main concern was that the humidifiers generated permanent flaws in the conventional electrical wiring complicating the incubation process. (*op cit*).

The system would get even more complicated due to the mixing of eggs of different ages with no data as to what female they originated from or when the hatching date was expected. Later on the nests were placed in boxes of different materials and sizes with the objective of separating clutches. Eggs were placed on leaf, mulch and wood shavings.

Water was provided by way of spray bottles or hoses and the temperature through hot stove metal or warmed water reservoirs placed at the bottom of the chamber. This did not allow an even distribution of the humidity and temperature causing high egg mortality.

**Updated System**

Afterward new techniques were developed in order to manage individual clutches with the use of racks, trays and were supplied with water by way of light humidifiers (spray systems and nebulizers). Trays were placed over racks and suspended over water containers that were 3cm deep, air distribution was achieved through a complex system of hoses and tray covers made out of plastic with no adequate control of the trays internal humidity and the bubbling of the water generated by the air hoses caused a permanent loss of clutches. The system was simplified in the year 1994 and later in two years the dry incubator (Medrano 2001) was developed. This incubator utilized the neutral mineral (ph7.2) and reusable known as vermiculite\(^3\). This material has been used traditionally in several zoos and herptariums and is used as a substrate for the incubation of a wide variety of reptile eggs sometimes *Sphagnum* moss. Vermiculite can also be replaced by zeolite (aluminosilicate) and perlite (amorphous volcanic glass) those of which function efficiently as substrates.

The key to this system lies in the *water/vermiculite* ratio (volume/weight) of 10/1 or 15/1 ratio which is used in the majority of incubators that hatch caiman eggs in Colombia. The ratio most often used is the first and the other minor variations are applied with no dramatic alterations that affect the hatchability of the eggs. With this ratio and with a standard sized tray that is used in our incubation systems the ratio consisting of 1500gr of vermiculite and 150cm\(^3\) water was established. This same amount of water added at the beginning is available throughout the incubation process which takes approximately 75 days. Managing this proportion and making sure that the vermiculite is dry prior to adding the water is imperative for success in hatching.

Smaller trays must be evaluated due to the volumes of air that are stored in them once closed and to which the oxygen that will be available to the eggs throughout the incubation process will be supplied.

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\(^2\)Isolated chambers in which the walls are subject to a permanent waterfall which runs down the wall in a continuous manner and is accomplished by way of a complex network of pipes, pumps, and heaters in which the desired temperature is achieved through the warming of the water itself.

\(^3\)Expansive medium comprising of the mineral mica with a great capacity for holding water, low cost and easy to obtain.
The use of this material (vermiculite) coupled with the monitoring of other variables and careful collection of data have permitted that this same technique be applied to other species such as *Crocodylus acutus*, *Iguana iguana*, *Trachemys scripta callirostris*, *Kinosternon scorpiodes*, *Chelonoides carbonaria* and was successfully used in two clutches of Colubrids of the genus *Liophis sp.* and *Oxibelys sp.*

Due to the small volumes of water that are utilized in this system and to the fact that it is added at the beginning of the incubation process there have been reasons to name this incubator a dry incubator which differs markedly in contrast to the Australian Water Jackets. This system is used successfully in 85% of the commercial breeding programs in Colombia.

The dry incubator is of simple design and low cost permitting it to become an important tool in efforts for establishing effective conservation programs focused on many species of reptiles.

From experience it is known that one of the major limiting factors affecting reptile conservation efforts focused on the possibility of giving sustainable use to many species of reptiles such as turtles and crocodilians lies in the adequate management of nests and transfer of egg clutches for protection and control.

**Justification**

Next noted are some considerations which are gathered from Medrano (2001) for the use of artificial incubation systems.

Beforehand there must be clarity as to specify that this system of artificial incubation is an invasive system and must be managed with caution. From every point of view it is clear that natural processes are very important and must be prioritized before any type of intervention is taken. On the other hand certain aspects have to be kept in mind in order to obtain a more detailed analysis of what would be defined at this day and age as a natural process being that this concept can be evaluated in different ways:

- We should assume that global climate change with its rapid warming pattern is a natural process? Or in contrary this global warming is caused and has accelerated because of the natural activities of man? In either case the evaluation focused on whether or not artificial incubation should be developed for conservation purposes should be applied for use with the species that are most affected by these changes.

**Social Component**

In another sense, conservation programs must include a strong social component in the sense that native communities must benefit from this resource and must participate actively in the process. For this reason it is important to determine if the conservation program views the possibility of artificial incubation of egg clutches. Such a study must be done in an area where the community participates directly in this process and that it will only work if it is involved. If absent from the process the desired results will probably not be obtained.

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4 Increase in temperature from 1 to 3.5 degrees centigrade in the course of this century
Once there is an active role in the community, there will be a possibility to develop a conservation program that views artificial incubation as a main objective. In an intrinsic manner the development of this objective will have the virtue of being involved with the different participants belonging to these communities in which there will be recognition for women and children that otherwise would not be in contact in an educational and conservation oriented manner with the specimens that are utilized for cultural and commercial reasons.

A system of artificial incubation that is organized and technified is the fundamental principle in an environmental educational program that is focused on a successful long term commitment by way of getting to know in a practical sense two fundamental periods in the life of these organisms; incubation coupled with the delicate handling of eggs and the hatching of the new beings. With intelligent management of this material it would be very difficult for an educational program to fail.

**Development of the System**

In order to implement effectively the dry incubator in a communal environment there has to be a baseline study of the area in order to determine where exactly the system will operate. For this reason there must be a carefully selected area where the incubator will be constructed keeping in mind the following aspects:

- If possible, the area that is chosen should not be more than 15 or 20 minutes by foot from the area where the egg clutches will be collected.\(^5\)
- There must be good shade above the incubator in order to prevent the direct rays of the sun from hitting the incubator directly.
- If this possibility does not exist an area of shade must be constructed above, it could be below the tree line or a cover may be constructed consisting on palm leaves or darkened shade cloth (75% protection) in which the incubator shall be constructed below. A good alternative could be to install and adapt the incubation chamber in a room belonging to a house of some community member that takes part in the project Medrano (2001).
- The chamber must have a volume sufficient enough for the air to be stable with respect to temperature as long as possible. Volumes below 12m\(^3\) are not recommended.
- Whichever the final design, an incubation chamber located in a specific place or in a makeshift room must include a thermal barrier that is effective so that the temperature of the incubation chamber never exceeds 29 degrees centigrade in the hottest day of the year. In addition to using and effective insulating material with the purpose of keeping the temperature stable inside the egg chamber. Both concepts are different, overheating can be prevented but if there is no insulating material present the temperature will rise and fluctuate rapidly generating unnecessary strain on temperature control devices (thermostats).
- If the area chosen lies with no protection against the elements the incubator must be isolated thermally by way of the previously described methods and in fact be constructed of hollow brick, wood or other insulating material that will prevent the air in the chamber to escape.
- In order to achieve thermal isolation and stability there will be a room built and surrounded by a perimetral corridor limiting with a second wall leaving one

\(^5\) Given the case that these conditions are not encountered the area must be accessible through a motorized vehicle (terrestrial or aquatic) or of animal labor that permits the transport of clutches in a quick and safe manner.
In the interior of the chamber a system of racks made out of wood in order to place and organize the egg trays, this rack system must be designed consisting of various levels that are between 5cm above ground to 1.8 cm tall.

The interior electrical system must contain sufficient outlets and electrical switches.

Heat will be generated through various methods depending on the size of the chamber. Small chambers will have in their interior a spiral oven heater connected in sequence to a medium speed fan that will push the air within the chamber. This system will turn on and off depending on the thermostat (type sauter) electromecanic, set for this function or other digital device. For this reason the more thermically isolated the chamber the heating device will most likely turn on between long intervals and be in heating mode for short periods of time. If there is no electrical power in the area, the system should be energized by a small power engine. In chambers comprising of larger incubation chambers the hot air will be conducted through 6” PVC pipe that is perforated with small holes and installed.

Figure 1. Illustration showing incubation chamber. The air chamber created between the two walls in the perimetral corridor is fundamental in keeping the incubators temperature at low Temps that should remain between 26-29 Centigrade in the hottest days.
Chamber Function

Posterior to the construction of the system and of the incubation chamber the next step would be to manage in a routinely basis the revisions and collection of data in which the specific information pertaining to egg clutches will be gathered. One system will operate in a permanent and efficient manner in accordance to the following principles.

a) Individual egg tray clutch management.

b) Collection of individual data for each of the nests in which the information pertaining to the date of recollection, place and time of nest retrieval, number of eggs, sterile eggs, level of incubation, monitoring of mortality in a periodic manner in periodic time lapses (days), date of hatching, total hatched and finally incubation length (Table 1).

c) Follow up on temperatures in the different levels of incubation and collection and filing of data in a format specially designed for this purpose.

Table 1. Register of data collected from clutches incubated artificially in an incubator under controlled conditions, H* refers to fetuses that are completely formed but fail to hatch and N** registers the neonates born but dead in the incubator. The numbers under the column “mortality check” refer to days that pass until another revision is due.

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The placement of the clutch in the incubator can determine the sex of the hatchlings keeping in mind that incubators without permanent internal ventilation tend to exhibit thermal stratification which give rise to differences of even 3 degrees centigrade between the lower and upper areas; the lower could give readings of 29 degrees centigrade and the higher of 32 degrees with an approximate distance of 2.2m between the two.
In the majority of farms embryonic death occurred due to poor recollection techniques that
gave rise to a significant percentage occupying an important place in diagnostic studies.
Keeping this in mind the following factors are presented that must be controlled and that
have an effect in the successes or failures of the systems of artificial incubation. In addition
to this it is important to note that embryonic death occurs principally within two stages of
embryonic development, at the beginning of incubation and at the end. This is due to the
fact that early in development embryos die because of nutritional deficiencies exhibited in
the breeding females, damage that occurs during recollection and transport or alterations
in their genetic makeup. At the same time embryonic death at the end of incubation is due
mostly to the lack of energy stores in the egg reserves of genetically deficient eggs.

Considering the previously stated facts there should be an extremely careful and diligent application
of these techniques in order to minimize embryonic death due to nest and egg manipulation. Next
we will present some of the factors that must be observed, analyzed and if possible controlled due
to the fact that they influence the success or failure of artificial incubation systems.

- Habitat characteristics, availability of nesting sites and material for nest building.
- Detection routines and recollection techniques.
- Clutch placement in plastic trays
- Careful management of ratios between vermiculite and water in each tray.
- Daily supervision of the incubation system
- Daily monitoring of temperature inside the egg chamber

If these steps are followed it is possible to attain a 75% or above hatch rate.

Final Considerations

For the specific case of crocodilian conservation it is emphasized that natural management
must prevail over just good intentions that are usually accompanied by unfounded manipulation
of the term conservation. Nevertheless in cases where populations that are studied present
a certain degree of decline and detriment in their structure any effort in conservation no
matter at what level (eggs, hatchlings, juveniles or adults) a well founded conservation
program is a good and viable alternative. With respect to artificial incubation, this technique
that has already been applied with success in various species of reptiles can be replicated
with sure results and is an important tool for acquiring information that otherwise would
be difficult to attain. Being that we are dealing with conservation programs in wild habitats,
the surrounding communities must be well informed and active and must participate fully
of all expectations an results of such programs.

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Variation of incubation temperature in nests of *Crocodylus moreletii*

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ABSTRACT: To date, very few studies on the evaluation of the variations of the incubation temperature in nests of crocodiles in natural conditions have been developed. The main goal of this study was to analyze and the variation of incubation temperature in nests of *Crocodylus moreletii*, in relation with the environmental conditions. During the harvesting season of 2007 of *C. moreletii* (June-August), eight nests located near Campeche City, Mexico were selected: six nests were located in the Centro de Estudios Tecnológicos del Mar N° 2, and the other two were located at a local breeding farm. In each nest, three digital thermometers were placed at the bottom, in the middle and at the upper parts of the egg cavity. Data loggers were programmed to record incubation temperature every 30 minutes, until the eggs hatched. In general, incubation temperature showed significant differences in the different levels inside the egg cavity, recording the highest temperature in the middle part. On the other hand, the incubation temperature is higher during the night than during the day in all layers. Environmental temperature and precipitation were the variables with more influence in the variation of temperature in the egg cavity.

RESUMEN: Hasta la fecha son pocos los estudios enfocados a evaluar las variaciones de la temperatura de incubación en nidos de cocodrilos en condiciones naturales; debido a ello, el objetivo de este estudio fue analizar y comparar las variaciones de la temperatura de incubación en nidos de *Crocodylus moreletii*, así como sus variaciones dentro del nido y la relación de la temperatura de incubación con las condiciones ambientales. En la temporada de reproducción 2007 (junio-agosto), fueron seleccionados ocho nidos ubicados cerca de la ciudad de Campeche, México: seis nidos localizados en el Centro de Estudios Tecnológicos del Mar N° 2 y otros dos en un criadero local. En cada nido se colocaron tres termómetros digitales en diferentes estratos de la cámara de incubación (superior, media, inferior). Los termómetros fueron programados para monitorear cada 30 min la temperatura, desde el momento que fue localizado el nido hasta su eclosión. En general, la temperatura de incubación presentó diferencias significativas en los diferentes estratos de la cámara de incubación siendo mayor en el estrato medio. Por otro lado, la temperatura de incubación es mayor durante la noche que en el día en todos los estratos, y en cuanto a la relación con el clima, la temperatura ambiental y la precipitación son las variables que más influyen en su variación.
The invasion and subsequent radiation of Caimaninae in the Neotropics, and the relationships of the extant species, with special reference to the Caiman complex

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ABSTRACT: Fossil records indicate a Laurasian origin of Caimaninae, with the split from Alligatorinae about 69 mya. Unfortunately, caiman evolutionary history is perhaps the least complete of all crocodilians. The earliest fossil caiman from the Neotropics (Argentina) is dated at about 50 mya. Fossil evidence for the extant genera is virtually non-existent and their evolution is unknown. Geologic studies during the last two decades have produced new information on potential faunal corridors through Central America, and a new vision of the genesis of the great river basins of South America. Molecular data from this study is used to demonstrate the relationships of the extant Caimaninae taxa. Divergence of Caiman yacare and C. crocodilus is estimated at about 7.5 mya. Results indicate that C. yacare is a distinct Evolutionary Significant Unit that merits full species status. Analyses of C. c. fuscus from Honduras are presented and it also is distinct, significantly different from both C. c. crocodilus and C. yacare in all tests. These data, combined with recent geologic findings, are used to hypothesize the potential evolution within the Caiman complex, including a recent re-invasion of Central America.

INTRODUCTION

Crocodylian origins are estimated to have arisen over 200 million years ago (mya) (Brochu 2001). A remarkable radiation of species developed from their Archosaurian ancestors and this rich evolutionary trajectory continues today. Modern forms are traditionally divided into three lineages: Crocodyloidea (‘true’ crocodiles and relatives), Gavialoidea (gharials), and Alligatoroidea (alligators and caimans), all with fossil records dating from the Late Cretaceous (Brochu 2003).

The extant species of Alligatoridae have developed relatively recently and very little fossil evidence exists for any of the caiman species. Their morphological characters lend scant inference to phylogeny for the group. Molecular analyses were employed to define the topology and to add information on their possible evolution. Details on laboratory procedures have been omitted for simplicity. Molecular clock calculations, along with calibration from fossil evidence, were used to make divergence date estimations. Recent geological findings give new insights into the emergence of the Central American isthmus, closure of the Panama Seaway, and the development of the major river basins in South America. The development of the Neotropical caiman species resulted as a consequence of these processes. I consider below how historical biogeography might have occurred.

The Alligatoroidea (Alligator mississippiensis and all crocodylians closer to it than Crocodylus niloticus or Gavialis gangeticus) is composed of two Alligator species and a monophyletic
clade of 6 caiman species, the Caimaninae. This subgroup is composed of *Caiman crocodilus* and all crocodylians closer to it than to *Alligator mississippiensis*. This includes *Caiman yacare*, *C. latirostris*, *Melanosuchus niger* and the more primitive *Paleosuchus palpebrosus* and *P. trigonatus*.

**Figure 1.** Diagram of phylogenetic nomenclature for extant crocodylians. Arrows indicate stem-based group names (groups including a species and any other more closely related to it than to another species), and black circles denote node-based group names (last common ancestor of two or more species and all of its descendents) (simplified from Brochu 2003).

The early fossil records place alligatorid development in Laurasia due to fossils found in Europe and North America from the late Cretaceous (Taplin and Grigg 1989). *Alligator* appears to have originated in North America with fossils from the late Eocene, about 35 mya (Brochu 1999) and a subsequent radiation to Asia led to *A. sinensis*.

Few fossils exist for Caimaninae and Brochu (2003) describes the knowledge of the caiman evolutionary history as the least complete of all crocodilians. Brochu (2004a,b) estimates the alligator-caiman divergence occurred under the lower Paleocene, about 65 mya. Early caiman fossils from the Eocene have been located from North America. An ancestral lineage is believed to have dispersed to South America where subsequent radiation resulted in the living species. The Caimaninae appears to have an exclusive South American radiation with a recent invasion of Central America by *Caiman crocodilus*.

*Eocaiman cavernous* remains have been recovered in southern Argentina from Eocene strata dated at about 50 mya. *Eocaiman* is believed to have given rise to the modern genera (Langston 1965; Brochu 2003), but the fossil record provides no clear information about their relationships. *Melanosuchus* has the best fossil record for the group with specimens dating to the Pliocene (Medina 1976). Fossil remains attributed to a precursor of *Melanosuchus* and *Caiman latirostris* date from the Miocene (Langston 1965). No fossils have been reported for *Paleosuchus*. The two *Paleosuchus* species have features distinct from the rest of the Caimaninae and are generally considered more primitive. Biochemical and morphological analyses place *Paleosuchus* basal to the rest of the group (White and Densmore 2001; Brochu 2003).
MATERIALS AND METHODS

All of the samples prepared for this study consisted of fresh tissue, usually blood, and some published sequences were also taken from GenBank. Blood samples were taken from the cervical sinus using sterile 2 cc syringes and needles (Olson et al. 1975). A sample of about 1 ml was drawn and introduced into a vial containing blood lysis buffer (protocol modified from White and Densmore (1992). All DNA isolations were performed with a phenol-chloroform isomyl alcohol (PCI) isolation protocol modified from Hillis et al. (1996) with 95% ethanol precipitation.

All samples were obtained with proper documentation. The Bolivian Wildlife authorities issued CITES permit No. 00470 for export of specimens. Entry into the US was under CITES import permit No. 816827. Argentine samples were exported by Proyecto Yacare, S.A. with CITES permit No. 023752 and imported under US CITES permit No. 03US714329/9. Honduran tissue samples were obtained by the FLMNH during a CITES funded population survey mission. Venezuelan material was obtained by FLMNH from the caiman survey team of ProFauna, the Venezuelan Government Wildlife Service. Alligator samples were provided by the Florida Fish and Wildlife Conservation Commission. Paleosuchus trigonatus samples from the St Augustine Alligator Farm, St. Augustine, Florida were kindly provided by Dr. Kent Vliet.

Molecular Investigations

Once DNA isolations of the samples were completed, molecular analysis began. The following samples resulted in unique mitochondrial haplotypes (in brackets) Caiman c. crocodilus (n=12[4]), Caiman c. fuscus (n=20[1]), Caiman yacare (n=213[25]), Caiman latirostris (n=5[1]), Melanosuchus niger (n=5[2]), Paleosuchus palpebrosus (n=3[3]), and Paleosuchus trigonatus (n=2[2]).

The entire mitochondrial (mt) genome for Caiman crocodilus (Janke et al. 2001) had been published and served as the nucleotide base reference sequence. The Caiman mtDNA genome is 17,900 bp long and all further position references described below are relative to the Caiman mitochondrial genome of Janke et al. (2001) unless otherwise noted. Published sequences for Alligator mississippiensis (Janke and Arnason 1997), and A. sinensis (Wu et al. 2003), were incorporated in analyses. Additional sequences for Caiman crocodilus and Melanosuchus niger from Farias et al. 2004 were also used.

Birds have Archosaurian ancestry and are considered the closest living relatives to crocodylians (Sereno 1999; Brochu 2001). Sequences for the domestic chicken, Gallus gallus (Desjardins and Morais 1990) were used for comparison as an outgroup in some analyses. Recent molecular studies have determined that Testudines are likely a sister clade to crocodylians (Kumazawa and Nishida 1999; Iwabe et al. 2005). The mtDNA genome for the green sea turtle was published (GenBank accession number NC_000886.1) and sequences were also used as an outgroup in some analyses.

The highly conserved 16S rRNA gene was chosen for phylogenetic analyses. The Caiman 16S rRNA gene is 1593 base pairs (bp) long. I was able to successfully amplify a fragment over 1100 bp long for all taxa in this study. The highly variable cytochrome (cyt) b gene
was chosen due to great value for phylogenetic research and widespread use in intraspecific relationship analyses (Avise 2000, 2004). The *Caiman cyt b* gene is 1150 bp long, from position 14,461 to 15,610. I was able to amplify a sequence about 1200 bp long for all the taxa. The reconstructed fragment, corresponding from positions 14,461 to 15,660, represents the entire cyt b gene. Most PCR amplifications above were 25 µl volumes and the product were processed on ABI 3700 automatic sequencers.

Data Analysis

Sequences for 16S and cytochrome b were separately evaluated, and aligned with Sequencher 4.2. The resulting 16S contigs were then trimmed of missing data resulting in consensus sequences of about 1077 bases depending on insertion or deletions. The same process was performed for the cytochrome b data, resulting in sequences of about 1145 bases depending on indels. For one data set, the two sequences were joined into one string of approximately 2200 bases per species. Both *Gallus gallus* and *Chelonia mydas* served as out groups for initial analyses of Alligatoroidea as mentioned above. Files were then imported into PAUP 4.0b (Swofford 1998) for phylogenetic analyses and tree generation. The data set was subjected to the hierarchical likelihood ratio test (LRT, Huelsenbeck and Rannala 1997), by means of Modletest v.3.06 (Posada and Crandall 1998) to assign the most appropriate of 56 evolutionary models. A general time reversal plus rate heterogeneity among sites (GTR+G+?) was selected. Maximum likelihood (ML), minimum evolution (ME) distance and maximum parsimony (MP) trees were constructed by means of branch and bound or tree-bisection-reconnection algorithms. Analyses were performed using 16S and cytochrome b separately and combined. Additional statistical support was provided by Bayesian inference using MrBayes v. 3.1.1 (Huelsenbeck and Ronquist 2001; Ronquist and Huelsenbeck 2003).

RESULTS AND DISCUSSION

The constructed data set of 16S rRNA and cytochrome b sequences was employed for a preliminary analysis of Alligatoroidea. One sequence for each of the following species was used for the analyses: *Alligator sinensis* (As), *A. mississippiensis* (Am), *Caiman latirostris* (Cl), *C. yacare* (Cy), *C. crocodilus* (Cc), *Paleosuchus palpebrosus* (Pp), *P. trigonatus* (Pt), *Melanosuchus niger* (Mn), as well as *Gallus gallus* (Gg) and *Chelonia mydas* (Cm) as outgroups.

Alligatoroidea

Figure 2 shows the relationships between the species of Alligatoroidea under criteria for maximum parsimony. The general topology follows that given in recent publications using DNA (White and Densmore 2001), and a combination of DNA and morphological characters (Brochu 2003). There were a total of 2328 unordered characters of equal weight, 1167 constant characters, 517 parsimony-uninformative variable characters and 644 parsimony-informative variable characters. Gaps were treated as missing data. Starting trees were obtained via simple stepwise addition using *C. crocodilus* as the reference taxon. Tree-bisection-reconnection (TBR) branch swapping algorithm was employed. Bootstrapping was performed with branch-and-bound search and a 50% majority-rule consensus tree was enforced.
Figure 2. Maximum parsimony phylogram representing base changes for 2200 bp concatenated partial sequences of mitochondrial 16S and cytochrome b genes. Tree length is 2057, CI=0.761, RI= 0.565, RC=0.430 and HI=0.239. Species abbreviations are: Cc (Caiman crocodilus), Cy (C. yacare), Cl (C. latirostris), Mn (Melanosuchus niger), Pp (Paleosuchus palpebrosus), Pt (P. trigonatus) Am (Alligator mississippiensis), As (A. sinensis) C. mydas (Chelonia mydas), Gallus (Gallus gallus).

A maximum likelihood model of evolution (GTR+G) was established by Modeltest v3.06 using the Akaike Information Criterion (AIC). The assumed nucleotide frequencies (A=0.31910, C=0.30880, G=0.14440, T=0.22770) were calculated from the data set. A substitution matrix was constructed from the data set by Modeltest and six substitution types were used. Starting branch lengths were obtained using the Rogers-Swofford approximation method and no molecular clock was enforced during the test. All but one branch had uniformly high bootstrap agreement (see Figure 3).

This analysis supports the historic assumption of monophyly within Alligatoroidea and also within Caimaninae. Traditional systematic diagnoses for the clade have relied heavily on morphological cranial characters with certain assumptions on derived states. When Alligator serves as the most distant group, the bootstrap percentage values for unrooted trees following the same criteria above equal 100 for MP (10,000 replicates), and 100 for ML (1000 replicates) for the Paleosuchus branch in question.

Figure 3. Bootstrap values for support of Alligatoroidea phylogeny. Bootstraps values are maximum likelihood (ML-top), minimum evolution distance (ME-middle) and maximum parsimony (MP-bottom). Bootstrap values are for 1000 replicates. Bayesian inference in brackets (5x10^6 generations, 50,000 trees, 25% burnin). Species abbreviations as in Figure 2.
Caimaninae

With the basic Caimaninae phylogeny firmly established for this data set, the next step was to determine the relationships within Caiman. A new data set was constructed in which Gallus and Chelonia were eliminated. A sequence was constructed for Caiman c. fuscus from Honduras, near the northern extreme for the species, and added to this data set. The subspecies diagnosis is not clear as there is great overlap in characters with C. c. crocodilus, and the detailed distribution has not been determined. Questions remain whether the taxon represents a distinct evolutionary lineage or simply clinal variation within the Caiman crocodilus distribution. Results of analyses were inconclusive regarding the relationship of C. c. fuscus with C. c. crocodilus and C. yacare even with a reduced data set which eliminated distant Paleosuchus.

A new data set was constructed using only cytochrome b sequences. The 16S sequence was removed to eliminate possible confounding effects on these closely related lineages from this slowly evolving gene (see Figure 4). A 1092 base sequence was used for each taxa.

Tree generation under various criterion resulted bootstrap associations of C. fuscus with C. yacare over 50% of the time as seen by the bootstrap values in ML, ME and MP hierarchies, but sometimes was weakly associated with C. crocodilus (ML=29, ME=11, MP=20). Alternatively, C. yacare was associated with C. crocodilus (ML=11, ME=35, MP=20) (see Fig. 4).

A new data set was constructed for Alligatoroidea from cytochrome b sequences, with Gallus as the outgroup. Estimates of evolutionary events were subsequently made using rooting time estimates found in the literature. The early origin of birds has been calculated at about 240 mya (Brochu and Norell 2000) and the split between alligator and caiman was estimated in literature from 65 mya (Brochu 2003) to 75 mya (Wu et al. 2003). With my data set, the alligator–caiman split was estimated at 69 mya, consistent with the above calculations.

Figure 4. Minimum evolution distance phylogram (uncorrected 'p') for cytochrome b sequence comparison rooted with Melanosuchus (score 0.22141, branch length above; 1000 bootstrap replications with values below branch: top-ML, middle-ME, bottom-MP). Alternate trees and bootstrap values on the right. Species abbreviations are: Cc (Caiman c. crocodilus), Ccf (Caiman c. fuscus), Cy (C. yacare), Cl (C. latirostris), Mn (Melanosuchus niger).
Based on ML distance values generated with enforcement of a molecular clock using the cytochrome b only and combined with 16S data sets, the Cc-Cy/Ccf split occurred about 7-8 mya, with the emergence of Caiman yacare and C. c. fuscus at ~7 mya. This predates the rise of the Isthmus of Panama and closure of the Panama Seaway between the Atlantic and Pacific basins. Migration scenarios to account for this possible occurrence are discussed below.

Further investigation was undertaken to clarify the Caiman crocodilus complex and a new data set was constructed with cytochrome b and partial Control Region sequences of 1193 bases. Since many authors differ on the subspecies of the common caiman, analyses were constructed to represent one species with various populations. Sequences for two haplotypes from each of the major basins occupied by C. c. crocodilus (Orinoco and Amazon) and C. yacare (Amazon and Paraná) were selected for comparison with the C. fuscus haplotype. C. yacare and C. crocodilus were consistently separated (see Figure 5). With this data set C. fuscus is usually associated with C. yacare but with weak support and little additional resolution was established. Alternate trees associated C. fuscus with different arrangements of C. yacare haplotypes (ML=43, ME=35, MP=46) more often than with C. crocodilus (ML=32, ME=23, MP=31).

A new data set was constructed with cytochrome b sequences for analysis to determine not only the relative position of Caiman c. crocodilus with C. c. fuscus, but also to include comparisons with C. yacare, often regarded an additional subspecies. A total of 274 caiman representing 40 haplotypes were used for analysis.

![Figure 5](image-url)

**Figure 5.** Minimum evolution distance tree for cytochrome b data set using GTR+Γ evolutionary model; score=0.15676. Bootstrap branch support for Ccf not strong and the relationship remains unclear. Bootstrap values (1000 replications): top-ML, middle-ME, bottom-MP. Species abbreviations are: Cc (Caiman c. crocodilus), Ccf ((Caiman c. fuscus), Cy (C. yacare), Cl (C. latirostris). O = río Orinoco, A = río Amazon, P = río Paraná.

For the purpose of analysis, the six discreet populations were associated geographically into 4 groups referring to the sample localites: Central America (Honduras), Orinoco (Venezuela), central Amazon (French Guiana, Brazil) and southern Amazon (Bolivia, Paraguay). The French Guiana (FG) sample is grouped with the Brazilian population due to the most
parsimonious geographic connection for resulting gene flow. This logic is also applied to
associating the *C. yacare* populations even though the Paraguay haplotype technically lies
outside the Amazon basin boundaries, as does the FG sample. An AMOVA pairwise difference
test revealed 83.55% variation among groups, 12.63% variation among populations within
groups, and 3.82% percent variation within populations, all significant at the p=0.05 level.
Significant differences also were found for the population pairwise Fst test results at an alpha
level of 0.05 (see Tables 1, 2).

**Table 1.** Pairwise Fst test results, all significant at an a level of 0.05.

<table>
<thead>
<tr>
<th></th>
<th>Honduras</th>
<th>Venezuela</th>
<th>Fr Guiana</th>
<th>Brazil</th>
<th>Bolivia</th>
<th>Paraguay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Honduras</td>
<td>0.0000</td>
<td>46.4286</td>
<td>47.2500</td>
<td>46.3750</td>
<td>38.4615</td>
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</tr>
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<td>45.5934</td>
<td>1.6703</td>
<td>12.4643</td>
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<tr>
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<td>11.3791</td>
<td>0.5000</td>
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<tr>
<td>4) Brazil</td>
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<td>10.3936</td>
<td>1.0145</td>
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<td>40.3135</td>
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<tr>
<td>5) Bolivia</td>
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<td>40.3882</td>
<td>40.0486</td>
<td>39.0910</td>
<td>1.9589</td>
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</tr>
<tr>
<td>6) Paraguay</td>
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<td>40.6369</td>
<td>40.1918</td>
<td>39.2063</td>
<td>5.6868</td>
<td>1.4933</td>
</tr>
</tbody>
</table>

**Table 2.** Population average pairwise distances. Above diagonal: Average number of pairwise
differences between populations (πxy). Diagonal elements: Average number of pairwise
differences within population (πx); Below diagonal: Corrected average pairwise difference
(πxy-(πx+πy)/2), all significant at an a level of 0.05.

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As seen in column 1 of the two distance tables above, the closest group association to Central
America (Ho) is southern Amazon (Bo, also row 1 in Table 2). As seen in by the Fst values
(Table 1), there is no gene flow among *C. fuscus* and the other populations. The lowest value
is still very high (0.6002) between Brazil and French Guiana.

The results from this data set indicate that the *C. fuscus* samples used here represent a
distinct evolutionary lineage. Further investigation will be required to determine if there is
a clinal variation from Honduras to the distribution extremes of southern Ecuador and
western Venezuela. The caiman of the central Venezuelan coast have not been clearly
identified, and the relationship to *C. crocodilus* in rest of the country is unclear. The *C.
fuscus* populations west of the Andes have been isolated from *C. crocodilus* populations for
about 5 million years by vicariance events as outlined below.

In the hypothetical reconstruction of conditions during the time frame leading up to and
including the proposed migration events, three interrelated processes must be taken into consideration:

1) The geologic evolution of northern South America including the influence of Andean tectonics and development of the Amazon and Orinoco basins
2) The dynamic conditions of changing paleocurrents affecting the Panama Seaway and environs
3) The progression of emerging land mass and eventual closure of the Seaway by the isthmus.

Northern South America and caiman migrations

South American geography has been strongly influenced by the Guyana and Brazilian shields. These pre-Cambrian massifs dominated drainage and erosion patterns in the pre-Andean landscape. Early continental drainages flowed off the shield in a generally western direction to the Pacific (White et al. 1995). The influence of these highland regions continues today and they are the source for many affluents of the Orinoco, Amazon and Paraná drainages.

The South American Plate has been impacted by several peripheral plates. Most notable has been the convergence with the oceanic Nasca Plate along most of the western margin, leading to the rise of the Andes. This mountain building process began at least 90 mya and has not been uniform over the 7000 km length. The Andes north of Ecuador rose most recently and have divided into 3 principal branches (cordilleras): Western, Central and Eastern. The rising Andes fundamentally changed the drainage and weather patterns over the continent and the world.

As the mountains rose, a parallel axial trough was formed by crustal downwarping in the eastern foreland basin. As the previous drainage to the west blocked, new drainages off the forming Andes then flowed east into the trough. Fluctuating sea levels produced periodic intrusions that penetrated the continent along these trough basins. From the Caribbean, penetrations reached into the western Amazon and central Bolivia and from the south Atlantic, intrusions into the proto-Paraná area reached southern Paraguay (Haq et al. 1987; Hoorn et al. 1995; Lundberg et al. 1998).

By the late Cretaceous, the central Amazon appears to have had two important drainages: a minor one flowing east toward the present delta, and the other draining north toward the alternately brackish or marine foreland basin. The early Paleocene hydrology was characterized by reduced marine intrusions and increased fresh water flow northward from a huge watershed. The caiman lineage is believed to have invaded South America from Central America at about this time. Although no evidence exists for a stable land bridge between continents, there was a large volcanic arch that may have aided dispersal (see Figure 6).

This proto-Amazonian drainage system dominated much of South America from ~67 to ~8 mya (Lundberg et al. 1998). A fresh water plume would have extended outward from the coastal margin and created brackish conditions for a great distance. Successful migration may also have depended on the oceanic currents to extend this brackish environment along the volcanic Ave arc. Fluctuating sea levels could have, at times, reduced inter-island distances and provided a ‘stepping stone’ archipelago enhancing faunal connections. There are numerous records of continental interchanges in both directions between the late
Cretaceous and early Paleocene, including freshwater fish, birds, reptiles and mammals (Hallam 1994).

The pattern in northern South America continued for the next 50 million years. As the Andes grew in height and width, it imposed strong weather modifications. A western Amazon inland sea, “Lago Pebas’, has been proposed due to pooling of fresh water and periodic marine intrusions (Hoorn 1993, 1994). The cyclic marine intrusions continued but, partly due to erosional infilling of the forebasin, they did not reach the previous interior extensions.

Flow increased northward into the proto-Orinoco basin from a system that extended from Bolivia. Outflow existed in a large area near present day Lake Maracaibo and Falcón further east (Hoorn et al. 1995). Collision with the Caribbean Plate to the north and Cocos Plate to the northwest produced profound changes. There were significant drainage disruptions as the eastern Cordillera began to rise (ca. 12 mya) in Colombia and Venezuela. The Magdalena river valley was isolated and its large input to the Maracaibo basin ceased. From ~10 to ~8 mya there was an increased drainage via the Maracaibo and Falcón basins. Deep marine incursions ceased and to the south, the proto-Paraná drainage extended from southern Bolivia (Lundberg et al. 1998).

In the intervening time period to the present, active tectonism in the northern Andes resulted in closing the Maracaibo basin and forcing the río Orinoco eastward. The course of the Amazon also changed to the current Atlantic outflow. Major rearrangements occurred resulting in multiple interbasin exchanges of species (Albert et al. 2005). This accounts for the apparent incongruent distributions of many aquatic species and may be reflected to some degree in caiman distribution. A dynamic mosaic of marine, brackish and freshwater environments were evolving over a huge tropical area. Conditions were excellent at this time for caiman species development in northern South America.

Figure 6. Possible configuration at the end of the Cretaceous (ca. 65 mya) when the caiman lineage may have migrated to South America. Major Central American blocks have sutured allowing faunal movement (Me=Mexican, Ma=Mayan, Ch=Chortis). Arc ultimately moved east, forming the Lesser Antilles. Arrows indicate plate movement (after Donnelly 1988).

Measurements of the outflow of the río Amazon today indicate the magnitude of potential effects of an ancient river draining into the Maracaibo basin and adjacent Falcón basin. The
present Amazon annual average discharge is about 175,000 m$^3$/second (Sioli 1984) and the 250 km wide sediment fan reaches 680 km into the Atlantic (Putzer 1984). Depending on the season, the fresh water plume is transported northwest 600-800 km to French Guiana (Goulding et al. 2003). The ancestral plume of fresh water flowing north into the Panama seaway would have affected the salinity of near shore seawater for many hundreds of square kilometers.

Alligatoroidea do not possess lingual salt glands or display urine modification as seen in Crocodylus (Leslie and Taplin 2001). The lack of resistance to marine conditions has been attributed as a primary reason for geographic restriction of the group. But despite apparent physiological restrictions, caiman (and alligators) are not restricted solely to fresh water. Caiman populations resulting from natural migration events are found on islands off Colombia, Venezuela, Nicaragua and Panama, as well as Trinidad and Tobago. Occupied habitats within caiman distributions include brackish lagoons, estuaries and mangrove swamps (Medem 1981, 1983; Gorzula and Seijas 1989; Grigg et al. 1998). These occurrences demonstrate partial salt tolerance and the possibility for coastal marine migrations. In addition to effects from a river discharge plume and partial salt tolerance, proposed north and western oceanic currents at the time period would favor transport of both caiman and brackish water mass toward the emerging peninsula.

**Evolution of the Isthmus**

In the Middle Miocene (15.1-12.9 ma), the shallow seaway was open allowing warm Atlantic water to enter the Pacific and continental vertebrate faunas were generally isolated. By the late Middle Miocene (11.8-7.0 ma), there was partial emergence of the Panama Isthmus as sea levels varied, causing a disruptions of warm, westerly Atlantic currents. The cool California current flowed south along the west margin of Central America. Terrestrial faunal interchanges were first recorded at ~9.3-~8.0 ma (Marshall et al. 1979, 1982; Webb 1985; Duque-Caro 1990).

As time progressed, sea levels fell and the isthmus emerged as continuous (or nearly) dry land. The Great American Biotic Interchange (GABI) commenced in force about 3 ma (Stehli and Webb 1985; Webb 1991). Sea level changes may have produced temporary seaway connections in the late Pliocene in southern Panama. (Cronin and Dowsett 1996). Even today, areas of the Darien in Panama have a maximum height of only tens of meters above sea level.

Addition physiological factors may have contributed to successful colonizations of Central America by caiman before a continuous terrestrial landscape. Multiple paternity has been shown for *Alligator mississippiensis* (Davis et al. 2001b). There is also evidence that caiman (*Paleosuchus*) may employ sperm storage in reproduction (Davenport 1995). If these factors prove true also for *Caiman*, a single migration event of a gravid female could have resulted in the establishment of a new population with a robust genetic compliment.

There is compelling evidence that the conditions outlined above were advantageous for caiman expansion northward. Land mammals such as ground sloths migrated north from South America during the Late Miocene. Procyonids from North America traversed the route south about the same time. In addition to vagile mammalian species, several freshwater fish
taxa made successful migrations to Central America before a continuous land connection (Lundberg 1992; Bermingham and Martin 1998; Martin and Bermingham 2000; Lovejoy and Collette 2001).

The Central American freshwater ichthyofauna is largely of South American origin (Bussing 1985). In Bermingham and Martin’s (1998) analysis, they described freshwater fish species the Central American Atlantic coast slope drainages as more isolated than the Pacific slope drainages. They found the extant fish fauna to be the result of multiple colonizations across the isthmus beginning about ~7 mya near the close of the Miocene. Phyogeographic signal due to sea level rise and the re-establishment of the seaway (Haq et al. 1987) is observed in several studies (Bermingham and Martin 1998; Knowlton and Weigt 1998; Zeh et al. 2003).

The biogeographic history of Caiman c. fuscus may have followed a pattern similar to these histories. Andean tectonism, starting in northern Colombia and western Venezuela ~10 mya (Hoorn et al. 1995), gave rise to the Eastern Cordillera. This produced drainage division and vicariant separation of the existing caiman populations. The area biogeography outlined above, produced conditions for caiman colonization of Central America. The current evolutionary lineage, Caiman c. fuscus, is considered a subspecies of Caiman crocodilus but today is reproductively isolated west of the Andes. The Honduras population, the most distant Atlantic drainage C. c. fuscus from the source C. c. crocodilus population, has a ~7 ma history and has significant sequence divergence.

Conclusions

The following conclusions are given with the caveat that this data set is limited to molecular analyses of mitochondrial DNA sequences from 16S and/or cytochrome b genes only. Given the immense distribution of the Caimaninae, point locality sampling produces large intervening gaps in the data and transitional intermediate haplotypes certainly exist undetected.

1) Alligatoroidea forms a monophyletic clade derived from a common Archosaurian ancestor as recognized historically by conventional, morphological systematics.


3) Caimaninae forms a monophyletic clade with Paleosuchus in the basal position and Caiman yacare as the most recently derived species.

4) The lineage leading to Paleosuchus split from the other caiman ~53 mya (54 mya; Brochu 2004). Caiman crocodilus dates from about 7.5 mya.

5) The lineage leading to Melanosuchus split from the group at about 30 mya, with a more recent splitting of the C. latirostris line at about 24 mya.

6) Caiman crocodilus from the Orinoco and Amazon basins are currently geographically (reproductively) isolated and have formed distinct genetic populations. Divergence is estimated at ~2.75 mya and within basin radiation occurring in the last million years.

7) Caiman yacare and Caiman c. fuscus (Honduras population) are unique and separate evolutionary lineages, which arose independently from Caiman crocodilus ~6 mya in a combination of vicariance and dispersal events. They are also geographically, and hence reproductively, isolated from populations of C. crocodilus of the Orinoco and Amazon basins.
LITERATURE CITED


The Enigmatic Cuban Crocodile

John Thorbjarnarson1, Roberto Ramos2, Roberto Soberón2 and Manuel Alonso Tabet2

1Wildlife Conservation Society, PO Box 357625, Gainesville, FL 357520 USA
2Empresa Nacional para la Protección de la Flora y la Fauna: Calle 42 y 514 Esq.7 Ave., Miramar, Ciudad Habana, Cuba

ABSTRACT: The Cuban crocodile is the most morphologically, ecologically and behaviorally distinctive member of the genus Crocodylus. We argue that this is a result of species having evolved largely to fill the niche of a terrestrial predator in Cuba and adjacent Caribbean islands during the Pleistocene. During this period Cuban was home to megafauna of several species of ground sloths and no species of large mammalian predators. Contemporary fossil remains of Cuban crocodiles indicate the species grew significantly larger than it does today and. In this presentation we discuss evidence to support the hypothesis of Cuban crocodile was preying to a large extent on terrestrial mammals and much of its unique character are derived from its evolution as a terrestrial or semi-terrestrial predator. We also discuss the consequences of the extinction of the mammalian megafauna on Cuba some 6,000 years ago, and interpretations of how the Cuban crocodile has adapted. This information is vital for planning a conservation future for the species.
Use of archival tags to track large estuarine crocodiles in 3-dimensions

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The University of Queensland, Brisbane, QLD4072 Australia.

ABSTRACT: Satellite and radio-telemetry has been successfully used to remotely monitor the movements of crocodilians in their natural habitats. The advantages of using this type of telemetry include being able to monitor the position and movement of animals over large spatial and temporal scales. However, monitoring the fine scale movements, behaviours and activities of crocodiles through telemetry is problematic because of the high rates of data collection and transmission required. It is here, that the use of archival tags (data-loggers) comes to the fore as high sampling frequencies (e.g. >4 Hz) and large data storage capacity (>1 Gb) can now be easily achieved. There are however problems with the use of dataloggers, one being that the logger needs to be jettisoned from the animal and retrieved. In a recent study we attached data loggers to estuarine crocodiles that could determine their movements in 3-dimensions, including accelerations and compass bearings. I describe a novel method to allow for a timed release of the data-logger from the crocodile and present some preliminary data analysis.
Den construction and use by the American crocodile (*Crocodylus acutus* Cuvier) at the Monte Cabaniguan Wildlife Refuge, Cuba

Manuel Alonso Tabet 1,2, Roberto Rodriguez Soberón 2, Roberto Ramos Targarona 3, John B. Thorjarnarson 4

1 Monte Cabaniguan Wildlife Refuge
2 Empresa Nacional Flora y Fauna, Cuba
3 Parque Nacional Ciénaga de Zapata, Cuba
4 Wildlife Conservation Society

**ABSTRACT:** The American crocodile (*Crocodylus acutus*) is a proficient den digger; crocodiles of different ages use dens for thermoregulation, and as shelters to protect themselves or their offspring from predators, to prevent being swept along by too fast streams, and to store food.

In the five-year period comprised between 2003 and 2007, we documented several aspects of den construction and their use by American crocodiles of different sex and age classes, at the Monte Cabaniguan Wildlife Refuge, South-west Cuba. Our main subjects of research were den site selection, den dimensions, structure, and the structure-related role of red and black mangrove root systems; differences in the use of dens by hatchlings, juveniles, adult males and females; the relationship between den temperature and external temperatures of air and water, and their role in thermoregulation. We also describe den digging techniques, and the role of dens in the transformation of the swamp landscape by the crocodiles.
Genotoxicity of the herbicide formulation Roundup® (glyphosate) in *Caiman latirostris* evidenced by the Comet assay and the Micronucleus test.

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ABSTRACT: The genotoxicity of pesticides is an issue of worldwide concern. Any damage induced in essential portions of the DNA can become particularly pronounced when the lesions are produced during embryogenesis, when rapid organogenesis is taking place. The present study was undertaken to evaluate the genotoxic potential of a widely used herbicide formulation, Roundup® (glyphosate), in erythrocytes of broad-nosed caiman after *in ovo* exposure. Caiman embryos were exposed at early embryonic stage to different sub-lethal concentrations of Roundup® (50, 100, 200, 300, 400, 500, 750, 1000, 1250 and 1750 µg/egg). At time of hatching, blood samples were obtained from each animal and two short-term tests, the Comet assay (CA) and the Micronucleus (MN) test, were performed on erythrocytes to assess DNA damage. A significant increase in DNA damage was observed, at concentration of 200 µg/egg or higher, compared to untreated control eggs (p < 0.05). Results from the CA revealed a dose-dependent effect. This study demonstrated adverse effects of Roundup® on DNA of *C. latirostris* and confirmed that the comet assay and the MN test applied on caiman erythrocytes are useful tools in determining potential genotoxicity of chemical agents.
Identification of structures and reproductive stage in *Caiman crocodilus fuscus* females through ultrasound methodology

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**ABSTRACT:** In December 2006, we examined and identified the reproductive structures in 723 females of *Caiman crocodilus fuscus* using ultrasound methodology. The females averaged 63.2 cm snout-vent-length and 7.1 kg body mass. These individuals are part of the breeding stock in Salazar crocfarm close, to Barranquilla, Colombia. December is the month when courtship begins, therefore none of the females would have ovulated or nested. A total of 521 females without visible follicles (immature or non-reproductive) were diagnosed. Only 180 presented vitellogenic follicles between 3 and 30 mm in the ovary. Ninety of these females showed vitellogenic follicles in both ovaries; 51 females showed vitellogenic follicles in one ovary only; 39 females with follicles in ovary and/or oviduct on the right side. 22 females had calcified eggs from 32 mm to 69 mm in the process of reabsorption in different parts of the abdominal cavity. One female had 5 eggs in different states of resorption within a sac located in abdominal cavity and a ruptured oviduct around an egg. These abdominal eggs came from ruptured oviducts, failure to enter the oviduct after ovulation, or reverse oviductal peristalsis. Also we determined that the reabsorption process could occur in different parts of the abdominal cavity. This was observed after sacrificing 6 individuals to corroborate diagnoses.
Presence of red fire ants (*Solenopsis invicta*) in broad-snouted caiman (*Caiman latirostris*) nests.

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**ABSTRACT:** Sustainability of crocodilian ranching programs is based on the high losses of both eggs and hatchlings. *Solenopsis invicta* (Red Fire Ant - RFA) infestations on Caiman nests were related to a possible cause of the death of hatchlings before they can leave the nest, but this aspect was not studied in the original distribution of this ant. Our goal in this work was to analyze the proportion of *Caiman latirostris* nests infested with RFA during the last four nesting seasons. In order to know the amount of infested nests, we search for RFA in wild caiman’s nests during the entire nesting season. We observed that the proportion of infested nests increased as the season advanced, and by the last month, of incubation the infection was as high as 50\%.
Rainfall effect on the reproduction of *Caiman latirostris* (Crocodylia: Alligatoridae)

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**ABSTRACT:** Weather affects crocodilians’ biology, such as reproduction. Studies that could provide future information about nesting are extremely important for management programs based on nests harvesting. In this work, we analyzed the relationship between number of caiman nests collected and rainfall in Santa Fe province (Argentina) on six reproductive seasons with the aim of predicting future number of nests. First, we worked within a local scale; analysing number of nests in a certain area and rainfall for a nearby place. We then searched for a relationship in a regional scale. We found no relationship when looking at local scale, however, when we examined the regional scale, number of nests and clutch size were related to precipitation. Precipitation during September had a positive effect on clutch size. In addition, number of nests was affected by rainfalls during reproductive seasons 2002-2008.
Crocodiles Of the Regional Park Of W of Niger: Status and Perspectives of the Conservation

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ABSTRACT: Niger is a Sahélian country which contains significant faunal potentialities. In spite of these natural resources, the country has only one national park: The Regional Park of W of the Niger River. Thanks to its statute of integral and absolute protection, this park conceals more than 80% of the biological diversity of Niger. That is made up of approximately 150 species of reptiles and Amphibians. Among these reptiles one notes a very noticed presence of the crocodile of the Nile (Crocodylus niloticus) in the three (3) principal rivers (River Niger, Rivière Mékrou, and Tapoa River) which are on the way today to become, its sanctuary. One also finds the crocodile of the Nile in the multiple interior water points in particular on the level of certain ponds, permanent (Pérélegou, Bata, and Anana), semi permanent (Adamou pond, pond of Moussiémou) and some temporary (pond of Tchirobì Gangani). However, no situation nor given quantified complete on the manpower of the population of the crocodiles of the Park W is available before the partial census of November 2007 at the time of the 1er African Western Congress of the group of the specialists in the crocodiles. This study proposes to fill this vacuum through the realization of a counting of the crocodiles in the water levels of the Park W. With this intention; three (3) methods of counting were used: the direct counting of the individuals; indirect counting by Traces and Deposit; and the counting of the Burrows. With regard to direct counting, it was carried out on the level of the permanent water points of the rivers Mékrou and Tapoa, the river part of the park as well as the pond of Pérélegou. Counting of the traces and lees especially related to the drained point of water i.e., semi permanent and temporary. The counting of the burrows was carried out on all the water levels.

Keywords: Niger, Regional Park W, Crocodiles, Counting, Pond, river, Burrows, Deposit,
Crocoland SRL: First experience on farming and ranching of
*Caiman yacare* in Bolivia

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**ABSTRACT:** Crocoland S.R.L. is the first *Caiman yacare* farm installed in Bolivia. Under a management proposal that combines ranching and captive breeding systems. Crocoland began its activities in September 2006. The farm initiated with a parental stock of 2,000 yacares, 1,600 female and 400 males, extracted of wild populations from the Bolivian Pantanal, relocated at 29 kilometers of Santa Cruz de la Sierra city in 8 lagoons of 60 meters in length by 18 meters in width, with a density of 250 yacares in each lagoon. During the first year (2007) 853 nests were harvested from wildlife, producing 25,590 eggs, with a hatchling percentage of 73%. From the closed cycle, 312 nests were collected (9,360 eggs), with a hatchling percentage 75.01%. The total hatchling obtained (less 40 cm of total length) was of 26,291. In the first semester the mortality was of 11.75%, reducing the stock to 23,863 yacares. The ranching in wildlife in 2008 was 1,300 wild nests like that 35,932 eggs. For the closed cycle the nests production increased in 37%, obtaining 430 nests (like 12,480 eggs).

**RESUMEN:** Crocolond S.R.L.es el primer zoocriadero de *Caiman yacare* instalado en Bolivia. Bajo una propuesta de manejo que combina sistemas de *ranching y farming*, Crocoland inicia sus actividades en septiembre de año 2006. El zoocriadero cuenta con un plantel parental de 2.000 ejemplares, 1.600 hembra y 400 machos, extraídos de poblaciones silvestres del pantanal boliviano, reubicados a 29 kilómetros de Santa Cruz de la Sierra en 8 pozas artificiales de 60 metros de largo por 18 metros de ancho, con una densidad de 250 animales por poza. Durante el primer año de rancheo (2007) se cosecharon 853 nidos, de los que se obtuvieron 25.590 huevos, con un porcentaje de eclosión del 73%. Ese mismo año, en el ciclo cerrado, se produjeron 312 nidos, 9.360 huevos, con un porcentaje de eclosión del 75.01 %. El total de neonatos menores a 40 centímetros logrados fue de 26.291. En la etapa de desarrollo de los neonatos (6 a 7 meses), la mortalidad fue de 11.75%, produciéndose un plantel juvenil total de 23.863 animales. En el rancheo de año 2008 se colectaron 1.300 nidos silvestres, 35.932 huevos. Para el ciclo cerrado la producción de nidos se incrementó un 37%, obteniéndose 430 nidadas de las que se recogieron 12.480 huevos.
The status of the Saltwater crocodile (*Crocodylus porosus*)
inhabiting the Nilwala River, Matara District, Sri Lanka,
and its impact on the community

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INTRODUCTION

Two species of crocodiles: the Mugger or Marsh crocodile (*Crocodylus paluster* Lesson 1831) and the Saltwater or Estuarine crocodile (*Crocodylus porosus* Schneider 1801) are known from Sri Lanka (Deraniyagala 1939; Whitaker & Whitaker, 1979; Das & de Silva, 2005; de Silva 2007). References to crocodiles are found in the early literature of the country such as Buddhist Jataka stories (written around 5-8th century AC) e.g. Vanara Sumsumara Jataka, kumbila. The ancient chronicle *Culavamsa* (1: 70.4) also records that during the reign of king Gajabahu 1132-1153 AC, King Parakkramabahu's men could not pass the deep waters at Yatthikanda and Dumbara due to man-eating crocodiles (Geiger, 1929).

P. E. P. Deraniyagala was one of the first to conduct studies of both species of crocodiles of Sri Lanka (1930, 1939). However, the first status and census survey of crocodiles of the island was carried out by Rom Whitaker & Zai Whitaker in 1977 (1979). The present study could be mentioned as the first detailed investigation of the saltwater crocodile inhabiting one specific locality: the Nilwala River (south Sri Lanka). The present study also investigated several other related aspects of the saltwater crocodile, such as approximate numbers, status of their habitats, including nesting, human conflict and the knowledge and attitude of the people living in crocodile habitats along the Nilwala River. Awareness programs too were conducted to vulnerable people of the precautions that they need to take to avoid attacks by crocodiles and the importance of these reptiles in the river ecosystems.

*Crocodylus porosus* is highly a threatened reptile in Sri Lanka. It has only a few favoured natural habitats left, and presently most of these habitats are cleared, altered and under pressure by human activities. The study gave an overall perspective on where crocodile concentrations still occur (especially outside the Wildlife Protected Areas) and identify places where crocodiles are likely to continue to survive given some assistance with awareness and protection to the community in these areas.

STUDY AREA AND METHODOLOGY

Nilwala River, Matara, from Modara (Lands End) (North 5° 56’ 42.7” and E 80° 32’ 26.0”)
to Paraduwa (North 06° 04’ 09.3” and East 080° 30’ 55.0”), land water interface area, riverine mangroves and vulnerable people at Fort and Piladuwa, Matara (See Figures 1).

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1 The importance of this paper relates to the fact that this appears to be the first report from Sri Lanka since 1979. Since then we have had very few reports on the status of Saltwater crocodiles in this region.
METHODOLOGY USED

A structured questionnaire was administered to 53 householders in Fort and Piladuwa, Matara by the chief investigator and a survey team of six people from Sri Lanka Red Cross (DP) team.

Conducted boat cruises in the Nilwala River in the study area from 0800 to 1300 hours on three days for physical verification of the presence of crocodiles, assess the status of their habitats and discuss possible plans of action with people residing along the riverbank within crocodile locations.

The same river route was cruised at night (2000 to 2400 hours) to conduct the night “eye-shine” sampling technique using powerful spotlights. The survey team was dressed in dark clothes so they were not conspicuous to the crocodiles.

Interviewed fishermen to estimate the number of crocodiles accidentally trapped and killed in their nets.

Interviewed family members of victims who were killed by crocodile attacks as well as people who sustained minor injuries due to attacks.

Collected samples of mangrove plants and mangrove associate plants along the riverbank. These were immediately placed into separate plastic bags, and secured with rubber bands. These plants were subsequently taken to the National Herbarium, Botanical Gardens, in Peradeniya for identification.

RESULTS (SUMMARY):

- Observed fourteen *C. porosus* yearlings (under 600 cm) and 13 adults including a large (approximately 4.5 m) specimen.
- Encountered 31 and 39 pairs of eye-shines respectively during the night ‘eye-shine’ technique, which was conducted on two nights.
- Observed about 25 species of riverine mangrove plants and mangrove associate plants
- Investigated eight people who were attacked and killed by crocodiles.
- Investigated ten people who sustained minor injuries from crocodile attacks.
- Investigated 70 abandoned and in use ‘crocodile exclusion pens’ and 3 crocodile ‘fences’ that have been installed along Nilwala River.

THREATS

Direct threats to crocodiles due to human activities

Direct threats to crocodiles by human activities are: killing of supposed ‘man-eaters’, destroying eggs to control the growth of the species, killing of yearlings and sub adults which get trapped in fishing nets, (some drown in the fishing nets). In fact, one fisherman informed the author of killing five sub-adult crocodiles that had got trapped in his fishing nets in the past. Evidence of similar instances of fishery related mortality was revealed while interviewing several other fishermen. Furthermore, there is an increase in the fishing industry in Matara. Occasional attacks on humans give crocodiles a bad reputation. Just a single confirmed man-eater inevitably leads to many of the crocodilians in the vicinity being killed.
Direct threats to crocodile habitats due to human activities

Vast extents of the riverine mangroves and mangrove associated plants along the Nilwala River have been cut down for firewood, cleared for agricultural purposes as well as other development projects over the years.

Predators

The water monitor (*Varanus salvator*) attacks and feeds on large number of animals, including other reptiles, such as venomous and non-venomous snakes and crocodile yearlings and crocodile eggs. Deraniyagala (1939) also reports water monitors feeding on crocodile eggs. In addition, eagles, hawks and mongoose have all been observed to prey on yearlings. Large water monitors were common in the Nilwala River.

CONCLUSIONS

The KAP (Knowledge, Attitude and Practice) survey indicated that vulnerable people were unaware of most of the general facts about crocodiles. However, many important and interesting observations can be learned about the activities of crocodiles from these people as they observe them daily.

Regarding the human-crocodile conflict and attacks, investigations revealed that in all cases studied the fault was on the part of human beings. Yet many use insecure crocodile exclusion pens for bathing and washing. Thus, an intensive awareness program coupled with protective measures like installing ‘crocodile exclusion pens’, ‘crocodile exclusion fences’ and installing warning sign boards in risk areas were suggested. As far as crocodile attacks on pet and farm animals is concerned, most of these attacks have taken place in the river-land interface, pointing to the negligence of the respective owners of these animals. During our survey of residents living near the river we observed that some tie their dogs in the backyard of their homes adjoining the river, which prompts the dog to bark at the slightest disturbance. This unfortunately helps to attract crocodiles. During the survey, we encountered five such cases.

Regarding the direct threat to crocodiles by humans, such as killing of supposed ‘man-eaters’, destroying eggs and yearlings and sub-adults that get trapped in fishing nets could be minimized by educating the relevant people. In addition, killing crocs for its flesh is an additional threat. In areas where crocodile flesh is eaten, we surveyed people who related that the flesh tastes good and is of high medicinal value.

ACKNOWLEDGEMENTS

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LITERATURE CITED


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A nearing to caiman ethology (*Caiman crocodilus fuscus*) in conditions of captivity, Crocodile Museum, Zoomat, Chiapas, México

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ABSTRACT: The ethology of Mexican crocodilians is poorly studied, reason why made a first approach with *Caiman crocodilus fuscus* searching to create basis lines for future studies. This work was performed on the areas of the Crocodile Museum, in the Regional Zoo Miguel Álvarez Del Toro, located in Tuxtla Gutierrez, Chiapas, Mexico. We worked with 6 reproductives specimens; 2 males and 4 females between 10 and 17 years old, from the Coast of Chiapas. Made between August and September of 2007, with a total of 21 days of observations; it was used a chronogram with stratified sequences of observations to have the entire spectrum light during day hours. The used technique was the focal animal, based on an ethogram to *Crocodylus moreletii*. We observed 16 different behaviors where the most frequent were those of visible eyes, visible nose and sunning d. statistically significant differences where not found in the behavior of males and females; however, it is possible to infer that one of the males would be acting dominant. The reproductive behavior was not observed, this was because of the stress that individuals suffered by their recent change of site in 2006.

RESUMEN: La etología de los cocodrilianos mexicanos ha sido poco estudiada, por lo que se hizo un primer acercamiento con *Caiman crocodilus fuscus* buscando crear líneas bases para futuros estudios. Esto se realizó en las áreas del Museo Cocodrilo, del Zoológico Regional Miguel Álvarez del Toro, ubicado en Tuxtla Gutiérrez, Chiapas, México. Se trabajo con 6 ejemplares reproductores; 2 machos y 4 hembras; de entre 10 y 17 años de edad, originarios de la Costa de Chiapas. Realizándose entre agosto y septiembre 2007, con un total de 21 días de observaciones; se utilizó un cronograma con secuencias de observaciones estratificadas para tener todo el espectro durante las horas luz. La técnica utilizada fue la de animal focal, basado en un etograma para *Crocodylus moreletii*. Se lograron identificar 16 conductas distintas, donde las más frecuentes fueron los ojos visibles, nariz visible y asoleo d. Estadísticamente no se encontraron diferencias significativas en los comportamientos de machos y hembras; sin embargo, se puede inferir que uno de los machos estaría actuando como dominante. No se observaron los comportamientos reproductivos, esto se atribuyó al estrés que sufrieron los individuos por su reciente cambio de sitio en el 2006.

INTRODUCTION

The crocodilians have a series of adaptations that have allowed them to survive by many million of years like group: the habitat in wich they are, the structural characteristics for feeding, the way they capture their prey, the complex social behavior that they exhibit,
and their reproduction are some of the things that make it attractive for study (Casa-Andreu, 1969).

The state of Chiapas has the three species of Mexican crocodilians: *Crocodylus acutus* species predominantly of the Mexican Pacific, in the Atlantic from the coast of Florida and in the islands of the Caribbean to Venezuela, *Crocodylus moreletii* which is in the Gulf of Mexico, in Belize and Guatemala; and *Cayman crocodilus fuscus* with distribution is from the south of Oaxaca to the Paraguay River in South America. In Mexico and Central America is restricted to the coast, but in South America it occupies the coast of the Atlantic and penetrates to the interior of the continent (Álvarez del Toro & Sigler. 2001).

The state of Chiapas has been divided in several physiographical regions, of which, four have populations of crocodilians, the similarity in them is the tropical climate, the abundance of water and the altitude of 600 meters on the level of the sea. In general, the custom and behavior of the Mexican crocodilians are poorly studied (Sigler, 1996); reason why made a first approach with *Caiman crocodilus fuscus* (*C. c. fuscus*) searching to create basis lines for future studies is important.

**MATERIALS & METHODS**

**Workplace:** Crocodile Museum (MUCRO), Regional Zoo Miguel Alvarez del Toro (ZOOMAT), located in Tuxtla Gutierrez, Chiapas, Mexico. This work was performed in the area well-known like outside exhibition (Fig. 1), in where are reproductive specimens of *C. c. fuscus*. The total area of the pool is of 158.74 m² of which 89.77 m² correspond to earth and 68.97 m² correspond to water. The total amount of water is 34.49 m³ (Fig. 1). The work was made in the months of August to September of the 2007 year.

![Figure 1. pool outside exhibition 3 of reproductive specimens of *C. c. fuscus.*](image-url)
**Observations:** The observations were done using the technique of focal animal, in which the specimen was identified for each characteristic of the individuals. We used an ethogram (16 different behaviors) made for *C. moreletii* (Orozco, 2006). An extra behavior (semi submerged) was added. Semi submerged: head, and back outside the water, the rest of the body is submerged. The individual is static in that position or it can move (Fig. 2). In addition for this work semi submerged sunning was considered to the behavior taken from Orozco as a type of sunning to which we denominate sunning e.

**Figure 2.** specimen semi submerged.

A chronogram of observations was made, using a sequence of observation stratified with variation day to day to have the entire spectrum light during day hours. This chronogram followed during 21 days, doing a total of 81 hrs. of observations. They studied to 6 individuals.
that coexist in the pool, in day 19 of work was introduced a pair of *C. c. fuscus* that they were in the area of handling of the MUCRO, located in bathtubs, being a total of 8 specimen that correspond to 5 females and 3 males (table 1). Daily, the temperature of the atmosphere, the wind, the cloudiness and rain, were written to determine the possible zones of ovoposition.

**Analysis:** We used Microsoft Excel software to make the tables and the graphics, and Info Stat to make the statistical analysis (ANOVA).

**RESULTS AND CONCLUSION**

As follow, an histogram with the behaviors frequencies (Fig. 3) showing that the most frequent behaviors are visible eyes with a total of 1364 observations, sunning d with 1020 observations and visible nose with 912 observations, making the 74.47% of total, whereas the remaining (26.53%) is distributed in the other 14 behaviors.

![Behaviors frequencies](image)

**Figure 3.** Frequencies of the observed behaviors total.

We made an ANOVA to observe if these differences were significant obtained: walking b, roaring, sunning c, vertical tail, walking a, bubbling, submerged, displacement and semi submerged are significant different with sunning b, sunning a, visible head, visible sunning, nose, eyes and sunning d.

The comportamentales frequencies for males and females are show in Fig. 4 & 5.
For the three males observed the most frequent behaviors were shows in Fig. 6, 7 & 8.
The only one which have territorialidad and courtship behaviors was Colamocha; three of these behaviors were observed, that are the bubbling, the vertical tail and the roar that constitute 2.59% of the total. This percentage is low but if it is compared with the other individuals, could be indicating a dominancia of Colamocha on Hocicudo.

Taiwan, male who was introduced in day 19 of the study, like for Hocicudo had behaviors of sunnings and visible nose and eyes, representing the sunning e 49.37% of the behaviors and sunning d 37.98%. It is possible to mention that these two behaviors were outside the water mirror. In addition we observed that in this introduction, Colamocha increase the frequencies in the territorialidad behaviors as the bubbling and semisubmerged, too increase the frequencies of displacement, which would be sustaining the dominancia of Colamocha mentioned previously. According to the results exposed in Fig. 6 the behavior most frequents for females are visible eyes, sunning d and visible nose.

Figures 9, 10, 11, 12 & 13 show the percent for each female.
For Lupita, the female introduced with Taiwan, observed that the frequent behaviors were visible eyes and nose with 35.5% constituting both 71% of the total. This would indicate that the female did not have any type of disadvantage in its introduction to the pool, its was not attacked for any of the individuals that were in.

From the exposed results previously we can say that for the females and males, the most frequent behaviors are those of location (visible nose and visible eyes) and sunning. Then an ANOVA were made to analyze if there are differences between the individuals obtaining that there are no significant differences between the individuals that coexist in the pool. Although according to the observed (Fig. 4) only Colamocha had territorial behaviors. In the 3 last days of observation this individual showed a modified behavior of type the alert, semisubmerged in water, whereas Taiwan stayed outside the pool occupying a very small space and always near the border. Nevertheless Taiwan was not used for the statistical analyses because it was only observed during 3 days, for that reason believe that the result had been different if the observations had continued. For the other hand females behave of equal way, as it was not to be expected because the time in which the study was made was the time of reproduction and nesting which did not take place. The reproductive behaviors was not observed possibly due to the stress of the individuals, because these relocated to another place in where latitude and altitude were different, as well as the average temperature. For the same reason the possible zones of nesting could not verification (Fig. 14).
Then, in figure 15 observed the relationship between behaviors and temperature. Displacement, to walk b and to walk a; occurred when the temperature is about 27°C. Respected to sunning the most frequent is d (head high and closed snout) which has two tips (27°C & 24°C) this type of sunning does not depend of the temperature. The other types of sunnings stay constant in the different temperatures, except for the sunning type b (head elevated with open snout) which is minimum in low temperatures (23°C to 26°C) and maximum at high temperatures (26.5°C to 27.5°C); this would indicate that C. c. fuscus opens the snout to expel heat and it does not for take it (Fig. 15).
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Orozco, Deyli de León, 2006 Conducta prereproductiva y reproductiva del cocodrilo de pantano Crocodylus moreletii bajo condiciones de cautiverio.
Abundance and Population Structure of *Melanosuchus niger* and *Caiman crocodilus* (Crocodylia, Alligatoridae) in Araguaia National Park, Tocantins, Brazil.

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ABSTRACT: Information about abundance and structure are essentials to determine the current conditions of a population. Several studies about crocodilians biology and ecology were conducted in Brazil, however it knows not much about the species present in the Tocantins state. This work aims to extend the knowledge about population ecology of *Melanosuchus niger* and *Caiman crocodilus* around the Araguaia National Park, Tocantins. The study was conducted between August 2004 and November 2006, with spotlight surveys using an aluminum boat in 50 km of shoreline in the Rio Javaés. We counted 4887 caimans, of which, 774 belonged the specie *M. niger* (0,1 to 2,5 animals per Km of shoreline) and 1849 of *C. crocodilus* (0,1 to 8,6 animals per km of shoreline). Individuals of all size class were found, indicating a possible stability in the development of these populations. We observed that species occupied different microhabitats, where *M. niger* remained in the main bed of the river and in the parts deepest of the reentrance while *C. crocodilus* occurred most frequently in shallow or grassy areas. The data obtained in this study help in assessing the current status of conservation of these species in a little studied region of the Brazilian Amazon.
Abundance and population structure of Spectacled Caiman (Caiman yacare) in Isla del Encanto and El Combate communities (Yapacani and Grande rivers), Santa Cruz - Bolivia.

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ABSTRACT: Surveys of Spectacled Caiman (Caiman yacare) were conducted during December 2005 and January 2006 (corresponding to the wet season) and in September 2006 (dry season). This population assessment was carried out in Grande and Yapacani rivers, and floodplain lagoons (Obispo Santistevan province, department of Santa Cruz) under the National Harvesting Program of Spectacled Caiman (Caiman yacare). We selected 9 water bodies in the area of Grande and Yapacani rivers, and we conducted night surveys with 3 replicates on different days in two seasons to establish the abundance and population structure of spectacled caiman, and to find differences between the results found in wet and dry season.

C. yacare is widely distributed throughout all the study area but not in a uniform way, we found a population median of 6.83 ind / km of shore, while the population structure is dominated by Class II juveniles, and with low percentage of Class IV individuals (13.10%); this could suggest a population which has been subjected to extraction of adult males.

RESUMEN: En el marco del programa Nacional de aprovechamiento del Caiman yacare, se realizaron evaluaciones poblacionales de este recurso en la provincia Obispo Santistevan del departamento de Santa Cruz en los ríos Grande y río Yapacani y lagunas fluviales durante el mes de diciembre del año 2005 y Enero del 2006 correspondiente a la época húmeda y en Septiembre del 2006 correspondiente a la época seca.

Se establecieron 9 cuerpos de agua en la zona en los ríos Grande y Yapacani realizando conteos nocturnos con 3 repeticiones en diferentes días en dos épocas del año para establecer la abundancia y estructura poblacional del lagarto Caiman yacare y determinar diferencias entre los resultados obtenidos en época húmeda y época seca.

C. yacare está ampliamente distribuido en toda la zona de estudio pero no de una manera homogénea, se encontró una mediana poblacional de 6.83 ind/km de orilla recorrida, mientras que la estructura poblacional se encuentra dominada por individuos juveniles clase II (50 a 120 cm de longitud total) con un bajo porcentaje de individuos clase IV (13.10 %), lo cual podría sugerir que se trata de una población que ha sido sometida a extracción de machos adultos.

INTRODUCTION

America concentrates the greatest diversity of crocodiles that can be found in relation to other areas of the world, throughout history, this region has been the largest source of commercial exploitation of crocodiles on the planet. This fact, boosted also by an increasing decline in suitable habitat, caused a quantitative decline of wild populations; led in some cases, extinctions (Messel, 1991, quoted in Prado, 2003).
Crocodiles are an important ecological component of tropical fauna and represent a natural resource of considerable value, primarily by the quality of their leather, as well as their meat by-product, has great potential especially for export. The main causes that produce the decline in natural populations of these reptiles are illegal hunting and habitat destruction (Aparicio, 1999; Bost, 1983; Pacheco and Aparicio, 1996; Thorbjarnarsson, 1991). In Bolivia, hunting of spectacled caiman (Caiman yacare) acquired greater importance since the 70’s, when the populations of black caiman (Melanosuchus niger) and the broad snouted caiman (C. latirostris) almost disappear as a result of the strong pressure of commercial harvest (Aparicio, 1997; Llobet and Goitia, 1997).

The great potential which represents the species C. yacare like an usable resource as well as its important role in the dynamics of the ecosystems they inhabit, makes an urgent implementation of programs to ensure the conservation of this species and make possible sustainable development (Llobet and Goitia, 1997) since the use of diverse wildlife species in the neotropics constitutes an alternative element as economic and food for local people, indigenous and peasant (Bodmer et. al., 1996).

OBJECTIVES

Determine the relative abundance and population structure of the spectacled caiman (Caiman yacare) in the cattle ranche Isla del Encanto and community El Combate, in the fluvial lagoons of the Grande river and Yapacani river, in two different seasons of the year.

Compare the population abundance and the population structure in the two seasons of the year (humid and dry time).

METHODOLOGY

This study was conducted in the municipality of Mineros province Obispo Santistevan in the Northwest of the department of Santa Cruz-Bolivia to 243 km. to the city of Santa Cruz de la Sierra in the towns of Isla del Encanto and El Combate community. The town Isla del Encanto is surrounded by rivers Yapacani (old and new channel) Piraycito, and the Grande river. The community "El Combate" is based on the Grande river north of the Isla del Encanto.

Counts were conducted during the night into the wet and dry season. Corresponding to the wet season the campaigns of December 2005 and January 2006. During the dry season only a raid was conducted fieldwork in September 2006 for lack of funds could not be entering a second time this season. 9 aquatic ecosystems were sampled in two communities settled in the course of the rivers Yapacani and Grande.

In each of these 9 water bodies were conducted with 3 counts repetitions carried out on different days trying to start night counts at the same time and under similar climatic conditions such as moon phase, rainy days.

Individuals were located at night using 12-volt spotlights, 500000 candles power. Maglite flashlights of 3 batteries and 4.5 volts 22000 candles power.
The abundance of spectacled caiman population was calculated including individuals observed from the population for classes II, III and IV and is expressed in individuals per kilometre from shore (ind / km). (Aparicio 1997, Godshalk 1994, King and Videz Roca, 1997; Godshalk 1997, Llobet and Aparicio 1999, Llobet and Goitia 1997, Pacheco 1993), individuals found in Class I were not taken into account when calculating the abundance due to the high mortality rate that has during the first year of life.

To determine the population structure were conducted Histograms size, following criteria established by Velasco and Ayarzagüena (1995). According to these, the animals were divided into four classes according to size the following characteristics:

- Class 1: animals with a total length (snout-tail) of 50 cm. corresponding to 25 cm. length ventral (snout-sewer). Includes most of the juvenile in the first year of life. This kind usually not taken into account in determining the characteristics of the population, because in this stage of life is estimated that the rate of survival this coming more than 20% of individuals who are born, which makes this class suffers strong monthly changes.
- Class 2: animals with a length of 50 to 119 cm. (snout tail). This class is composed of young males and females.
- Class 3: adult animals with a total length of 120 to 179 cm. In this class include the full range of reproductive females and a portion of adult males reaching about 20% of the Class.
- Class 4: adult animals with a greater length of 180 cm. The class consists almost entirely by adult males reproductive and is being used for the program of commercial exploitation of spectacled caiman in Bolivia.
- Eyes Only: when it was not possible to estimate the size of an individual identified spectacled caiman, is assigned to the category Eyes Only (OS).

The population structure was carried out three counts of repetitions in each of the water bodies in the two seasons of sampling. Applying the method of minimum and maximum Messel (1991), this method is to take the maximum number of individuals observed obtained from the three repetitions in each size class.

We compared the results statistically abundance and population structure of spectacled caiman between the two seasons of sampling. The analysis of the data was carried out with the statistical programs Infostat and Statsoft (Statistica 6.0) where the results obtained during the seasons samplings were compared statistically, this way to be able to determine if significant differences exist among bodies of water or among sampling time. In the case of the population abundance using a nonparametric test (Kruskal - Wallis test) and for the structure population contingency tables with Chi squared.

RESULTS

It succeeded in registering a total of 672 individuals between the two field campaigns, covering a total of 189.76 kilometers from the shore of the 9 places sampling during the 2 sampling seasons (wet and dry). We show a square with the individuals found by sampling seasons and the total kilometers of shore sampling among the two seasons by water bodies...
Table 1. Number of individuals found by sampling season and km of shores sampled.

<table>
<thead>
<tr>
<th>Place</th>
<th>Rainy season</th>
<th>Dry season</th>
<th>Km. of shore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Río Yapacani</td>
<td>19</td>
<td>14</td>
<td>18.00</td>
</tr>
<tr>
<td>Río Grande</td>
<td>83</td>
<td>83</td>
<td>48.00</td>
</tr>
<tr>
<td>Laguna Buey sarazo</td>
<td>52</td>
<td>44</td>
<td>24.00</td>
</tr>
<tr>
<td>Laguna Media luna</td>
<td>21</td>
<td>12</td>
<td>10.80</td>
</tr>
<tr>
<td>Río Yapacani2</td>
<td>20</td>
<td>43</td>
<td>48.00</td>
</tr>
<tr>
<td>Laguna El Placer</td>
<td>5</td>
<td>92</td>
<td>8.40</td>
</tr>
<tr>
<td>Laguna Las Petas</td>
<td>7</td>
<td>21</td>
<td>10.80</td>
</tr>
<tr>
<td>Laguna Yapacani río seco</td>
<td>20</td>
<td>103</td>
<td>18.96</td>
</tr>
<tr>
<td>Laguna El Bufeo</td>
<td>7</td>
<td>26</td>
<td>2.80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>234</strong></td>
<td><strong>438</strong></td>
<td><strong>189.76</strong></td>
</tr>
</tbody>
</table>

Based on the night counts in the water bodies in the study area we found that the highest index of abundance is found in the lagoon El Placer during the dry season with 23.57 ind / km followed by the lagoon El Bufeo with 18.57 ind / km from shore during the dry season. While the lowest values found in the Yapacani river 2.50 ind / km in the rainy season, followed by the lagoon El Placer with 3.57 ind / km.

Table 2. Relative abundance of spectacled caiman (Ind/km) in the different water bodies.

<table>
<thead>
<tr>
<th>Place</th>
<th>Water bodies</th>
<th>Abundance Rainy season (ind/km)</th>
<th>Abundancia Dry season (ind/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isla del encanto</td>
<td>Río Yapacani</td>
<td>5.33</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>Río Grande</td>
<td>9.50</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>Laguna Buey Sarazo</td>
<td>11.75</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>Laguna Media luna</td>
<td>10.56</td>
<td>6.67</td>
</tr>
<tr>
<td>El Combate</td>
<td>Río Yapacaní 2</td>
<td>2.50</td>
<td>5.38</td>
</tr>
<tr>
<td></td>
<td>Laguna El Placer</td>
<td>3.57</td>
<td>23.57</td>
</tr>
<tr>
<td></td>
<td>Laguna Las Petas</td>
<td>3.89</td>
<td>11.67</td>
</tr>
<tr>
<td></td>
<td>Laguna Yapacaní</td>
<td>6.01</td>
<td>12.34</td>
</tr>
<tr>
<td></td>
<td>Laguna El Bufeo</td>
<td>5.00</td>
<td>18.57</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td></td>
<td>6.01</td>
<td>7.00</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td></td>
<td>3.28</td>
<td>6.75</td>
</tr>
</tbody>
</table>

We contain the abundances for sampling time to see if they present significant differences for the season, not finding significant differences for the relative abundances in the sampling season to 95% and 99% (OR = 25.5 p = 0.18).
**Figure 1.** Relative abundance by sampling season.

**Figure 2.** Relative abundance of spectacled caiman were found in water bodies in the two seasons of sampling.
An analysis containing the values of abundance by type of water bodies using two categories: running water (rivers) meanders (lagoons of fluvial origin). Among the two categories they registered 189.76 kilometers for shore sampled in the two seasons of sampling, which correspond 114 kilómetros near running water (rivers), and 75.76 miles are along meanders (lagoon origin river). The analysis of the abundances by type of water bodies shows that there are no significant differences (U = 6.0, p = 0.44).

![Figure 3](image)

**Figure 3.** Relative abundance by type of water bodies.

As for the population structure we can see that is dominated by youngs animals Class II up to 120 cm. total length, followed by adult class III, then individuals infants Class I and finally the adult class IV.

![Population structure](image)

**Figure 4.** Population structure of spectacled caiman expressed as a percentage of individuals found to the area sampling.
Regarding the population structure for sampling seasons find that the rainy season is dominated by youngs individuals class II, continued by individuals adults class III, later individuals class IV (figures 5).

![Population structure in rainy season](image)

**Figure 5.** Population structure in rainy season.

In the dry season we found that the population structure is dominated by individuals infants Class I, followed by youngs individuals Class II, adult Class III and finally adult class IV (Figure 6).

![Population structure in dry season](image)

**Figure 6.** Population structure in dry season.

When comparing the structures for sampling times applying a Chi squared test ($X^2$) it shows us that highly significant differences exist in the population structure ($X^2 = 101.75; p = 0.0001$), these significant differences could be due to the presence and absence of individuals infants in the population structure in dry season and rainy season. Similarly comparisons were made in the population structure by type of water body (rivers and lagoons) regarding the season (rainy season and dry season). That shows that there are highly significant differences for the two seasons: rainy season ($X^2 = 14.32, p = 0.0025$); dry season ($X^2 = 37.75, p < 0.0001$).
CONCLUSIONS

The species *Caiman yacare* is distributed throughout the study area, covering all water bodies in the region, including lagoons of tectonic origin, fluvials lagoons and rivers, but is not an evenly distributed. The species *C. yacare* was the only crocodilian species recorded in the region during the nights counts. However, We note the presence of black caiman *Melanosuchus niger* by the presence of the head skull of a specimen recently killed by a community member of El Combate, and testimony from community members who claim the presence of black caiman *M. niger*, which did not comment records for the area.

The spectacled caiman *C. yacare* presents a median annual population abundance of 6.83 individuals per kilometers, showing a higher value to different records of this species to other areas. In rainy season presented an average of 6.01 ind / km in dry season and a value of 7.00 ind / km.

The records of Class IV for the populations of *Caiman yacare* in the study area show a fairly low percentage by far of classes of individuals’ youth, suggesting that these stocks, on the one hand have a high-pressure hunting. This became evident with the report of the prefecture of extracting more than a thousand skins of spectacled caiman, from across the Grande River Basin. In addition to information for community residents El Combate ensure that intermediaries come from the Beni department to market hides extracted by community members in exchange for commodities of basic necessities.

As to factor human intervention, even though it was not conducted an analysis of the index of shyness could demonstrate that there is a high level of intervention because of the existence of communities on the river Grande performing harnessing spectacled caiman.

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Alligators and Crocodiles as Indicators for Restoration of Everglades Ecosystems

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ABSTRACT: Ecological monitoring is a key part of adaptive management and successful restoration. Not everything within an ecosystem can be monitored so it is important to select indicators that are representative of the system, show clear responses to system change, can be effectively and efficiently monitored, and are easily communicated. Crocodilians (alligators and crocodiles) are one of the indicators that meet these criteria within the Everglades ecosystem. The alligator indicator uses relative density, body condition, nesting effort and success, and occupancy rates of alligator holes, while crocodile indicators use growth and survival, and trends in their populations related to hydrology. Correlations between biological responses and environmental conditions contribute to an understanding of species’ status and trends over time. Positive or negative trends of crocodilian populations relative to hydrologic changes permit assessment of positive or negative trends in restoration. The crocodilian indicator is currently stable; with alligator trends negative in seven management areas and stable in two, and crocodile trends in Everglades National Park and Biscayne Bay Complex showing a stable trend. Restoration success or failure can be evaluated by comparing recent and future trends and status of crocodilian populations with historical or reference population data and model predictions.
An enrichment experience for hatchling researchers

Renato Filogonio¹, Carla Barriga², Victor Batista³, Melina Simoncini⁴, Francisco Arroba⁴, José Maria Damasceno⁶, Ilba Carolina Figueroa², Thiago Portelinha⁸, Magaly Rengifo⁹, Robinson Botero-Arias¹⁰, John Thorbjarnarson¹¹

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ABSTRACT: As the interest for crocodilian conservation programs and the inherent demands for new researchers grow, the Instituto Mamirauá and the Wildlife Conservation Society promoted the “II Workshop for Training in Alligators Research”, which occurred during December 1st to December 15th in the Reserves for Sustainable Development Mamirauá and Amanã, both situated next to Tefé, Amazonas, Brazil. The course offered an unique opportunity to young researchers (which included recently graduated, Master students and Phd students) from South America to interact and share their experience while learning with experienced researchers. Nine students were present and came from Argentina, Bolivia, Brazil, Colombia, Equator and Peru. There were lectures and discussions about subjects concerning crocodile’s biology and conservation. Standardized methodology such as night counts, nest search, capture of individuals, collection of blood samples and analysis of diet and wounds were also part of the training course. Three documents were produced using the data collected during the field training.

The workshop achieved its goals by stimulating the formation of a new network of South American alligator researches and standardizing the methodology for scientific surveys, contributing to a greater exchange of information. We hope this experience could be eventually repeated in a III Workshop.
Broad-Snouted caiman growth (*Caiman latirostris*) under different periods of UV radiation (UVA-UVB) exposition

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**ABSTRACT:** UV radiation is necessary in many vital processes; all organisms depend directly or indirectly on UV radiation. In natural conditions, quantity and quality of radiation received by organisms depends on numerous factors. Under artificial conditions, it is possible to regulate UV exposure in order to estimate how long broad-snouted caiman would have to be exposed to affect specific biological processes. This study will allow us to evaluate *Caiman latirostris* growth, as well as serum calcium and phosphorus homeostasis, under different periods of artificial UV radiation, as well as make an estimation of the effects and implications of a possible greater environmental radiation exposure. Growth, and serum phosphorous and calcium concentrations, were measured in 72 broad-snouted caiman (6 month old) maintained with diurnal cycles of 8 or 16 hours of UVR (UVA-UVB) exposure, and another control group maintained in complete darkness during 90 days with controlled temperature.
**Caiman latirostris** embryos exposed to pesticides in a field experiment simulating agrochemical application practices

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**ABSTRACT:** Roughly 85–90% of pesticides applied agriculturally never reach target organisms directly, but they disperse through the air, soil and water. In Argentina, some areas of the broad-snouted caiman habitat are situated near agricultural lands where high amounts of agrochemicals are applied.

The practice of creating pesticide cocktails/mixtures can produce a potentiation of the individual properties of chemicals, such as genotoxic effects, which may be negligible when individual chemicals are considered.

The aim of this study was to determine the effects of pesticides on *C. latirostris* exposed *in ovo*. We carried out a field experiment in which common agricultural pesticide applications were used to simulate the maximum environmental exposure that a caiman nest can receive in neighbouring croplands habitats. Three groups of artificial caiman nests were constructed and eggs placed inside. One group remained untreated, the second received an application of a glyphosate herbicide formulation and the third was spread with a pesticide mixture consisting on this herbicide and two insecticides: endosulfan and cypermethryn based products.

Neonate caiman were examined using morphological endpoints (mass and length) and genotoxic effects were probed via the Micronucleus test and the Comet assay in order to compare data from caiman exposed to different pesticide applications with untreated animals.
Caiman’s Abundance in Sustainable Development Reserves Mamirauá and Amanã, Central Amazonia, Brazil

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ABSTRACT: We studied the relative abundance of the crocodilian’s species presents in the Sustainable Development Reserves Mamirauá y Amanã through night counts in metallic canoes with motor, traveling distances up to 15 kilometers in rivers, floodplain and lakes, including areas of várzea and igapó. The relative abundance was obtained by means of the rate of encounter that consists of the number of individuals detected divided by the whole range. The results showed a greater amount of caimans in várzea, this would be because várzea has a greater amount of organic matter, resulting in a greater amount of food available for these animals. Considering the microhabitat where the caimans were seen, it was observed that the greater amount of caimans were in macrophytes. The greater rate of encounter took place in the sector of Paranã de Jarauá, finding 11.1 caimans per kilometer of border; the lower rates of encounter occurred in the Sustainable Development Reserves Amanã, with a rate of encounter of 0.07 caimans per kilometer of border.
Center educational and demonstrative of the program
“Yacarés de Entre Ríos”

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ABSTRACT: One presents the experience that arises in the Program "Yacarés de Entre Ríos" from the of integration approach that is done on having spoken about Cayman latirostris as natural inhabitant of the sweet water. The analysis of the problematics of the natural resources and of the environment, it is done relating his presence to the good availability of water and ideal offer of food, taking the method as a practical example of ranching in the commercial exploitation of the species when we speak of " develop sustentable ". By means of holding a permit visits, photos, chats, projections, walks, there is visualized the narrow interrelationship that exists between the different animal, vegetable, species and his environment, and the way that the evil affects in the quality of life of the communities use of pollutant products or inadequate managing of the soil, water or mount. The aim is to generate an environmental culture from conducts that allow a suitable use of the natural resources and the environment, revaluing the resource sweet waters down on having defended the crocodile.
Characterisation of Endogenous Retroviruses in Crocodilians

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ABSTRACT: Endogenous retroviruses (ERVs) are copies or remnants of exogenous retroviruses that integrated into a host genome at some stage in the past. ERVs are vertically transmitted from the host to the progeny. Most ERVs are defective, having accumulated random inactivating mutations and are not normally pathogenic. However, functional ERVs are potential agents of disease. Previous studies have identified the presence of a distinct clade of ERV from six species of crocodilians. Here we analyse the functionality, distribution and phylogenetic relationships of ERVs in twenty extant species of crocodilian. The ERV pol gene (~1 kb) was amplified, cloned and sequenced. Preliminary analyses show that two types of ERV sequences, possessing stop codons and deleterious mutations are distributed in most species of crocodilian. Thus, crocodilian sequences are generally, if not universally, defective as has been observed in many other ERVs. Phylogenetic analyses show that crocodilian ERVs cluster in two clades within the Retroviridae family. One clade in particular appears to be specific to most species of crocodilians, suggesting that this type of ERV may have infected the crocodilian lineage before the modern lineages diverged from the common ancestor about 250 million years ago. Further analyses to assess the evolutionary relationships and look for evidence for functional ERVs within crocodilians are underway.
Cliteropenis’ morphology of hatchlings *Caiman latirostris*:
Sex separations based on simple measures

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**ABSTRACT:** We study the cliteropenis (CTP’s) morphology of *Caiman latirostris*, a species with temperature sex determination. We used 19 hatchlings which eggs were incubated at 30 ºC and 33 ºC, with the aim of ensure that males and females will be availables. In order to determine positively the sex of the animals, we inspectioned by direct observation the gonads after the sacrifice. CTP’s measurements were: Total Length, Lateral width and Head width. This structure are single medial organs and the body develops on the ventral wall of the cloacae, both penis and clitoris protrude from the cloacae in early embryonic stages but disappear into it, sometime before the hatch moment. We found significant differences (α=0,05) between sexes in lateral width of CTP (p < 0,01) and head width of CTP (p < 0,01). From this results and other analysis, we developed a preliminary protocol that’s allow the discrimination of sexes based on the differences of the CTP measurements of *C. latirostris* at piping moment. The conclusion of this research is that based on simple morphometric measures of hatchlings, it is possible to sex them with a confidence of 89.4 %.
Comparison of Analytic Assays to Detect Sexual Hormones in *Caiman latirostris*

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ABSTRACT: Sexual hormones detection is a key factor for *in situ* and *ex situ* wildlife handling. Knowledge of these hormones values will help us to understand even more about the species biology, make estimations regarding sex proportion in newly born animals by nest or in juveniles, as well as monitor potentially contaminated environments, among others. Sensitivity and specificity of detection methods are always subjects of study and continuous advances. The aim of this study is to compare three methods to detect Estradiol and Testosterone in *Caiman latirostris* juveniles’ serum. Serum concentrations of these hormones were analyzed by the following methods: RIA (radioimmunoassays), MEIA (Microparticle Enzyme Immunoassay) and QL (Quimioluminescence). Identifying more sensitive methods than those traditionally used will let us detect smaller concentrations in small sample volumes and evaluate the concentration of these hormones in different fluids.
Contribution to the Knowledge of the Population State of the Yacaré Overo, *Caiman latirostris* (Reptilia, Alligatoridae), in Entre Ríos Province, Argentina

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**ABSTRACT:** In this work are presented the obtained results of the campaigns carried out during the year 2006 and 2007 in the frame of the “Yacarés of Entre Ríos Program” that has been developing since the year 2000 in the north-central region of the Entre Ríos province, Argentina. Day and night censuses were carried out on foot and oar boat using information obtained from the local settlers. For the night censuses halogen lamps of 1,500,000 B. and hand lanterns were used. The places of nest building were registered by a GPS Garmin 72. The observed caimans were classified under categories of classes of sizes (I= 0-40 cm; the II = 41-1,30 cm; the III= 1,31-1,70 cm; the IV= more than 1,70 of entire length) for the evaluation of the population structure. Surveys of 43 bodies of water and 34 km of coast were done. A whole of 247 individuals were detected registering a predominance of individuals of type the II and III, and 50 nests were located. The age structure of *Caiman latirostris* in the north-central region of the province would indicate that the specie is in state of recovery after decades of intense hunting pressure because of the demand of its leather.
Croc FISH – Fluorescence in Situ Hybridisation of *Crocodylus porosus*

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**ABSTRACT:** Fluorescence *in situ* hybridisation (FISH) is a molecular cytogenetic technique which is commonly used in the creation of physical genome maps. Here we present the initial stages in the physical map of the saltwater crocodile (*Crocodylus porosus*). In conjunction with construction of the linkage map, a bacterial artificial chromosome (BAC) library was established with 2.8x coverage of the *Crocodylus porosus* genome. Several BAC clones containing microsatellite markers were fluorescently labeled and used to anchor informative linkage markers onto chromosomes. We also present further refinement of the standard G banded *Crocodylus porosus* karyotype, including production of a chromosome ideogram with band allocation providing a standardized reference.
Crocodiles as a Bushmeat Resource in the Lac Tele Community Reserve, Republic of Congo

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ABSTRACT: The Lac Tele Community Reserve (LTCR) is a protected area of 4,400 km² located in the vast Likouala swamp forests of northern Republic of Congo. As Congo’s only Ramsar site, the LTCR protects important populations of resident and migratory bird populations, but is also home to high densities of lowland gorillas, forest elephants, chimpanzees, buffalo and all three species of African crocodiles. The goal of the Reserve, with a human population of ≥16,000 inhabitants living in 26 villages, is to protect the natural resources and ecosystems services provided by the wetlands while sustaining the livelihoods of its human inhabitants. Although fish constitute the largest source of protein for Reserve inhabitants, some 43 species of non-fish vertebrates are harvested for food or local sale. Of those non-fish species, the African dwarf crocodile (Osteolaemus osborni) contributes the greatest volume to the harvest. Beginning in August, 2006, I developed and implemented the first program for long-term harvest monitoring of fish and wildlife resources in the LTCR. Training national Reserve staff and village assistants, we have collected monthly harvest data in five villages spanning the major habitat types found in the region. I present preliminary data on seasonal shifts in the resource base, habitat-specific harvest composition and the role of crocodiles in the harvest and village economies.
Cross-Species Amplification of Microsatellites in Crocodilians

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ABSTRACT: Microsatellite DNA loci have emerged as the dominant genetic tool for addressing questions associated with genetic diversity in many wildlife species, including crocodilians. Despite their usefulness, isolation and development of microsatellite loci can be costly and labour intensive, thus limiting their wider use in many crocodilian species. In this study, we investigate the cross-species amplification success of 82 existing microsatellites previously isolated for the saltwater crocodile (Crocodylus porosus) in 18 other crocodilian species; Alligator sinensis, Caiman crocodylus, Caiman latirostris, Caiman yacare, Melanosuchus niger, Paleosuchus palpebrosus, Mecistops cataphractus, Crocodylus acutus, Crocodylus intermedius, Crocodylus johnstoni, Crocodylus mindorensis, Crocodylus moreletii, Crocodylus niloticus, Crocodylus novaeguineae, Crocodylus palustis, Crocodylus rhombifer, Crocodylus siamensis, and Osteolaemus tetraspis. Our results show a high level of cross-amplification with an average success rate of 90% in Crocodylidae species and marginal success in the Alligatoridae species. These results make available many polymorphic markers for a range of crocodilian species previously lacking informative genetic markers.
Culture of chorioallantoic fluid and neonate mouths

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ABSTRACT: Frequently, organisms live in contact with a great number of diverse microbes, especially bacteria. Most of them are commensal and do not under normally cause illnesses. Flora normal composition can be different. Some microorganism in the normal flora can vary to pathogen if physiological or environmental conditions are modified or when these microorganisms enter sterile places. In order to verify the presence of bacteria or fluids or cavities that should be sterile we have taken samples from neonate mouths and its chorioallantoic fluid (CAF). CAF was taken by sterile needle and syringe by punction of the chorioallantonic membrane. Samples were taken by means of hyssops being the neonate still inside the egg. They were cultured in base agar and Mac Conckey Agar in aerobiosis during 24 hours and then identified the genus as possible.
Development of Crocodile Blood Collection Process on Animal Life Maintains for Innovation of Crocodile Blood Product

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ABSTRACT: Crocodile blood collection process on animal life maintains of captive Siamese crocodile (Crocodylus siamensis) was developed. By collecting the anterior dorsal sinus blood in a 100 milliliters volume from 9 crocodiles, there were divided into 3 groups according to the duration time in each crocodile blood collection as following. The crocodiles that their bloods were collected every 4, 8 and 12 weeks. And the control group (n= 3) were taken 10 milliliters every 4 weeks. The results were evaluated by crocodile blood donor behavior i.e. food feeding and social behaviors, determination of hematological and biochemical values, and the concentration of cortisol hormone. These data revealed no significant differences between control group and treated groups (p>0.05). Therefore, the crocodile blood collection might be taken at least 100 milliliters in volume and the duration time for each collection should not less than 12 weeks. However, the optimal blood volume has remained to be elucidated.

INTRODUCTION

Crocodile blood and other products have been widely consumed not only for its nutritious composition, but also for its claimed medicinal value. The practice of consuming crocodile blood for improving human health is found in the traditions of many Asian cultures. The anti-microbial activity of crocodile blood has been scientifically investigated (Chaeychomsri et al. 2003; Siruntawineti et al. 2003, 2004, 2005; Merchant et al. 2003, 2004, 2005). Crocodile blood is a waste material in slaughtering industry. Recently, it was added value as a supplemented food product (Chaeychomsri et al. 2006; Siruntawineti et al. 2006). The process of freeze-dried crocodile blood in capsule was developed (Thai patent application No. 0601001179, 16 March 2006) for maintaining nutrients such as protein (83.1%), iron (164 mg/100gm) and calcium (90 mg/100 gm) in a blood. The crocodile blood in a capsule can be preserved more than one year (Toraktakul et al. 2007). For production of the crocodile blood capsules, the bloods are collected from captive crocodiles before slaughter. In the future, it may not adequate for blood supplying if the demand of crocodile blood material increase. Therefore, the blood collection process on animal life maintain of captive Siamese crocodile should be an interesting option for sustainable use.

The purpose of this study was to determine the duration time of blood collection from normal crocodile for life maintain without health hazard. It was intended that these data would provide guidelines on repeated blood collection from captive crocodile. Moreover, they would promote a sustainable use and increase the production of crocodile blood as an alternative way for consumers who do not want animals to be killed for their blood.
MATERIALS AND METHODS

Animals: Twelve captive Siamese crocodiles (Crocodylus siamensis) used in this study were juvenile crocodile (4 males, 8 females) about 5 years old. Total length and body weight were about 177.42 cm and 21.28 kg, respectively. All crocodiles were hand captured and snared with catapult. They were divided into a control group and 3 treated groups according to duration of time for blood collections: - 1) Collected blood every 4 weeks, 2) Collected blood every 8 weeks and 3) Collected blood every 12 weeks. The identification number was tagged on the crocodile before releasing back into the pen. The control and group 1- crocodiles were retained in the same pen, and the other groups were maintained in another pen.

Blood collections: Blood sample was collected with an 18 gauge needle from anterior dorsal sinus. A total volume of 100 ml of blood was collected from treated groups (group 1, group 2 and group 3) according to duration of planning time for blood collecting and 10 ml of blood were collected from control group in every 6 weeks. To evaluate the health status of these crocodiles, the blood was withdrawn ten milliliters from each crocodile at the week-1, -6 and -12 of experiment for hematological, biochemical and cortisol measurements. Two milliliters of blood was placed immediately into tube containing EDTA - anticoagulant, well mixed and stored at 4°C until measurement of hematological values. Another was placed into a clot activated tubes. Upon returning to laboratory (3-4 hours) blood samples were centrifuged at 5,000 rpm for 5 minutes. Serum were separated and stored at -20°C until analysis of biochemical values and cortisol levels.

Temperature and relative humidity measurement: As temperature and humidity could influence the cortisol levels, hematological values, the temperature and relative humidity of captive pens were record three times a day.

Behavior observation: After blood collection, crocodile behaviors including feeding, basking, diving and social behaviors were observed. The food intakes of crocodile were determined and recorded.

Hematological measurements: The hematological tests included hemoglobin, hematocrit, red blood cell count, white blood cell count (WBC), differential WBC - count, and red cell indcies (MCV, MCH and MCHC) were performed. Hemoglobin was measured by using Cyanmethemoglobin method. Hematocrit was determined using microhematocrit centrifugation. Red blood cell count and white blood cell count were measured by using hemocytometer. Thinwedge smears of blood were made and Wright-Giemsa’s strain was used for microscopic differential counts.

Biochemical and cortisol measurements: Biochemical values including blood urea nitrogen (BUN), creatinine, cholesterol, triglyceride, total protein, albumin, globulin, aspartate aminotransferase (AST) and alanine transaminase (ALT) were analysed by using automatic biochemical analyser (Hitachi 912, Japan). For quantitative analysis of cortisol, the serum was analysed by radioimmunoassay (RIA).

Statistical analysis: The results were reported as mean ± SE, analysed by using one way ANOVA and followed by Duncan’s multiple-range test. A value of \( p < 0.05 \) was considered statistically significant.
RESULTS AND DISCUSSION

Body weight and length of all groups had no significant difference from initial values. These values were not difference between the groups (p>0.05). As this study was performed during winter, low temperature might be the cause of stress and might affect immune system (Huchzermeyer 2003). The maximum and minimum temperatures around the pen were 29.60°C in the 7th week and 25.38°C in the 12th week, respectively. In addition, the maximum and minimum relative humidity was 60.2% in the 9th week and 38.98% in the 5th week, respectively.

After blood collection, all crocodiles in this study showed the normal in basking and diving behaviours. Feeding behavior reduced 2 weeks post blood collection, and then increased gradually. The crocodiles of both pens represented similar feeding behavior, although blood collection was not taken from group 2 and group 3 that stayed in another pen. It might be involved by disturbance, temperature and distress call of crocodiles. Although, the food intake of the crocodiles in this study after two week of the blood collection was increase, but it still lower than other nearby crocodiles that not involved in this experiment. Hence, the blood collection in group- 1 (designed for blood collecting every 4 weeks) and group- 2 (designed for blood collecting every 8 weeks) were not performed.

About crocodile health status determination, almost crocodile was no significant difference in hematological values and biochemical values between treated groups and control group or with in group (p>0.05). However, there was significant difference in cholesterol levels. This may due to food available in the pen, stress, sex, age and environment. The significant difference in AST and ALT within group 3 were be demonstrated. Anyway, these measured values were within reference range when compared with saltwater crocodiles (Crocodylus porosus).

The total blood volume of crocodile is approximately 4-5% of body mass (Huchzermeyer, 2003). In this study, collection of 100 ml of blood is about 10% of blood volume. Malikides et al. (2001) found that, the optimal blood volume for horse blood donor was about 25% of total blood volume. This blood volume causes some changes in the tested values. However, they recovered rapidly within 24-48 hours to their normal rang values. Moreover, heart rate and respiratory rate increased during blood collection then declined within 1-2 hours post collection and reach their normal values within 31 days post collection.

CONCLUSION

This study of crocodile blood collection process on animal life maintains demonstrate that crocodile could be donated the blood 100 ml in volume very 12 weeks with normal behaviours and no significant difference in hematological values, hormonal levels and biochemical values between treated crocodiles and control group. The repeated 100 ml of blood collection is not hazardous to crocodile health and welfare. However, the optimal blood volume has remained to be elucidated.
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LITERATURE CITED


**Keywords:** Crocodile blood, Crocodile blood collection, Crocodile blood product
Diet of the Broad Snout Caiman (*Caiman latirostris*, DAUDIN, 1802) in urban environment located in two municipal natural parks, Rio de Janeiro, Brazil

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**ABSTRACT:** *Caiman latirostris* in Rio de Janeiro lives in urban coastal lagoons (Tachas and Marapendi Lagoons situated in Municipal Natural Park Chico Mendes and Marapendi, respectively). Our goal was to analyze how the animals live in the urban environment and if they present a specific diet. Previous reports on the diet of the broad-snouted caiman include several invertebrates and vertebrates. In this work we analyzed stomach contents from 74 animals, 36 in Tachas Lagoon, 26 in Marapendi Lagoon and 12 in Tachas channel. The Lagoons are two different water bodies that are interconnected by Tachas channel. We observed that Caimans from Tachas channel at Tachas Lagoon presented a poorer diet, composed of hexapods associated with polluted environments, than those from Marapendi’s pond, including vertebrate and invertebrate organisms, including fishes and crustaceans but mainly small invertebrates as prey items. The diet of adult caiman’s was different to that of juveniles at both sites. Despite the large variety of prey available in Marapendi Lagoon the adults there consume mainly small invertebrate prey. In this study, *C. latirostris* did not show preferences for any specific prey, feeding on all possible prey available in the environment. Our results suggest that prey items found in stomach contents of *C. latirostris* could be a reflection of the prey’s diversity in the environment, which indicates a great capacity for adaptation in this species.
Effects of Alligator Leukocytic Peptides on Antibiotic-Resistant Human Bacterial Pathogens

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ABSTRACT: Treatment of clinical isolates of human pathogenic bacteria, which were known to be resistant to multiple antibiotics, with refined leukocyte extracts from the American alligator (Alligator mississippiensis) resulted in a concentration-dependent reduction in growth. The alligator leukocyte extract exhibited the strongest antibacterial effect on Klebsiella pneumoniae and Acinobacter baumannii, followed by Enterococcus faecium, and then Pseudomonas aeruginosa. The antibacterial activities were heat stable at 70°C for up to 30 minutes, stable in the presence of 50 mM ethylenediaminetetraacetate, and sensitive to protease treatment (10 units/mL protease for 30 minutes). Collectively, these data strongly suggest that the molecule(s) responsible for the observed antibacterial activities are small, cationic peptides. These peptides may prove to be useful as a new class of antibiotics for human use.
ABSTRACT: Treatment of clinical isolates of human pathogenic bacterial strains, which were known to be resistant to multiple antibiotics, with serum from the American alligator (Alligator mississippiensis) resulted in a concentration-dependent reduction in growth. The bacteria were grown in the absence, or in the presence of 10%, 25%, 50%, 75%, and 100% alligator serum. The alligator serum had the strongest growth inhibitory effect on Klebsiella pneumoniae, followed by Acinobacter baumannii, Pseudomonas aeruginosa, and Enterococcus faecium. The antibacterial properties were completely inhibited by heat treatment of the serum at 56°C for 30 minutes, addition of 10 units/mL protease, or by the addition of 50 mM ethylenediaminetetraacetate, indicating that the activity was due to serum complement protein activity.
Effects of El Niño on growth in captivity of *Crocodylus acutus* in Tumbes, Peru

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ABSTRACT: Temperature affects the growth rate of crocodiles. However, there is no information about the effects of temperature variation caused by El Niño-South Oscillation (ENSO) on crocodiles. Therefore, our goal is to determine the effect of ENSO on growth rates of *Crocodylus acutus* in captivity during 1997 to 2001. Total length and body weight of 40 captivated crocodiles were recorded in the Centro de Acuicultura La Tuna Carranza, located in Puerto Pizarro, Tumbes, Peru. We did not observe statistical differences in total length rate among years, but we did found differences in body weight rates among years. We observed that warm episodes of ENSO represented higher average in total length rate and cold episodes represented a higher average of body weight. The sea surface temperature was significantly related with total length rate; however, the relationship between sea surface temperature and the growth rate of body weight was not significative. As a conclusion, we suggest that ENSO events are an important factor that affects growth rates of crocodiles, thus it should be considered in management policies of captive populations.

RESUMEN: La temperatura afecta el crecimiento de los cocodrilos. Sin embargo, hasta la fecha no existe información acerca del efecto de la variación de la temperatura durante los eventos de El Niño sobre los cocodrilos. Por ello el objetivo del estudio fue determinar el efecto de El Niño sobre el crecimiento de *Crocodylus acutus* en cautiverio en el período 1997-2001. Se trabajó con un grupo de 40 cocodrilos cautivos en el Centro de Acuicultura La Tuna Carranza, localizado en Puerto Pizarro, Tumbes, Perú. Se midió la longitud total y la masa corporal de los cocodrilos. En general, se observaron diferencias en el incremento de peso por año, pero no se observó una diferencia en la longitud. Por otro lado, observamos que durante los episodios cálidos de El Niño la tasa de crecimiento en longitud es mayor mientras que durante los episodios fríos fue mayor el aumento en peso. Observamos también una relación significativa de la temperatura superficial del mar con la tasa de crecimiento en longitud, pero no con el peso. En conclusión, consideramos que los eventos de El Niño son un factor importante que afecta el crecimiento de los cocodrilos por lo cual deben ser considerados dentro del manejo de las poblaciones.
Evaluation of genotoxic effects induced by UV radiation in *Caiman latirostris*: Progress report

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ABSTRACT: Ultraviolet (UV) radiation is a component of the solar energy emission spectrum. The ecological importance of UV light has been extensively studied during many years, on account of stratospheric ozone depletion in certain areas of the planet, which has led to an excessive UV radiation over ecosystems. Overexposure of organisms to UV radiation may produce different biological effects as a result of photochemical absorption by significant molecules such as proteins and nucleic acids. Among them, DNA damage induced by UV-A/UV-B exposure, which included mainly thymine dimers and chromosomal fragmentation, are considered of prime importance. The aim of this study is to evaluate genotoxic effects of UV-A and UV-B radiation in juvenile *Caiman latirostris*, using the Micronucleus (MN) test as a biomarker.

Seventy two juvenile caimans were reared during 3¹/₂ months under one of three conditions: 24 hours darkness and exposure of 8 or 16 daily hours of artificial UV-A/B light, respectively. Blood samples were collected at the beginning and at the end of the experiment to determine the incidence of UV/A-B radiation on erythrocyte MN frequencies and evaluate differences between treatments. Up to the moment, 75 % of the samples have been analysed.
ABSTRACT: The designation of protected areas is one of the mechanisms created to promote the conservation of wildlife. However any protected area was established specifically for the conservation of these animals. San Miguelito, is a property with approximately 40,000 hectares, an area designated as Private Reserve in the San Julian River Basin, conditions ecological, in fact it is an alternative to preserve the biological richness of this lowland region.

This study summarizes preliminary information of the current status of alligators populations present in the San Miguelito area. In 2005 count at night were performed data of abundance (Indv/Km) were obtained in the Rio San Julian (37.31), Rio Zapoco (33.34) and Rio Tuná (67.44). In relation to population structure, the three rivers showed a high level of the individuals on the Class III on the Class IV. Its proportion was more than 60%.

RESUMEN: La designación de áreas protegidas es uno de los mecanismos con que se cuenta para favorecer la conservación de cocodrilianos. No obstante ningún área protegida fue establecida específicamente para la conservación de estos animales. La estancia San Miguelito, es una propiedad ganadera de aproximadamente 40.000 ha, y incluye una superficie categorizada como Reserva Privada en la cuenca del Río San Julián, considerando sus condiciones físicas y biológicas, en la actualidad es una alternativa para conservar la riqueza biológica de este sector de las Tierras Bajas de Santa Cruz.

El presente estudio resume información preliminar del estado actual de las poblaciones de lagartos presentes en la estancia En el año 2005 se realizaron conteos nocturnos en los cuales se obtuvieron datos de abundancia (Indv/Km) en el Río San Julián (37.31), Río Zapoco (33.34) y Río Tuná (67.44). En cuanto a la estructura poblacional, los tres ríos presentaron un alto dominio de los individuos clase III, sobre los de clase IV, su proporción fue más del 60%.
Experimental treatment in *Caiman latirostris* (Reptilia, Alligatoridae) on the “Yacarés of Entre Ríos program”, Entre Ríos, Argentina.


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**ABSTRACT:** In the year 2006, on fields of the “Yacarés of Entre Ríos program”, were 206 yacarés (*caiman latirostris*) in captivity, which were born in March of that year. Those animals, with 5 month old, started to present the following symptoms: Opistotono, extensive pupils, swimming inability, difficult breathing, distension abdominal, commuting of the head. After individual blood test, fecal matter, food, etc. we determine that those animals had high- glycemia, which was made by routines tests of glucose with values over 600mg/dl. Until that moment, the animals were feeding with a mixing of meat, chicken and fish in the same percentage. When the high- glycemia was determinate, the diet was replaced by a mixing of meat without fat 30% and food balanced for diabetic cat 70%. Supported this diet for 10 weeks, the levels of glycemia began to diminish and since November of 2006 we obtained values flanked by 64mg/dl and 120mg/dl, depending on the time of fasting of the animals. This allows us to conclude that the replaced of the diet was favourable for the decrease of the glycemia and for the normal development of the animals, since the weight and size to the year of birth were ideal for the age.
First experience in ex-situ incubation of wild clutches of the American Crocodile (*Crocodylus acutus*) in Machiques de Perijá, Zulia State, Venezuela.

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**ABSTRACT:** As part of a conservation proposal for the American crocodile (or *Kanta* in Bari indigenous dialect) which will involve colonist and local and indigenous people, the first experience in searching, collecting and then artificial incubation of American crocodiles eggs took place in January 26 and 27, 2007. Two nest were found, one in river Negro (24 eggs) and the other in river Santa Rosa (38 eggs). Sixty of the collected eggs were incubated in three plastic boxes, using sand from the original nests. These boxes were kept in a house of the Barí community in Senkay. From April 25 to 28, forty three eggs hatched successfully. The smallest and largest hatchlings were 240 and 300 mm in total length, respectively.

**RESUMEN:** Como parte de una propuesta de conservación de *Crocodylus acutus* o *Kanta* en dialecto indígena Bari que involucrará actores locales e indígenas, se realizó una primera experiencia de búsqueda e incubación forzada de nidadas durante enero 2007. Los días 26 y 27 se encontraron 2 nidadas en los ríos Negro y Santa Rosa respectivamente. Las nidadas fueron de 24 y 38 huevos para los ríos mencionados. 60 huevos en total se incubaron en 3 cavas de plástico y utilizando la arena de ambos ríos. Se incubaron en una casa de la comunidad Bari de Senkay. Del 25 al 28 de abril de 2007 nacieron 43 caimancitos, los de menor y mayor tamaño midieron al nacer 240 y 300 mm respectivamente.
Front or Rear, Top or Bottom: Measuring and Using Snout-Vent Length in Crocodilians

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ABSTRACT: Crocodilians have been monitored globally for decades and long-term data within and between species and regions has typically been collected using different procedures, resulting in data sets that can be difficult to standardize and compare. The most common data collected on crocodilians are morphometric measurements (e.g., head length, snout-vent length, total length, and weight). These measurements are used in a wide range of analyses, from ecological to taxonomic to evolutionary. However, these analyses are only as accurate as the data from which they are derived. When measurements are taken by different individuals using different landmarks, comparisons between species and across regions can be difficult or impossible to make. For example, snout-vent length (SVL) have been measured along both the dorsal and ventral surfaces of a crocodilian and culminated at both the anterior and posterior portion of the vent. The magnitude and importance of effects of different techniques of measuring SVL are unknown. Here, we compare effects of using different SVL measurement techniques in calculating indices of body condition for three species of crocodilian, Crocodylus acutus, C. moreleti, and Alligator mississippiensis.
Importance of Evolutionarily Significant Units to conservation and management \textit{Caiman crocodilus}

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ABSTRACT: Facing radical acceleration in the rate of extinction, habitat transformation and niche displacement, conservation biologists and decision makers play a very important role in safeguarding biodiversity. Better conservation and management plans should be made to achieve the goal of preserving natural diversity of independent evolutionary lineages, their habitats, and their ecological relationships; and also to maintain the ecosystems that they inhabit, which will enhance human well-being. The \textit{Caiman crocodilus} complex is a widely distributed, charismatic, and economically important Latin American crocodylian species. The complexity of \textit{Caiman crocodilus} taxonomy, systematics and ecology, in combination with high levels of exploitation, require a multidisciplinary approach to ensure its long-term conservation. The goal of this research was to define more realistic conservation units based on objective operational methodology to be used for conservation and management purposes. This methodology integrates taxonomy, systematics, population genetics, biogeography, ecology, natural history (historical and contemporary use and threats), political and social information, as well as resent trends and published predictions. Our results support conservation efforts for five independent conservation units which are genetically differentiated, reproductively isolated, and ecologically distinct, each with a unique evolutionary trajectory. This research offers the opportunity of using a coherent methodology to define conservation units that can be replicated with other taxa.

RESUMEN: En esta época en la que nos encontramos enfrentado una aceleración de la tasa de extinción, transformación de hábitats y desplazamiento de nichos los biólogos de la conservación y los tomadores de decisiones juegan un papel muy importante en el resguardo de la biodiversidad. Mejores planes de conservación y manejo deben desarrollarse para alcanzar la meta de preservar la diversidad natural de linajes evolutivos independientes, sus hábitats y sus relaciones ecológicas, y a la vez mantener los servicios ambientales que sostienen el desarrollo humano. \textit{Caiman crocodilus} es un complejo de linajes independientes ampliamente distribuido por América Latina; este taxa es carismático y de gran importancia económica para América Latina. La complejidad de la taxonomía, la sistemática y la ecología de este grupo de cocodrilos, en combinación con los niveles de explotación hacen necesario un acercamiento interdisciplinario para lograr su conservación a largo plazo. La meta de esta investigación fue definir unidades de conservación más acordes con la realidad basándonos en una metodología operacional de múltiples niveles. Esta metodología integra la taxonomía, la sistemática, la genética de poblaciones, la biogeografía, la ecología, la historia natural (incluye amenazas históricas y contemporáneas), así como también se incluye información...
política y social del área donde se encuentra el recurso y efectos del mercado. Al mismo tiempo se adiciona al análisis información acerca de las tendencias y predicciones de las posibles amenazas a la sobrevivencia del grupo a largo plazo. Nuestra investigación propone concentrar los esfuerzos de conservación en cinco unidades independientes de conservación que son genéticamente diferente, que están aisladas reproductiva y ecológicamente y que a su vez tienen historias evolutivas distintas; principalmente en *Caiman crocodilus chiapensis*. Estas unidades de conservación fueron diseñadas en base a una metodología coherente que se puede replicar en otros taxones.
Influence of two different diets on size and body weight of *Crocodylus acutus* hatchlings in Manzanillo Breeding Center, Cuba

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ABSTRACT: An experiment was designed with 90 newborn specimens that were raised and fed with the standard diet during 50 days and with two experimental diets for 30 days, in three experimental square tanks (A, B C), during 30 days. The influence is analyzed, on size and corporal weight increment, of two types of diets against the standard diet in *Cocodylus acutus* of the Manzanillo Zoocriadero (Province of Granma) and the cost of same. The fish diet (B) is much more effective than the standard diet (fish, and cow liver and lung) and than the one with larval flies since the growth rate was of 3.5 mm / day and grew 1.35 times more. The weight increase was of 3.71 g./day, a number superior to the values of the other two diets. The relation coefficient (Cr.) between the size and weight by tanks was calculated in order to express the prevalence of the size over weight or vice versa according to the applied diet. It is demonstrated that with diet (B), the newborn specimens grow 1.35 times more than with pattern diet (A) and larval flies diet (C). However, each newborn specimen fed with diet (B) costs 14 times more than the ones fed with the other two diets.

RESUMEN: Se diseñó un experimento con 90 neonatos recién nacidos que fueron criados y alimentados con la dieta patrón por 50 días y dos dietas experimentales por 30 días, en tres cuartones (A, B C). Se analiza la influencia, sobre la talla y el incremento del peso corporal, de dos tipos de dietas contra la dieta patrón en *C. acutus* (caimán americano) del Zoocriadero de Manzanillo (Provincia Granma), y así como el costo de las mismas. La dieta con pescados marinos (B) es mucho más efectiva que la dieta patrón (compuesta de pescado, hígado y pulmón de res) y la de larvas de moscas ya que la tasas de crecimiento fue de 3,5 mm. / día. Por tal razón los ejemplares con las dieta (B) y crecieron 1,35 veces más y la de con un incremento en peso de 3,71 g. / día, valores superiores a los valores de las otras dos dietas que incluyó la patrón. Se calculó el coeficiente de relación (Cr.) entre la talla y peso por cuartones para determinar el predominio de la talla sobre el peso o viceversa según la dieta suministrada. Se demuestra que con la dieta B los neonatos crecen 1.35 veces más que con la dieta patrón (A) y larvas de moscas (C), sin embargo cada neonato alimentado con la dieta B cuesta 14 veces más que con las otras dos.
Lack of Acute Phase Response to Infection in the American Alligator (*Alligator mississippiensis*)

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**ABSTRACT:** Five juvenile alligators (6.4-8.1 kg) were injected intraperitoneally with a mixture of bacterial lippopolysaccharides (LPS) derived from *Eschericia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. Blood was collected prior to treatment, and 1, 2, 3, 4, 5, 7, 9, and 11 days post-injection. The serum was subjected to clinical agarose gel electrophoresis to determine the changes, relative to pretreatment condition, of protein expression in the serum. Surprisingly, unlike the drastic changes in protein expression observed in mammalian and avian systems upon infection, no changes in protein expression were detected after LPS-treatment. Injection of LPS intramuscularly and in the hind foot pad revealed the same lack of acute phase response. Injection of other substances, such as phytohemagglutinin (an immune system stimulator) and heat-killed bacteria also yielded negative results. Several attempts to isolate C-reactive protein and serum amyloid A, acute phase proteins that are expressed at low levels, but increase up to 100-fold in mammals upon infection, yielded no results. These data lead us to believe that the American alligator, and perhaps other crocodilians, do not exhibit the typical acute phase response, characterized by large changes in serum protein expression, observed in more modern vertebrates.
Microsatellite DNA markers applied to detection of multiple paternity in *Caiman latirostris* in Santa Fe, Argentina

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ABSTRACT: This work describes a method for using microsatellite markers to examine the mating system of broad-snouted caiman. Also, we provide the first data concerning the detection of multiple paternity on wild populations of this species. We obtained DNA samples of four nest-guarding *Caiman latirostris* females and their hatchlings from Santa Fe Province, Argentina. Eight microsatellite primers were tested and amplification products were analyzed by electrophoresis on 10% polyacrylamide gels and visualized with silver staining. Of the eight markers tested, four were found to amplify reliably and yield useful data. The methodology of using polyacrylamide gels with silver staining provided sufficient resolution to obtain the individual genotypes. To assess the presence or absence of more than two parents in each clutch we used the single locus Minimum Method, and applied Cervus 3.0 and Gerud 2.0 software in parentage analysis. Our results indicate more than one father in, at least, two families. These data could suggest multiple paternity in these families, although, a wider sampling of nests and loci is necessary to corroborate this behavior. Understanding the mating system may be important in maintaining viable populations under management programs like those of *C. latirostris*. 

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Mitochondrial DNA analysis of saltwater crocodiles
(Crocodylus porosus) from northern Australia

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ABSTRACT: This study presents preliminary analyses of the mitochondrial DNA control region (mtDNA CR) sequence variation and phylogenetic relationships of more than 50 wild Australian saltwater crocodiles from Australia’s Top End (Northern Territory). CR sequences were aligned and compared with saltwater crocodile sequences in Genbank from Queensland in Australia, Southeast Asia and the western Pacific Ocean, as well as other crocodilian species. CR phylogenetic analyses show that saltwater crocodiles from Australia clustered in a separate clade from specimens from other countries. Surprisingly, one GenBank C. porosus sequence from Queensland clustered with specimens from the Asia Pacific. This unexpected clustering may suggest natural migration from this Pacific clade into Australian populations. Alternatively, smuggling of some specimens into Australia could be considered although there is currently no evidence to support this. CR pairwise genetic comparison shows that the level of divergence within the saltwater crocodile is lower than that observed within the wild Central American Morelet’s crocodile, similar to that observed in wild American Alligators and higher than that observed in captive Chinese alligators and the other crocodile species included. Further studies are underway to increase our understanding of the genetic diversity within the Australian saltwater crocodile.
Modeling of caiman abundance as a tool for the management of Caiman yacare in Bolivia

Alvaro Crespo, Dennis Mendez, Fernando Cisneros, Paul A. Van Damme

ABSTRACT: The Bolivian Program for the Conservation and Sustainable Use of spectacled caiman (Caiman yacare) foresees the annual harvesting of 45000 adult males, mostly in the Beni and Santa Cruz states. The deficient system of assignation of harvest quota is one of the main weaknesses of the Program. There is an urgent need to develop tools that can be used to improve caiman management. The objective of the present study is to develop a predictive model for caiman distribution and abundance in the Bolivian Amazon using vegetation units as spatial units. The model is based on the hypothesis that there exist a high correlation between vegetation structure and relative abundance of the species. Vegetation structure reflects abiotic factors such as temperature, precipitation, altitude, and inundation, which also affect the relative abundance of the species. The model can be tested by monitoring of caimans in vegetation units and by regression analysis.

RESUMEN: En Bolivia, el Programa para la Conservación y Aprovechamiento Sostenible del Lagarto (Caiman yacare) permite la cosecha anual de 45000 adultos machos, principalmente en los departamentos de Beni y Santa Cruz. A causa de la demanda de nuevos interesados para ingresar al programa y ante las dudas sobre el mejor sistema de asignación de cupos de lagarto, surge la necesidad de crear herramientas que permitan la gestión de este recurso. En este trabajo se presenta un modelo de predicción de la abundancia del lagarto en la Amazonia Boliviana usando unidades de vegetación como unidad espacial de estudio. El modelo se basa en la hipótesis de que existe una alta correlación entre los sistemas de vegetación existentes y la abundancia relativa de la especie. La vegetación engloba factores abióticos como ser la temperatura, precipitación, altitud, inundación, y otros, los cuales determinan la abundancia de esta especie. El modelo puede ser validado mediante el muestreo de la abundancia de lagartos en ciertas unidades de vegetación y análisis de regresión. El modelo permite predecir abundancias relativas las más próximas a la realidad.
Molecular genetic tools to improve the selection of juvenile saltwater crocodiles (*Crocodylus porosus*) for use in genetic improvement

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**ABSTRACT:** Traditional genetic improvement programs have used performance data to estimate breeding values with little or no understanding of the underlying genes responsible for their control. Furthermore, the accuracy of the predicted breeding values relies on the pedigree structure and amount of data available. However, the development of molecular genetic technology has provided new means for aiding the prediction and accuracy of breeding values at the gene level. This improvement can be achieved by exploiting linkage between molecular markers and quantitative trait loci (QTL), known as marker-assisted selection (MAS).

QTL studies are being conducted in most livestock industries for the following reasons: 1) favourable alleles for economically important traits can be introduced into a commercial population from exotic stock using marker-assisted introgression (MAI) or repeated backcrossing; 2) selection accuracy can be improved by identifying markers linked to QTL and incorporating this information into the estimation of breeding values; and 3) the potential to increase selection intensity and reduce generation interval (because animals can be genotyped immediately after hatching). Using the linkage map presented by Miles et al. (2008; this conference), the results of the first QTL analysis in crocodilians will be presented herein.
Monitoring populations of American Crocodiles (*Crocodylus acutus*), in the states of Aragua, Falcon, Trujillo and Zulia, Venezuela

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ABSTRACT: From July 2006 and January 2008, we carried out population census and habitat evaluation of American crocodile, at nine sites located in the states of Aragua (1), Falcon (3), Zulia (4) and Trujillo (1). Crocodiles were present at all sites visited, numbering a total of 238 individuals, distributed in five size classes as follows: class I (n=36), class II (n=121), class III (n=57), class IV (n=18) and class V (n=4). On the other hand, 22 of the capture individuals were marked and released for future monitoring purpose. Among the studied sites, rivers Chama and Torondoy and water reservoirs located at Machango (Zulia) and Agua Viva (Trujillo), are confirmed as new distribution area for the American Crocodile. Finally and as a conservation and management measure, a total of 64 American Crocodiles raised in private farm and zoos, were released in both: a Wildlife Reserve (Falcon) and a Wildlife Refuge (Zulia) located in western Venezuela.

RESUMEN: Se censaron caimanes y se evaluaron sus hábitat en nueve localidades entre julio del 2006 y enero del 2008 en los estados Falcón (3), Aragua (1), Zulia (4) y Trujillo (1). Se detectó la presencia de esta especie en todas las localidades. El total de cocodrilos observados fue de 238 clasificados en: 36 Clase I, 121 Clase II, 57 Clase III, 18 Clase IV y 4 Clase V. Se obtiene por vez primera información presencial de la especie en los ríos Chama y Torondoy y en los embalse Machango y Agua Viva, datos de una sospechada distribución histórica o anecdótica de *C. acutus*. 22 ejemplares fueron capturados en las localidades evaluadas, luego marcados y liberados. Adicionalmente se reforzaron algunas poblaciones en los estados Falcón y Zulia al liberar 64 caimanes provenientes de un centro de cría en cautiverio en el estado Guárico y del Zoológico de Maracaibo en Zulia.
Morphometric Analysis in Embryos of Black Yacare Caiman yacare
(Crocodylia, Alligatoridae)

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ABSTRACT: In embryology it is important to establish a descriptive system of classification of stages of embryo development that serves to correlate the different phases in a temporary scale and under specific conditions of incubation (temperature and humidity). At the same time, it is useful evaluate the existence of biometric relationships that, together with the system of stages, could serve to develop a tool that consider the precise moment of the oviposition. The objective of this work is to formulate a method base for the taking of morphometric measures and to analyze the growth patterns. For it, 33 embryos collected in the Argentinean province of Chaco (at 26°43´39,1´´S; 59°03´27,4´´W) were used. Each embryo stage was determined under a dissecting microscope, 18 morphometric measures were taken with a digital caliper (±0.01 mm). A guide instructive with photographs was designed to measure the structures. We used the Statgraphics Centurion XV software to describe the growth patterns, correlating the morphometrics measured and the different stages. The models that better adjusted to the growth of the different structures in embryos from Caiman yacare correspond to second order curves: Y = ax + bx² where “Y” is the morphometric measure and “x” is the stage.

RESUMEN: En embriología es importante establecer un sistema descriptivo de clasificación de estadios de desarrollo embrionario que sirva para correlacionar las diferentes fases en una escala temporal y bajo condiciones específicas de incubación (temperatura y humedad). Al mismo tiempo, resulta de utilidad evaluar la existencia de relaciones biométricas, que junto con el sistema de estadios, sirva para desarrollar una herramienta que permita estimar el preciso momento de la oviposición. El objetivo de este trabajo es crear un método base para la toma de medidas morfométricas y analizar los patrones de crecimiento. Se utilizaron 33 embriones colectados en la Provincia del Chaco, Argentina (26°43´39,1´´S; 59°03´27,4´´W). Se determinó el estadio de los embriones bajo la lupa, se tomaron 18 medidas corporales con un calibre digital (±0,01 mm). Se confeccionó una guía-modelo para medir las estructuras acompañadas de fotografías explicativas. Empleando el software Statgraphics Centurion XV se buscó describir patrones de crecimiento correlacionando las variables morfométricas medidas y los diferentes estadios. Los modelos que mejor se ajustaron al crecimiento de las diferentes estructuras en embriones de Caiman yacare fueron los correspondientes a curvas de segundo orden: Y = ax + bx² donde “Y” es la variable morfométrica y “x” es el estadio.
INTRODUCTION

In embryology it is important to establish a descriptive system of classification of stages of embryo development that serves to correlate the different phases in a temporary scale and under specific conditions of incubation (temperature and humidity) (Ferguson, 1987). At the same time, it is useful evaluate the existence of biometric relationships that, together with the system of stages, could serve to develop a tool that consider the precise moment of the oviposition. Previous works exist that describe the reproductive biology and embryology of crocodiles (Ferguson, 1985), others analyze the patterns of ossification in the skeleton of Alligator mississippiensis (Rieppel, 1993) or the sex determination by temperature for the same species (Lance & Bogart, 1994).

On South American caimans many works refer to Caiman latirostris, dealing with effect of incubation temperature in the sex determination and survivorship (Piña et al., 2003), the size at hatching (Piña et al., 2007), relationships between the period of incubation and the embryonal development at three different temperatures (Donayo, 2002), and one description of embryonic stages, considering the age of embryos with unknown date of ovoposition (Iungman et al., 2005). Much less work refers to the black jacare, C. yacare. For this reason, our objective is to formulate a base method for taking of morphological measures and to analyze the growth patterns in this species.

MATERIALS & METHODS

Thirty-three embryos of Caiman yacare were collected in the Argentinean province of El Chaco (26° 43´ 39.1´´ S; 59° 03´ 27.4´´ W). Each embryo stage was determined under a dissecting microscope following Ferguson (1987), and 18 morphometric measures were taken with a digital caliper (± 0.01 mm). The total length, snout-vent length, and tail length was first verified with the aid of a thread, then the resultant distance was measured on the caliper. A guide instructive with photographs was designed to measure the structures (Table 1, and Figures 1-3).

Table 1. Morphometrics in Caiman yacare embryos.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Total length</td>
<td>Measured from the tip of snout to the end of the tail. (Figure 1)</td>
</tr>
<tr>
<td>2 Snout depth</td>
<td>From the middle of nose to the inferior border of the jaw, transversal to the snout length. (Figure 1)</td>
</tr>
<tr>
<td>3 Snout length</td>
<td>From the most anterior limit of the eye to the tip of the snout, parallel to the mouth border. (Figure 1)</td>
</tr>
<tr>
<td>4 Jaw length</td>
<td>From the tip of jaw to the posterior angle of it. (Figure 1)</td>
</tr>
<tr>
<td>5 Smaller diameter of the eye</td>
<td>(Figure 1)</td>
</tr>
<tr>
<td>6 Greater diameter of eye</td>
<td>(Figure 1)</td>
</tr>
<tr>
<td>7 Arm length</td>
<td>Taken on the right arm from the shoulder to the elbow. (Figure 1)</td>
</tr>
<tr>
<td>8 Forearm length</td>
<td>From the elbow to the carpus. (Figure 1)</td>
</tr>
<tr>
<td>9 Hand length</td>
<td>From the carpus to the tip of the second finger. (Figure 1)</td>
</tr>
<tr>
<td>10 Thigh length</td>
<td>From the groin to the knee, on the right thigh. (Figure 1)</td>
</tr>
<tr>
<td>11 Tibial length</td>
<td>From the knee to the ankle, on the right leg. (Figure 1)</td>
</tr>
<tr>
<td>12 Foot length</td>
<td>From the ankle to the third toe. (Figure 1)</td>
</tr>
<tr>
<td>Nostril-eye length</td>
<td>Straight distance between the nostril and the eye. (Figure 2)</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Snout-vent length</td>
<td>By ventral, from the tip of the snout to the anterior limit of the vent. (Figure 2)</td>
</tr>
<tr>
<td>Tail length</td>
<td>By ventral, from the end of the vent to the tip of the tail. (Figure 2)</td>
</tr>
<tr>
<td>Armpit -groin length</td>
<td>In straight line, on the right side of the embryo. (Figure 2)</td>
</tr>
<tr>
<td>Head width</td>
<td>On a transversal plane, behind the eyes. (Figure 3)</td>
</tr>
<tr>
<td>Head length (excluding the snout)</td>
<td>From the anterior border of the eyes to the beginning of the neck. (Figure 3)</td>
</tr>
</tbody>
</table>

Figure 1.
The Statgraphics Centurion XV software was used to describe the growth patterns, correlating the morphometrics measured and the different stages.

RESULTS & DISCUSSION

Figures 4-7 show the model that better adjusted to the growth of the different structures analyzed. These follow to second order curves: \( Y = ax + bx^2 \) where “\( Y \)” is each morphometric measured, and “\( x \)” the stages. Table 2 shows the values of \( R^2 \) obtained to describe the relationship between the morphometrics and the stages. For each \( R^2 \) showed ANOVA values of \( p<0.05 \), suggesting a statistically significant relationship between the measures and the stages.
Table 2.

<table>
<thead>
<tr>
<th>Morphometric measure</th>
<th>$R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>98.10</td>
</tr>
<tr>
<td>Armpit-groin length</td>
<td>96.83</td>
</tr>
<tr>
<td>Snout-vent length</td>
<td>98.08</td>
</tr>
<tr>
<td>Tail length</td>
<td>97.82</td>
</tr>
<tr>
<td>Head width</td>
<td>97.99</td>
</tr>
<tr>
<td>Head length (excluding the snout)</td>
<td>99.06</td>
</tr>
<tr>
<td>Nostril-eye length</td>
<td>94.98</td>
</tr>
<tr>
<td>Smaller diameter of eye</td>
<td>96.64</td>
</tr>
<tr>
<td>Greater diameter of eye</td>
<td>98.23</td>
</tr>
<tr>
<td>Jaw length</td>
<td>98.12</td>
</tr>
<tr>
<td>Snout length</td>
<td>97.11</td>
</tr>
<tr>
<td>Snout depth</td>
<td>94.91</td>
</tr>
<tr>
<td>Arm length</td>
<td>95.32</td>
</tr>
<tr>
<td>Forearm length</td>
<td>97.19</td>
</tr>
<tr>
<td>Hand length</td>
<td>99.54</td>
</tr>
<tr>
<td>Thigh length</td>
<td>94.69</td>
</tr>
<tr>
<td>Tibial length</td>
<td>98.03</td>
</tr>
<tr>
<td>Foot length</td>
<td>97.21</td>
</tr>
</tbody>
</table>

Figure 4.
Figure 5.

Figure 6.
Development of the reptilian embryo *per se* involves two distinct but related processes. One is the differentiation, *i. e.* the origin of tissues and organ systems. The other is growth, *i. e.* the increase in the size of the embryo (Andrews, 2004). The basic events during the organogenesis phase happen in the first half of development (Ferguson, 1987), which corresponds to the 35th day after oviposition (stage 21) for *Alligator mississippiensis* (Ferguson, 1985), and to 30-32th day (stage 21) for *Caiman latirostris* (Iungman, 2005). Variations in the relative sizes and proportions of structures such as the tail, snout, limbs and others, appear principally during the second half of development (Ferguson, 1985). This seems be the rule also for *C. yacare*, which shows (Figs. 4-7) an increment in the growing at beginning of the stage 21.

REFERENCES


Piña, C., A. Larriera, M. Medina & G. J. W. Webb. 2007. Effects of incubation temperature on the size of *Caiman latirostris* (Crocodylia: Alligatoridae) at hatching and after one Pansteatitis in Nile crocodiles (Crocodylus niloticus) associated with fish die-offs in the Loskop Dam, South Africa.

Pansteatitis in Nile crocodiles (*Crocodylus niloticus*) associated with fish die-offs in the Loskop Dam, South Africa

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²Pathology, Department of Paraclinical Sciences, Faculty of Veterinary Science, P/Bag X04, University of Pretoria, Onderstepoort, 0110, South Africa (mark.williams@up.ac.za);  
³P O Box 12499, Onderstepoort, 0110, South Africa (crocvet@mweb.co.za)

**ABSTRACT:** Nile crocodile (*Crocodylus niloticus*) numbers have been declining in the Loskop Dam, South Africa, over the last decade. The quality of water flowing into the dam is generally poor and is known to cause regular fish die-offs at the inflow area. During 2006 a clinically ill mature crocodile was caught alive and a necropsy was performed after it was euthanized. Typical lesions of steatitis were observed in all fat depots in the carcass. Following a large fish die-off in 2007 several crocodiles were observed to be affected. These crocodiles were reluctant to move on land or could not swim properly. Further necropsies were performed and similar lesions of steatitis were observed. As the affected fat hardens, animals become partially immobile and we suspect that the clinically affected animals die of exposure because they are less mobile or they drown because they cannot swim properly. The predisposing factors, pathogenesis and lesions will be discussed and illustrated. This report should serve to alert veterinarians and other scientists to the fact that the consumption of rancid fish over long periods (weeks) by crocodiles may cause pansteatitis and subsequent mortality.
**Pathological Investigation of Runting in Farmed Saltwater Crocodiles**

* (*Crocodylus porosus*) **in Australia.**

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**ABSTRACT:** Runting in farmed saltwater crocodiles (*Crocodylus porosus*) is a major cause of mortality marked by poor growth and emaciation. The purpose of this study was to perform a thorough pathological investigation. Forty animals (5-7 months old) were selected for the study over two years (twenty each in 2005 and 2007). Each group consisted of ten runts and ten clinically healthy (“normal”) crocodiles. The study included full post-mortems, general bacterial culture, faecal parasitology, standard diagnostic haematology and serum biochemistry, histological evaluation of an extensive range of tissues, and, in the 2007 group, serum corticosterone. There were no differences with respect to bacterial culture or faecal parasitology. Haematological and serum biochemical findings in runts included marked non-regenerative anaemia (mean PCV 13% runts, 20% normals) and hypoalbuminaemia (mean albumin 10.9g/L runts, 17.6g/L normals), likely secondary to cachexia (prolonged poor-doing). Runts also had significantly lower serum phosphorus (1.0 mmol/L) than normal crocodiles (1.6 mmol/L), which, along with decreased growth plate activity evident histologically in runts, likely reflects poor growth. Histologically, there was severe lymphoid atrophy, most notably involving the thymus and tonsils. The adrenal glands in runts appeared relatively active whilst serum corticosterone levels were higher (mean 18.8 ng/ml runts, 8.3 ng/ml normals) suggesting increased stress levels.
Phenotypic plasticity of the crocodile lingual salt glands in response to salinity

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ABSTRACT: The estuarine crocodile, Crocodylus porosus is found inhabiting water of varying salinity, from freshwater to hypersaline. In salinities, hyperosmotic to their plasma, estuarine crocodiles are understood to excrete excess salt via the lingual salt glands to maintain osmoregulatory homeostasis, although the functional significance salt glands in salt and water balance is debated. Here, we examined the morphological and functional phenotypic plasticity of the lingual salts to environmental salinity. We hypothesised that in crocodiles acclimated to freshwater environments, gland size and ion transport capacity would be reduced, and conversely in animals chronically exposed to hyperosmotic salinities they would demonstrate a greater capacity for salt excretion. Juvenile C. porosus were acclimated to freshwater and 70% seawater for six months, after which we compared between the two treatments, the morphology of the glands, ion transporters, and maximal excretory rates for NaCl. C. porosus shows a highly adaptive phenotypic response to increased environmental salinity which is functionally significant.
Population diagnosis and some reproductive aspects of “Caimán Aguja” 
(*Crocodylus acutus*) in Bahía Portete, La Guajira peninsula, Colombia

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**ABSTRACT:** The current research corresponds to the first stage of the *Crocodylus acutus* conservation program in Bahía Portete - Colombia, developed by the company CARBONES DEL CERREJÓN LIMITED.

The population of the *C. acutus* is ubicat on three fragments of mangrove swamp. 70 individuals were observed, and 31 animals were captured and marked with two identification systems. In 50.8 km (31.7 miles) traveled across, a density of 1.37 individuals per kilometer were estimated. In the mangrove swamp area, 0.054 individual per hectare with a proportion of sex of 1:1 were also determined. The population is composed by hatchlings (<30cm) 10%, juveniles (31-90cm) 44.29%, subadults (91-180cm) 24.29% and adult class (>180cm) 21.42%; which is typical distribution of a population that has been subdued to overexploitation.

According to the relative fatness index, the physic condition of these animals is healthy. Three nesting areas were identified, confirming that the reproductive period is between March and September. Ten nests were registered, finding a litter size of 26.7 ±11.35 eggs, which largest diameter was 71.63±3.11mm, and shortest diameter of 44.61±2.17mm, and an average weight of 76.65±8g; fertility rate 85.2%, embryo mortality rate 13.48%, indicating a high reproductive capability. Incubating period lasts 8-9 weeks approximately. Factors that affect litter survival are: scarcity of proper nesting areas, predation by *Procyon cancrivorus*, flooding and plundering by the inhabitants. According to the biotic potencial, it is estimated that the maximum time for its recovery is from 4 to 5 years, under nonextration conditions.

**RESUMEN:** La presente investigación constituye la primera fase del programa de conservación del *Crocodylus acutus* en Bahía Portete- Colombia, adelantado por la empresa CARBONES DEL CERREJÓN LIMITED.

La población de *C. acutus* se ubica en tres fragmentos de manglar. Se observaron 70 individuos y se capturaron 31 animales y se marcaron con dos sistemas de identificación. En 50.8km recorridos se estimo una densidad de 1.37ind/km. En el área de manglar de 0.054ind/há con una proporción de sexo 1:1. La población esta compuesta por neonatos (<30cm) con un 10%, juveniles (31-90cm) con 44.29%, subadultos (91-180cm) con 24.29% y la clase adulta (>180cm) con 21.42%, características distribucionales propias de una población sometida a sobre explotación. Según el Índice de Gordura Relativa la condición física de estos es saludable.

Se identificaron 3 áreas de anidación, confirmándose que el periodo reproductivo es de marzo a septiembre. Se registraron 10 nidos con un tamaño de camada de 26.7 ±11.35 huevos, con un diámetro mayor de 71.63±3.11mm, un diámetro menor de 44.61±2.17mm y un peso
promedio de 76,65±8g; la tasa de fertilidad de 85,2%, mortalidad embrionaria de 13,48%, indicando una alta capacidad reproductiva, el período de incubación dura aproximadamente 8-9 semanas. Los factores que afectan la supervivencia de las camadas son: escasez de áreas adecuadas para la anidación, depredación por Procyon cancrivorus, inundaciones y saqueo por los pobladores. De acuerdo a su potencial biótico, se estima que el tiempo máximo para su recuperación es de 4 a 5 años, bajo condiciones de no extracción.

**Key words:** Crocodylus acutus, population density, reproduction, wild population

**INTRODUCTION**

Worldwide, Crocodylus acutus (Cuvier 1807) is currently recognized as “endangered” according to the criteria established by the UICN (2003) and listed in the Index I of the CITES, exempting Cuba (anonym 2004). In Colombia the specie is also ranked as “endangered” (Mora-Castaño 2002), due to factors such as indiscriminate hunting prior to 1960 (Medem 1981), the habitat degradation, has contributed to the decrease in the natural population which is actually fragmented into subgroups of population (Rodriguez 2000), among this subgroups is located the Bahia Portete.

Between July 5th to 20th and September 12th to 14th of 2007, the current state of the population was evaluated and the confirmation of the reproductive period of the C. acutus in Bahia Portete, as one of the objectives that constitute the first stage of the Conservation Program of the C. acutus. The program presents the interest from the company Carbones del Cerrejón Limited, which is aimed at the integration of the local indigenous population (Wayuu) with the conservation of the specie.

**MATERIAL AND METHODS**

Study area: Bahia Portete (Fig. 1) is the biggest of a series of Bahias located in the northern sector of Colombia, it is located in the town of Uriábia and communicates with the Caribbean Sea, with an approximate extension of 12.793ha, and it is located between 12°16’48” N and 72°02’21” W (Anonym 2005). The region presents an average annual precipitation of 451mm, with the values between the 50-1300mm. The area is very dry since early December until mid-April, after two months of moderate rainfall, continues a dry season between July and August and finally a winter season between September and November, this being the main and sometimes the only rainy period, which represents over 60% of annual rainfall. It does not receives and input of fresh water directly from the continent, except for runoff from small streams formed during the rainy seasons

According to the structural and functional classification of mangroves, the mangrove formations of Bahia Portete, are considered as mangrove edge, framed within the low type, highly branched, leading to the formation of very narrow strips, under 50m, presents dry conditions and saline areas marked with water deficit, with a predominance of Rizophora mangle and Avicennia germinans. In general, this ecosystem is behaving like a forest in recovery, showing a sign of good health, the process of succession is recognized by the large number of enclaves or islands of R. mangle colonizing new areas.
Recruitment and establishment of transects. - The area was divided into six sectors and they in turn locations, nominated according to the indigenous place names. The mangrove areas were measured using Satellite image of true color of Google Earth Plus. The tours were conducted by boat and walking, to establish routes within the sampling channels, lagoons, mangrove and inland beaches. During this inspection were identified places of transit, sunbathe, nesting sites and caves. These tours were conducted between 7:00 and 15:00 hours (Figure 2).

Night counting, catch and identification systems. - The "Counts night with lamps," methodology was used, standardized by the Ministry of Environment (Martínez 1994), these transects (11 in total) were conducted between 18:00 and 04:00 hours, 2,000,000 lumens lamps and hands free 150,000 lumens were used. At the time of the sighting, the time,
number of individuals were registered, as well as the environmental variables of the air temperature and relative humidity with a digital thermo-hygrometer, water temperature and salinity levels with a refractometer (Hanna Instrument), the pH of the water with a digital meter (0.1 watt Hanna Instrument) and features of the site observation and / or capture.

The class structure proposed by Thorbjarnarson & Platt (2000) was used; Class I (hatchlings) under 30 cm, Class II (juveniles) between 31 and 90 cm, Class III (subadults) between 91 and 180 cm and class IV (adults) larger than 180 cm, by the presence of a female pregnant with LT of 180cm.

During the catches the biometric features of Total Length (TL), Snout-Vent length (SVL), measured from snout to the tip of the middle part of the sewer), carried out with tapes (± 0.5 cm) were recorded, the weight with pesolas of 300 and 500gr, 25 and 250 kg, for the evaluation of the physical conditions of the animals Concerning the Relative Fatness Index (RFI, figure 3) was employed, proposed by Seijas et al. (2003) for Caiman crocodilus crocodilus, where \( W_R \): equals Real Weight, \( W_E \): Expected Weight, a: and b: are constants obtained from regression analysis of data on the length and weight of the animals in obtaining the Expected Weight (WE).

\[
RFI = \frac{W_R}{a \times TL^b}
\]

**Figure 3.** Index Formula of Relative fatness

The sex determination was conducted by direct palpation of the gutter and use of claw and/or forceps. Individuals were marked with two identification systems: an electronic identifier (Micro chips brand AVID) and the amputation of their single and double caudal whorls on the tail, the latter suggested by the Ministry of Environment (Anonymous 2000), each whorl successive from the simpler region single caudal whorls is assigned a number from the series 1, 2, 4, 7, 10, 20, 40, 70,100, 1000 ... In this work the tens and hundreds are marked in double whorls as follows: in the caudal whorls of the right row the dozens and to the left the hundreds, and in the simple caudal whorls the units. The observation sites and captures were georeferenced using GPS (Garmin 60CSx).

The intensive search for nests was carried out between 7:00 and 15:00 pm. These were georeferenced using a GPS (Garmin 60CSx). Appraising the excavations according to their condition, taking into account the following criteria: good nest (with eggs), drowned nests (embryonic death by floods), old nest (used in previous posture periods), abandoned nest (with signs excavation and were not used), preyed nest (with signs of having been preyed), plundered nest (extraction of eggs by humans) and hatched nest (in those that became apparent signs of hatching). In active nests were reported, length, width and depth, distance at which these were at the edge of the mirror of water, and by triangulating the height of this with respect to the level of the mirror of water, also were recorded: temperature and relative humidity, identification of close vegetation and distance to the nest.

Each active nest was object to record their litter size, major and minor diameter of eggs with a type vernier caliper (Electronic Digital Caliper) and Weigt (Balance of 200g), the embryonic state (fertility, infertility and embryonic death), and physical conditions of the
egg (fractured or broken) and the length of embryonic development with the assessment of an opaque bandwidth (Ferguson 1995, In Gutierrez and Rodriguez in 1993).

RESULTS

Population density.- We traveled a total of 50.8 km, having observed a total of 70 individuals in 9 transects, presenting an average of 7.7 ± 3.5 animals daily and a density of 1.37 ind/km, transects 1 and 11 were not sampled as there is no evidence of the presence of individuals during the daylight inspection (Fig. 2).

Individuals of C. acutus were observed in 3 of the 6 sectors, more accurately in the sectors of Ian, Waâbpana, Wasinsay, Turruli, Wayetalo and Kupterra.

Sector 2 (locality if Ian): It covers an area of about 500ha. Characterized by having a series of internal channels and not been easily accessible by boat, providing protection to animals of fishing activities (Figure 2). In this sector a density area of 0.114 ind/ha was founded. (n: 57, chart 1)

Sector 3 (localities of Waâbpana and Wasinsay): Between these two locations is a patch of mangrove of 20ha, which posses interior channels and clayish soil, is a zone of high floods and on its inner edge lies a patch of dead mangrove (Figure 2). In this sector a density area of 0.00793 ind/ha was founded (No: 8, table 1).

Sector 4 (localities of Turruli, Wayetalo and Kupterra or Puerto Portete): A thin patch that is growing and has a navigable interior channel, wide and deep, the inner edge of the mangrove is sandy, tall and suitable for nesting the mangrove area covers an area of 630ha (Figure 2). In this sector a density area of 0.400 ind/ha was founded (No: 5, table 1).

Sector 1 (localities of Los Cocos, Kashiara, Achii, Savaincle, Salinaru, Utûana and Siluru), Sector 5 (town of Puerto Nuevo) and the Sector 6 (locality of Media Luna): these have in common being thin strips of mangroves and in growing process, no interior channels, the beaches and the internal border of the mangrove are clay soil (Figure 2). No evidence of utilization from the C. acutus was founded in any of these sectors.

Table1. Densities per area of C. acutus mangrove.

<table>
<thead>
<tr>
<th>Mangrove</th>
<th>Area(ha)</th>
<th>Nº de Indiv</th>
<th>Ind./ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinaru</td>
<td>140</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ian</td>
<td>500</td>
<td>57</td>
<td>0.11400</td>
</tr>
<tr>
<td>Wasinsay</td>
<td>20</td>
<td>8</td>
<td>0.40000</td>
</tr>
<tr>
<td>Puerto. Portete</td>
<td>630</td>
<td>5</td>
<td>0.00793</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1290</strong></td>
<td><strong>70</strong></td>
<td><strong>0.05420</strong></td>
</tr>
</tbody>
</table>

Structure of the population - Of the 70 individuals that were spotted, 31 were captured, of these, 29 were marked with caudal whorls and from this group 19 were marked with electronic identifiers. The 70 individuals were distributed as follows: 10% hatchlings, 44.29% juveniles, 24.29% sub-adult and 21.42% adults (Fig. 5). The captured: 10% neonates, 50% juveniles,
45.83% sub-adults and 4.16% adults (Fig. 6). The classification structure is characteristic of a population subject to overhunting (Figure 7, d.) According to the class structure proposed by Velasco and Ayarzagüena (1995) submitted for wild populations of *Caiman crocodilus*.

**Figure 5.** Distribution of all classes of individuals observed in the population of *C. acutus* in Bahia Portete

**Figure 6.** Distribution of class *C. acutus* captured in Bahia Portete

**Figure 7.** Class structure proposed by Velasco and Ayarzagüena (1995) from a wild population of *Caiman crocodilus* in Venezuela.
The catch had a sex range of 1:1, with 50% of females and 50% males. The distribution of sex in classes presented for the case of a female 41.66% in Class II, 50% and class III, and only 8.3% in Class IV; in the case of the males 58.33% in class II, 41.66% in class III and there were no captures for class IV (Fig. 8).

Figure 8. Distribution of sexes in the structures of classes of people captured in C. acutus in Bahia Portete (S.O = single eyes).

**Estimating the physical conditions of individuals.** - The animals presented a range of TL between 25.8 and 200 cm and weights between 300 and 30,000 g. The Weight-Length relation is defined by the following equation (Equation 1), with a correlation coefficient of r : 0.97 and R² 95.5%.

\[
W_e = 0.00191633 \cdot TL^{3.07563} \quad (\text{Equation 1})
\]

Where the rate of obesity corresponds to the equation 2

\[
RFI = \frac{W_R}{0.00191633 \cdot TL^{3.07563}}
\quad (\text{Equation 2})
\]

With a Relative Fatness Index average of 1.03, indicates a healthy population. The animals showed no signs of mutilations, scars or obvious signs of disease (Fig. 11).

Figure 11. Relative fatness index of individuals caught in Bahia Portete.
Hours of sighting.- the population began their evening activities around 18:00 hour until the 4:00 hours, being the time range between 20:00 and 1:00 hours, the most active and the peak of maximum activity at 22:00 (n: 17) hours.

Sighting locations. - The largest number of observations were submitted among the vegetation with a 84.28% (n: 59) and a 15.71% (n: 11) located in open waters, there were no animals on land. With regard to the depth of water, largest number of sightings were sighted, in shallow waters with a 91.43% (n: 64) and an 8.57% (n: 6) in deep water.

Environmental variables and physical-chemical registered .- The animals were among the 26 to 32 °C ambient temperature and a single individual observed during the day (38 degrees °C), the largest number of animals were found among the 27-30 °C (n: 41). The values of relative humidity were recorded among 61% to 84%, for the individual caught in the day a value of 40% was registered. Individuals were observed at a superficial temperature of the water between 26 to 30 °C.

Nesting area distribution. - 3 nesting areas were identified. Two islands located in Sector 2 and in the sand dunes located in sector 4.

Pioyoi Island is the largest and covers an area of 1,0689 ha (without the flood peak), presents characteristics of the subxerofítical dry forest vegetation, with cacti, scrubby trees and low, the soil is composed of burdensome material and only in 0.0003 ha sandy material. On this island 8 nests were located, with a density of 7.48 nests/ha, of which 6 were found in the sandy substrate to form a communal nesting area, the remaining nests were located in other parts of the island (Table 2).

Espirol Island is divided by two small portions of mangrove and for greater clarity known as Espirol 1 with an area of 0.0588 ha and Espirol 2 with 0.2819 ha (areas calculated without the flood peak). This just like Pioyoi, shows characteristics of the subxerofítical dry forest vegetation, the soil is composed of burdensome material. In Espirol 1 no active nests were located and in Espirol 2, 1 active nest was located, with a density of 3.50 nests/ha (Table 2).

The third corresponds to the sand dunes (located in sector 4) formed behind the mangrove, these are colonized by Batis maritima and have a height of about 2 m of sand-clay material, R. mangle which forms the edge provides shade for nests, the area behind the dune is a flood zone. Here, 1 nest was located. The area of sand dunes could not be determined.

Table 2. Clutches found in the areas of search in Bahia Portete.

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (ha)</th>
<th>Activ Nests</th>
<th>Nest under Construction</th>
<th>Old Nest</th>
<th>Drowned Nest</th>
<th>Destroyed Nest</th>
<th>Total Nest</th>
<th>Nests Density/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pioyoi Island</td>
<td>1.0689</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>7.48</td>
</tr>
<tr>
<td>Isla of Espirol 1</td>
<td>0.0588</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Island of Espirol 2</td>
<td>0.281</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Dunes *</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
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<tr>
<td>Total</td>
<td></td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

* It could not be established
Characteristics of the nests. A total of 29 digs were located, 10 of these presented postures which correspond to a 34.48% (Table 2), 31.0% were found evidence of construction activity, 24.13% corresponded to old nests, 3.44% to drowned in nests and 7.83% destroyed nests by activities of other females.

The ten nests showed the an average size 62.7 ± 31.21 cm long (Table 3), a width 63.8 ± 41.31 cm and depth to bottom of clutch 31.5 ± 12.06 cm, in the last six nests, for been located in a communal nesting area. The registration of the dimensions of the communal nest shows a bias in the values due to the closeness between them, which impeded the certain determination of the limits

Table3. Biometric characteristics of the nests in which they recorded the existence of eggs of *C. acutus* found in Bahia Portete.

<table>
<thead>
<tr>
<th>Nest Nº</th>
<th>Location</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pioyo</td>
<td>103</td>
<td>93</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>Pioyo</td>
<td>58</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>Pioyo</td>
<td>71</td>
<td>86</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Espiro 2</td>
<td>128</td>
<td>160</td>
<td>41</td>
</tr>
<tr>
<td>5</td>
<td>Pioyo</td>
<td>43</td>
<td>38</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>Pioyo</td>
<td>58</td>
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</tr>
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<td>9</td>
<td>Pioyo</td>
<td>35</td>
<td>26</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>Wayetalo</td>
<td>31</td>
<td>25</td>
<td>19</td>
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<table>
<thead>
<tr>
<th></th>
<th>Average</th>
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<tbody>
<tr>
<td>Nest</td>
<td>62.7</td>
<td>63.8</td>
<td>31.5</td>
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<td>DS</td>
<td>31.2198299</td>
<td>1.31128</td>
<td>12.0669</td>
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</tbody>
</table>

A 100% of the clutches are under shade most of the day, located between 20 to 100cm from the base of the nearest bush, 8 nests beneath a *Cesalpinacea sp*, a nest under an *Astronium sp* (*Anacardiacea*) and one below a *R. mangle*.

The direction of the actives nests was to the West for 60% of cases, 20% to the East, 10% to the North and 10% to the South.

The nests showed temperatures between 31.8 °C and 36.8 °C with an average of 34.13 ± 1.58 °C and relative humidity between 31% and 56% with an average of 44.1 ± 9.12%. The temperatures recorded during the environmental assessment of the nests were between 32 and 41.3 °C with an average of 35.62 ± 3.37 °C and relative humidity of the environment was between 32 and 45% with an average of 38.8 ± 4.8% (Table 4).
Table 4. Characteristics of temperature and relative humidity in the nests of *C. acutus*.

<table>
<thead>
<tr>
<th>Nest Identification Nº</th>
<th>Environmental Temperature</th>
<th>Environmental Humidity</th>
<th>Nest Temperature</th>
<th>Nest Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41.3</td>
<td>32</td>
<td>31.8</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>42</td>
<td>32.6</td>
<td>56</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>42</td>
<td>33.1</td>
<td>56</td>
</tr>
<tr>
<td>4</td>
<td>37.6</td>
<td>41</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>5</td>
<td>36.5</td>
<td>45</td>
<td>33.5</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
<td>42</td>
<td>34.4</td>
<td>44</td>
</tr>
<tr>
<td>7</td>
<td>32</td>
<td>42</td>
<td>35.7</td>
<td>41</td>
</tr>
<tr>
<td>8</td>
<td>37.1</td>
<td>34</td>
<td>34.9</td>
<td>35</td>
</tr>
<tr>
<td>9</td>
<td>37.1</td>
<td>36</td>
<td>36.8</td>
<td>37</td>
</tr>
<tr>
<td>10</td>
<td>38.6</td>
<td>32</td>
<td>35.5</td>
<td>31</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>35.62</strong></td>
<td><strong>38.8</strong></td>
<td><strong>34.13</strong></td>
<td><strong>44.1</strong></td>
</tr>
<tr>
<td><strong>DS</strong></td>
<td><strong>3.37</strong></td>
<td><strong>4.8</strong></td>
<td><strong>1.58</strong></td>
<td><strong>9.12</strong></td>
</tr>
</tbody>
</table>

Through the evaluation of the embryonic band of development were estimated the probable dates for the clutches, like this: clutch number 1 presented a developmental band of approximately 18 days and it would be June 28, 2007 the probable date of position (Figure 12c); clutches number 2-5 and 10 showed a band of embryonic development of two weeks’ stance setting the likely date between 1 and July 2, 2007; clutches number 6-9 showed a band of two weeks’ positions, even though the day July 13 the position had not taken place in the afternoon, the probable dates of positions are between July 13 2007 in night time and July 18 in the morning hours (Figure 12b). It is estimated the last week of June as the possible start of the positions of *C. acutus* in Bahia Portete.

**Figure 12.** a) Development of the opaque band under artificial incubation of *C. acutus* eggs with temperature conditions of 32.5 °C and relative humidity of 99% (Mejia F. com Pers.). Characteristics of different nests of *C. acutus* found in Bahia Portete, evaluated according to Ferguson (1985 in Gutierrez and Rodriguez 1993): b) Nests. No 2-10 and c) Nest No 1.
Characteristics of the Clutches - The clutch size showed an average of 26.7 ± 11.35 eggs. The evaluation of the viability of the eggs showed that 95.5% of the eggs were fertile, 77.9% variables, 4.5% infertile and 17.6% showed embryonic mortality (Table 5). The eggs length average diameter 71.69 ± 3.11mm, a width average diameter of 43.64 ± 2.17mm and average weight of 77.89 ± 8g (Table 6).

Table 5. Viability of the litter of active nests in Bahia Portete.

<table>
<thead>
<tr>
<th>Nest Identification Nº</th>
<th>Location</th>
<th>Date</th>
<th>Nº of Eggs</th>
<th>% Viable Eggs</th>
<th>% Infertile Eggs</th>
<th>% Embryonic Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pioyoi</td>
<td>11-jul</td>
<td>30</td>
<td>73.3</td>
<td>0</td>
<td>26.7</td>
</tr>
<tr>
<td>2</td>
<td>Pioyoi</td>
<td>13-jul</td>
<td>25</td>
<td>48</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Pioyoi</td>
<td>13-jul</td>
<td>28</td>
<td>82.1</td>
<td>3.5</td>
<td>14.4</td>
</tr>
<tr>
<td>4</td>
<td>Espirol2</td>
<td>13-jul</td>
<td>10</td>
<td>60</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>Pioyoi</td>
<td>14-jul</td>
<td>41</td>
<td>68.2</td>
<td>19.51</td>
<td>12.19</td>
</tr>
<tr>
<td>6</td>
<td>Pioyoi</td>
<td>19-jul</td>
<td>42</td>
<td>95.3</td>
<td>0</td>
<td>4.7</td>
</tr>
<tr>
<td>7</td>
<td>Pioyoi</td>
<td>19-jul</td>
<td>20</td>
<td>60</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>Pioyoi</td>
<td>19-jul</td>
<td>27</td>
<td>81.5</td>
<td>0</td>
<td>18.5</td>
</tr>
<tr>
<td>9</td>
<td>Pioyoi</td>
<td>19-jul</td>
<td>35</td>
<td>97.1</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>10</td>
<td>Wayetalo</td>
<td>19-jul</td>
<td>9</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>267</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>26.7</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DS</strong></td>
<td></td>
<td></td>
<td><strong>11.35</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Biometrics of the eggs.

<table>
<thead>
<tr>
<th>Nest Identification Nº</th>
<th>Clutch size</th>
<th>Egg Length Average</th>
<th>Egg Width Average</th>
<th>Weight Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>74.86</td>
<td>44.34</td>
<td>85.3</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>68.97</td>
<td>45.82</td>
<td>80.23</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>67.4</td>
<td>41.17</td>
<td>62.52</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>74.34</td>
<td>42.96</td>
<td>77.6</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>70.81</td>
<td>45.63</td>
<td>79.15</td>
</tr>
<tr>
<td>6</td>
<td>42</td>
<td>71.73</td>
<td>44.9</td>
<td>82.58</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>70.51</td>
<td>39.57</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>23</td>
<td>77.82</td>
<td>46.23</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>34</td>
<td>70.81</td>
<td>43.53</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>69.73</td>
<td>42.31</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>244</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>71.698</strong></td>
<td><strong>43.646</strong></td>
<td><strong>77.896667</strong></td>
</tr>
<tr>
<td><strong>DS</strong></td>
<td></td>
<td><strong>3.11331</strong></td>
<td><strong>2.17069</strong></td>
<td><strong>8.0036009</strong></td>
</tr>
</tbody>
</table>
Factors affecting the survival of the nests.- Four factors that affect the survival of nests were identified, the first and most important is the shortage of areas suitable for nesting by the silviculous use of the mangrove, the second is the predation from the *Procyon cancrivorus* specie; the third, are floods and the fourth but no less significant is the looting by the indigenous inhabitants of the area.

Births.- During the visits from 12 to Sept. 14, 2007, the emergence state of all clutches was verified, egg shells were found around the nests and in the adjacent mangrove area, apparently they had been allegedly removed by the females to help out the hatchling, proving the birth of the clutches and the help received from the females during hatching. We found no evidence of embryonic mortality after the first revision, apparently all of the fertile eggs were born (n: 208). On the Island Espirol 1 were the nests under construction were located, no stance was realized.

7 hatchlings were captured near the nesting areas, 5 of those with complete healing of the navel, which gives an age of approximately two weeks, the remaining 2 had an age of about a week, placing births in the first week of September.

The hatchlings had a TL between 25.8 and 31.8 cm and an average of 29.62 ± 1.19 cm in SVL between 12.2 and 15.5 cm and an average of 14.41 ± 1.12 cm and weighed between 39.6 and 72.1 g and an average of 61.91 ± 10.42 g. They were captured between the neumatophorus of *A. germinans* in an area that had a depth of about 5 to 20cm, with an abundance of food represented in fingerlings of various species. The hatchlings showed a brown color darker than the color of the adult.

The hatchlings presented a RFI of 0.954, which indicates that these individuals were in relatively good health (Fig. 13).

![Figure 13](image.png)

**Figure 13.** Relative Fatness Index of hatchling captured in the island Pioyoi.

Reproductive period.- Taking into account the evaluation of the embryonic band of development and the probable dates of onset, the reproductive period for the specie *C. acutus* in Bahia Portete was estimated between March and October, where the courtship and mating would be between March and May, the oviposition by mid-June until mid-July and finally hatching is presented with the onset of the rains in September and culminates in October (Fig. 14).
DISCUSSION

The mangroves which are habitats to most individuals have the greatest area, inland canals, places to sunbathe, for nesting and inland lakes where they feed.

The crocodile census of Colombia between the years 1994-1997, presented as a result 0.47 ind/km in a transect of 21km, with a population made up of 10 specimens (juveniles and sub-adults) with sizes of inferior than 180 cm (Rodriguez 2000). Abadia and Drew in 1981 reported a low population because the population is subject to overexploitation, the same author in 1993 ensures that the population is in recovery and estimating population size of 140 individuals based on the finding of 9 structures, nest under construction, in 1998 conducted a monitoring and taking into account his previous reports concluded that the population remains stable, however the basic information collected is not statistically significant for the conclusion. The density founded during this study is higher than those reported previously for this area but it cannot be assumed that the population is in recovery, since previous studies do not report a database detailed enough to clearly compare, evaluate and infer about the development of population density far less about its spatial and temporal variation.

The area used by *C. acutus* is 35.58% of the total mangrove area (1290ha), with 831ha in which there were no animals and that have the potential to be used by individuals or the non-use of these areas is due to the existence of anthropic activity.

Most part of the population is concentrated among the youth and sub-adults, it seems that the adult class is being decimated by a selective approach; Rodriguez (2000) comes to similar conclusions, by reporting that this population was subjected to a sustainable harvest, the removal of the adult class in Bahia Portete can be linked to meeting the food needs of the local indigenous population. But a population dominated by juveniles may indicate that the population or the portion affected is recovering from the overexploitation that occurred in previous years (Seijas 1986, Llobet & Seijas 2003, En Grajales Garcia *et al.* 2007).
The catch had a sex ratio of 1:1, equal to those reported in other populations (Kuslan & Mazzotti 1989, Platt & Thorbjarnarson 2000 and Cedeño-Vasquez, 2002, En Grajales Garcia et al. 2007) unlike those found in Window (Mexico) by Garcia-Grajales (2007), with a ratio of 3 males for every female.

The physical conditions of the individuals captured were healthy; there were no signs of disease or infection, no scarring or mutilation. The conditions under which the animals were can be influenced by the time of reproduction and climatic conditions.

Abadia (1981) reports two areas of nesting in Bahia Portete, which are the islands known as Pioyoi and Espirol 2, in this work he identified a new nesting area for the zone (dunes in sector 4), which suggests the possibility that there are other nesting areas which have not yet been identified, that is why it is necessary to carry out further searches.

The presence of a small sandy portion in the area of the Island of Pioyoi for the development of nests has resulted in the existence of a communal nesting area, which increases the possibility of the destruction of nests, aggressive encounters between female and partial loss Egg by breaks.

Near the Island of Pioyoi there is an area with characteristics similar to islands, which are being used by the settlers as grazing area (cows, goats and goats) and for extraction of plant material (wood), an area that is being used by animals as a zone to obtain food (in adjacent mangroves) and could have been used by animals for nesting in the recent past, this area can fit into a future with a proper handling for this purpose.

The nests in Bahia Portete were found at a depth of ≥ 19cm, at a distance from vegetation of 0.20 m to 1m, where 60% of these were in direction to the West, conditions that despite the climatic characteristics (desert), and low vegetation of the place, it provides the clutches the necessary protection against direct radiation from the sun's rays in the morning and midday, when the sun's rays are more incidents.

The ecology of the C. acutus nesting in Bahia Portete requires further study, involving fluctuations of temperature and relative humidity during the day and night, to know their relationship to the development of the incubation period.

In Bahia Portete an clutch average of 26.7 ± 11.35 eggs was obtained, a 95.50% fertility, an egg lenght average of 71.69 ± 3.11 cm, a egg width average of 41.66 ± 3.18 cm and an average weight of 77.89 ± 8.00 g, nesting females showed a total length greater than 180cm. Casas-Andreu (2003) reports for Jalisco an average eggs for clutches of 2.9 ± 13.2 eggs, a greater average diameter of 74.6 ± 4.2 mm, lesser diameter of 45.5 ± 2mm and a weight of 93.1 ± 10g, and a fertility of 81 ± 21%, where the population of nesting females were between 225 and 305cm in length, asserting that the relationship between the size, weight and fertility of eggs is directly proportional the size of the female; Mejia (pers.) reports that in breeding farms the females with sizes of less than 225cm are synonymous with small litters, small eggs and infertility increased to 18%, which would suggest that breeding females in Bahia Portete are phenotypically small. This may be related to the fact that for a long time the population of C. acutus has been subjected to extraction, where the adult class is the most affected, especially male individuals because of their larger size, giving
to young males to reproduce at reduced age or eliminated intraspecific competition between adults and sub-adults.

Given the above, it is expected that individuals who are reproducing have similar sizes, so it is possible that this selection has eliminated those elements of the population who are phenotypically larger in size.

In Bahia Portete a short reproductive period has been registered, compared with those recorded in the closed-loop farms in the department of the Atlantic (Colombia), which began in December with the mating, the positions starting in the last week of January, Continuing the months of February, March and until the first week of April, where births occur between April and June.

The short reproductive period in Bahia Portete, may be due to factors such as, the short incubation period due to climatic conditions, mainly the occurrence of rains and the unbalanced structure of the groups that have an impact on the organization of the hierarchy and dominance, linked to the size of the animal, presenting a possible homogeneous distribution of animals within the area of mangroves, increasing the likelihood of a meeting of individuals over the age of reproduction thus reducing the time for courtship and mating.

Bahia Portete infants showed LT average (29.6 ± 1.91cm) and average weight (61.91 ± 10.41g) higher than those reported by Arzuza in 2000 (LT Avg 24.16 ± 2.53cm and Weight Avg 51.76 ± 9.88g) and Perez & Escobedo in 2005 (LT Avg 24.54 ± 0.98cm and Weight Avg 46.13 ± 4.28g) for newborn individuals, however lies in the size ranges and weight reported by Brazaitis (1973, in Sanchez 2001) with LT 25-30cm and weights between 40-70g, Alvarez del Toro (1974, Sanchez in 2001) with LT between 25-30cm and Medem (1981, Sanchez in 2001) with LT between the 25-30cm between 40-70g for the species. The total longitudes of newborns in the Bay may be due to the time of birth of the animals, from about 4 to 15 days of birth. The state of thinness found in infants may be because they were still absorbing the yolk and developing strategies to catch food.

The identification of factors affecting the survival of the litters, is of great importance when it comes to implementing management plans that share the conservation of a specie, especially when one of these factors comes directly from the use of the resources specially by the settlers , Which in our case in particular is an indigenous population, hence to achieve it is of utmost importance to perform a work of socialization and awareness to people about the importance of conservation, creating economic alternatives to provide welfare to population derived from resource conservation.

CONCLUSIONS

• It confirms the reproductive period of C. acutus, which covers the period from April to October
• To C. acutus in Bahia Portete found a density 1.37 ind/km in a total route of 50.8 km.
• A low density of individuals by area of mangrove was determined (0.05420 ind/ha).
• The status of the population of Bahia Portete presents characteristics by distributional classes of a population subjected to exploitation.
• It is not clear what the conditions of selection that makes the residents to use the
species are, the same for the routes or destinations that the products have.

- The proportion of sexes was a 1:1 relationship, one female for every male, for the population of Bahia Portete.
- Trapped animals showed healthy physical condition (weight, vitality and free from external pathology).
- The average litter size was 26.7 eggs. Fertility rate of 95.5% and 17.60% of embryonic mortality which indicates a high reproductive capacity of the species in this environment.
- A new nesting area was identified and there is the probability of locating other areas with similar characteristics on which nesting might be occurring, and must be located for protection.
- Nesting areas present a pastoral use, an activity on which there is yet to establish a standard for the conservation of these areas, an example of this is the area known as Toloí, which found signs of being used by *C. acutus* in a not-too-recent past as a nesting site.
- The registration of births presented to the hatch during the second period of rain during the month of September.
- *C. acutus* represents for the local indigenous population a component of the diet product of opportunist hunting, determining efforts in the valuation of the appeal by the Wayuu community and its participation in any management plan for conservation of this species, given the importance of mangrove ecosystem for the villagers and Cayüshi.

ACKNOWLEDGEMENTS

To Carbones del Cerrejón Limited, the residents of Bahia Portete for their unconditional support for hosting us, for the dedication and joy demonstrated during the development of the field work.

LITERATURE CITED


Population Study of *Caiman yacare* in the Province Ángel Sandóval (San Matías region), Santa Cruz, Bolivia

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**ABSTRACT:** In the northern zone of influence in the area of integrated management San Matías, Santa Cruz, Bolivia, counts in the night were conducted on Yacare Caiman (*Caiman yacare*) in the months of December 2004, May and June 2005, sampling 91 waterbodies, 48 ponds, 13 curiches, 9 lakes, 14 small lakes, 6 rivers and 1 stream. The results obtained show greater abundance (indiv/Km) in small lakes < 1Km, curiches and ponds, while the greatest abundance of Yacare of the Class IV occurred in rivers, small lakes and ponds. The population's structure showed a bigger number of individuals of the classes II and III. In conclusion a low number of individuals of the class IV (adult for optimal utilization) was observed possibly by the time when the counts were performed (season high water where they are scattered), in addition to agreement to interviews with local residents, reported that the area is the subject of an intensive harvest.

**RESUMEN:** En la zona norte de influencia y el Área de manejo integrado San Matías, Santa Cruz Bolivia, se realizaron conteos nocturnos de lagarto (*Caiman yacare*) en los meses de diciembre del 2004, mayo y junio del 2005, muestreándose 91 cuerpos de agua, 48 estanques, 13 curiches, 9 lagunas, 14 lagunetas, 6 ríos y 1 arroyo. Los resultados que se obtuvieron muestran una mayor abundancia (indiv/Km) en lagunetas, curiches y estanques; mientras que las mayores abundancias de lagartos de la Clase IV se registraron en ríos, lagunetas y estanques. En cuanto a la estructura poblacional del lagarto en el área de estudio corresponden en mayor número a las Clases II y III. En conclusión para la zona de estudio se observa una baja cantidad de individuos de la categoría IV (adultos óptimos para el aprovechamiento) posiblemente por la época en la que fueron realizados los conteos (temporada de aguas altas donde se encuentran dispersos), además de acuerdo a las entrevistas con pobladores locales, informaron que la zona es objeto de una intensa cosecha.
Production of Superoxide Ions by Leukocytes of the American Alligator  
(Alligator mississippiensis)

Mark Merchant†, Stetson Williams, and Ross Hardy

†Department of Chemistry, McNeese State University, Lake Charles, Louisiana

ABSTRACT: We used WST-1, a tetrazolium salt which can be reduced to a water-soluble formazan compound with high molar absorptivity at 438 nm, to probe the production of superoxide by alligator leukocytes. Incubation of alligator whole blood with WST-1 resulted in a time- and concentration-dependent increase in absorbance of the plasma at 438 nm. The reduction of WST-1 was inhibited in a concentration-dependent manner by superoxide dismutase, an enzyme that catalyzes the reduction of superoxide to peroxide, confirming that the reduction of WST-1 was due to the presence of superoxide. Treatment of whole blood with NBT resulted in the staining of only heterophils and macrophages, showing that the production of superoxide is due to the presence of leukocytes. It is interesting to note that the production of superoxide by the alligator leukocytes required no external stimulation while human leukocytes must be stimulated with an immunological challenge before producing superoxide.
Program for rescuing and protecting American crocodile’s eggs from human predation with participation of indigenous people and communities in Zulia state, Venezuela

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ABSTRACT: We have been working to capacitate and to achieve participation of local communities, Barí Indigenous people and landowners from part of Maracaibo lake basin in a conservation program for the American crocodile (Kanta in Barí dialect) around their living areas (basins of rivers Negro, Santa Rosa and Aricuaizá). These people supported by specialists (Crocodile Specialist Group of Venezuela) could search for nest and collect the eggs, which will be incubated in a safe place until hatching. In this way illegal commercialization of eggs could be diminished. The hatchlings produced will be raise in captivity and then used in programs to restore and reinforce populations of the species.

RESUMEN: Se ha estado trabajando en capacitar y lograr la participación de comunidades locales, indígenas Bari y hacendados en parte de la Cuenca del Lago de Maracaibo para que ejecuten anualmente acciones de conservación relacionadas con el Caimán de la Costa (Kanta en dialecto Bari) en las cercanías de sus espacios de vida (Cuencas de los ríos Negro, Santa Rosa y Aricuaizá). Ellos, apoyados por asesores y especialistas en el área (Grupo de Especialistas en Crocodilos de Venezuela) podrán buscar y recoger los huevos de la especie e incubarlos hasta su nacimiento. De esta forma se busca disminuir la comercialización ilegal de los huevos. Los cocodrilos nacidos serán criados en cautiverio y usados luego en programas de restauración y fomento poblacional de la especie.
Public Opinions, Attitudes, Risk Perceptions, and Knowledge of Alligators in Florida

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ABSTRACT: As American alligator (Alligator mississippiensis) populations in Florida have recovered from depressed levels in the 1960’s, human-alligator conflicts have increased. Maintaining populations of potentially dangerous wildlife species at levels consistent with human desires can be a challenge. The Fish and Wildlife Conservation Commission’s Alligator Management Program (FWC) recently sought input from stakeholder groups and received conflicting feedback. Some suggested that alligator populations are excessive while others believed that populations are below desirable levels. Although informal, this survey highlighted the need for a more sophisticated examination of Floridians knowledge and opinions. FWC has previously conducted surveys of public attitudes about alligators in 1976 and 1996, and these can provide information against which to measure changes in public attitudes and knowledge over time. The purpose of this study is to determine current public knowledge, attitudes and risk perceptions about alligators, to assess changes in these characteristics since 1976 and 1996, and to determine if regional differences in these exist within the state.
Social component of the Management Plan for Spectacled Caiman (*Caiman yacare*) in the Protected Area of San Matías, Santa Cruz – Bolivia

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ABSTRACT: The Natural Area of Integrated Management (ANMI) San Matías is located at East of the Department of Santa Cruz; it is the second bigger protected area of Bolivia with a total of 2.918.500 hectares, containing a varied dispersed social geography in their surface. To elaborate a Management Plan of Spectacled Caiman for the ANMI San Matías, which should be concerted and approved by the direct beneficiaries (indigenous communities and cattle ranches) 32 communal workshops, 2 regional workshops, 2 workshops with cattlemen were made, plus diverse meetings with institutions and local organizations. The development of the management plan was based on the respect to the communal organizations, the local actor’s leading role in the taking of decisions, strengthen of the organizations and institutions for the integral and adaptive management of the resource and increment of revenues by means of a bigger role of the direct actors (communards and cattlemen) in the productive chain. Despite of the complex human mosaic of the ANMI San Matías, extension of the area, difficulty of accesses and scarce advance in the legal tenure of lands, it has been possible to concert in a participative way the administration system for the conservation and use of the Spectacled Caiman and to plan the first harvest for the year 2008.

RESUMEN: El Área Natural de Manejo Integrado San Matías se encuentra ubicada al Este del Departamento de Santa Cruz; es la segunda área protegida más grande de Bolivia con un total de 2.918.500 ha. albergando una variada geografía social dispersa en su superficie. Para elaborar un Plan de Manejo de Lagarto para el ANMI San Matías (PML), concertado y aprobado por los beneficiarios directos (comunidades indígenas y estancias ganaderas) se efectuaron 32 talleres comunales, 2 talleres regionales, 2 talleres con ganaderos y diversas reuniones con las instituciones y organizaciones locales. El desarrollo del PML se basó en el respeto a las organizaciones comunales, protagonismo del actor local en la toma de decisiones, fortalecimiento de las organizaciones e instituciones para el manejo integral y adaptativo del recurso e incremento de ingresos mediante un mayor protagonismo de los actores directos (comunarios y ganaderos) en la cadena productiva. A pesar del complejo mosaico humano del ANMI San Matías, extensión del área, dificultades de acceso y escaso avance en el saneamiento de tierras, se ha logrado concertar de manera participativa el sistema de gestión para la conservación y aprovechamiento del Lagarto y planificar la primera cosecha para el año 2008.
Spectacled Caiman (*Caiman yacare*) Integrated management plan in the Tacana III TCO (Original Communitarian Territory), aimed for the conservation and sustainable use of the natural resources of the indigenous people in Beni Department, Bolivia.

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**SUMMARY:** The management plans represent an alternative for improving the National Program of Conservation and Sustainable Use of Spectacled Caiman (PNASL) in Bolivia, they become essential tools for generating shared-responsibilities, giving active participation to the indigenous people and representing an opportunity for obtaining permanent information. In the context of the National Program of Sustainable Biotrade, the ‘Asociación Boliviana de Conservación’, Central de Pueblos Indígenas del Beni, and the Organización de Comunidades Indígenas Tacanas worked together to establish the bases of the sustainable management plan of *C. yacare* in the Tacana III TCO, member of the PNASL since 2004. Between December 2006 and February 2008, biological and social activities combined to elaborate a concerted Management Plan for the spectacled caiman in the Tacana III TCO. An integrated management proposal generated from a local perspective, that includes harvesting and ranching activities with an adaptive management view, focused in the conservation and sustainable use in different levels (economical, ecological, and social). This process gives interesting experiences to be used in the PNASL and new options for the sustainable development and integrated communal management of the indigenous natural resources.
Status of American Crocodiles, *Crocodylus acutus*, in Santa Rosa and Las Baulas National Parks, Guanacaste Costa Rica

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ABSTRACT: *Crocodylus acutus* populations in Costa Rica are reported as healthy by the International Union for the Conservation of Nature and Natural Resources (IUCN) Crocodile Specialist Group (CSG), however little census work has been undertaken. We conducted daylight surveys and nighttime spotlight surveys within Santa Rosa National Park (Nancite and Naranjo estuaries) and Las Baulas National Park (Tamarindo estuary) in 2007. The majority of crocodiles encountered were juveniles (0.5-1.0 m) and subadults (1.0-2.25 m), with few adults (>2.25 m). Encounters rates for Las Baulas National Park and Santa Rosa National Park were 1.68 and 3.39 crocodiles/km respectively. Encounter rates include all crocodiles sighted and observed over all surveys. Two nests were located in the Naranjo estuary system. Hatchlings were encountered in Tamarindo, but no nests were located. We collected tissue and blood from *C. acutus* in Santa Rosa (27 individuals) and Las Baulas (40 individuals) to investigate the conservation genetics of this species along the Pacific coast of Costa Rica. We will determine the genetic structure, extent of gene flow and relatedness in Guanacaste and the Osa Peninsula. Local population estimates and genetic information will enhance the conservation and management of *C. acutus* in Costa Rica.
Survival and Growth of the American Crocodile (*Crocodylus acutus*) from the nests of the rivers Negro and Santa Rosa, Machiques de Perijá, Venezuela

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**ABSTRACT.** During May of 2007, 43 offspring of American Crocodile entered into Vereda del Lago Park. They were born as a result of two nests incubated *ex-situ* in a house in the Bari of Senkay indigenous community. The smallest and largest hatchlings when arrived to the Park were 230 and 300 mm (TL), respectively. Their weight was between 70 and 200g. The crocodiles are being kept in plastic tanks with a constant change of water (every 4 days). The crocodiles are been fed with cow hearts, cow kidneys, chicken stomach and fish. After 10 months in captivity, only two individuals died (95 % survival rate). The smallest and largest size reached by these juvenile crocodiles was 335 and 560 mm, respectively. They have also reached a weight in grams between 245 and 664.

**RESUMEN:** Durante mayo del 2007, 43 caimancitos ingresaron al Parque Vereda del Lago, ellos nacieron como producto de sendas nidadas incubadas *ex-situ* en una casa de la comunidad indígena Bari de Senkay. El menor y el mayor tamaño (LT) de estos neonatos al llegar fue de 230 y 300 mm respectivamente. El peso en gramos varió entre 70 y 200. Los cocodrilos se mantienen en tanques de plástico con recambio constante de agua (cada 4 días) y alimentados con corazones de res, riñones de res, estómagos de pollo y pescado. Luego de 10 meses de cría en cautiverio, únicamente murieron 2 individuos (95 % de sobrevivencia). El menor y mayor tamaño alcanzado por estos jóvenes caimanes fue de 335 y 560 mm respectivamente. A su vez han alcanzado un peso en gramos que va desde 245 a 664.
Television documentaries: Tools for the conservation of crocodiles

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ABSTRACT: Are we able to invest the same efforts in the recovery and protection of the false gharial as we do, for example, with the orangutan?
How the local people who coexist with these species could be involved to participate and make possible their conservation?
One of the main aims of the Biology of the Conservation is to establish some priorities about specific places and “taxa” where effective strategies for conservation can be developed. However, most of the time, the establishment of political and financial efforts for the conservation, can only be seen in some “emblematic species “.
The Balikpapan Orangutan Survival Foundation, born under the economic protection of some TV channels of Japan has allowed, by protecting orangutans, the avoidance of the mass destruction of thousands hectares in the jungles of Borneo (Kalimantan-Timur).
Currently, in the medieval fort of Ranthambore (Rajasthan) thanks to the fees, canons and taxes collected from TV’s of countless countries, the reborn of the Tiger Project is again taking shape.
The reduction –or extinction- of some crocodiles in Indonesia could be a dramatic result for the health of many rivers and wetlands, but the conservation efforts have found no social or institutional response, with some exceptions.
Can the documentaries help in the protection of crocodiles?
Verification of the Skeletochronology Technique in the Broad-snouted Caiman, *Caiman latirostris* (Reptilia, Alligatoridae)

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**ABSTRACT:** Skeletochronology is the name of a technique used to estimate the age in different extant and living vertebrates based on counting bone growth rings that are expressions of histological changes in the rates of osteogenesis influenced by external factors. Bone diameter growths by deposit of successive layers of new bone from the center to the external border, usually named as bone marks, that in an histological cross section looks like rings. This technique has been successfully applied on fishes, amphibians and reptiles. In crocodiles, the information about the applicability of this technique is scarce, and particularly in caimans nothing is known. To determine the actual age through this method, two main objectives must be achieved: the observation of histological bone cross sections in order to investigate the cyclic growth represented by bone marks, and to determinate if each growth mark corresponds exactly to one year old of the specimen. In the present work, details of the technique and preliminary information are presented on the use of this in phalanxes of South American broad-snouted caimans for the first time, showing that *Caiman latirostris* presents bone growth rings similar in structure to those observed in other reptiles and amphibians.
Vocalizations in juveniles of *Caiman latirostris* (Daudin, 1801) I: acoustic structure and individual discrimination.

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**ABSTRACT:** Acoustic communication is essential for social behaviors such as parent-offspring interactions. Crocodilians show a sophisticated repertoire of acoustic signals that vary within a wide range of contexts. Juveniles start to vocalize before they emerge from the egg and continue after hatching. These vocalizations usually elicit maternal care and induce crèche cohesion. The aim of the study was to describe the acoustic structure of *Caiman latirostris* juveniles' calls and to determine the possibility of individual discrimination. The analysis of 100 notes from seven individuals showed a basic acoustic structure of strongly frequency modulated sounds usually composed of a main frequency band (1036.8 ± 91.9 Hz) associated to several side-bands (range: 5-20). The note can be divided into two temporal segments: an ascending frequency modulation that continues into a descending one. Sixty percent of individuals show both parts of the signal. A Discriminant Analysis of all the vocalizations showed that individual discrimination could be attained in 89% of the cases. These results can be related to juveniles' age, size and/or sex, to them being part of different clutches or to environmental temperature variations.
Vocalizations in juveniles of *Caiman latirostris* (Daudin, 1801) II: acoustic structure and comparison with other crocodilians.

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**ABSTRACT:** Crocodilians show a sophisticated repertoire of acoustic signals that vary within a wide range of contexts. Juveniles start to vocalize before they emerge from the egg and continue after hatching, and these vocalizations usually induce crèche cohesion and elicit maternal care. The results of the analysis of 100 notes from seven individuals of *Caiman latirostris* were compared with published data on similar vocalizations from other eight crocodilian species. Most crocodilians share a basic acoustic structure: strongly frequency modulated notes usually composed of a main frequency band associated to several side-bands. In addition, calls can be divided into two temporal segments: an ascending modulated frequency that continues into a descending one. Not all species showed this condition. A Discriminant Analysis of the calls showed that main frequency and acoustic energy appear as the most significant variables. Furthermore, the arrangement of the species in the dispersion diagram loosely followed their phylogenetic relationships. The mentioned differences in sound characteristics could be explained by age and size of the sampled individuals for the other species, their habitat and ecology, or the context of the sampled vocalizations.
Zoocriadero Puerto Pizarro:
An alternative for conservation of American Crocodile
(Crocodylus acutus) in Peru

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ABSTRACT: The American crocodile is the only member of family Crocodylidae in Peru. The Peruvian government categorized the species as critically endangered because their wild populations are decreasing by the habitat loss, illegal hunt and other anthropogenic activities. Its distribution in Peru is restricted to mangrove ecosystems in the Northwest region; however it has been reported its disappearance in the Chira River. In 1997, the Crocodile Specialist Group determines that not more than 6 reproductive couples were found in Tumbes River. In 1996, the Peruvian government created Zoocriadero La Tuna Carranza, in Puerto Pizarro (Tumbes) for the conservation of the species. Currently this centre has 16 breeding pools and around 300 of animals, grouped according the biological and size cycle stage. Despite the deficiencies of infrastructure has been achieved the increased of the number of individuals by natural reproduction, although with some problems. Currently with the participation of Universidad Peruana Cayetano Heredia has been initiated the evaluation and health control of all the animals, and an artificial incubation program is going to be developed.

RESUMEN: El cocodrilo americano es el único miembro de la familia Crocodylidae en el Perú. El Estado Peruano la categoriza como una especie en Peligro Crítico debido a que sus poblaciones silvestres están decreciendo por la pérdida de hábitat, caza ilegal y otras actividades antropogénicas.
La distribución de esta especie en el Perú está restringida a los ecosistemas de manglar en la región noroeste, sin embargo se ha reportado la posible desaparición en la cuenca del río Chira. En 1997, el Crocodile Specialist Group determinó que no más de 6 parejas reproductivas estaban presentes en la cuenca del río Tumbes.
En 1996 el Gobierno Peruano crea el Zoocriadero La Tuna Carranza, en Puerto Pizarro (Tumbes) para la conservación de la especie. Actualmente éste cuenta con 16 pozas de crianza y alrededor de 300 ejemplares, agrupados según la etapa de su ciclo biológico y tamaño.
A pesar de las deficiencias de infraestructura se ha logrado aumentar el número de animales por reproducción natural, aunque con ciertos problemas. Actualmente con la participación de la Universidad Peruana Cayetano Heredia se ha iniciado la evaluación y control sanitario de los ejemplares, y se desarrollará un programa de incubación artificial.
Current status of the species in Peru

Tumbes’ crocodile or American crocodile (*Crocodylus acutus*) is the only species of the family Crocodylidae in Peru; this species is categorized in Appendix I by CITES and as Critically Endangered by the Peruvian legislation (D.S. 034-2004-AG); these because their wild populations are declining due illegal hunting and habitat loss caused by anthropogenic activities (Thorbjarnarson, 1989; Ross, 1998).

The distribution of the species in Peru is restricted to mangrove ecosystems in the Northwest region of the country, from Chira River at the South to Zarumilla River at the North (Medem, 1983) However recent evaluations reported the possible disappearance of the population in Chira River basin (Escobedo and Mejia, 2003), also in 1997 members of the Crocodile Specialist Group identified the presence of no more than 6 breeding couples in Tumbes River basin (Escobedo and Mejia, 2003).

History of the Zoocriadero Puerto Pizarro

In 1996, the Fondo Nacional de Desarrollo Pesquero (FONDEPES), a Peruvian Government Agency created a breeding center for the species in the locality of Puerto Pizarro in the Departamento of Tumbes. This center started with an experimental module of 220 m², with pools of concrete for the animals. For this phase two goals were proposed, the first was to obtain individuals for reproduction and the other to evaluate the captive adaptation of these animals. For this reason, the center collected around 40 specimens, from different sizes and genders, captured in the wild and also some of them were donate by fishermen who captured them accidentally. In 1999, the area of the center was increased to 1800 m², and more facilities were built to complete the reproductive cycle. The center started having reproduction successful since 2002, and in 2004 the center was extended to 8 hectares, changing its name to Zoocriadero Puerto Pizarro from 2005.

Current status of the Zoocriadero Puerto Pizarro

Currently the breeding center has 267 animals distributed in 14 pools; they are grouped according the age and size (Table 1). The items used to feed the animals are fish and chicken, and these are provided at different frequencies per week and percentages, according the total biomass of each enclosure. The neonates are feed with pellets of a mixture of small crustaceans and fish, supplemented with chicken liver.

The reproduction is not controlled; the adult females are maintained in two separate groups, each one with one adult male permanently. Despite some lack of basic services, as electricity and full-service water, the center is increasing every year significantly the number of individuals in captivity through natural reproduction; but without technical support, the center is obtaining a larger amount of male neonates, which is why an artificial incubation program is going to start this year. Other problem observed with neonates is malformations, but in very low percentages. The facilities are currently available for tourist visits.
Table 1. Distribution of individuals in pools according the phase of the life cycle.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Phase duration</th>
<th>Nº of animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates</td>
<td>0 – 1 year</td>
<td>11</td>
</tr>
<tr>
<td>Youngs 01 year old</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Youngs 02 year old</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Youngs 03 year old</td>
<td>1 – 7 years</td>
<td>73</td>
</tr>
<tr>
<td>Youngs 04 year old</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Youngs 05 year old</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Sub-Adults</td>
<td>7 – 12 years</td>
<td>19</td>
</tr>
<tr>
<td>Adults</td>
<td>12 to more years</td>
<td>14 (02 ♀and 12♂)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>267</strong></td>
</tr>
</tbody>
</table>

Prospects for the Future

Currently with the initiative and collaboration of the Laboratory of Wildlife of the Faculty of Veterinary and Zootechnics of the Universidad Peruana Cayetano Heredia, a health evaluation of the animals have been done, including physical exams, and hematological and parasitological analysis, but this is the first step for improving the management of the center. For this reason since 2007, the Universidad Peruana Cayetano Heredia and FONDEPES have an agreement to work together to develop the center and help to conserve the species.

Current objectives

- To develop the management plan for breeding center.
- To develop a reproduction program to achieve a higher percentage of hatching and control the proportion of sexes in neonates, and increase the number of individuals in captivity for future reintroduction.
- To obtain more information of biology and ecology of the species to support an appropriate strategy for their conservation.
- To establish a health and preventive medicine program for the animals of the breeding center collection.
- To obtain more health information of the species in captivity.
- To realize a genetic evaluation of the animals of the breeding center.
- To establish environmental education programs to promote conservation of the species, especially with local people.

LITERATURE CITED


Workshop Reports

Workshop 1: Sustainability criteria (biological, social, economic) for the success of national management programs (Perran Ross)

Participants: about 35 Working Meeting members.

Objective

The objective of the workshop was to assess the economic and social sustainability criteria to be considered to start and -achieve in time- a successful management program of crocodile species from a “national” program point of view.

Methodology

Discussion was conducted sequentially in English and Spanish with assistance and great good will and tolerance from all participants. The chairman addressed a short introduction to all participants and led a guided brainstorm in which the main ideas were considered and written; all participants were also asked to write down on individual cards the main criteria they considered crucial for the purpose of establishing national management programs. Both of them were considered by a small reviewing group who summarized the workshop in the results shown below. Despite of the short time to discuss such a complex issue, the main criteria were defined and some measurement indicators were proposed.

Results

Since sustainable Management Programs usually involve different aspects and several stakeholders, they may be considered as a chair sustained by three-legs including: Economic, Social and Environmental issues.

=> SOCIAL because many actors are involved; for instance in the Bolivian case, indigenous communities play a major role as well as peasants, cattle owners, tanneries, government, NGO’s and scientific bodies. A successful Management Program has to be considered as such by all actors.

=> ECONOMIC because it has to be fair and generate income for all actors based on transparent operations.

=> BIOLOGICAL because it has to be sustainable and verifiable;

Undoubtedly, all 3 aspects must be integrated in the development of the Program to be SUCCESSFUL.

But first of all, some basic principles should guide the establishment and operation of a Management Program:

=> Transparency

=> Participation of all Stakeholders

=> Equal Power.
If any of them is hindered by one or more actors, it would pose an obstacle to the development of the Program as a whole.

Even though each country possesses its own particularities, general applicable criteria may be considered for national management Programs, as described in Table 1.

But, while criteria are useful to describe the main Economic, Social and Biological issues involved, they are valid to evaluate success of a program only when accompanied by measurement indicators; though in some cases it may be difficult to establish concrete ones. Table 1 shows proposed measurement indicators for each criterion, which may be adjusted to the reality of each country and to the status of advancement of the Program.

**Table 1. Economic, Biological and Social Criteria for National Management Programs**

<table>
<thead>
<tr>
<th>ECONOMIC</th>
<th>PROPOSED QUANTIFIABLE INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common vision for economic development</td>
<td>Vision and future goals of stakeholders established.</td>
</tr>
<tr>
<td>Tools for economic management</td>
<td>Regulations and materials in place.</td>
</tr>
<tr>
<td>Distribution of benefits (first links of production chain)</td>
<td>Established distribution of benefits especially to local communities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOLOGICAL</th>
<th>PROPOSED QUANTIFIABLE INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consider traditional knowledge</td>
<td>Knowledge provided by local actors has been translated into program guidelines.</td>
</tr>
<tr>
<td>Sustainability criteria must be quantifiable</td>
<td>Appropriate Biological and Ecological Indicators clearly developed and communicated to the actors.</td>
</tr>
<tr>
<td>Articulate with other management alternatives &amp; species</td>
<td>Analysis of other alternatives of sustainable management (biologically-based) including their conclusions &amp; interactions among them in order to conserve their habitat.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOCIAL</th>
<th>PROPOSED (QUANTIFIABLE?) INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consensus among all actors establishing clear objectives</td>
<td>Guidelines established signed by all actors</td>
</tr>
<tr>
<td>Understanding of the market by all actors</td>
<td>Training sessions developed and records</td>
</tr>
<tr>
<td>Education to all actors (sustainability and win-win strategy; create a mission-oriented role)</td>
<td>Training sessions developed and records</td>
</tr>
<tr>
<td>Truthful information flow to all actors</td>
<td>System developed for information flow among all actors.</td>
</tr>
<tr>
<td>Applied to local reality</td>
<td>Guidelines of the Program have considered the particularities and constraints of the management areas (e.g. accessibility, cultural issues, climatic and geographic factors, etc.)</td>
</tr>
<tr>
<td>Assure that program does not affect social structures</td>
<td>Representatives of communities and representatives of all actors are clearly and legally defined, as well as their scope of action and decision power.</td>
</tr>
</tbody>
</table>
Conclusions

National Management Programs are complex and to assure their sustainability, they should involve the main stakeholders as principal actors in the frame of three guiding principles of Transparency, Participation and Equal Power. It has to be considered that a Sustainability Program is not a Product but a Process, not a destination but a road to walk through.

The goal is not to comply with all criteria at the beginning but instead consider them all, try to measure them in a realistic way and adjust them in a continuous improvement process.

Workshop 2: Local organizations in conservation and management of crocodilians (Silvia Ovando)

Among the topics approached in the workshop, for their high social content, the participation of the indigenous sector was very significant because the Bolivian Yacare Program has a great regional representation of different indigenous communities and indigenous territories participating as key actors in the management of *Caiman yacare*.

Among the most relevant conclusions we can remark that this type of Programs should be managed in an integral way, looking for the conservation of the species, but also assuring the social sustainability, with established programs for the Fair Distribution of Benefits among all the actors of the productive chain.

Another important point to highlight, it was the indispensable coordination that should exist between the State and the civil society, with clear rules that allow a sustainable use of crocodilians, implementing national and international rules.

Finally the experiences of countries with strong participation of local organizations in the crocodile’s management were highlighted, and we conclude that it is very important to consider that any management program have high-priority social particularities to be assessed.

Workshop 3: Aspects affecting the sustainability of trade (Don Ashley)

Don Ashley (Chairman), John Caldwell and Alvaro Velasco (Rapporteurs), Jerome Caraguel, Hideki Sakamoto, Mariana Paz, Ana Cristina Paz, Sebastian Paz, Heidi Abadia, Matthew Shirley and Laurie Cotroneo.

Points discussed:

1. Clarify CITES Guidelines for issuing:
   a. Export and Import permits for biological specimens, crocodilian parts (Blood, biopsies, etc).
   b. Stream line the re-export of manufactured items.
2. Reauthorize California for future trade in crocodile items (if the law is changed will be necessary to review the crocodile trade).
3. After many actions to eliminate the negative information shows in the airports, we
need to identify other ways to change the information displays. Evaluate using positive sustainable examples to replace the information.

4. Fully implement personal effects CITES Resolution (Some Parties reduce the exempt items and is necessary to find a mechanism to ensure that Parties apply the CITES Resolution according to the original recommendations).

5. Provide customs and port inspectors training materials on CITES and sustainable use (The Secretariat offers to all Parties a CD of customs training course).

6. Encourage research on hide and leather quality

7. Provide CSG Industry Committee updates on priorities for actions to be implemented.

8. CSG to act as a clearinghouse to ensure that trade is legal, sustainable and verifiable and to identify ways to ensure that the trade remains like this.

9. Evaluated the situation in the EU community regarding the imports of meat from wild harvest.

**Workshop 4: Management Plans as conservation tools in Latin America (Alejandro Lariera).**

Coordinated by Alejandro Larriera, assisted by Patricia Amavet, Karina Bello, Sergio Medrano and Carlos Piña.

By definition, managing is to handle, to rule, to direct something trying to achieve by mean of an intervention, a previously defined objective. So we can say that every activity aimed to conserve and/or to obtain a benefit from the crocodilians populations do constitute itself a “Management Plan”.

**The sustainable use programs on wildlife**

The world strategy for the conservation of nature from 1980, recommended in its article 3°, and as a relevant matter: “to ensure the sustainability of any kina of utilization of species or ecosystems”. In 1991, the document “Care the earth”, do define that sustainable use is only referred to the “utilization of the renewable resources, when the utilization level do not overpass its renewal capability”. Today the benefits of such activities are out of discussion in terms of the “economic valorization of the ecosystems”, “incentives for the conservation by the local inhabitants”, and “generation of genuine income for the producing countries”.

As we’re talking here about crocodilians, we do basically recognize three different mechanisms for its utilization and conservation (Hunting, Ranching and Farming). The strengths and weakness of everyone are discussed openly during the workshop.

**Hunting**

It is clearly the most economic system to produce crocodilians products.

It is the system that provide most direct benefits to the local inhabitants that used to live in contact with the wild populations.
It is the most difficult to control and also the system that more risks present if there is not an appropriate design.

The harvest in a hunting program are usually around a 5% to a 15% of the estimated adult population for every year.

Ranching

Do require investments that still are uneconomic for many abundant and low value species.

It is easy to control and also is beneficial for the local inhabitants who are responsible of the nests identification and eggs harvest.

By far, is the system that can guarantee the security for the wild populations. It is actually possible to harvest up to the 50% of all the eggs in the wild, with no additional measures of conservation.

Farming

It is the more expensive system in terms of money investment and time.

It is easy to control, at list in productive terms, and from a commercial point of view it is the one that in some way can guarantee more accurately can predict the production level.
It is uneconomic for the great majority of the species, and clearly it is the one with less benefits offer from a conservationist approach.

Conclusions

After a productive interchange of ideas and opinions, where the strengths and weakness of every system were analyzed, it was concluded that by far, if it is well designed on abundant populations, hunting programs are the best way to produce an incentive for conservation of the ecosystems involving the local inhabitants. On the other hand, ranching programs still have a remarkable effect as incentives, when the local inhabitants gets more and more involved in other activities more that simply identifying the nesting areas. Finally, it was very clear that farming programs are the weaker ones, in terms of incentives for the conservation of the ecosystems, and that must look for different strategies in order to improve its benefits on this issue.

It was also clear that no matter which system you’re planning to develop, a well designed management plan is crucial for the success of the all program, and should have a strong structure from the beginning, mainly with regard to the objectives, benefits for the ecosystem and the local inhabitants. At the same time should be based on the adaptive management strategy, in order to modify or re-direct the activities, as the information on the impact of the activity is collected.

Workshop 5: Report of CSG Veterinary Science Group (Paolo Martelli)

Agenda:

1. Restate broad mission of this group
2. Identify areas of veterinary science and medicine that require work
3. Examine how to best use the resource brought about by the new website to the benefit of this group and its clients

There were 25 participants, 13 of which vets, others farm managers, biologists from 10 countries
Mission of the group: “Advance crocodile veterinary medicine and science”

1. Serve clients:
   - Animals under human care: farms and zoological or educational institutions
   - Biologists and researchers that require veterinary procedures: sampling, anesthesia, surgery
   - Conservation partners and organizations: mortalities, population health status

2. Areas of veterinary science and medicine that require work:
   - Immunology acquired and innate
   - Response to stress, monitoring, physiological effects, impact on health
   - Emerging diseases and biosecurity, including at international levels
   - Reviewing health screening in the context of reintroduction following IUCN-SSC reintroduction specialist group
   - Specific veterinary training of managers and veterinarians in various areas. Specific for crocs and adapted to the situation
   - Medical and husbandry training of the animals

3. Use of new website:
   - Veterinary procedures (general exam, sampling, medication), Samuel Martin Terry Cullen
   - Post mortem procedures and reports, Paolo Martelli
   - Histology image data base, Paolo Martelli
   - Compilation of (anecdotal) veterinary information including contra-indications and cautionary warnings: ad hoc, needs a space
   - Literature resources, Kent Vliet
   - Imaging database and techniques, Charlie Manolis
   - Anesthesia, Sam Seashole
   - Introduction techniques for new animals in captivity, Samuel Martin Terry Cullen

4. Others:
   - Good disclaimers, passwords and access Diego Forrisi
   - IP and copyright waivers for material provided to CSG site.
   - Feedback from users to allow improvement of service
   - Procedures to contact vet group members: send to CSG chairman who’ll distribute as best
   - Offer to start a once off or seasonal course dedicated to crocodile medicine in the South American region Oscar Rendon
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Workshop 6: CSG Zoos and Community Education Thematic Group (Kent A. Vliet)

A small group of people interested in the Zoos and Community Education thematic group met on Wednesday afternoon, June 4, to further discussions of the group’s goals and strategies. The CSG ZooEd group communicates by means of a listserv that currently has about 45 members, not all of whom are CSG members. We are very interested in building membership in this thematic group and encourage anyone interested in zoos and/or education to contact me at kent.vliet@zoology.ufl.edu. This group includes a diverse group of people with diverse interests including zoo biology, captive breeding, education in all forms, community-based conservation, and aspects of human-crocodile conflict.

Education. Our approach to facilitating crocodilian conservation through education is to provide resources for educators relevant to crocodilian biology, “aware-raising”, conservation status, sustainable utilization, etc.. We will make these available through the CSG website. We are currently collecting prepared educational materials – lesson plans, activities, exercises and data sheets, presentations, booklets, etc., that we can post for download on the site. If you have any materials that would be appropriate for this, please contact me. We will also prepare our own presentations, species accounts, image banks, posters, etc., for this site. Dr. Adam Britton has agreed to oversee the production of species account signage and posters which can be used “as is” or can be modified for individual educational uses. The educational materials collected to date are in English and related to the American alligator. We are very interested in collecting materials in other languages and for other species of crocodilians to make the site as useful as possible internationally.

Community education is clearly exceptionally important and the group wishes to encourage and support these activities. But how? We have not yet developed the strategies to be of most assistance. There are clearly numerous initiatives in community education being undertaken by members of the CSG. We would like to hear about these initiatives and discuss how this group could facilitate these activities.

Zoos. The group wants to facilitate links between ex situ resources in zoos and in situ crocodilian projects. We are establishing liaisons between our group and regional zoo associations to further communication and cooperation. We recognize that activities in zoos can be very effective models for the conservation of critically endangered crocodilian species, those species for which sustainable utilization is not currently feasible. Zoos can participate in fund raising activities linked to endangered crocodilians. Grahame Webb highlighted a prime example of this during one of the CSG socials at the Bolivian meeting by acknowledging the tireless efforts of René Hedegaard, from the Krokodile Zoo in Denmark, for fund raising efforts at his own zoo as well as for encouraging donations from other European zoos. One part of these efforts include establishing agreements with several European zoos to provide continued annual donations to the Mabuwaya Foundation’s community-based programs for Crocodylus mindorensis in the Northern Sierra Madre mountains of the Philippines. We discussed many examples and strategies for fundraising that the group can encourage among zoos. So, we will work to stimulate much more of these sorts of activities within zoos world-wide as well as post many of these examples of effective fund-raising strategies on the CSG website.

We are in agreement that zoos and education are intricately intertwined with one another and that our thematic group is an appropriate grouping and should not be split into two thematic groups. We will be coordinating our various activities discussed in the meeting through the ZooEd listserv. Lastly, preliminary discussion was made of organizing an international meeting on the importance of zoos and education in crocodilian conservation in the next two years.
IUCN/Species Survival Commission

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

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

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