Crocodile Specialist Group of the Species Survival Comission

CROCODILES

Proceedings of the 19th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN – The World Conservation Union convened at Santa Cruz de la Sierra, Bolivia, 2-6 June 2008

(Unreviewed)

2008
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Depósito Legal: 2-1-2307-09

Published by: IUCN/SSC Crocodile Specialist Group
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The Crocodile Specialist Group

The Crocodile Specialist Group (CSG) is a worldwide network of biologists, wildlife managers, Government officials, independent researchers, non-government organization representatives, farmers, traders, tanners, manufacturers and private companies actively involved in the conservation of crocodilians (crocodiles, alligators, caimans and gharials). The group operates under the auspices of the Species Survival Commission (SSC) of the IUCN. The CSG provides a network of experts to assess conservation priorities, develop plans for research and conservation, conduct surveys, estimate populations, provide technical information and training, and to draft conservation programs and policy. CSG also assists monitoring of international trade and identifying products. Working meetings of the group are held every two years.

Foreword

The 19th working meeting of the IUCN-SSC Crocodile Specialist Group (CSG) was held in Santa Cruz, Bolivia, on 3-7 June 2008. The meeting was preceded by the CSG Steering Committee meeting, open to all members, which addressed a wide range of current CSG priorities. These included various aspects of crocodilian conservation and management in Madagascar, Colombia, Ecuador, Paraguay and South East Asia generally. They also included the proposed West African CSG sub-regional meeting, to be held in Burkina Faso.

The CSG is extremely grateful to the Beni Department Prefecture which hosted the meeting. The Organizing Committee (Karina Sauma, Alfonso Llobet, Silvia Ovando, Alvaro Velasco, Alejandro Franulic, Ana Karina Bello, Francisco Aguilera, Omar Rocha, Aleida Justiniano) and their support staff did a marvelous job in preparing and running what all considered to be a wonderful meeting. Their efforts make a very significant contribution to the CSG, and through them, to the SSC and IUCN.

None of this would have been possible without the generous financial support provided by the major sponsors of the meeting, whom I thank here on behalf of all CSG members: Programa Nacional de Biocomercio Sostenible (PNBS), Fundacion Amigos de Naturaleza (FAN), Prefectura del Departamento del Beni, Prefectura del Departamento de Santa Cruz, CIENSA, Curtiembre Moxos, Bolivian Leathers and Food, and Bolivian Croco. Additional financial and in-kind support was provided by the Buganvillas Hotel and ICEA.

For the many people who work on crocodilians around the world, the biennial working meetings of the CSG are an important event. Working with crocodilians requires a special effort by special people. Crocodilians live in remote and inhospitable places, where access is difficult. Because they range in weight from less than 50 g to over 500 kg, catching and handling is always a challenge, not to mention the personal risks involved. In the eyes of the general public, it is often a thankless task, because crocodiles are truly viewed as being "wicked" by most people. Not so amongst CSG members.
CSG working meetings, bring together an exceptional array of talented people, from all around the world. For most of them, the time and travel involved is a significant personal cost. The major reward is the ability to share one week with like-minded people, equally passionate about crocodilians. It recharges often tired batteries, stimulates interest, fosters camaraderie, creates new friendships, puts new faces to names, provides a genuinely sympathetic ears for discussion of problems, and most important, provides an opportunity to pass on new results and findings.

The core business of CSG is to help the IUCN and SSC achieve their conservation missions with crocodilians. This involves a raft of different CSG initiatives and activities in different countries, some simple others immensely complex. They are all addressed openly within the Working Meetings. As the complexity of the world expands, so the "biopolitics" of crocodilian conservation becomes more challenging. But the CSG adapts well. We do an exceptional job, quickly, honestly, transparently and usually by consensus. That we do it largely as volunteers, with very few paid staff, is remarkable in its own right.

An important key to the success of the CSG is that its membership includes representation from a great diversity of different stakeholders. We can look at the same problem through many different eyes. Particularly important are members representing the international crocodile skin industry. They keep us focused on attainable goals, make sure our concerns about trade are valid, and offer sound advice and a wealth of experience when required.

The proceedings of the 19th Working Meeting of the CSG is a unique compendium of current information on problems, research and new ideas about crocodilian conservation and management. It is both a source book and a reference book. We take this opportunity to thank the organizing committee for their efforts in getting the proceedings published in a timely way.

Profesor Grahame Webb,
Chairman, IUCN-SSC Crocodile Specialist Group
The 19th Working Meeting of the IUCN-SSC Crocodile Specialist Group (CSG) was held in Santa Cruz, Bolivia, from 3-7 June 2008, and was preceded by a CSG Steering Committee meeting on 2 June.

The meeting was hosted by the Beni Department Prefecture, and the CSG is extremely grateful to them and the organising committee (Karina Sauma, Alfonso Llobet, Silvia Ovando, Alvaro Velasco, Alejandro Franulic, Ana Karina Bello, Francisco Aguilera, Omar Rocha, Aleida Justiniano) for their considerable support for the meeting. Karina Sauma and Alfonso Llobet were the chief co-ordinators for the meeting, and expended considerable effort in the months leading up to and during the meeting to ensure that everything ran smoothly – they did a wonderful job.

Professor Grahame Webb (CSG Chairman) welcomed 220 participants from 27 countries (Australia, Argentina, Bolivia, Papua New Guinea, Japan, Thailand, USA, Mexico, Panama, Colombia, Venezuela, Paraguay, Guatemala, Uruguay, Brazil, Germany, Netherlands, Spain, Hong Kong, Italy, France, United Kingdom, Costa Rica, Ecuador, Madagascar, Guyana and Denmark). In particular, there was good representation from Latin America.

CSG working meetings, held every two years, are the primary international meeting dedicated to crocodilian conservation, management and research. They have become the major forum for discussion of conservation issues, presenting new findings and new directions, and the 19th meeting was no exception.

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

• Conservation, management and sustainable use of crocodiles in Bolivia
• Conservation, management and sustainable use of crocodiles in Latin America
• Trade and impacts on crocodiles
• Systematics, taxonomy and genetics of crocodiles
• Genetics and immunology of crocodiles
• Breeding in crocodiles
• Population status of crocodiles
• Endangered species actions
• Miscellaneous.

A series of workshops were also held:

1. Sustainability criteria (environmental, social, economic) for the success of national management programs.
2. Local organisations in conservation and management of crocodilians.
3. Aspects affecting the sustainability of crocodilian trade.
4. Management plans as conservation tools in Latin America.

In addition, the CSG’s Veterinary Science (Vice Chair, Paolo Martelli) and Zoos and Community Education (Vice Chair, Kent Vliet) groups met during the course of the meeting. Merlijn van Weerd took the opportunity to convene a meeting of interested people to discuss conservation and management of the Philippine crocodile.
The deliberations of each workshop and thematic group were summarised at the end of the working meeting.

No CSG meeting would be complete without the various social activities, and this meeting was no exception. Monday’s welcome function featured classical “baroque” music and singing by the “Coro y Orquesta de San Javier”, and the following night’s dinner included rock band “Track”. On Wednesday, typical Bolivian cuisine featured at “La Casa del Camba”, where traditional dancers provided entertainment.

After participants had dined on a range of local foods (and drinks) at La Casa del Camba, auctioneers Joe Wasilewski and Carlo Piña “extracted” SUS3003 for various articles donated by people for the CSG auction. These funds will be contributed towards important research being undertaken on Indian gharial to better understand the cause of the recent mass mortality in the Chambal River. The auction is proving to be a popular event, and is set to become a permanent feature of future CSG working meetings.

Crocoland S.R.L., the first crocodilian farm established in Bolivia, was visited during the field trip on 7 June. About 29 km out of Santa Cruz, Crocoland has been in operation since September 2006. It started with 1600 female and 400 male adult *C. yacare* extracted from the Bolivian Pantanal. The breeding stocks are held in 8 lagoons. Farm stocks are derived from captive breeding and ranching of eggs. The visit was hosted by owners Jorge Baldivieso V., Jorge Baldivieso O., Carlos Ormachea and Alejandro Franulic. It was preceded by a magnificent barbeque at the adjacent San Juanito, giving participants a chance to “wind-down” and enjoy more Bolivian hospitality.

Zilca Campos from Brazil became the latest recipient of the Castillos Award for her significant contribution to crocodilian biology, management and conservation dedication and significant contribution are summarised by long-time colleague Alejandro Larriera:

“When one sees Zilca Campos at some international meeting, it is easy to mistake her for just another enthusiast and young researcher who attends workshops and conferences trying to learn something, and to know more about the “great” researchers of the CSG. Even if you speak with her, she will ask more about your work and research and be more interested in your results and successes, rather than being proud of her own successes, of which there have been many.

For over 20 years Zilca has worked enthusiastically, as much in the field as in the office, for the conservation of South American caimans. At times she has studied species of economic importance such as *Caiman yacare*, with her results being applied to programs of use and management. Yet she has also directed a great deal of effort to species with no commercial value, such as *Paleosuchus*.

Whatever her line of work, the common denominator has always has been her professionalism, stability, capacity to learn, and ability to work in a team - and luckily for all of us, her ability to teach. In this regard, it is worth clarifying that Zilca not only teaches us what she knows, but much more importantly, she serves as an example not only for young people starting in these activities, but for all of us. I hope there is still time to follow her lead.”

The 20th CSG Working Meeting will be held in Manaus, Brazil, in September 2010.
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- Prefecture of Beni Department

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Key funding was kindly provided by the following organizations:

- Programa Nacional de Biocomercio Sostenible (PNBS) - FAN Bolivia.
- Prefectura del Departamento del Beni.
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We are very grateful to the following people and/or organizations for their financial and in-kind support of the meeting:

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- Bunganvillas Hotel
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Chairman of the CSG, Prof. Grahame Webb. Included in the background are Charlie Manolis, Javier Castroviejo and Rafael Antelo (Photo: Mariana Escobar).

Joseph Wasilewski holding an excellent reproduction of a Gharial skull during the auction to raise funds for Gharial conservation (Photo: Alfonso Llobet).
Members of the Organizers Committee and some sponsors (Prefectura de Santa Cruz, Bolivian Leathers & Food, Bolivian Croco, Prefectura del Beni, Crocoland, Curtiembre Moxos, ICEA) of the 19th CSG Working Meeting (Photo: Mariana Escobar).

Some participants of the CSG 19th Working Meeting during the barbeque at Crocoland (Photo: Alfonso Llobet).
Charlie Manolis (one big croc), Alfonso Llobet and Tom Dacey (another big croc), happy after having a fine CSG Working Meeting (Photo: Mariana Escobar).

Alvaro Velasco being interviewed for a local news channel during the closure of the meeting (Photo: Mariana Escobar).

Charlie Manolis (one big croc), Alfonso Llobet and Tom Dacey (another big croc), happy after having a fine CSG Working Meeting (Photo: Mariana Escobar).
Results of the first harvest of *Caiman yacare* by Takana communities in northern Bolivia: implications for sustainability and harvest regulations.

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**ABSTRACT:** *Caiman yacare* harvest is an important economic activity of the Takana people. The construction of the management plan for spectacled caiman harvest began in 2001, through an alliance between the Takana representative organization CIPTA and the Wildlife Conservation Society, which supported a student thesis and research on the abundance and distribution of caiman in the Takana indigenous territory. On the basis of this information a management plan was approved in August 2007 which permitted the harvest of 524 individuals. These individuals where harvested from 23 water bodies of the 34 originally planned. The majority of individuals where harvested from lagoons (260), followed by streams (136), lake Moa (65) and the Beni river (63). 78.8 % of hunted individuals had total lengths of over 180 cm, but 100 % of harvested individuals produced waist coats of at least 90 cm in length, as established by the harvest regulations. In the harvest process 136 individuals where reported as injured and lost. As a result of the harvest 11 females where removed of which 4 had measurements above 180cm. Accidental harvest of 5 black caiman (*Melanosuchus niger*) was also reported. The presentation of these results aims to guide the improvement of harvests throughout Bolivia and perhaps other countries. We consider that there is a wealth of information which could guide the revision and improvement of the regulation guiding caiman harvest in Bolivia and that monitoring efforts of this and other initiatives will continue improving the program to ensure that viable populations of *Caiman yacare* continue to be available as a sustainable harvested resource for future generations.

**RESUMEN:** El aprovechamiento de *Caiman yacare* es una actividad económica importante del pueblo tacana. La construcción del plan de aprovechamiento se inició el 2001, a través de una alianza entre la organización representativa de los tacanas (CIPTA) y Wildlife Conservation Society (WCS) la cual apoyó la ejecución de una tesis e investigaciones sobre la abundancia y distribución de lagartos en la TCO Tacana. En base a estos estudios, se elaboró un plan de manejo que fue aprobado en agosto de 2007 permitiendo la cosecha de 524 individuos. Estos individuos se cazaron en 23 cuerpos de agua de los 34 originalmente previstos. La mayor cantidad de individuos cosechados provino de lagunas (260), seguida de los arroyos (136), lago Moa (65) y del río Beni (63). El 78.8 % de los individuos cazados superó los 180 cm de largo total, pero el 100 % de los individuos cosechados produjeron chalecos iguales o mayores a 90 cm, conforme a lo establecido en el reglamento. En el proceso de la cacería se han reportado 136 individuos heridos y no recuperados. Como un efecto de la cacería 11 hembras fueron cazadas, de las cuales 4 tenían medidas superiores
a los 180 cm. También se ha reportado la caza accidental de 5 caimanes negros (*Melanosuchus niger*). La presentación de estos resultados y análisis tienen como fin que estas experiencias sirvan como referencia para el mejoramiento del aprovechamiento en la zona así como en otras del territorio boliviano, y por que no en otros países de la región. Consideramos que existe mucha información y muchas implicaciones que podrían servir como base a para una potencial revisión del reglamento de aprovechamiento de lagarto en Bolivia y que los esfuerzos de monitoreo de ésta y otras iniciativas continuarán enriqueciendo a este programa con el fin de asegurar que poblaciones viables de *Caiman yacare* sigan constituyéndose en un recurso aprovechado sosteniblemente y esté disponible para muchas más generaciones.
Conservation and Sustainable Use Program of Yacare Caiman
\textit{(Caiman yacare)} in Beni, Bolivia

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**ABSTRACT:** The Conservation and Sustainable Use Program of Yacare \textit{(Caiman yacare)} has been the first management and harvest program of wildlife on a large scale in the Beni Department of Bolivia. With an experimental beginning in 1997 -1999, the Program has been adjusted to the biological and cultural characteristics of the social sectors that participate in it: (indigenous, farmers and ranch owners). At present, in the Beni Department, its develop a big strategy to correct some deficiencies observed inside the Yacare Program through the implementation of specific Management Plans, that include new actors, like Municipalities and NGOs, and a direct participation of Departmental and National Authorities. The Prefecture of Beni Department conscientious that the Yacare program needs a feedback that permit adapt to the new trade, biological and climatic changes, are organizing themselves to respond more efficient and practical to the new challenges, through make better the control and monitoring the yacare wild populations.

**RESUMEN:** El Programa del Conservación y Aprovechamiento Sostenible de Lagarto \textit{(Caiman yacare)} ha sido el primer programa de aprovechamiento y conservación de fauna silvestre a gran escala en el Departamento del Beni. Con un inicio experimental en el periodo 1997 -1999, el Programa se ha ido ajustando a las características biológicas y culturales de los sectores sociales que participan de él: indígenas, campesinos y ganaderos. En la actualidad, en el Departamento del Beni se esta haciendo un gran esfuerzo por corregir algunas deficiencias observadas dentro del Programa de Lagarto a través de la implementación de Planes de Manejo específicos para esta especie, resaltando el involucramiento de nuevos actores al programa, como Municipios y ONGs, y la mayor participación más directa de Autoridades Departamentales y Nacionales. En el futuro, concientes que el Programa Lagarto se debe retroalimentar para adaptarse a los cambios del mercado, biológicos y climáticos que repercuten directa e indirectamente en los avances del Programa, la Prefectura del Departamento del Beni se está organizando para responder a esto nuevos retos de una manera más práctica y eficiente, realizando los esfuerzos para lograr un buen control y monitoreo del estado poblacional del \textit{Caiman yacare}.
Assignment of harvest quota of *Caiman yacare* in Bolivia

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**ABSTRACT:** The 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 of Bolivia. The present paper reviews the different systems that have been used in the past to assign harvest quota. Strengths and weaknesses of the different assignment systems are discussed and recommendations to improve these systems are provided.

**RESUMEN:** El Programa para la Conservación y el Uso Sostenible del *Caiman yacare* contempla la caza anual de 45000 machos adultos, primordialmente en los departamentos del Beni y Santa Cruz (Bolivia). Este estudio tiene como objetivo el de discutir los sistemas de asignación de cupos de caza que se han aplicado en el pasado. Se presentan las fortalezas y debilidades de los distintos enfoques y se formulan recomendaciones para mejorar los métodos.
Analysis of models to assign harvest quotas and to estimate habitat potential of Yacare caiman in Bolivia

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ABSTRACT: In the framework of the Bolivian caiman (Caiman yacare) conservation and sustainable harvesting program one model was developed in 2004 to assign harvest quotas for each registered property and another model was developed in 2005 to estimate the relative potential of caiman habitats at the micro-watershed level. However, none of them was validated due to a lack of enough population data. With the development of 14 caiman management plans in indigenous lands, municipalities and protected areas, a significant census effort conducted between 2004 and 2007 produced enough data to analyze and validate the models. As a product of this analysis, we discuss the need to adjust and improve the existing models, as well as the usefulness of developing a new model to estimate in a more precise and reliable way the harvesting quotas for Bolivian caiman.

RESUMEN: En el marco del Programa Nacional para el Aprovechamiento Sostenible del Lagarto (Caiman yacare) en Bolivia, se avanzó en el desarrollo de un modelo para la determinación de cupos de cosecha de lagartos a nivel de predios, así como en otro modelo destinado a analizar el potencial de hábitat de la especie a nivel de microcuencas. Sin embargo, ninguno de estos modelos pudo ser validado por falta de información confiable sobre datos poblacionales de la especie en el campo. Actualmente, con el desarrollo de 14 planes de manejo para el aprovechamiento del lagarto en tierras indígenas, municipios y en áreas protegidas, entre los años 2004 y 2007, se ha desarrollado un importante esfuerzo de muestreo que permitió contar con la información de campo suficiente para poder encarar un proceso de análisis y validación de los mencionados modelos. Producto de este análisis, se discute la necesidad de ajustar y mejorar los modelos existentes, así como la pertinencia de desarrollar un nuevo modelo que permita calcular de forma más precisa y confiable los cupos para el aprovechamiento sostenible del lagarto en Bolivia.
Indigenous vision about the management of *Caiman yacare*: changing attitudes based on our reality

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**ABSTRACT:** The management of *Caiman yacare* on Bolivia has already started before the National Programme of *Caiman yacare* (PNASL) begins but without transparent to assure the sustainable management and with no real benefits for indigenous communities. Once the *C. yacare* Programme in Bolivia began, was recognized the right of local people to obtain benefits through the use of this resource in their areas; however, instead of to have the rights in the more richness zones for de specie, the Government didn’t give them the right to decided over the gestion of the Programme, with all this problems they didn’t feel the benefits. With the indigenous experience in the territorial management they change the attitude changing the pression over the Government for a new way of development norms. In this way the PNASL moved on to a new sustainable management based in the development of management plans, where the indigenous are the leading actors. This new model wants to improve the social management to assure the sustainability of the harvest, and to promote the generation of responsibility over the taken actions. At the same time, strengths the role of the indigenous in the productive chain, avoiding manipulations from other actors and looking for better information to adjust de management in an adaptive approach.

**RESUMEN:** El manejo del lagarto en Bolivia comenzó antes del programa nacional, pero sin reglas claras ni criterios para asegurar un manejo sostenible, y sin que existan beneficios reales para los indígenas. Una vez que inició el Programa Lagarto en Bolivia, se reconoció el derecho indígena de obtener beneficios de este recurso en sus territorios; sin embargo, a pesar de tener derechos sobre las zonas con mayor potencial de aprovechamiento, siguieron marginados para poder decidir sobre la gestión del programa, y no recibían beneficios justos en un Programa Nacional donde no estaban claramente asumidos derechos y responsabilidades de los diferentes actores.

Con la experiencia indígena en la gestión territorial, se inició un cambio de actitud con el que se dejó de lado las medidas de presión para ser escuchados y se planteó el desarrollo de normas y criterios de manejo construidos participativamente, con base en la realidad local y con mejores posibilidades de aplicación. De esta forma, el Programa Lagarto evolucionó hacia un manejo bajo planes, en el que el sector indígena es el principal protagonista. Este modelo busca mejorar el manejo social para asegurar la sostenibilidad del aprovechamiento y promover la apropiación del recurso y del propio manejo, generando conciencia de responsabilidad sobre las acciones que se toman. Al mismo tiempo, se fortalece la participación de los indígenas en la cadena productiva, evitando las manipulaciones a las que estuvieron sometidos y obteniendo mejor información que permite ajustar el manejo bajo una visión de gestión adaptativa.
Tools to promote caiman management plans with local communities of eastern Bolivia

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ABSTRACT: The yacare (Caiman yacare) skins have a great economic potential for the indigenous peoples of eastern Bolivia. The revenues from this resource should strengthen the communities and stimulate their responsibility on the wild caiman populations they harvest following management plans. In addition to the market for Class IV skins, there are options for handicrafts and other skin products. The communities with best access to buyers can also sell fresh or dry meat. The opportunity presents the challenge of reaching fair and long-term stable markets. There is enough knowledge and technical experience in the academy and the local people to reach a sustainable production of caiman in Bolivia. However, there is little experience in the communal management of this promising resource. In this document we share some experiences developed by indigenous peoples and tools applied to promote the active participation of hunters in the sustainable harvest and control of skins produced in their management areas.

RESUMEN: Los cueros de lagarto (Caiman yacare) tienen gran potencial económico para los pueblos indígenas del oriente de Bolivia. Los ingresos provienen de este recurso deben fortalecer las comunidades y estimular la responsabilidad de producir su cosecha, aunque son extraídos de vida libre siguiendo un plan de manejo. Además de vender el cuero salado, existen mercados para artesanías fabricadas de cueros completos y pedazos no vendibles. Para las comunidades con acceso a los compradores, tienen potencial de vender la carne fresca y salada. El resultante reto de toda esta oportunidad es para lograr mercados justos y estables en el tiempo. Existe el conocimiento y experiencia técnica para lograr la producción sostenible de lagarto en las tierras bajas de Bolivia, en el mundo académico y en la sabiduría local. Lo que falta es mayor experiencia local en el manejo comunitario de este recurso promisorio. En este documento se busca compartir algunas experiencias adquiridas por los pueblos indígenas y algunas herramientas para promover la participación activa de los cazadores en la cosecha sostenible y el control de los cueros que salgan de sus áreas de producción.
Spatial models of management: Strengths, threats, weaknesses and opportunities in the Spectacled Caiman Management Plans

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ABSTRACT: The Spectacled Caiman (Caiman yacare) National Program of Conservation and Sustainable Use, in operation in Bolivia since 1997, applied the assumptions of the Venezuelan model of biological sustainability for the use of this crocodilian species. Because problems arisen with the assignment of quotas to the properties that are annually registered in the Program, the participation of the hunters in the productive process, the distribution of benefits and other, from the year 2001 they have been a development of management plans in Beni and Santa Cruz. The spatial differences, the stakeholders, ownership of the land, organization, participation in the Program, history of use, and other outline problems and different opportunities, that are fundamental for the definition of the management system proposed and the design of management plans.

The experience demonstrates that all the proposed management models are viable, but their strengths, threats, weaknesses and opportunities shows that some previous conditions are key in the design of the management plans, and they demand follow-up systems to foster previously and to achieve the execution of a management plan.
Equitable Sharing of Benefits in the Caiman Productive Network.

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ABSTRACT: The Equitable Sharing of Benefits (ESB), besides being a principle of bio-commerce, is one of the up-to-date postulates in the world of business with social responsibility. ESB is the sum of activities with the purpose of obtaining equitable benefits for all the actors involved in a productive chain as a whole; the distribution of benefits should be closely related to the effort and outcome of each actor. In Bolivia the productive chain of spectacled caiman (Caiman yacare) is being developed within the frame of the Program for Conservation and Sustainable Exploitation of Spectacled Caiman, implemented by the Bolivian State since 1997. The Program operates on the basis of harvesting wild animals observing an annual quota according to CITES recommendations. One of its goals is to offer economic opportunities to the actors of the productive chain, consisting of native communities, peasants, stock farmers, merchants and enterprises (tanneries). The weakest links in the chain are, beyond any doubt, the resources’ providers, i.e. the numerous native and peasant communities who hunt caimans to generate income for their households since the beginning of the Program. Available records allow us to question the Program efficiency which, up to the date, has failed one of the main goals: to offer income opportunities to the resources’ providers. In general producers, hunters and/or gatherers are exploited by merchants or enterprises who take for themselves a major share of the benefits. In general the producers (hunters) they have not improved their situation of poverty since the middlemen or companies are taken most of the benefits.

On the other hand, we can not ignore the entrepreneurial sector, who has open its own way by overcoming several difficulties and performing important financial efforts to carry on this business, and now claims for support from the State to obtain profit according to its effort. Other actors of the productive chain are the public institutions (national and local government) in charge of controlling and monitoring the Program implementation. These institutions represent the Bolivian State, owner of the natural resources, and do not profit from the ESB because they do not even have enough assets to accomplish their tasks, therefore it is unavoidable to look for their financial sustainability. Watching over the interest of all the actors involved, public and private, to attain the Program’s sustainability, we propose the implementation of the following five tools to achieve the ESB in this productive chain, whose bigger threat is the inequity in the distribution of benefits:

a) To develop relations based upon confidence, dialogue and mutual benefit;
b) To improve commercial and legal capabilities of the resources’ providers;
c) To establish fair and equitable commercial relations;
d) To obtain a wide cooperation between different actors to promote local development and to preserve biodiversity and traditional knowledge;
e) To generate a permanent exchange of transparent information.

RESUMEN: La Distribución Justa y Equitativa de Beneficios (DJEB), además de ser uno
de los principios del biocomercio, es uno de los postulados que está en boga en el mundo de los negocios con responsabilidad social. La DJEB es el conjunto de actividades que tiene la finalidad de lograr beneficios equitativos para los actores que intervienen en una cadena productiva, esta distribución deberá estar directamente relacionada con el esfuerzo y aporte de cada uno de los actores. En Bolivia la cadena productiva del lagarto (*Caiman yacare*) viene desarrollándose en el marco del Programa de Conservación y Aprovechamiento Sostenible del Lagarto (PCASL), implementado por el Estado desde el año 1997. Este Programa tiene como base la cosecha de animales silvestres a través de cuotas anuales de extracción de acuerdo con lo estipulado en CITES. Uno de sus objetivos es el de brindar oportunidades económicas a los actores de la cadena, que son comunidades indígenas, campesinas, ganaderos, intermediarios y empresas (curtiembres). El eslabón más débil de la cadena es, sin duda alguna, el de los proveedores del recurso, nos referimos a la gran cantidad de comunidades indígenas o campesinas que desde el inicio del Programa cazan lagartos para generar ingresos económicos para sus hogares. Antecedentes disponibles nos permiten cuestionar la eficiencia del Programa, en el que hasta ahora no se ha cumplido uno de los objetivos fundamentales, que es el de brindar oportunidades de ingresos económicos para los proveedores del recurso. En general los productores, cazadores y/o recolectores de la materia prima no han mejorado su situación de pobreza ya que los intermediarios o empresas se llevan la mayoría de los beneficios.

Por otro lado no se puede ignorar al sector empresarial, que se ha abierto camino en este rubro superando muchas dificultades y realizando grandes esfuerzos económicos para llevar adelante este negocio y reclama, de parte del Estado, el respaldo y apoyo que le permita obtener rentabilidad en función a su esfuerzo. Otro actor de la cadena productiva son las instituciones públicas (gobierno nacional y gobiernos departamentales) encargadas de controlar y supervisar el cumplimiento del Programa. Estas instituciones representan al Estado boliviano, propietario del recurso, y tampoco gozan de una DJEB, ya que ni siquiera cuentan con los medios económicos necesarios para desarrollar sus tareas, por lo que resulta indispensable buscar su sostenibilidad financiera. Velando por el interés de todos los actores, públicos y privados, en aras de la sostenibilidad del Programa, se plantea la alternativa de implementar las siguientes cinco herramientas que permitan una DJEB en esta cadena productiva, en la que la gran amenaza es la desigualdad en la distribución de beneficios:

a) desarrollar relaciones basadas en confianza, diálogo y mutuo beneficio;
b) mejorar las capacidades comerciales y legales de los proveedores del recurso;
c) establecer relaciones comerciales justas y equitativas;
d) obtener amplia cooperación entre los diferentes actores para promover desarrollo local y conservar la biodiversidad y conocimientos tradicionales; y
e) generar un intercambio constante de información transparente.
PNBS strategy for a sustainable use of *Caiman yacare* in Bolivia

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**ABSTRACT:** Classified as Lower Risk category by the UICN, spectacled caiman (*Caiman yacare*) is currently commercially used in Bolivia. The value chain of this crocodilian involves principally indigenous communities, local communities and private companies. There are difficulties between these actors about the resource use and these difficulties threaten the sustainable use of the specie.

The Biotrade National Program (known in Spanish as Programa Nacional de Biocomercio Sostenible - PNBS) is a government of Bolivia initiative, implemented by ‘Fundación Amigos de la Naturaleza’ and supported by the governments of the Netherlands and the Swiss Confederation. The Program facilitates the trade of products and services of native biodiversity, produced with ecologic, social and economic sustainability criteria and thereby to generate income for the country.

Some of the products that the PNBS has selected to support are spectacled caiman leather and meat. The biotrade initiatives related with these products, were evaluated in order to meet the Biotrade Principles and Criteria. Combined with local workshops, these assessments allow identifying the needs of different actors and allow defining the PNBS’s strategy for this value chain. This line of action identified the elaboration of management plans like a key activity. Because of, the PNBS has supported the elaboration of eleven management plans, which were designed in collaboration with the actors.
Population Status of Spectacled Caiman (*Caiman yacare*) in areas under Management Plans for sustainable use of the specie in Beni and Santa Cruz, Bolivia

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ABSTRACT: Within the National Program for Sustainable Use of Spectacled Caiman in Bolivia, management plans are being developed on indigenous lands, protected areas, and municipalities for improving key aspects of the program; such plans are improving organization, establishing local controls, transparency of the reliable management and information about the specie. In this aspect, data were collected on the abundance and population structure of crocodiles in 419 sites in 10 Indigenous Lands (TCO), one protected area and one municipality. The data of abundance presents a major variation from places with 0 ind/km of shore (no animals) up to 1945.45 ind/km of shore (as in artificial pounds) on cattle ranches. The population structure also presents variations among areas, suggesting different degrees of pressure over the specie. Our data shows that on a national level, the population of the species is good enough to be subject of a sustainable management of the species as long as local controls are improved to stop the hunting of the animals that are too small or not during hunting season. However, the individual analysis per area shows that in some places the maximum amount of animals to be harvested could be some thousands of animals, while in other areas there are not enough potential to face the harvesting model in a sustainable way.

RESUMEN: En el marco del Programa Nacional para el Aprovechamiento Sostenible del Lagarto (PNASL) en Bolivia, se están desarrollando Planes de Manejo en tierras indígenas, áreas protegidas y municipios para mejorar aspectos clave del aprovechamiento como: fortalecimiento organizativo, establecimiento de controles locales, transparencia del manejo e información biológica confiable sobre la especie. En este último aspecto, se tomaron datos de abundancia y estructura poblacional del lagarto en 419 puntos de muestreo que corresponden a 10 Tierras Comunitarias de Origen (TCOs), un área protegida y un municipio. Los datos de abundancia presentan una gran variación, desde lugares que fueron registrados como 0 ind/km (sin animales) hasta 1945.45 ind/km de orilla en estanques artificiales en ranchos ganaderos. La estructura poblacional igualmente presentó grandes variaciones mostrándose estructuras por clases de tamaños en forma de escalera ascendente, escalera invertida y estructuras piramidales. Nuestros datos sugieren que a nivel nacional la especie se encuentra con un estado poblacional que permite llevar a cabo el aprovechamiento de manera sostenible, siempre y cuando se mejoren los controles locales para evitar la cacería de animales fuera de talla o de temporada. Sin embargo, el análisis individual por predios muestra que en algunos lugares los cupos de cosecha pueden representar varios miles de animales, mientras que en otros no se cuenta con el potencial necesario para que dicha actividad se lleve a cabo de forma sostenible bajo el actual modelo de manejo.
Lessons learned from the Pilot Sustainable Management Plan for Spectacled Caiman (*Caiman yacare*) in the San Matías Protected Area

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**ABSTRACT:** The San Matías Protected Area is a conservation unit of national and global importance, with the objective to compatibilize Chiquitano Dry Forest and Pantanal ecosystem conservation with the sustainable development of the local people/communities. There are 26 communities living in the protected area, as well as 60 cattle ranches. The indigenous communities living in the protected area subscribed to the National Program for Sustainable Use of Spectacled Caiman in 2003, being represented by the Provincial Chiquitano Organization (*Central Indígena Reivindicativa de la Provincia Angel Sandoval* CIRPAS) and the National Ayoreo Organization (*Central Ayoreo Nativa del Oriente Boliviano* CANOB). In the San Matías Protected Area, on request of the communities interested in using this resource and due the lack of a specific management plan, during fiscal year 2005, a pilot sustainable management plan for caiman was implemented in order to use this species legally within the framework of the General Regulations for Protected Areas and the National Caiman Regulations. As a result of this pilot experience, the following lessons can be drawn: local stakeholders as direct beneficiaries learned about the functioning of the National Program of *Caiman yacare*. Moreover, this enterprise of use within a protected area contributed through good caiman management, and avoiding conflicts and divisions within their traditional organizational structures, to broadening the positive effect of sustainable use and - on the other hand – to generating additional income for their families.
Social Participation in the TIPNIS Caiman Management Program

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ABSTRACT: The Isiboro Sécure National Park (1965) was recognized as the Indigenous Territory of the Mojeño, Yuracaré and Chiman in 1990. Since 2004, the TIPNIS has a General Management Plan that includes instructions, guidelines, and policies for managing the Protected Area and Indigenous Territory. One of the strategic objectives is to promote increased social and economic development of local communities, based on the sustainable management of natural resources. Within this framework, social and organizational processes are being carried out since 2003, around the protection and management of spectacled caimans (Caiman yacare). These processes have in the design of a Caiman Management Plan, focused on developing short, medium and long-term community-based management and conservation and local capacity building strategies to avoid illegal use of this specie. Since 2005, TIPNIS is part of the National Sustainable Management Program for Spectacled Caiman. Commercial harvesting of C. yacare carried out on three separate occasions, has already produced economic benefits for the families of 30 indigenous communities. Species conservation is supported by participatory protection schemes, community organizational strengthening for caiman management, and biological and social monitoring of the specie.

RESUMEN: El Parque Nacional Isiboro Sécure (1965) fue reconocido como Territorio Indígena de los pueblos mojeño, yuracaré y tsimane en 1990. Desde el 2004 cuenta con un Plan General de Manejo que brinda directrices, lineamientos y políticas para la gestión integral del AP/TCO donde uno de los objetivos estratégicos apunta a que las comunidades logren un mayor desarrollo socioeconómico en base al manejo sostenible de los recursos naturales. En este marco, desde el 2003 se han desarrollado procesos sociales y organizativos en torno a la protección y aprovechamiento del lagarto (Caiman yacare), culminando en el Plan de Manejo del Lagarto como instrumento que enfatiza el desarrollo de estrategias comunales de aprovechamiento y conservación y la generación de capacidades locales a corto, mediano y largo plazo y así evitar el aprovechamiento ilegal del lagarto. Desde el 2005 el TIPNIS participa en el Programa Nacional de Aprovechamiento Sostenible del lagarto, con 3 cosechas realizadas que han generado beneficios económicos para familias de 30 comunidades indígenas y apuntalado la conservación de la especie mediante sistemas participativos de protección, el fortalecimiento de la organización intercomunal para el manejo de lagarto y el monitoreo biológico y social de la especie.

INTRODUCTION

One of the characteristics of Bolivia’s Protected Areas is the resident populations (it is currently estimated that some 200,000 people live and develop economic activities in the 22 National Protected Areas). A large percentage of these are indigenous and/or native peasant populations, with ancestral territorial rights and traditional knowledge of land and natural resource management. Additionally, the protected areas coincide with or are adjacent
to 14 indigenous territories. As a result, two of the protected areas have also been formally recognized as indigenous territories.

Considering this reality, and within the framework of its authority, the Strategic Management Agenda (SERNAP, 2005) states that “... Based on this new general political and regulatory framework, protected areas are to be conceived and managed as spaces ‘with people’. This means recognizing not only the explicit right of their inhabitants to live in the areas, to own the lands, and to sustainably use the renewable natural resources ...”. The Agenda also establishes “sustainable economic and social development” as a strategic objective. According to this objective, managing biodiversity resources will not only generate income, employment and socioeconomic benefits for the local populations, but will also support biodiversity conservation in the PA’s, and improve their acceptance and recognition.

More recently, and in a new political and social context, SERNAP has adopted a new management model to introduce the concept of “Protected Areas of the people”, which highlights the social and economic function of protected areas, focusing on increased ownership by resident populations, and proposes to discuss new roles and responsibilities for joint management of the country’s protected areas and their service areas.

**SOCIAL PARTICIPATION IN THE TIPNIS CAIMAN MANAGEMENT PROGRAM**

The Isiboro Sécure National Park and Indigenous Territory is located in the central part of Bolivia (north of Cochabamba and south of Beni), in a transition zone between the Andes and the Amazon. The park stretches over hills, mountains and plains, with altitudes ranging from 3,000 to 180 meters above sea level. The TIPNIS has more than 170 lakes, the majority of which were created as a result of meanders. These bodies of water are particularly rich in hydrobiological resources, including the spectacled caiman. In normal years, 70% of the alluvial plains (representing 40% of the total surface area of the park) is under water for 3 to 5 months.

The Isiboro Sécure National Park was created in 1965, when there were no institutions or regulations dealing with protected area management. In 1990, the Park is formally recognized as an Indigenous Territory, home to the Mojeño, Yuracaré and Chiman tribes, and becomes the Isiboro Sécure National Park and Indigenous Territory (TIPNIS). The TIPNIS is managed under a co-administration agreement signed by SERNAP and the indigenous organization (TIPNIS Sub-Central).
Historically, the TIPNIS has undergone extensive plundering of its natural resources. There is evidence of illegal commerce of spectacled caiman and black caiman (*Melanosuchus niger*) hides between 1960 and 1985, with dramatic consequences for the populations of both species, particularly the black caiman, which was in danger of becoming extinct. In the 90’s, as a result of the enactment of the Decree of ecological pause or indefinite Prohibition (1990), the spectacled caiman population started to recover. However, in 2001-2003, poachers have started to hunt the spectacled caiman in the TIPNIS, where the practice is illegal according to the National Sustainable Management Program for Spectacled Caiman. Hunting is legal, within the framework of CITES, in cattle ranches, and indigenous and peasant communities in Beni and Santa Cruz. Unfortunately, authorities lack the capacity to enforce regulations prohibiting hunting in the TIPNIS.

**a) The Regulatory Framework**

Although Bolivian legislation provides for the sustainable use of renewable natural resources by local populations within the country’s protected areas and indigenous territories, in the case of the TIPNIS, the path to obtaining authorization to do so was a long one. Efforts were undertaken to raise the express prohibition to harvest spectacled caimans in the TIPNIS, and, in 2005, the Ministerial Resolution approving the Caiman Management Program in the Isiboro Sécure Protected Area and Indigenous Territory was issued. A second Ministerial Resolution approved the Addendum to the Plan, in 2007, extending the scope of application to the other management areas.

Management of the spectacled caiman in the TIPNIS is protected by law and feeds back into the law, particularly with respect to the mechanisms that ensure that harvesting is not excessive (preventive principle) and that its economic benefits reach all the families of the indigenous communities involved in management activities.

Another regulatory instrument is the General TIPNIS Management Plan. It is precisely during the initial stages of the participatory development of this plan (during the sub-regional workshops), that the spectacled caiman was identified as a natural resource having a potential for sustainable use. It was decided to develop a spectacled caiman management plan, and thus both planning processes ran parallel to each other. For this reason, the strategic objective of the General TIPNIS Management Plan “increased socioeconomic development, based on the sustainable management of natural resources in the communities of the protected area, the indigenous territory and its surroundings” supports economic initiatives, such as spectacled caiman harvesting, and other productive activities carried out by the indigenous communities.

**b) The TIPNIS Caiman Management Program**

Developing the TIPNIS Caiman Management Program was a long (2002-2005), complex process. The indigenous communities of the lower areas of the TIPNIS participated extensively in the process. In addition to local knowledge, the planning process was based on aquatic habitat suitability models, interviews with hunters, and preliminary night counts, showing that this area of the TIPNIS contained a large population of spectacled caimans.

The TIPNIS Caiman Management Program represents a new resource management model in Bolivia. In addition to biological monitoring of the state of the spectacled caiman
population, the Plan incorporates social participation elements through the strengthening of indigenous organizations; monitoring and evaluation of the processes comprising the entire spectacled caiman production chain; the division into zones, taking into account the general division of the protected area into zones but creating new ones (three management zones and 2 protection zones are considered); and particularly when it stipulates that annual caiman harvesting quotas should be based on criteria such as the relative abundance of spectacled caimans, economic viability studies, and assessment of the social benefits to be obtained.

Spectacled caiman management in the TIPNIS is generally in line with the natural resource conservation approach integrating two interrelated dimensions: resource protection and resource sustainable management. One of the characteristics of the integral management of the spectacled caiman is its adaptability. The management plan can be adapted to new scenarios or as a result of progress made, as well as to changes in the environmental and/or social conditions. A second characteristic is the diversification of spectacled caiman management strategies.

c) Implementing the TIPNIS Caiman Management Program

Notwithstanding the fact that the TIPNIS Caiman Management Program, approved by a ministerial resolution, provides a legal framework for the Indigenous Territory, one of the privileged areas of social monitoring has been the development of internal regulations. The process focused on encouraging local participation in activities that, while not unknown to the protected area’s resident populations, are organized differently in terms of the actual work performed (e.g. group hunting using appropriate techniques). Other areas of focus included marketing (public auctions), distribution of benefits to all inhabitants without exceptions, and a more participatory resource protection system.

An important element when implementing the Spectacled Caiman Management Plan, was the consolidation of an institutional structure comprising the Intercommunal Spectacled Caiman Management and Marketing Committee, representatives of traditional authorities at community level (corregidores) and supracommunal authorities (Subcentral del TIPNIS). The institutional structure also recognized both national level (DGB and SERNAP) and regional level (Prefectura del Beni) public entities. The institutional strengthening of local organizations and the Intercommunal Committee necessitated training in organizational, technical, economic and administrative issues to enable the organizations to control the different stages of the spectacled caiman production chain, and the resource protection system.

d) Main Results and Outlook

One of the main results has been implementing a transparent system for marketing spectacled caiman hides through public auctions. In 2005 and 2006 harvesting took place in the Ichoa river catchment basin area only (10 communities) but in 2007, the three TIPNIS zones (30 communities) were involved. The following table provides a summary:
The funds distributed directly to the communities (approximately US$ 800 per year) have been used to finance a series of local initiatives, such as, purchasing cattle for communal cattle raising, setting up local grocery stores, and others. The idea is to improve social interconnexion based con common projects.

Taking into account global figures for the three years, we are talking about a total injection of funds of more than US$ 60,000 (approximately US$ 1,000 per family) into an impoverished indigenous economy where the estimated annual per capita income is US$ 300. Still, it should be noted that spectacled caiman management is considered a complementary economic activity in the TIPNIS, and the income generated is in addition to the population’s traditional income.

There are other aspects to be considered when reviewing the results of spectacled caiman management implementation. Apart from the economic results, spectacled caiman management facilitates local and regional capacity building and strengthening around a given natural resource. At the local level, under a participatory management system, with an integral approach to conservation (oriented toward protection and controlling illegal hunting, which seems to have succeeded as the number of hides seized has gradually declined in recent years), pointing to the biological sustainability of a natural resource the management of which involves individual sacrifice. At the Indigenous Territory level, spectacled caimans (and wood) have been identified as one of the strategic resources whose sustainable use should guide the integral management of the TIPNIS for the benefit of the indigenous communities, and the conservation of the protected area.

e) Lessons Learned

There is evidence of support and ownership by the communities involved. In fact, in 2006, the Intercommunal Committee was able to organize hunting and marketing activities with practically no external assistance. In order to consolidate these developments, there is a need to promote increased training and technical advisory services at community and Intercommunal Committee level. At the regional TIPNIS level, efforts should focus on developing knowledge and tools for appropriate decision-making (regulations, monitoring data, etc.), and at the community level, on building technical and integral resource management capacities (self-monitoring, production, marketing).

As with any process, there are also weaknesses. These weaknesses can entail risks, particularly when there are signs of possible conflicts between the communities due to the way in which benefits are distributed among the communities (in equal shares), which is unfavorable to the more populated communities. Also, decisions as to the destination and use of funds could create problems within the communities.
CONCLUSIONS

Some general learning can be obtained from this experience, including:

- The processes involved are long-term processes, where social monitoring is critical and involves technical (productive and administrative) training and advice on social and organizational matters.
- In terms of sustainability, social and economic developments are encouraging. The challenge is the environmental issue. The biological monitoring to be conducted at the time of the fifth harvest (2009) will show the actual impact of the activity on the resource, and its biological sustainability. So far, monitoring data show a positive trend.
- The experience has had a positive impact on protected area management, as shown by the results of the implementation of the “social perception monitoring” tool. The social perception among the TIPNIS resident populations, according to interviews conducted with different age groups, is that natural resource management is important both for the population involved –because of the economic benefits- and the protected area itself, in view of the participatory protection and conservation of the resources.
- In the socio-political sphere, successful natural resource management experiences support the strengthening of social organizations from the bottom up, which in turn stimulates the emergence of new leaderships in communal, supra-communal and regional organizations.
- The TIPNIS pilot project can serve as a model for other protected areas or indigenous territories.

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Spectacled caiman (*Caiman yacare*) hunting in the low basin of the river Ichoa in the Indigenous Territory and National Park Isiboro Secure (TIPNIS), Beni-Bolivia.

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ABSTRACT: The hunting of spectacled caiman in the Amazon region of Bolivia has been registered since the beginning of the XX century, with particular peaks in the 60’s. Less or nothing is known in Bolivia about the hunting of caimans in the wild. In the low basin of the river Ichoa places of hunting (tectonic lagoons fluvial and meandered, streams, rivers and “yomomos”), sex, length (ventral and total), length of the head, distance between the eyes, distance between the nose and the eye, weight, hunting and skinning effort were registered during the hunting of 191 spectacled caiman. 56% of the aquatic places visited were tectonic fluvial lagoons where 80% of the total animals were taken out, 33% were streams where they got 14% of the total *C. yacare* and 11% were yomomales where they got 6% of the animals. 100% of the hunted animals were males. An average of the measures of the head, ventral and total of *C. yacare* were of 29 (±3.2), 113 (±7.3) y 220 (±16.9) centimetres respectively. The distance between eyes was 7.6 (±0.7) centimetres and between nose-eye was 20 (±2.1) centimetres. Average weight was 48 (±8.9) Kg. Hunting effort was of 9 (±2.9) hours/2 men and the skinning time was of 34 (±12.6) minutes for 4 (±1.4) men.

Key words: Hunting, *Caiman yacare*, TIPNIS, Bolivia, “yomomos”

Yomomo: is a marsh like type of aquatic habitat in the amazon region.
Hunting Evaluation of Spectacled caiman (*Caiman yacare*) in San Matías, Santa Cruz – Bolivia

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**ABSTRACT:** in order to evaluate the yield of the effort that the *Caiman yacare* hunt gives, in 2005 one carries out the pursuit to 4 hunters groups and 32 events carried out in 210.83 hours, in a locality called San Matías, being observed that the yield gives spectacled caiman hunted hourly was 1.27 individuals of a total 737 individuals, which 66.45% were bigger at 1.80m., 6.74% gave measure but it was not employee to present mishaps in its flanks, 13.7% was among 1.70 1.79 (no allowed by the regulation), 4.53% was not recovered of the water after being shooted, and 8.55% it was hunted to be sold in Brazil’ s hatcheries. These results indicate us that exists a 33.42% surplus hunt on the total quotas granted by the government, if we added to this result the existence an internal smuggling leathers harvested outside of season, it is possible that the harvest in some areas wouldn’t be sustainable, but with trainings and a rigorous control we could improve this situation.

**INTRODUCTION**

Latin America has the highest wealth of crocodilians species that can be in any comparable area in the world; twelve taxa (including subspecies), are distributed from Mexico to the Argentina. The vast area gives wetlands and immense riverside systems this portion of the continent provides an extensive habitat for caiman and crocodiles, reason for which the number of these animals in the region is probably the highest gives the world, although at the moment the real figures continue being ignored (Messel et al. 1995). This situation makes that the crocodilians represents a resource of considerable ecological valor and with a great economic potential (Pacheco 1996).

The Latin America region has supported the biggest crocodilians exploitation in the world. Historically, the over-exploitation for the international trade of skins has caused a serious decline and local extinctions of some species; even though ironically still in the ‘90 decade the region provided more than half of the skins crocodilians in the world trade (Messel et al. 1995).

In Bolivia the development of a pilot program for sustainable use of the *Caiman yacare* began in 1995 with the project “A Programme for the Sustainable Utilization and Management of Cayman in Bolivia” (King 1995), which gave cause so that in 1997 the Regulation was promulgated for the Conservation and Use of yacare (*C. yacare*) for Santa Cruz and Beni Departments (D.S. 24774, July 31 of 1997). At the same time, the DNBC (current General Direction of Biodiversity and Protected Areas–DGBAP), elaborated the National Program for Conservation and Sustainable Use of Caimans (PNASL), in which provides the evaluation and the populations monitoring for caiman and other crocodilians species (Llobet and Aparicio 1999).
Starting from that moment, due to the lack consent among the different actors, they were raised a series inconvenient that impeded the good development of the program up to 1999, year in the fact that a new legal mark was granted for the management wildlife, allowing the rising of the prohibition for susceptible species of sustainable use (D.S. 25458). The same year an Interim Regulation was approved with exception character that allows the use of yacare during 1999 and the crop and storing of 36500 skins (D.S. 25555, Ministerial Resolution No 307/99, Ministerial Resolution No 330/99). During the year 2000, the DGB with support of CESO/SACO (Canadian Executive Service Organization) began a echo-regionalization process of the Program through the use geographical information systems (GIS), like a proposal to be adjusted in function of new information gathered in the field, at the same time that they were carried out new monitoring in Beni, Santa Cruz and Pando Departments (MDSP 2002, you PEEP 2001). With the purpose of evaluating the development of the process and the operation of the yacare program, the year 2002 it was carried out the Evaluation of the Sustainable National Program of Caiman (Caiman yacare) (Llobet 2002).

The Santa Cruz department started the use of yacare from the year 2000 with a shared quota among the municipalities of Guarayos and San Matías. When having the town San Matías a high potential of caimans (MHNNKM, 2005), exists the risk that during the harvest some animals could be discarded (the small individuals or those that don't present an appropriate physical constitution) increasing the number of hunted caimans to reach the quota.

The present work seeks to quantify the hunt effort of the San Matías residents and to verify the harvest of the species, determining the real amount of hunted caimans, constituting this way in a tool that provides data to be used for the success of the yacare program.

**Study Area**

The study area corresponds to the San Matías municipality, county Ángel Sandoval located in the east end of Santa Cruz Department (figure 1). It presents two main physiographic units: 1) the Brazilian or Chiquitano Precambrian Shield, with slightly wavy, very eroded landscapes or cutleries give silts, and Pantanal that constitutes the floodplains of the Paraguay river. The floors are sub-hydrical type and have fine texture, result of the recent fluvial deposition silts in a surface area with scarce or null pending (Prevails et al. 2000, Rivero 2003).

![Figure 1. Study Area and sampling points inside and outside the ANMI San Matías, county Ángel Sandoval.](image)
METHODS

The field work had duration of 40 days distributed in the months of August, September and October. The habitat where the evaluation of the caiman hunt was carried out was: 9 artificial ponds, 1 river and 6 different areas within the swamp “Curichi Grande” in the Bolivian Pantanal (figure 1). The hunters were accompanied by direct way in the river Bella Vista and the Curichi Grande, and indirectly (I waited on the shore) in the ponds, because of these water habitat don't present perimeters bigger than 300 m.; when concluding the event I consulted to the hunters about the caimans shoted but not recovered.

Hunt Registry:

For each hunt event they registered the following variables:

- **beginning Hour (HI):** registered starting from the moment of beginning of the hunt.
- **completion Hour (HF):** registered in the moment of finish hunt.
- **Hunting time (T):** it was calculated starting from the equation $T=HF-HI$ (final Hour–Hour gives beginning).

For the classification of water habitat the classification that was used proposed by the MHNNKM (2004), described hereinafter:

- **Tectonic lagoons:** they are water bodies generally isolated from the rivers, they have not fluvial origin, and we consider them when they have a superior perimeter to 1 km.
- **Fluvial lagoons:** they have fluvial origin, connected temporarily with the river, many are abandoned meanders
- **Lagunetas:** lagoons minor to 1 km of perimeter.
- **Artificial ponds:** artificial ponds, in the border roads or for the livestock.
- **Rivers:** water courses that are continuous in the images Landsat (30 m of pixel) although variable wide that should be verified in the field. They are considered white waters (rivers that are born above the 500 m in the Andes and clear waters from the basin of the Iténez).
- **Streams:** water courses that are not continuous in the Landsat images, and they are born in the plains (the ‘streams Andean’ is considered gulches, and they would not be excellent for the caimans).
- **Swamp lagoons (Curichi):** they are areas annually permanent or lingering flood, they include “yomomo” areas (floating vegetation).

To obtain information on the logistics employed in the hunt and characteristics of the trade, I carried out informal interviews directed to different actors (hunters, transport, middlemen, etc.).

The obtained data was organized in field schedules designed by the MHNNKM (2004) for such an effect, where they were considered some specific data like: habitat’s names, beginning hour and completion hunt; number of hunters that intervened and type of used weapon.
Measures and sex determination:

The taken measures to the hunted individuals were: total length (LT), measured ventrally tip of the mouth until the end of the tail; head-body longitude (BL), from the tip of the mouth until the later end of the cloacae opening; longitude head (LCab), from the tip of the mouth until the trailing edge of the cranial chart; and weight (P) (Llobet 2002).

The sex determination was carried out for direct observation of the penis or clitoris. In the individual class II had to bend to the animal lightly and to exercise a lateral pressure in the seer region, for the profitable adults it was necessary the introduction of the little finger inside the cloacae (Llobet 2002).

Results Analysis:

The results analysis began with a normality test for the data (Shapiro–Wilk´s), and when not following a normal distribution, statistical not parametric was used to analyze the information (statistical Statsoft programs - Statistica 6.0). A test Kruskal Wallis was applied to compare the corporal longitudes so much among the different water habitats, as effort/hour/man (h/men) and yields for individuals and vests (Ind/h/men = total gives individual hunted hourly and Flank/h/men = total gives utilized vests hourly) for each water habitat type lastly, was carried out an analysis correspondence among the sizes vests and the different valued hábitats (Ji–square).

They were also carried out correlations and lineal regressions (Spearman) among the hunt effort in hours/man and the different yields.

RESULTS AND DISCUSSION

The caiman hunt in Ángel Sandoval County (San Matías) is given in three types of properties:

a) In private properties where the proprietor is the same one and give the bindings is made by the services a contractor that takes the responsibility to mobilize the hunters for the share extraction assigned by the Government. The contract is only by word of mouth, and in him the proprietor fixes the price for salted leather. The election of the sizes depends on the contract that the proprietor has with the tannery, always inside the normative one effective: vests give 110 cm, 115 cm and 125 cm (R.M. 147/02). The case is also given in the one that the contractor becomes buyer of the leathers or intervenes in the intermediation of the proprietor and the tannery.

b) In the communities the use is carried out by the leaders, which take charge give to hire the hunters with experience in San Matías town and give to sell the leathers with bindings to the tanneries. They also exist community that carry out this task in a secret way and they sell the leathers to the middlemen without binding.

c) In the ANMI San Matías (where the TCO is CIRPAS and private properties), the use was carried out legal way and only give experimental form the year 2005 (in previous years it was illegal hunted form on the part of the leadership and strange hunters without the knowledge forest keeper). During this year the hunt was directed by the president the TCO through the recruiting external hunters to the communities. These hunters were controlled by the forest keeper, responsible besides placing the bindings to the extracted leathers.
Ecological description of the hunt places evaluated:

11 environments water were analyzed that correspond to 9 ponds, 1 river, and 1 Curichi, which was evaluated in 6 different points (Chart 1).

The ponds are artificial water environments with a maximum perimeter of 0.34 km and a minimum of 0.16 km, waters slightly sour greenish color (pH 6) and not very oozy sandy substrate whose depth varies from 1 m to 1.5 m. These water environments don't dry off in low water time due to the presence underground pipes that extract water from the first phreatic table.

The valued River during the hunt presented waters clear brown color and pH 6, with oozy sandy substrate. The onsite registered maximum depth gives the hunt was 1.5 m. During the time of low waters this river it doesn't present current giving place to the formation of isolated puddles where the caimans concentrate. The perimeter gives hunt was of 4 km bank.

The Big Curichi, border division between Bolivia and Brazil, was evaluated in the high basin, being presented two areas gives hunt: the “Capon del Tigre”, with marshy substrate with enough deposition of organic silts, it presents a depth of 30 centimeters for his navigability in the hunt moment and very hot waters 35°C; and the “Capon Garrapatilla”, with crystals waters up to 2 meters depth and loamy substrate - sandy not very stony. The surface hunt area was 6 Km bank for the “Capon Garrapatilla” and give 2 km bank for the “Capon del Tigre”.
Chart 1. Town, environment’s name, geographical location (UTM) and environments water types evaluated during the hunt of caimans *Caiman yacare* in San Matías.

<table>
<thead>
<tr>
<th>Town</th>
<th>Environment’s Name</th>
<th>Environment water Type</th>
<th>Dates</th>
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<th>Y</th>
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<td>Curichi</td>
<td>25 10 2005</td>
<td>340968</td>
<td>8144791</td>
</tr>
</tbody>
</table>
Hunt Aspects:

Individual hunted number

During the 32 hunt events evaluated, they were hunted a total of 737 *Caiman yacare* individuals, 514 leathers took advantage like court type vest, 102 didn't give the allowed measure according to regulation, 55 individuals didn't serve to present wounded in the flanks and to have the damaged leather, and 35 caimans were shot but they could not be rescued of the water, for what you/they were not considered in the total hunted individual, but yes in the percentages use. Finally an illegal category use was presented for Bolivia (“rabudinhos”), conformed by individuals among the class II and III, giving a total of 66 hunted individuals (figure 2).

**Figure 2.** Graphical representation of the total hunted individual (for: flanks, rabudinhos, broken or damaged, that didn't give size and escaped), in the three types environment with use, indicating the percentages of each one of these.

Of the total percentage individual that were hunted, 66.58% took advantage as leather type flank, 8.55% was “rabudinhos” and 24.86% didn't arrive to be taken advantage of in its entirety (to some they were extracted the leather of the line, other they were simply discarded) (it figures 3). If we added the percentages that are not taken advantage of for the National Sustainable Program Use of the Caiman (PNASL) we have that the allowed share for the hunt in the area rises in 33.41%.

**Figure 3.** Percentages give individual taken advantage of, not utilized and “rabudinhos.”
Use for sizes classes

Of the 737 harvested individuals, 605 belonged to the class IV forming 81.09%; 105 caimans were of class III corresponding to 14.25%; and 27 individuals give the class II, reaching 3.66% (Chart 2).

**Chart 2.** Absolute and relative abundance gives the utilized individuals according to classes.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Nº Individuals</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class II</td>
<td>27</td>
<td>3.66</td>
</tr>
<tr>
<td>Class III</td>
<td>105</td>
<td>14.25</td>
</tr>
<tr>
<td>Class IV</td>
<td>605</td>
<td>81.09</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>737</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Figure 4.** Frequencies Distribution of the Corporal Longitude (cm.) of the individuals belonging to the Classes III and IV.

The percentage of hunted caimans belonging to the class III are affected by the caimans discarded by the class IV in 48.57% (51 ind.) this percentage is inside the category 83-89 cm. BL. 51.43% (54 ind.) remaining, understood among 61-82 cm BL are taken advantage as “rabudinhos”, jointly with the entirety those belonging to the class II. (figure 4)

Of the total hunted caimans (without considering those escaped) 95.9% was male and 4% was female. 8.96% of the hunt were “rabudinhos.”

The percentages give use for sex show us that of 30 hunted females, 76.66% was hunted for “rabudinho”, and only a 6.08% of the males total (figure 5).
Figure 5. Absolute and relative caimans abundance according to the sex.

The discards of caimans hunted for “rabudinhos”, is subject at grade ossification level that these present in the ventral boards and number besides the damages that these can present in the leather.

**Effort and Product hunt for type environment water**

For the caiman hunt in San Matías participate groups of two or five people (conformed by one or two triggers ('proeros' is the person that takes charge to hire the pilot, function is to get places with good potential caiman for the hunt and during this to light, to shoot, to retire, to finish off dislocate de neck and to carry up to the canoe the depressed caimans), and one or two pilots ('singa ' or oar, function is to drive the canoe in the hunt moment, as well as to count the dead caimans on the canoe to determine the capacity of this), besides a cook in case they are 5 people) these data were obtained of four hunt groups. The groups are directed by a contractor that takes charge of food, service and hardwares hunt for the hunters, enable that it is discounted later on of the leathers obtained by these. It is also inside their responsibility the transport (going and turn) of the hunters and the canoe to the places where will be carried out the hunt.

In the ponds (private properties), with a total 9 hunt events, were an average of 6.51 hours for event, with an effort average of 1.63 h/men. The product for this environment water was of 27.14 Ind/h/men and 18.38 Flank/h/men (Chart 3a).

The event that bigger time lasted was in the Saltcellar, with a total of 10,75 hours and an effort of 2.69 h/men; while the smaller duration was registered in the Rodeo (stagnates 2), with 4.50 hours and an effort of 1.13 h/men. As for the product Ind/h/men, the biggest detected valor corresponds to Isla Verde, with 36.71 Ind/h/men; however a great difference exists with the products for flanks obtained in this water environment (17.65 flanks/h/men) this was due to that the hunt in this place (it was the only place) took place of stealthy way causing that 34.5% of the total hunt valued (737 Ind.) break down before being hides (“they didn't serve”) and 28.5% of this same one total doesn't recover from the water (“escaped”).
Chart 3a. Types environment water (Stagnate), total hunt time, Product hours/men and product flank for hunt event of *C. yacare* in San Matías.

<table>
<thead>
<tr>
<th>Name of water environment</th>
<th>Total hunt time</th>
<th>Eff. h/men</th>
<th>Efficiency Ind/h/men</th>
<th>Efficiency Flank/h/men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isla verde</td>
<td>5.67</td>
<td>1.42</td>
<td>36.71</td>
<td>17.65</td>
</tr>
<tr>
<td>S/N (Calvario)</td>
<td>8.17</td>
<td>2.04</td>
<td>26.45</td>
<td>22.53</td>
</tr>
<tr>
<td>Pirañas</td>
<td>3.00</td>
<td>0.75</td>
<td>30.67</td>
<td>12.00</td>
</tr>
<tr>
<td>El Salero (Ponds 1)</td>
<td>10.75</td>
<td>2.69</td>
<td>17.86</td>
<td>14.88</td>
</tr>
<tr>
<td>Rodeo (Ponds 1)</td>
<td>7.50</td>
<td>1.88</td>
<td>30.40</td>
<td>24.53</td>
</tr>
<tr>
<td>Rodeo (Ponds 2)</td>
<td>4.50</td>
<td>1.13</td>
<td>23.11</td>
<td>12.44</td>
</tr>
<tr>
<td>La Pampa</td>
<td>6.00</td>
<td>1.50</td>
<td>33.33</td>
<td>22.67</td>
</tr>
<tr>
<td>Garcero</td>
<td>5.50</td>
<td>1.38</td>
<td>27.64</td>
<td>23.27</td>
</tr>
<tr>
<td>Labrador</td>
<td>7.50</td>
<td>1.88</td>
<td>18.13</td>
<td>15.47</td>
</tr>
<tr>
<td>Average</td>
<td>6.51</td>
<td>1.63</td>
<td>27.14</td>
<td>18.38</td>
</tr>
</tbody>
</table>

The maximum product in flanks was presented in Rodeo (stagnates 1) with 24.53 flank/h/men. The securities minima as for the product was presented in Saltcellar, 17.86 Ind/h/men, and in the Pond Pirañas, with 12.00 flank/h/men.

In the Bella Vista river (ANMI San Matías) one could only witness an hunt with a duration of 2 hours and a product of 22 Ind/h/men and 14 flank/h/men (Chart 3b), not existing discards for the use of the hunters, but for the PNASL (of 11 Ind. hunted 4 were “rabudinhos”).

Chart 3b. Types of water environment (River), total hunt time, product hours/men and the product of flanks for hunt event of *C. yacare* in San Matías.

<table>
<thead>
<tr>
<th>Name of water environment</th>
<th>Total hunt time</th>
<th>Eff. h/men</th>
<th>Efficiency Ind/h/men</th>
<th>Efficiency Flank/h/men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buena Vista</td>
<td>2.00</td>
<td>0.5</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>2.00</td>
<td>0.5</td>
<td>22</td>
<td>14</td>
</tr>
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</table>

In Curichi (Curichi Grande) could evaluate 20 hunt events whose average in hours totals were of 6.83. During this time an effort was averaged of 3.41 h/men. The bigger event duration was the seventh, with a total of 9.50 h, and the minimum valor was registered in the event 1 of the Capon del Tigre with 3.25 h. As for the efficiency Ind/h/men, for the Curichi was of 4.68 and efficiency in flanks of 3.09 Flank/h/men (Chart 3c).
**Chart 3c.** Types of water environment (Curichi), total hunt time, product hours/men and the product of flanks for hunt event of *C. yacare* in San Matías.

<table>
<thead>
<tr>
<th>Name of water environment</th>
<th>Total hunt time</th>
<th>Eff. h/men</th>
<th>Efficiency Ind/h/men</th>
<th>Efficiency Flank/h/men</th>
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<tr>
<td>Capon del Tigre (even. 1)</td>
<td>3.25</td>
<td>1.63</td>
<td>5.54</td>
<td>3.08</td>
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<tr>
<td>Capon del Tigre (even. 2)</td>
<td>4.00</td>
<td>2.00</td>
<td>10.50</td>
<td>4.50</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 1)</td>
<td>7.00</td>
<td>3.50</td>
<td>2.86</td>
<td>2.00</td>
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<tr>
<td>Capon Garrapatilla (even. 2)</td>
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<td>3.50</td>
<td>4.29</td>
<td>2.57</td>
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<tr>
<td>Capon Garrapatilla (even. 3)</td>
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<td>3.75</td>
<td>2.67</td>
<td>1.60</td>
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<tr>
<td>Capon Garrapatilla (even. 4)</td>
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<td>3.75</td>
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<td>1.60</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 5)</td>
<td>6.25</td>
<td>3.13</td>
<td>7.68</td>
<td>6.72</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 6)</td>
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<td>3.13</td>
<td>6.08</td>
<td>5.44</td>
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<td>9.50</td>
<td>4.75</td>
<td>4.42</td>
<td>3.58</td>
</tr>
<tr>
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<td>3.75</td>
<td>6.67</td>
<td>4.27</td>
</tr>
<tr>
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<td>4.00</td>
<td>3.75</td>
<td>2.75</td>
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<td>4.00</td>
<td>7.25</td>
<td>3.75</td>
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<td>3.75</td>
<td>1.60</td>
<td>1.07</td>
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<td>5.07</td>
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<td>6.15</td>
<td>5.23</td>
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<tr>
<td>Capon Garrapatilla (even. 14)</td>
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<td>2.75</td>
<td>1.82</td>
<td>1.09</td>
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<tr>
<td>Capon Garrapatilla (even. 15)</td>
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<td>4.00</td>
<td>4.75</td>
<td>4.00</td>
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<tr>
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<td>2.75</td>
<td>2.91</td>
<td>1.82</td>
</tr>
<tr>
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<td>1.82</td>
<td>0.73</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 18)</td>
<td>7.50</td>
<td>3.75</td>
<td>4.27</td>
<td>3.47</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 19)</td>
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<td>3.75</td>
<td>8.00</td>
<td>3.20</td>
</tr>
<tr>
<td>Capon Garrapatilla (even. 20)</td>
<td>7.50</td>
<td>3.75</td>
<td>1.33</td>
<td>0.53</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>6.83</strong></td>
<td><strong>3.41</strong></td>
<td><strong>4.68</strong></td>
<td><strong>3.09</strong></td>
</tr>
</tbody>
</table>

The event that smaller efficiency presented was the 20 with 1.33 Ind/h/men and 0.53 flank/h/men.

The variations among efficiency Ind/h/men and Flank/h/men, is because of the Curichis is the area where bigger hunt exists of “rabudinhos”.

**Comparison between effort and efficiency for the different water environments**

To determine type in which environments presents a bigger effort during the hunt the effort man hour was compared by water environment type being verified a significant differences (Kruskal Wallis H=18.528; p=0.0001) (Figure 6).
Figure 6. Comparison among the effort man hour (Eff. h/men) and the different water environment types.

In the same way this analysis was applied to compare the efficiency, as much ind/hours/men, as flanks/hours/men, among the different water environment types, finding for both cases significant differences (Kruskal Wallis H=20.082; p=0.0000) (Figure 7).

Figure 7. Comparison among the efficiency ind/hours/men (effic. Ind/h/men), flanks/hours/men (effic. Flank/h/men) and the different water environment types.

The effort realized for the caimans hunt was bigger in the Curichis, but the efficiency as much in individuals as in flanks was bigger in the ponds, however the comparison among these two environment water indicate that the ponds present 63.02% of discard ("they didn't serve", "they didn't give measure" and "they were not found") in front of 32.35% presented in the Curichi, this is because of in the ponds where there is a bigger concentration of individual exist a bigger pressure in the hunt (the caimans spread to leave out of environment water and to hide in the coast vegetation) and that's why exists a high number of discard that don't give measure or that the skin breaks down.
Sizes comparison for hunt for the different types environment water

To compare the corporal longitudes with the different types environment water were carried out tests no parametric (Kruskal–Wallis), being observed that significant differences don't exist as much to the 95 as to 99% probability (H = 9.38; P = 0.0091) (Figure 8).

![Box plot comparing corporal longitudes by environment water types](image1)

**Figure 8.** Comparison of the Corporal Longitude (BL) of caimans hunted by environments water types.

To compare the tendencies of use of different sizes flanks among the types environment water was carried out a correspondence analysis, finding significant differences among these two variables ($X^2 = 74.3831; P < 0.000$).

![Correspondence analysis](image2)

**Figure 9.** Preferences of use of flanks sizes by environment water Types.

In the figure 9 observed that the flanks sizes are presented bigger in the Curichi (115 and 125) while in the ponds a tendency exists of flanks use of 110 cm since the populational structures of the species doesn't allow a bigger size in flanks and the efforts to reach this
size is subject to the leather stretched in the moment of the drying (caimans from 95 cm. BL gives 110 in flank), something that doesn’t happen if is not carried out this previous operation. In the Curichi caimans are looked for those have a BL from 100 cm. so that with this operation they reach 115 or 110 without more effort. However in Curichi is given the hunt mostly of “rabudinhos” (< 100) where 89.39% was extracted (59 ind.) from the total of rabudinhos hunted, while in ponds alone 4.54% (3 ind.) and in the river 6.06% (4 ind.) (Figure 10).

Figure 10. Frequencies Distribution among the percentages of individual harvested and the intervals of the flanks size for environment water type.

CONCLUSIONS AND RECOMMENDATIONS

• San Matías presented an over exploitation of share hunt allowed by the National Government for the Caiman yacare use in Bolivia in a 33.42%. this increment is caused by the leathers smuggling for hatcheries from Brazil, but mostly because of individuals that don’t present sizes and the don’t taken out of water and shooted.

• In the ponds (Private Properties) the biggest caiman populations are presented, but the sizes for the use are on the inferior cut-off (190 cm. LT and 90 cm BL) that indicates the regulation of the caiman, producing a bigger effort in the hunters to reach the measures allowed in flanks, this also indicate the no execution of the D.S. 24774 (regulate of the Caiman Use where it indicates that alone 25% of the populations individual class IV can be taken advantage of) extracting year to year 100% of the reproductive males.

• The Curichi Grande is the area where is carried out the biggest leathers exploitation with no allowed sizes for Bolivia, besides being the place where leathers are extracted to cover shares of other domestic areas, along of all the leathers evaluated in this place to none was placed the national binding for the use.

• It is advisable to carry out bigger control by the competent authorities in the legal use of sizes for Bolivia, also that the recent plans being carried out in the area (ANMI San Matías and Private) include a strong training in used sizes in Bolivia and how the good ones practice of management take us to a good use of the resource, planning to a short term to eliminate excessive hunt as much for the international smuggling (“rabudinhos”) as local smuggling (bindings of Beni are placed in leathers extracted in San Matías) among to considerate these percentage in the time to calculate the share.
ACKNOWLEDGEMENTS

This present work was framed inside the Project “Evaluation of the Size and Populational Structure of *Caiman yacare* in the 22 Ecoregión of the Santa Cruz department, County Ángel Sandoval” executed by the Museum of Natural History Noel Kempff Mercado and financed by The Prefecture of Santa Cruz department to who I express my gratitude. Equally to the Mr. Ernesto Pízarro, Gonzalo Inca and to the hunt groups of the Mr. Juan, Miguel and Antonio that without their acceptance this work has not been possible to carry out and to all those made possible to finish this work.

BIBLIOGRAPHY


Distribution, abundance and population structure of Spectacled Caiman (*Caiman yacare*) in the Natural Area of Integrated Management (ANMI) San Matias, Santa Cruz - Bolivia.

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**ABSTRACT:** We evaluated wild populations of spectacled caiman (*Caiman yacare*) between June and September 2007 during dry season within the Protected Area of San Matías. The relative abundance was determined using night counts data, collected in water bodies of communities and private properties within the protected area and its influence zone. The values of relative abundance vary from 1.98 individuals/kilometer of shore to 1945.45 ind/km of shore, showing maximum values in artificial pounds inside cattle ranches. The observed population structure was dominated by Class I individuals (25.70%), followed by Class III individuals (25.68%), Class IV individuals (20.28%) and finally Class II (14.00%) individuals. The population structure shows a well preserved population which could be subject to selective extractions of adult male individuals. Despite this, as the abundance is not uniformly distributed, certain areas would be excluded from harvesting. These data correspond to caiman population assessments in the context of the elaboration of the management plan for spectacled caiman (*C. yacare*) in ANMI San Matías; the main objective is to achieve sustainable use of caimans and to produce economic benefits that could improve the quality of life of local residents within the protected area.

**INTRODUCTION**

Latin America is the region of highest species richness in crocodilians that can compare with any other region of the world, spread from Mexico to Argentina that due to the amount of wetlands and coastal systems found throughout the region (Messel *et al.* 1995). This situation makes the crocodilians represent a resource of considerable ecological value and great economic potential (Pacheco 1996), this is a great potential that the region that also has suffered the further exploitation of crocodilians in the world. However, currently there is a change in the trend of conservation of crocodilians around the world. The adoption of new strategies for sustainable use of crocodilians has provided new incentives for the conservation of these species and their habitats (Messel *et al.* 1995).

In Bolivia, to develop a program of sustainable use of *Caiman yacare* the chosen model was the harvest of wild animals, based on the model of exploiting Venezuelan *Caiman crocodilus* (King and Godshalk 1997, Thorbjarnarson and Velasco 1998, Llobet and CIPTA 2006). This system requires less economic investment and the biggest beneficiaries are the landowners (Velasco *et. al* 1995). Harvesting is based in the sexual dimorphism of the species, which is used to establish the boundaries of minimum size of the animals to be harvested, so the harvest is focused towards animals greater than 180 cm. in total length, which generally are male, thus protecting breeding females.

A situation that must be considered is that hunting in the wilderness is more difficult to
regulate and has a high risk of not being sustainable. Populations of crocodilians can be reduced easily by the removal of breeding adults, if this is compounded by the vast over-exploitation of stocks crocodilians which led to many species to critical levels in terms of its conservation, was due largely to direct hunting (King, 1989), it is easy to deduce that this require different control systems that serve to adjust and correct the flaws of the program, so that it can ensure compliance with the same main goal: achieving Effective conservation Caiman yacare in Bolivia (Llobet and CIPTA, 2006).

METHODS

To evaluate the population of spectacled caiman of ANMI San Matías, we carried out four sampling campaigns in with night counts in water bodies, established under standardized methodologies in the crocodilians study.

ANMI San Matías was divided into 4 zones (North, Central, South and East), conducting a month of work in each area. The first campaign took place during the month of June in the northern zone, the second campaign was developed in July at the Center area, the third campaign was carried out into the south (August) and the fourth campaign was conducted in Parallel with two teams, one in the northern zone (in water bodies that could not be sampled during the first campaign) and other team in the eastern area.

We visited 13 communities (Bahía Negra, Candelaria, Corechi-Rincon del Tigre, Florida, Natividad Pozones, Puerto Gonzalo, San Fernando, San Miguelito, Santo Corazon, Tapera, Tornito and Villazon) and 30 private properties (Altamira, Bahía Grande, Buena Vista, Caribe, Cotoca, or Cotoca The Puquío, El Carmen, El Gato, El Junte, Espinal, Florida, Jesus, Esperanza, Union, Mojon, Motacú, Propiedad Barbosa, Curupau, Paraiso Santo Rosario, San Antonio, San Jose, San Miguel, San Roque, San Sebastian, Santo Tomas, Tel Aviv, Tres Hermanos, Urkupiña, and one name is not known for the absence of those responsible).

In all cases we worked with residents of the communities and/or workers of the properties. For some samples we obtained information from local perceptions, through informal talks with community members who worked as local technicians (trained in techniques of counting and estimating sizes of yacares). Additionally, several park rangers were trained in crocodile counts.

Censuses were carried out avoiding the presence of the moon and during the hours of more darkness (before the exit of the moon, after the exit of the moon or taking advantage of cloudy nights). During the counts we registered different variables as environment temperature, water temperature, wind speed, cloud cover, moon phase, aquatic vegetation coverage, as well as some characteristics of water bodies.

Analyses of abundance and population structure were conducted with the results obtained in all water bodies sampled. The index of relative abundance was calculated based on the number of animals recorded per kilometer from shore (without taking into account the individuals from Class I) (Aparicio 1997, Godshalk 1994, King and Godshalk 1997, Llobet and Aparicio 1999, Llobet and Goitia 1997, Pacheco 1993, Vasquez 1981). In those water bodies where the counting was extended by more than 6 hours and those in which for reasons of navigability we could not complete to circumnavigate all the perimeter, the relative
abundance obtained under the sampled section was applied to the rest of the water body.

The population structure of the caimans for the entire area, as well as for the different water bodies was calculated by taking the number of individuals positively identified and extrapolating this proportion to the rest of the population (identified as Eyes Only). We compared this structure between locations through a chi-square test ($X^2$) using contingency tables (Llobet 2002, Llobet 2005, Llobet and CIPTA 2006).

To guarantee compatibility of data generated in the monitoring of caimans in Bolivia, we used the water bodies’ classification from the Museum of Natural History Noel Kempff Mercado (2005):

- **Tectonic lagoons**: isolated bodies which are not home river, and they are regarded when they have a perimeter more than 1 km.
- **River lagoons**: temporarily connected with the river, many are abandoned meanders.
- **Small lagoons**: bodies of water less than 1 km perimeter.
- **Ponds**: artificial water bodies, on the edge of roads or dug for watering livestock.
- **Rivers**: watercourses that are continuing in the Landsat images (30 m pixel) wide although variable that must be verified in the field.
- **Streams**: watercourses those are not continuing in the Landsat images, and born in the plains.
- **Swamps**: permanent flood zones.

To this classification was added:

**Bays**: Parts of the rivers which have special characteristics in terms of their morphology therefore resemble broad parts or corners of the river.

**Big “Pantanal” Lakes**: large lakes in the far eastern border of Bolivia (Mandioré, Gaiba and Uberaba). Despite the name of “lakes”, these water bodies are in permanent connection with rivers.

**RESULTS**

As a result of the four-month campaign, we sampled 88 water bodies of which most were Ponds (40), followed by segments of Rivers (27), lagoons (9), Bays (8) and Small lagoons (4), sampling a total of 189.43 km of shore in different bodies of water in ANMI San Matías (Table 1).

**Table 1.** Bodies of water sampled in the ANMI San Matias Body Type Water Quantity of sites distance travelled (km) range represented shore (km).

<table>
<thead>
<tr>
<th>Bodies of water</th>
<th>Number of sites</th>
<th>Distance traveled (Km)</th>
<th>Distance of shore represented (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay</td>
<td>8</td>
<td>3.5</td>
<td>4.29</td>
</tr>
<tr>
<td>Ponds</td>
<td>40</td>
<td>7.75</td>
<td>8.05</td>
</tr>
<tr>
<td>Lagoons</td>
<td>9</td>
<td>30.31</td>
<td>35.99</td>
</tr>
<tr>
<td>Small lagoons</td>
<td>4</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td>Rivers</td>
<td>27</td>
<td>121.32</td>
<td>140.32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>163.66</strong></td>
<td><strong>189.43</strong></td>
</tr>
</tbody>
</table>

39
The figure below shows all the sampling points visited during the 4 months of fieldwork, you can appreciate that the largest number of points is in the northern part of the protected area and its zone of influence because of the increased amount of bodies water that exist in these areas (Figure 1).

![Figure 1](image)

**Figure 1.** Points within the sampling ANMI San Matías and its zone of influence.

We counted 9245 individuals of different size classes from hatchlings (class I) to adult males (Class IV) including those individuals identified as 'Eyes Only' (OS).

The higher values of abundance were presented in the ponds of private property with values of 1945.45 ind / km of shore (San Antonio), followed by Tel Aviv 2 ponds with 1750.00 ind/km of shore and La Union 1 to 1482.35 ind / km of shore, while the lowest values were found in the river Santo Corazon, and a swamp near Villazon community with 0.0 individuals per kilometer of shore.

We made an analysis by grouping the values of abundance by type of water body, using five categories: Rivers (grouping all water flows, rivers and streams), Ponds (artificial water bodies), Bays, Small lagoons (those places whose perimeter is less than 1 km) and lagoons. We found statistically significant differences ($H = 37.81, P = 0.00$) (Figure 2).
Figure 2. Changes in the values of abundance of spectacled caiman between different types of water bodies of ANMI San Matías.

Proceeds from the analysis can be seen that the ponds have a different behavior as they maintain the highest variation in abundance of all types of water bodies, hiding the differences that might exist in other categories. In this regard, in order to assess trends in different locations sampled was carried out further analysis, but excluding the ponds (Figure 3).

In this new analysis, although there are different types of trends in places, we can also see that the great variation in abundance in each type of water body makes the differences are not considered statistically significant at 95 and 99% of probability (H=6.59, P = 0.089). However, it is important to note that the Bays have a slight tendency to have higher values of yacare abundance than other water bodies (Figure 3).

Figure 3. Abundance values of spectacled caiman between different types of water bodies of ANMI San Matías without taking into account the artificial ponds.
Concerning the population structure, many individuals observed correspond to the Class I (25.70%), followed by Class III (25.68%), Class IV (20.28%) and finally the Class II (14.00%) of individuals observed (Figure 4). We include in this distribution percentages also to those individuals identified as OS (“eyes only”) finding that represent 14.34% of all animals observed that is that if we believe that could have a positive identification and estimated height of 85.66% of individuals observed, we can assume that the analysis of population structure will be highly reliable.

**Figure 4.** Structure population of the spectacled caiman of ANMI San Matías.

If we analyze the population structure only on Class II, III and IV, and following the criteria of Ayarzagüena and Velasco (1995) we observed that the structure correspond to a pyramidal structure with more than 15% of individuals Class IV, which represents a population with high potential for sustained harvests of adult males. Moreover, if we consider that under this type of analysis the percentage of spectacled caiman adult males Class IV of ANMI San Matías is 33.83%, an initiative to raise the use of spectacled caiman in the area accomplishes the National Regulations for the Conservation and Sustainable Use of spectacled caiman (*Caiman yacare*) which states that “permitted the harvest of spectacled caiman of 25% of the Group IV (animals with over 180 cm. in total length) in populations of good state of conservation” (Article 18), and which additionally states that “It is understood by population in a good state of preservation, when animals of group IV, exceeds 15% of total formed by groups II, III and IV”.

But this population structure observed for ANMI San Matías, during sampling could be seen that some areas showed significant differences in terms of the proportion of individuals from Class IV. In this sense, looking at the population structure for each area inside ANMI San Matías, we note that there are highly significant differences ($X^2=464.27, P <0.001$), with a northern zone where the percentage of Class IV individuals is greater than the other classes (40.32%), an eastern area in which the Class IV is in second place (34.32%) after the Class III, a central zone in which the Class IV is in third place (16.07%) after Classes III and II, and finally the southern zone where the Class IV (3.70%) is well below Class II and III (Figure 5, Table 5).
Figure 5. Structure of the spectacled caiman population in areas at the ANMI San Matias.

Table 2. Percentages of size classes in areas in the ANMI San Matías.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Class II</th>
<th>Class III</th>
<th>Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>19.94</td>
<td>63.99</td>
<td>16.07</td>
</tr>
<tr>
<td>East</td>
<td>10.62</td>
<td>55.06</td>
<td>34.32</td>
</tr>
<tr>
<td>North</td>
<td>25.64</td>
<td>34.03</td>
<td>40.32</td>
</tr>
<tr>
<td>South</td>
<td>62.96</td>
<td>33.33</td>
<td>3.70</td>
</tr>
</tbody>
</table>

Regarding the population structure of the spectacled caiman for each type of water body, it was noted that the Bays have a very high proportion of Class IV individuals. Ponds maintained a high proportion of individuals Class III, followed by Class IV; lagoons also features a high proportion of Class III animals, but in this case followed by Class II and Class IV animals; smalls lagoons maintain the same pattern described by Llobet (2005) and Llobet and CIPTA (2006) for the TCO Tacana, with a very high proportion of individuals Class I, followed by Class II and Class III; finally we found in rivers is a high proportion of individuals Class I, followed by Class III, II and IV (Figure 6).

Figure 6. Structure of the spectacled caiman population by type of water body in ANMI San Matías.
The differences ($X^2 = 1075.02, P < 0.001$) found on the population structure by type of water body may be because some of the small water bodies (in this case small lagoons) behave as breeding centers of the species. This segregation in the use of some water bodies represents an adaptive advantage to reduce the possibility of intraspecific predation.

**DISCUSSIONS**

It is important to note that an accurate size of the population is very difficult to estimate, in addition the monitoring of crocodilians presents some problems that have been treated extensively in the literature (Woodward and Marion 1978, Messel 1981, Magnusson 1982, Larriera et al. 1993, Abercrombie and Verdade 1995, 1994 Pacheco, Pacheco 1996). Additionally, it is theoretically possible to control the effect that the majority of environmental variables have on the night counts by doing them under similar conditions, but is more difficult to control biological variables as the caution of caimans and population density (Pacheco 1994, 1996) In areas where it has been practiced (or even practiced) hunting of animals for different purposes, they will tend to be more timid which may hinder its observation and produce a bias in the calculation of abundance. This tendency to underestimate the population also occurs in cases of population with very low densities, and that significantly reduces the probability of observing an individual. Finally, the relative abundance indices will underestimate the true size of the population, because a portion of it usually remains without being detected and it is very difficult to establish the relationship between the index of abundance and the true density in the area (Hutton and Woolhouse 1989).

The environmental factor that can affect more the night counts of crocodilians is the water level (Woodward and Marion 1978, Messel et al. 1981, Llobet and Goitia 1997). However, this variable can also be related to changes in behavior that can also affect the results of the counts. Seijas and Chavez (2000) in the river system Cojedes (Venezuela) reported variations in the number of juvenile alligators observed as the dry season passed, on the other hand, these same authors also noted an increase in adult individuals observed (particularly females) at the beginning of the breeding season. However, despite variations that may exist as the dry season passes, it is recommended for future work, and for reasons of accessibility to water bodies, to carry out the monitoring of the caimans in the interval of time since June (when it is falling water levels) until September (before the water level reaches its lowest point), because at this time animals are confined in bodies water, and secondly, not having reached the point of minimum water level, it facilitates navigation to perform the counts. These two factors must be added that at this time and all were born offspring, so that we can obtain valuable information on trends of reproductive crocodilians.

Other factors that may explain the variability in the abundance indices have to do with differences between sectors of visibility, which can introduce errors into the results (Hutton and Woolhouse 1989, Da Silveira et al. 1997). In almost all places sampled was presented an extensive vegetation cover, what makes us assume that in all cases it was possible to identify a fraction of the population and that the calculations are underestimating the real size of the same one. Additionally, we must point out that visits to places of sampling were conducted sequentially rather than simultaneously, namely that the recent visits to sites of counting should be conducted until 3 months after the first visit to the sites, this factor may have results in two consequences: on the one hand counts have facilitated the past due to greater concentration of alligators in the water remaining (Seijas, 1986), or on the contrary
if in some places there were extreme drought, have done more difficult to locate individuals who take refuge in forested areas or hide in the mud, which hinders their location (Medem, 1983). In addition to these factors are also taken as a limiting factor during the counts in the vast territorial extension introducing the protected area (nearly 3 millions hectares), the limited possibilities of mobilizing between places and the presence of a large number of water bodies.

It is also clear that the population structure can be shaped by human activities in a given area (Seijas and Chavez 2000). Animals of larger sizes are more visible than small ones and people probably kill the first more frequently. If to this situation, we add that there is a relationship between the caution of animals and human pressure present in a given area (Pacheco 1996), we could expect to observe greater distances to animals (distance to which the individual immerses when approaching an observer) in areas under greater pressure. In this sense, the larger animals, probably more experienced on activities carried out directly toward their hunting or trapping, will show more timid that juveniles, and may produce a bias on the outcome of the structure of the population sizes.

The population of spectacled caiman in ANMI San Matías is not evenly distributed. Among the different bodies of water were observed differences in the abundance of spectacled caiman. In general (not counting the ponds and values of zero), the values of abundance of spectacled caiman ranging from 1.98 ind / km (in the channel of Puerto Gonzalo) to 206.03 ind / km (Altamira’s Bay). While many values found in abundance in ANMI San Matías are similar, or are within the range of values reported for water bodies of the Department of Beni, most are significantly higher than those reported for the Chapare (Cochabamba) and Chaco (Tarija) (King and Godshalk 1997, King and Videz-Roca 1987, Llobet 1996, Llobet and Goitia 1997, Llobet and Aparicio 1999, 1993 Pacheco, Pacheco and Llobet 1998, Llobet 2005). The Museum Noel Kempff Mercado in 2005 in the area of San Matías found relative abundances of individuals to 100.62 per kilometer of shore in the Ponds of private properties, while in Rivers found an abundance of 50.09 ind / km, in the Gaps 14.08 ind / km, 91.5 ind/km in the swamps and only 37 Eyes Only in the stream sampled, these values fall within the range of values found in this work.

BIBLIOGRAPHY


Nesting habits of spectacled caiman (Caiman yacare) in Natural Area of Integrated Management (ANMI) San Matías

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ABSTRACT: We evaluated some reproduction aspects of spectacled caiman (C. yacare) in the North zone of the Natural Area of Integrated Management (ANMI) San Matías, and part of its influence zone within five local communities (Candelaria, San Miguelito, Natividad, Villazón & Tornito) and cattle ranches (Cotoca, San Roque, El Gato, Altamira, Pueblo Viejo & San Sebastián). The search for nests was carried out during day time in the surrounding areas of different water bodies (swamps, floodplains and lagoons). We collected data of every nest (number of eggs, proportion of fertile eggs, nest composition, and habitat characteristics). The comparisons of this data between different zones suggest that the largest percentage of nests is found in the swamp (57.29%), then the lagoons (26.04%) and finally the Floodplains (16.67%). We found a relative abundance of 0.18 nests per kilometers (nests/km.), in the floodplain, 0.46 nests/km. in the curichi (lagoons) and 2.78 nests/km. in the swamp. An average of 24.11 eggs per nest was determined, with a proportion of 96.94% of fertile eggs. The composition of the nests vary according to the surrounding environment; in the floodplains nest are made of dry leafs, dry branches and dirt, meanwhile in the swamp nests are made of aquatic vegetation (Eichornia sp., Salvinia sp. & Cyperaceae) and few dry stems.

RESUMEN: Se evaluaron algunos aspectos reproductivos del lagarto (Caiman yacare) en la zona norte del Área Natural de Manejo Integrado (ANMI) San Matías y parte de su zona de influencia, comprendiendo cinco comunidades (Candelaria, San Miguelito, Natividad, Villazón y Tornito) y ranchos ganaderos (Cotoca, San Roque, El Gato, Altamira, Pueblo Viejo y San Sebastián). La búsqueda de nidos fue realizada durante el día en áreas adyacentes a cuerpos de agua (pantanos, llanuras inundadas y lagunas). Se colectaron datos de cada nido (número de huevos, proporción de huevos fértiles, composición de los nidos y características de hábitat). La comparación de nuestros datos entre diferentes zonas sugiere que el mayor porcentaje de los nidos se encuentra en las zonas de pantano (57.29%), seguido de lagunas (26.04%) y llanuras inundadas (16.67%). Se encontró una abundancia relativa de nidos de 0.18 nidos/km en las llanuras inundadas, 0.46 nidos/km en las lagunas y 2.78 nidos/km en el pantano. Se determinó un promedio de 24.1 huevos por nido, con un porcentaje de 96.94% de huevos fértiles. La composición de nidos varía de acuerdo con el ambiente circundante; en la llanura inundada los nidos son construidos con hojas secas, ramas y tierra, mientras que en la zona de pantano están compuestos por vegetación acuática seca (Eichornia sp., Salvinia sp. y Cyperaceae) así como por tallos secos.

INTRODUCTION

Knowing the different aspects of the biology of a species is fundamental to the understanding of its position in the environment, their relations intra e interspecific, as well as its proper management and where appropriate use (Casas -Andreu 2003). The cocodrilians part of this
intricate tangle, occupying places higher in the food chain.

In Bolivia to develop a program of sustainable use of *Caiman yacare* the chosen model was the harvesting of wild animals, based on the model of exploiting Venezuelan *Caiman crocodilus* (King and Godshalk 1997, Thorbjarnarson and Velasco, 1998: Llobet, 2006). This system requires less economic investment and the biggest beneficiaries are the landowners (Velasco et al, 1995).

Both the programme of conservation and sustainable use of *Caiman yacare* (PNASL) and the Integrated Management of Natural Areas (ANMI) San Matías processes are at significant changes designed to effectuate the sustainable development of settlers in the target PNASL as in the creation of the protected area. In the process of learning in the years leading operating PNASL, it has been noting the need to present alternative management to beneficiaries in the insertion of the lessons learned, mainly regarding the role of local actors as a key element for environmental sustainability, social and economic use of this resource.

Within the information it seeks to generate PNASL, and to explore new models for harnessing the species has raised the need to investigate the reproductive potential of the caimans, because studies of nesting habits are quite scarce. The study of nesting habits is of particular importance, since it allows many infer population parameters, including distribution, habitat selection and reproductive rates (Prado et al., 2001). That is why in order to broaden knowledge about the nesting habits of yacare and the absence of prior information about it, has developed this study could provide the residents of the protected area of information which could in the future serve to propose ranching plans in the area of San Matías ANMI. The objectives of this study are

- Identify yacare nests in the communities of San Matías ANMI, with the help of local technicians.
- To assess the efficiency of search method in relation to the effort.
- Evaluate environments nesting.
- Obtain information about the nesting habits and assessing habitat preferences, distribution and characteristics of the nests.

**METHODOLOGY**

All search effort is concentrated in the northern zone of the protected area and the zone of influence, including the area of swamp in San Sebastian property. It worked in the communities of Candelaria, San Miguelito, Nativi, Villazón and Tornito. Also included private properties surrounding communities: Cotoca, San Roque, El Gato, Altamira, Pueblo Viejo and San Sebastian (Swamp) (Figure 1).

The search for nests was carried out through the help of local technicians in each community, in addition to the facilitators of the Management Plan of *Caiman yacare* and forest rangers of the protected area.

- Information collected in each of the nests found was:
  - Kind of environment,
  - Vegetati cover around the nest,
- Distance and type of water bodies associated with the nest,
- Dimensions of the nest,
- Material and composition of the nest,
- Presence and behavior of the female,
- Presence of predators.

- Type of search:
  - Working during the day by looking around the waterways near communities and visited places.
  - Location of places with fairly and vegetation that impede access to the nest.
  - Georeference the place,
  - Opening of the nest to record the amount of eggs, fertility rates, and size of the nest.

**Figure 1.** Yacare nests identified in the area of San Matías.

**RESULTS AND DISCUSSION**

Two rates were differentiated according to ecological environments, geomorphology of the area, the seasonal water and vegetation associated. Our observation in the field during the flood season confirms what has been described by Navarro and Maldonado (2002) established a clear differentiation of habitats according to the regime of flooding in the area, in this sense we can find:

Environments with vegetation of the shoals of seasonal waters:

- **Curichi (lagoons):** tackled water formed in the seasonally depressed parts of floodplains from the flooding of rivers, where there are two types of vegetation clearly associated with the geomorphology of the floodplain, savannas and clay soil seasonally flooded Várzea forests of clay soil (Navarro and Maldonado, 2002).

- **Flat River flood:** areas flooded by overflowing river, either with vegetation similar to curichi (lagoons), with the difference that the flood level of the river is always associated with lotic bodies of water.
Environments with vegetation of the shoals of water standing Swamp:

- Swamp: bodies of water that holds water all year or more than eight consecutive months a year. It develops in the most depressed areas of topographically floodplains flood (Navarro and Maldonado, 2002).

According to this classification, for further analysis will consider three types of water bodies already described, assuming that curichi (lagoons) and rivers, will be representing the behaviour of the area of temporary seasonal flooding, while the dam will represent the area of permanent flood.

There were 96 nests of which 45 nests (46.86%) have complete data and geo-referenced data on the position, number of eggs, material composition of the nest, and so on. There were 51 nests (53.13%) observed in the area of the swamp without obtaining data on the quantity of eggs from the position, that because of the impossibility of being able to approach the nests that were floating on aquatic vegetation.

Of the total nests found, 27.08% of the nests were found in communities, whereas 72.92% were found on private property. Of the nests found on the premises of the private properties, 75.71% was recorded in San Sebastian property, adjoining the border with Bolivia - Brazil, which coincides with the ongoing flood zone.

![Figure 2](image.png)

**Figure 2.** Number of eggs for nest in different areas of flooding.

We applied a test Kruskal - Wallis to compare the size of the position according to the types of flood areas. We found that there were no statistically significant differences (H=0.89, p=0.34); note that in the flood zone temporary shows greater variation in the number of eggs per clutch, while the area of permanent flood the range of variation is smaller (Figure 2). The clutches in general showed an average of 30 (SD ± 6.01) eggs per nest with a minimum of 13 eggs and a maximum of 41 eggs per clutch, these data were not taken into account those nests that were zero.
Figure 3. Number of eggs for nest in different types of water bodies.

It brought together the size of the clutches by type of water bodies: river, swamp and curichi (lagoons) in which they were found, showing that in rivers there is a greater variation in the number of eggs per nest, while in the curichi (lagoons) and the swamp is less variation (Figure 3) but the analysis (H = 0.89, p = 0.64) indicates that there is no statistically significant differences.

The dominant vegetation in search of places are for palm forests (*Copernicia alba*) and forests motacú (*Attalea phalerata*) sometimes forming islands of forests as part of the landscape group, along with other species known as ambaibo (*Cecropia polystachia*), mapajo (Kapok), with a predominant shrub layer around the islands of forests with forest scribbles (*Bromelia sp.*)

Generally nests were associated with the base of a tree with bushy vegetation around or below vines and creepers, even were in the midst of forests scribbles (*Bromelia sp.*) That hindered the registration of the position of the nest.

In the area of swamp nests have other characteristic that offers the atmosphere, which every year is water. The nests are mainly floating on the thick layer of aquatic vegetation, which is dominated by species taro (*Eichornia sp*), pochi (*Salvinia sp*) and several species of Cyperaceas.

Within the environments identified was found that 16.67% of the nests was found in rivers, 26.04% are found in the area of curichi (lagoons) and 57.29% of the nests was observed in the swamp area.

The distance from the nests to water bodies are differentiated by the environment in which the nests were found, where the nests were found in rivers 4.11 meters away until the nearest
bodies of water, but two nests found in community Villazón discovered 50 meters from the nearest bodies of water, nests in environments curichi (lagoons) were found at a mean distance of 9.84 meters to the nearest bodies of water and nests in the marsh area were floating on the aquatic vegetation, which was considered as the minimum distance to water (Figure 4).

**Figure 4.** Distance from nests to the nearest bodies of water by type of environment.

The greatest distance ranges are found in curichi (lagoons) as these are not associated with permanent bodies of water, but rather are seasonal training. The rivers have lower ranks to be associated with water bodies, while the nests observed in the swamp are floating in the river Curichi Bravo. These trends distances showed highly significant differences (H = 18.85, p = 0.0001).

The composition of the nests varies with the environment in which they find themselves, because the nests were observed in the area of swamp (permanent flood area) are composed mainly of aquatic vegetation (*Eichornia sp.*, *Salvinia sp.* and Cyperaceae) while the nests observed in the mainland (temporary flood area) are composed of dirt, sand, stems and nuts, including leaf litter scribbles (Bromeliaceae) nests were discovered in these environments and rivers curichi (lagoons) (Figure 5).

The width of nests varies between 65 cm. and 164 cm. with a median of 99.67 cm. (D.S. ± 23.54). The length of the nests ranged between 50 cm. and 150 cm. long with a median of 98.50 cm. (D.S. ± 23.78). While the height of the nests had a variation between 23 cm. and 46 cm. tall with a median of 33.50 cm. (D.S. ± 5.75).
The nests recorded had approximately a half spheroidal shape. The nests use a surface that ranges from 0.26 m$^2$ to 1.93 m$^2$ getting a median area of 0.68 m$^2$ (SD ± 0.34). We pooled the surfaces of the nests as the environment where they were discovered them, finding no significant differences (H = 3.77, p = 0.15). In the nests were recorded volumes between 0.06 m$^3$ and 0.52 m$^3$ obtaining a median of 0.15 m$^3$ (SD ± 0.09).

We analyzed the volume of clutches according to the flood area in which there are (H = 0.63, p = 0.42), demonstrating that there are no significant differences, however, is a small trend of smaller area and volume in the area permanent flood (Figures 6 and 7), perhaps this is because these nests are found floating in the swamp and to be composed of aquatic vegetation take up less volume than those who are on land which have more space and provision of vegetation to build nests.

**Figure 5.** (a) Nest in the area of temporary flooding. (b) Nest in the area of permanent flood.

**Figure 6.** Volume of nest according to the Flood Areas.
We found the same patterns to make an analysis by type of water bodies, where the tendency of nests found in rivers would have a greater surface regarding the other two environments identified, however the number of nests discovered in environments curichi (lagoons) and in the swamp is less than the river (Figure 8).

Nests were grouped according to the environment in which they were identified, found no significant differences ($H = 0.95$, $p = 0.62$) (Figure 9).
Figure 9. Volumes of nests in environments identified.

The highest values of abundance are presented in the swamp area reaching up to find nests 5.07 per hour search, while the lowest were found in the river flood plane with zero nests for the communities of Candelaria and Tornito.

Although it is noteworthy that the values observed in the swamp may have greater variations, since these nests were observed only and not as open nests found in both environments nesting identified. By accessing the nests discovered hours of search or the reverse could increase the value of relative abundance will decrease due to increased time used to record data clutches, as in the nests of other nesting environments.

As we see again the highest values of abundance are presented in the swamp, although there were no statistically significant differences (Figures 10 and 11), if we note that the swamp is a trend to greater abundance of nests that identified the two other environments. The highest values were found in abundance in the swamp with 2.82 and 8.72 nests per kilometre, while the lowest were found in the river with zero kilometers per nest.

In general the trend of relative abundance of nests using any of the two indices is the same as the swamp shows most successful gathering of nests in nests per hour search for nests and mileage.
CONCLUSION

We found and opened 45 nests in the 3 environments already described; clutches generally showed an average of 30 (SD ± 6.01) eggs per nest with a minimum of 13 eggs and a maximum of 41 eggs per clutch, these data are not took into account those nests that were zero. We obtained a rate of 96.94% of fertile eggs.
The material of which are composed nests varies with the environment in which they find themselves, in enclosed environments such as flood plains occupy as construction material nest dry leaves, nuts, stems and dry land. In places open in the swamp used as aquatic vegetation (*Eichornia sp.*), (*Salvinia sp.*), (*Cyperaceae*) and some dried stalks.

In the northern part of the protected area is clearly differentiated 3 environments nesting grouped into two areas:

- Area Flood permanent represented by the swamp area.
- Area Flood temporary or seasonal represented by curichi (lagoons) and river.

We appreciate that the swamp area shows a greater amount of nests observed, showing a great similarity in what has been described by Prado (2001) which states that the yacares show a greater affinity for nesting in open places, this place shows a larger problem of accessibility to nests because of the abundant aquatic vegetation. For this reason we have data from nests observed unregistered size of the position. These difficulties of access make the likelihood is that a nest predators is less than that of a nest that is located onshore.

Within the environments identified was found that 16.67% of the nests was found in rivers, 26.04% are found in the area of curichi (lagoons) and 57.29% of the nests was observed in the swamp area.

In terms of the number of eggs per flood zone and by type of water bodies could be seen that there were no statistically significant differences, but in showing that the area flood temporary shows greater variation in the number of eggs for nest, while the flood zone permanent the range of variation is smaller but we must note that our sample size is smaller. As for the types of bodies water, we find that in rivers there is a greater variation in the number of eggs per nest, while in the curichi (lagoons) and in the swamp is less variation.

Regarding the distance from the nests to the nearest water bodies, revealed that nests in rivers can have a very broad range of distance (4.11 to 50 meters) of the nearest bodies of water, while nests in environments curichi (lagoons) were found at a distance minors (average 9.84 meters) and nests in the area of marsh were floating on aquatic vegetation.

In data collected from surfaces and volumes of nests, although we found no statistically significant differences, however the results show a slight tendency for nests of swamp (permanent flood zone) to occupy areas and smaller volumes that nests temporary flood zones. This trend can interact with both the availability of material as with the physical space available for building the nest. In this sense it is clear that in the swamp area there are major constraints in these two aspects presenting a very particular dynamics of nests on floating aquatic vegetation in this area. This characteristic shows an interesting adaptation which in turn can enhance the reproductive success of the kind (to be inaccessible to most nests terrestrial predators).

The trend of relative abundance of nests, making the analysis number of nests per hour sampling and numbers of nests per kilometre, which was obtained using either of the two indices is the same as the Swamp shows most successful meeting nests in nests per hour search for nests and mileage. However under the field experience, the values of abundance of nests by mileage better suited for analysis of nests in the marsh area, as with the index
of abundance of nests per hour search could mask differences might exist from the sampling effort or carrying out other activities.

**BIBLIOGRAPHY**


Potential nesting status and prospection for egg harvesting of Caiman yacare in the region of San Matías, Santa Cruz, Bolivia

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(andresitoleo@hotmail.com)

ABSTRACT: Potential nesting estimation and biological evaluations allows us to establish an egg harvest quota that will ensure the conservation of natural resources and cover the production needs of the farm. To estimate nesting population size we made daily journey over 10 days, from 6:00 am to 18:00 pm, marking off the nest spots on a GPS and registering the hatching data. During daylight reconnaissance over 19.26 km², we collected 424 nests, registering a nest density of 19.93 nests/km². Mean number of eggs per nest was 27.64 ± 4.03 of 22 nests observed, with a mean egg viability of 24.23 ± 5.5. The mean egg damage was 0.14 ± 0.07 and mean egg infertility was 27 ± 1.26. The mean temperature of the egg storage pod was 32.2 ± 2.31 ºC. Mean hatching exploitation found in our study represents the 54.95%, 32.07% of the nests were not collected, but have shown signs of viability, and the other 12.97% of the nests represent the natural lost, either because of flooding or natural depredators. We estimate the nesting potential equal to 1250.21 for the 62.706 km² of the permanent flooding zone. For the year 2008, we registered 10500 eggs bought from the CIRPAS Indigenous Communities equivalent to 379.88 nests, and the harvest of 920.12 nests in the private stock farms, obtaining a total of 1300 nests equivalent to 35932 eggs for Crocoland farm.

INTRODUCTION

The legal exploitation in Bolivia is trying to reach steady levels in the use of species and generate economical benefits that could improve the level of life in rural areas, diminishing the usual economic activities over the environment (Aparicio y Rios 2004). Even though, the department of Santa Cruz is passing through a process of environment degradation with no precedents in Bolivia, because of the irresponsible use of natural resources without any control over the impact that it causes. That is why, Crocoland SRL is using private inversion in order to help with the National Strategy of Environmental Conservation (Franulic 2006).

The environmental management project – Crocoland SRL, proposes an alternative way on captivity breeding and sustained management of Caiman yacare that could be viable ecologically, socially and economically. We also have the advantage of working with a specie that shows great endurance to commercial exploitation, and because of its economical importance, it has become in one of the best models of management (Palacios 2006).

The success in this program depends on: a) technical support and capacity to lay out the foundations for abundance, density and population structure of the specie in all the regions involved in the Management Program, b) adequate techniques of breeding and c) activities to control every program in this project.
Even though, little is known about reproductive ecology of the specie in our country. All the information could be summarized on the studies about population estimations in Beni (Liceaga et al. 2001, Hombre y Naturaleza 2001, Salvatierra et al. 2001), on TCO Tacana of the department of La Paz (Ríos 2003), of the indigenous lands and Isiboro Secure National Park (Méndez y Van Damme 2004), and the evaluations in Guarayos, Santa Cruz (Paredes y Maldonado 2003) and San Matías (Romero 2004) (Rumiz y Llobet 2005).

That is why, in order to diminish this lack of information, Crocoland pretends to establish the basic foundations of densities and the nesting potential in the authorized regions for the egg harvesting in San Matías and to improve the Yacare National Sustained Management Program with relevant information.

**METHODS**

The evaluation and the trademarks of the nests on the GPS were done on February, in the property of “Cambará”, “Santa María”, “Santa Rosa”, “Bella Vista”, y “Cascabel”, in the municipality of San Matías, located between 16°36’ – 18°36’ South, and 57°26’ – 59°40’ West, in Angel Sandoval county town, Santa Cruz department.

We controlled the quantity of harvested eggs in the CIRPAS indigenous communities of San Manuel, San Francisco, Cañón de Fátima, San Joaquín, y Santa Clara, during january, and the ones that were collected by Crocoland farm, according to the sell-buy receipts that the farm give to the workers.

During the field work, we count the nests over 10 days, since 6:00 to 18:00, with break periods of half an hour. The journey was done in a canoe, registering every nest on a GPS, and the biological harvesting data. We only considered the nests that were collected in the properties of “Cambará” and “Santa Maria” (Figure 1) in order to estimate nests density, because guides told us that the harvesting effort is concentrated in this region.

**Figure 1.** Location map of the nests that were collected during the evaluation in Cambará and Santa María properties
We calculated the surface by marking a perimeter according to all the GPS nests marks and forming a “minimal convex polygon” (Figure 2).

![Figure 2. “Minimal convex polygon” that represents the total surface of the evaluation.](image)

To calculate the “potential nesting status” in this area, we use the total surface of the permanent flooding zones reported for the region of San Matías by the UOT – BID (2002), but not including the ANMI San Matías (Integrative Management Natural Area), and we extrapolate the real densities obtained during this evaluation in the region of “Cambará” and “Santa María” (Figure 3).

![Figure 3. Permanent flooding zone used to calculate the nesting potential status.](image)

RESULTS

a) Private properties evaluations:
We marked 424 nests in the private properties “Cambará”, “Santa María”, “Santa Rosa”, “Bella Vista”, and “Cascabel”, but the harvesting effort was focused in two of them (Table 1): “Santa María” with an evaluated surface of 16.23 km² and a density of 7.92 nests/km²; and
“Cambará”, with an evaluated surface of 3.03 km² and a density of 30.69 nests/km².

Table 1. Results for the nests counting in Cambará and Santa Marfa.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>NESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Marfa</td>
<td>291</td>
</tr>
<tr>
<td>Cambará</td>
<td>93</td>
</tr>
</tbody>
</table>

We evaluated 19.26 km² among Cambará and Santa Marfa, obtaining a final density of 19.93 nests/km².

b) Indigenous Communities harvesting (CIRPAS):
According to the sell-buy receipts delivered to the farmers, Crocoland bought 10500 eggs, and using the mean number of 27.64 ± 4.03 eggs/nests obtained during this research, those 10500 eggs are equivalent to 379.86 nests collected in CIRPAS Indigenous Communities (Table 2).

Table 2. Total quantity of eggs bought from Indigenous communities.

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>BOUGHT EGGS</th>
<th>EQUIV. IN NESTS (27.64 eggs/nests)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Manuel</td>
<td>2800</td>
<td>101.3</td>
</tr>
<tr>
<td>San Francisco</td>
<td>3140</td>
<td>113.6</td>
</tr>
<tr>
<td>Cañón de Fátima</td>
<td>1500</td>
<td>54.26</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>560</td>
<td>20.26</td>
</tr>
<tr>
<td>Santa Clara</td>
<td>2500</td>
<td>90.44</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>10500</strong></td>
<td><strong>379.86</strong></td>
</tr>
</tbody>
</table>

c) Harvesting and eggs collection during this research:
Depending on the characteristics of the evaluated nests, they were classified:

- Previously harvested nests: Nests with no eggs, with the nesting material removed from the upper section of the nests, and there are no biological data of the harvest.
- Viable nests: Natural nests that show no removal of the nesting material.
- Harvested nests: Nests where the eggs were removed from, and have the biological harvest data.
- Half-sunken nests: Nests with the half of their structure under the water level. They lean to be natural lost.
- Sunken nests: Nests with all the structure under the water level.
- Depredated nests: Nests with the nesting material removed. There are still not well developed embryos out of the eggshell.
- Natural hatching nests: Nests with the nesting material removed from the side and with eggshells out of the egg storage pod.

The evaluation checked 424 nests (Table 3).
Table 3. Classification of the nests.

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>CANT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previously harvested nests</td>
<td>211</td>
</tr>
<tr>
<td>Viable nests</td>
<td>110</td>
</tr>
<tr>
<td>Harvested nests</td>
<td>22</td>
</tr>
<tr>
<td>Half-sunken nests</td>
<td>49</td>
</tr>
<tr>
<td>Sunken nests</td>
<td>5</td>
</tr>
<tr>
<td>Depredated nests</td>
<td>1</td>
</tr>
<tr>
<td>Natural hatching nests</td>
<td>26</td>
</tr>
</tbody>
</table>

We registered the biological data of the 22 “harvested nests”. The quantities are resumed on table 4:

Table 4. Registry of the harvest.

<table>
<thead>
<tr>
<th>REGISTRO DE COSECHA</th>
<th>CANT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested eggs</td>
<td>608</td>
</tr>
<tr>
<td>Viable eggs</td>
<td>533</td>
</tr>
<tr>
<td>Damaged eggs</td>
<td>3</td>
</tr>
<tr>
<td>Unviable eggs</td>
<td>72</td>
</tr>
</tbody>
</table>

According to this results, we obtained a mean number of 27.64 ± 4.03 eggs/nests, 24.23± 5.5 viable eggs/nests, 0.14 ± 0.07 damaged eggs/nests, and 3.27 ± 1.26 unviable eggs/nests. The mean temperature of the storage pod was 32.2 ± 2.31 °C.

d) Evaluation of the exploitation:

We summarized the resource development in 3 categories:

- **Effective harvesting (54.95%)**: Percentage of the nests that were collected, either during this evaluation or previous harvesting works.
- **Natural hatchings (32.07%)**: Percentage of the nests that contained either viable eggs or shown indication of previous natural hatchings.
- **Natural lost (12.97%)**: Percentage of sunken or depredated nests.

e) General summary of the harvest:

The general exploitation is summarized in the next table:

Table 5. Final quantity of nests and eggs harvested in the year 2008.

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>HARVESTED NESTS</th>
<th>HARVESTED EGGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Manuel</td>
<td>2800</td>
<td></td>
</tr>
<tr>
<td>San Francisco</td>
<td>3140</td>
<td></td>
</tr>
<tr>
<td>Cañón de Fátima</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>San Joaquín</td>
<td>560</td>
<td></td>
</tr>
<tr>
<td>Santa Clara</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>Santa María *</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Cambará *</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Bella Vista *</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Santa Rosa *</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cascabel *</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* Private properties
According to this results, and with the mean number of $27.64 ± 4.03$ eggs/nests used as an “precaution equivalent number” , we competed the quantity of nests and eggs missing in the table (Table 6):

**Tabla 6.** Estimation of the final quantities of the harvest using the “cautious equivalent quantities”.

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>HARVESTED NESTS</th>
<th>HARVESTED EGGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Manuel</td>
<td>101.30</td>
<td>2800</td>
</tr>
<tr>
<td>San Francisco</td>
<td>113.60</td>
<td>3140</td>
</tr>
<tr>
<td>Cañón de Fátima</td>
<td>54.27</td>
<td>1500</td>
</tr>
<tr>
<td>San Joaquín</td>
<td>20.26</td>
<td>560</td>
</tr>
<tr>
<td>Santa Clara</td>
<td>90.45</td>
<td>2500</td>
</tr>
<tr>
<td>Santa María</td>
<td>142</td>
<td>3924.88</td>
</tr>
<tr>
<td>Cambará</td>
<td>37</td>
<td>1022.68</td>
</tr>
<tr>
<td>Bella Vista</td>
<td>29</td>
<td>801.56</td>
</tr>
<tr>
<td>Santa Rosa</td>
<td>2</td>
<td>55.28</td>
</tr>
<tr>
<td>Cascabel</td>
<td>1</td>
<td>27.64</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>590.88</strong></td>
<td><strong>16332.04</strong></td>
</tr>
</tbody>
</table>

In order to complete the egg harvest quota of 1300 nests authorized for Crocoland, 709.12 nests must have been harvested in the private properties of Cambará and Santa María, equivalent to 19599.96 eggs. Therefore, the final results for this year are summarized on table 7:

**Table 7.** General summarizing of the harvest – 2008.

<table>
<thead>
<tr>
<th>HARVEST AREAS</th>
<th>NESTS</th>
<th>EGGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRPAS Indigenous communities</td>
<td>379.88</td>
<td>10500</td>
</tr>
<tr>
<td>Cambara, Santa María, Bella Vista, Santa Rosa, Cascabel</td>
<td>211</td>
<td>5832.04</td>
</tr>
<tr>
<td>Private cattle-raising properties</td>
<td>709.12</td>
<td>19599.96</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1300.00</strong></td>
<td><strong>35932</strong></td>
</tr>
</tbody>
</table>

According to the 90% of hatching success in the farm, Crocoland has the license to breed 32338.8 hatchlings for the 35932 harvested eggs.

**f) Estimation for the nesting potential status:**
The permanent flooding areas in San Matías cover $62.706 \text{ km}^2$, and according to the density of $19.93$ nests/\text{km}^2, we get a nesting potential status of 1250.21 nests.

That is why, the 888.12 harvested nests in the private properties of Cambará and Santa María represent the 71.03% of the real nesting potential estimated for the permanent flooding area, not including the ANMI San Matías (Integrative Management Natural Area).
DISCUSSION

The most reliable information about nesting ecology of this specie in Bolivia are the studies published by Rumiz & Llobet (2005). That is why, this results would be the first ones related to abundance and nests densities in this area. This information will be used to adjusts, execute and control the future programs of the management project Crocoland SRL.

According to Yanosky (1990), the most commons nesting places are the floating vegetation (named as “yomomos”) that not only gives an adequate incubation environment for temperature and humidity, but also protect the eggs from predators and inundation. During this study, we didn’t marked de nests located inside this vegetal formations, either because of the distance to distinguish them or the difficulty to get inside this formations. It is also good to remark that the GPS marks were taken tight next to a nests, so it didn’t matter if we located a nests, we also had to get next to it in order to check it in our data. We consider that the results underestimate the real nesting potential, because of the extensive surface of this vegetal formations and the difficulty to search for nests inside them.

Another relevant aspect related to this study is the one published by Larriera (1991) who says that high mortality levels during the incubation are the predators and inundation. We think that this percentage could increase because “110 viable nests that were not harvested” are vulnerable to weather factors.

The average of 27.64 ± 4.03 eggs per nests is different from the ones published by Larriera e Imhof (2000) who found 34 eggs per nest according to their studies since 1990 to 2003, or the ones published by Piña et al. (2002) of 37 eggs per nest. Therefore, the 35932 eggs obtained from 1300 nests underestimate the real average of eggs per nest. This safety margin and the “cautious equivalent quantities” are used to control the estimation of harvested nests from indigenous communities, because farmers don’t get the biological data at the moment for the extraction, so, we don´t know the real quantities of harvested nests. By using this underestimated average, we just “estimate” the quantity of nests by using the number of harvested eggs.

Future prospection for the exploitation according to this study.

There are a lot experiences of captivity breeding in alligators, like the ones published by Mphande (1987) "Only the 2% of wild eggs would survive and turn into adults"; or the proposal of Mozambique presented for the last CITES meeting (Lausanne): "The percentage of survival of wild hatchling is 3% to 5%; and finally Hutton and Jarsveldt (1988) who said that the mortality of wild eggs and hatchlings could be more than the 95%". In the other side, Prado (2001) suggested that the survival percentage in wild conditions is less than the 20% because of predators and low temperatures during winter, but the survival could be more than the 90% under controlled breeding conditions.

In our case, Crocoland, in agreement with the Natural History Museum Noel Kempff Mercado, is working with a harvesting system where we can only collect the 50% of the located nests, with a maximum quota of 1300 nests. That is why, we estimate the production for this year, considering aspects of wild repopulation and the survival percentages and mortality levels that were mentioned before. We also propose new harvesting systems of exploitation.
considering the natural model of survival; in other words, we take account the percentages of lizards that would have survived in wild conditions to calculate the number of lizards that would be repopulated.

**a) Wild survival model:**

\[
\begin{align*}
1300 \text{ nests} & \rightarrow 35932 \text{ eggs} & \rightarrow 1616.94 \text{ adults} \\
\text{95% of mortality} & & \\
\end{align*}
\]

*Figure 4. Wild survival model of 1300 nests.*

According to this model, 35932 eggs are obtained from 1300 nests by using a mean number of 27,64 ± 4,03 eggs/nests, and only 5% will reach mature age because the inviability at embryonic development, weather factors, inundation and predators. Therefore, in wild conditions, we obtain 1616.94 adults from 1300 eggs.

**b) Current harvesting model used by Crocoland farm:**

\[
\begin{align*}
28745.6 \text{ adults} & \rightarrow 34135.4 \text{ viable eggs} & \rightarrow 32338.8 \text{ hatchlings} \\
1300 \text{ harvested nests} & & \\
& & \\
3593.2 \text{ deaths (10%)} & \rightarrow & 1796.6 \text{ eggs inviables (5%)} \\
& & \quad \rightarrow \quad 27128.66 \text{ for production} \\
1616.94 \text{ repopulation (5% inviability)} & & \\
\end{align*}
\]

*Figure 5. Current harvesting model in Crocoland and expectations for production.*
In this model we are authorized to collect the 50% of the located nests, so, we should find 2600 nests in order to harvest 1300 nests. Under controlled conditions and according to the result of this researching, we get 35932 eggs from 1300 nests; 5% shows inviability (1796.6 eggs), and another 10% shows young death (3593.2 hatchlings), therefore we obtain an 80% of success in the development of the animals that would reach mature age for the production of the farm (28745.6 adults).

From this 28745.6 adults, 1616.94 would be used to repopulate wild population, because this quantity would match with the real wild development success model. Under this system of repopulation, the quota of animals that would be repopulated takes as a parameter the quantity of the nests that have been harvested (nests as the sample unity) and the animals that would have survived and turned into adults from that quantity. So we establish the repopulation quota independently from the captivity breeding system. We consider that this is the only way to diminish to the minimum the wild impact of the harvesting. The production balance would be:

Table 8. Balance of the current harvesting model.

<table>
<thead>
<tr>
<th></th>
<th>LOST</th>
<th>SURVIVAL</th>
<th>PRODUCTION</th>
<th>REPOPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1300 WILD NESTS</strong></td>
<td>30721.86</td>
<td>1616.94</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>1300 HARVESTED NESTS</strong></td>
<td>7186.4</td>
<td>28745.6</td>
<td>27128.6</td>
<td>1616.94</td>
</tr>
</tbody>
</table>

(c) Proposal for a new harvesting model for Crocoland farm SRL.

Figure 6. Harvesting proposal to increase production and keep stable wild population.

This proposal assumes the harvesting of 100% of the located nests, in order to diminish the searching effort, increase the production and to keep wild population with the minimum
impact as possible in the harvesting areas.

With this model we get an improvement in the balance:

**Table 9.** Balance of the new harvesting model.

<table>
<thead>
<tr>
<th></th>
<th>LOST</th>
<th>SURVIVAL</th>
<th>PRODUCTION</th>
<th>REPOPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARVESTED</td>
<td>7186.4</td>
<td>28745.6</td>
<td>27128.6</td>
<td>1616.94</td>
</tr>
<tr>
<td>NESTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HARVESTED</td>
<td>7186.4</td>
<td>28745.6</td>
<td>27128.6</td>
<td>1616.94</td>
</tr>
<tr>
<td>NESTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

From 19.26 km$^2$ we get a density of 19.93 nests/km$^2$.

In this researching we harvested 22 nests, and we get a mean number of 27.64 ± 4.03 eggs/nest and a mean incubation pod temperature of 32.2 ± 2.31 °C.

The harvesting exploitation in this study represents the 54.95 % of the total quantity of located nests, the other 32.07% are represented by the wild viable nests, and the 12.97% are the natural lost, either because of inundation or predators.

We calculate 62.706 km$^2$ of permanent flooding zones in San Matías and according to the current density of 19.93 nests/km$^2$, we estimate a nesting potential of 1250.21 nests in the entire area, but only 888.12 nests were harvested (exploitation of the 71.03%, including the harvested nests that were not found during this evaluation). This final potential does not include floating vegetation, and those areas area considered as mitigation areas for the exploitation.

For Crocoland, 1300 nests represent 35932 eggs. We expect to get 32338.8 hatchlings for this year (2008), with the responsibility to repopulate 1616.94 young-adult lizards according to the wild survival model.

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Crocodile management, conservation and sustainable use in Latin America

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ABSTRACT: Latin America is one of the most diverse regions in crocodiles. The CSG Action plan in its 2nd edition recognizes 23 species around the world and in Latin America and we can find 10 of them. The status of each species in 1971 was nothing good; all are threatened or endangered, caused by over exploitation, illegal trade and uncontrolled harvest programs. Today this situation is completely different, through the conservation, management plan and sustainable use program implemented with all species. *Crocodylus moreletti* is recovering in its range distribution and is under captive breeding program. *Crocodylus acutus* is under conservation programs and in Colombia is under captive breeding and in Cuba it’s downlisted to Appendix II for commercial proposes. Only *Crocodylus intermedius* and *Crocodylus rhombifer* is not recovery completely. *Caiman crocodilus*, *C. c. fuscus*, *Caiman yacare* and *Caiman latirostris* are recovery and support wild harvest, ranching and captive breeding programs. *Melanosuchus niger* change recently the status in Brazil and would be support wild harvest. The *Paleosuchus* spp. status is unknown principally because this species do not have commercial interest. In 2006 the skins trade from Latin America was 1,000,442, dominated by Colombia with *C. c. fuscus* and very down in participation Venezuela and Bolivia. This quantity cold is change when the skins production from Argentina, Brazil and Mexico will be more open to international market, because in this moment they focus are in domestic market for Argentina and Brazil and Mexico downlisted the *C. moreletti* population.

RESUMEN: Latino América es una de las regiones más diversas en cocodrilos. La 2da Edición del Plan de Acción del CSG se reconoce la presencia de 23 especies en el mundo, de las cuales 10 de ellas se encuentran en Latino América. El status de esta especies en 1971 no era bueno, todas estaban amenazadas o en peligro debido a la sobre explotación, comercio ilegal y programas de cosechas incontrolables. La situación al día de hoy es totalmente diferente, gracias a la conservación, planes de manejo y la implementación de programas de uso sustentable en las todas las especies. *Crocodylus moreletii* se está recuperando y está bajo un programa de cría en cautiverio. *Crocodylus acutus* está bajo programas de conservación, en Colombia en cría en cautiverio y la población de Cuba fue transferida al Apéndice II de CITES con propósitos comerciales. *Crocodylus intermedius* y *Crocodylus rhombifer* no se han recuperado completamente. *Caiman crocodilus*, *C. c. fuscus*, *Caiman yacare* y *Caiman latirostris* se han recuperado y están bajo cosechas silvestres, rancho de huevos y neonatos, y cría en cautiverio. *Melanosuchus niger* ha cambiado su estatus recientemente en Brasil pasado al Apéndice y puede soportar cosechas silvestres. Se desconoce el estatus de los *Paleosuchus* spp. debido principalmente a que no tienen valor comercial. En el 2006 el mercado de pieles desde Latino América fue de 1.000.442 unidades, dominado por Colombia con *C. c. fuscus* y con muy baja participación Venezuela y Bolivia. Esta cantidad de pieles producidas podría cambiar al abrirse al mercado internacional Argentina, Brasil y México.
debido a que en estos momentos Argentina y Brasil están más enfocados en sus mercados nacionales y México reclasifique la población de *C. moreletii*.

**INTRODUCTION**

Latin America is the most diverse regions in crocodiles. The CSG Action plan in its 2nd edition (Ross 1998) recognize 23 species around the world and in Latin America we can find 10 of them (table 1).

**Table 1.** Species presented in Latin America region.

<table>
<thead>
<tr>
<th>Species</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Caiman crocodilus</em></td>
<td>Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guyana,</td>
</tr>
<tr>
<td></td>
<td>French Guiana, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru,</td>
</tr>
<tr>
<td></td>
<td>Suriname, Venezuela (introduced in Puerto Rico and Cuba)</td>
</tr>
<tr>
<td><em>Caiman yacare</em></td>
<td>Argentina, Brazil, Bolivia, Paraguay</td>
</tr>
<tr>
<td><em>Caiman latirostris</em></td>
<td>Argentina, Brazil, Bolivia, Paraguay, Uruguay</td>
</tr>
<tr>
<td><em>Melanosuchus niger</em></td>
<td>Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru</td>
</tr>
<tr>
<td><em>Paleosuchus palpebrosus</em></td>
<td>Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname,</td>
</tr>
<tr>
<td></td>
<td>Venezuela</td>
</tr>
<tr>
<td><em>Paleosuchus trigonatus</em></td>
<td>Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname,</td>
</tr>
<tr>
<td></td>
<td>Venezuela</td>
</tr>
<tr>
<td><em>Crocodylus acutus</em></td>
<td>Belize, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El</td>
</tr>
<tr>
<td></td>
<td>Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Mexico,</td>
</tr>
<tr>
<td></td>
<td>Panama, Peru, Venezuela</td>
</tr>
<tr>
<td><em>Crocodylus intermedius</em></td>
<td>Colombia, Venezuela</td>
</tr>
<tr>
<td><em>Crocodylus Moreletii</em></td>
<td>Mexico, Guatemala, Belize</td>
</tr>
<tr>
<td><em>Crocodylus rhombifer</em></td>
<td>Cuba</td>
</tr>
</tbody>
</table>

The status of each species in 1971 was nothing good; all are threatened or endangered (Thorbajarnarson 1992), caused by over exploitation, illegal trade and uncontrolled harvest programs. With the appearance of two institutions, the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Crocodile Specialist Group SSC/IUCN, institutions that help and produce guidelines to reduce the illegal trade, design strategies or tools to recover the wild populations and mechanism to control de international trade (Velasco 2005).

Now the situation is completely different, most of all species in Latin America region they status changes. The table 2 show the species status by IUCN red list and the CITES Appendix classification.
<table>
<thead>
<tr>
<th>Species</th>
<th>IUCN</th>
<th>CITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caiman crocodilus</td>
<td>Red list: Not Listed (LC, Least Concern)</td>
<td>Appendix II, except C. crocodiles apaporensis – Appendix I</td>
</tr>
<tr>
<td>Caiman yacare</td>
<td>Red list: Not Listed (LC, Least Concern)</td>
<td>Appendix II</td>
</tr>
<tr>
<td>Caiman latirostris</td>
<td>Red list: Not Listed (LC, Least Concern)</td>
<td>Appendix II in Argentina (Ranching) Appendix I in all other countries</td>
</tr>
<tr>
<td>Melanosuchus niger</td>
<td>Red list: LR/cd (Low Risk: Conservation Dependent)</td>
<td>Appendix II in Ecuador (Ranching) subject to quota cero from 1997, Appendix II in Brazil (Wild Harvest) Appendix I in all other countries</td>
</tr>
<tr>
<td>Paleosuchus palpebrosus</td>
<td>Red list: Not Listed (LC, Least Concern)</td>
<td>Appendix II</td>
</tr>
<tr>
<td>Paleosuchus trigonatus</td>
<td>Red list: Not Listed (LC, Least Concern)</td>
<td>Appendix II</td>
</tr>
<tr>
<td>Crocodylus acutus</td>
<td>Red list: VU A.1. a. c (Vulnerable)</td>
<td>Appendix I Appendix II in Cuba (Ranching)</td>
</tr>
<tr>
<td>Crocodylus intermedius</td>
<td>Red list: CR A.1.c. C.2.a. (Critically Endangered)</td>
<td>Appendix I</td>
</tr>
<tr>
<td>Crocodylus moreletii</td>
<td>Red list: LR/cd (Low Risk: Conservation Dependent)</td>
<td>Appendix I</td>
</tr>
<tr>
<td>Crocodylus rhombifer</td>
<td>Red list: CR A.1.c. B. 1. 2c. (Endangered)</td>
<td>Appendix I</td>
</tr>
</tbody>
</table>
Conservation and management programs

Central America and Mexico

In Central America and Mexico, we can find 4 different species in 8 countries. The table 3 shows each country, species, programs and goals.

Table 3. Central America countries and Mexico species, programs and goals.

<table>
<thead>
<tr>
<th>Country</th>
<th>Specie</th>
<th>Program</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td><em>Caiman crocodilus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus moreletii</em></td>
<td>Captive breeding</td>
<td>Conservation and Trade and Conservation</td>
</tr>
<tr>
<td>Belize</td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus moreletii</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td>Guatemala</td>
<td><em>Caiman crocodilus</em></td>
<td>Captive breeding</td>
<td>Local trade</td>
</tr>
<tr>
<td></td>
<td><em>Caiman crocodilus fuscus</em></td>
<td>Captive breeding</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus moreletii</em></td>
<td>Captive breeding</td>
<td>?</td>
</tr>
<tr>
<td>Honduras</td>
<td><em>Caiman crocodilus</em></td>
<td>Captive breeding</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>Conservation?</td>
</tr>
<tr>
<td>El Salvador</td>
<td><em>Caiman crocodilus</em></td>
<td>Captive breeding</td>
<td>Conservation?</td>
</tr>
<tr>
<td>Nicaragua</td>
<td><em>Caiman crocodilus fuscus</em></td>
<td>Wild harvest</td>
<td>Trade</td>
</tr>
<tr>
<td>Costa Rica</td>
<td><em>Caiman crocodilus</em></td>
<td></td>
<td>Translocation program</td>
</tr>
<tr>
<td>Panama</td>
<td><em>Caiman crocodilus fuscus</em></td>
<td>Captive breeding</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
</tbody>
</table>

Mexico

The Mexican government design The National Plan for Conservation, Research, Management and Sustainable Use of crocodiles and caiman in Mexico (Semarnap 1996). Under this National Plan, during 2002 – 2004 was developing surveys around *C. moreletii* distribution area to determinate the population status (Dominguez et al 2004). The result of this investigation is a document was summit to Fisher Wildlife Services of USA proposing a downlist in the Endangered Action List (Conabio 2005) and more recently to CITES Animals Committee proposing the transfer the specie from Appendix I to Appendix II (AC23 Doc. 18).

All species are under captive breeding program, principally for conservation goals, with the exception of *Crocodylus moreletii* that are under commercial proposes in the domestic market. For *C. moreletii*, 33 captive breeding farms we found in Mexico, but only 3 are registered in CITES.
Belize

Non official programs with crocodiles Belize have, only with *Crocodilus acutus* they have one captive breeding farm for conservation goals. With *C. moreletii* private researches are developing.

Guatemala

Three species are under captive breeding program, *Caiman crocodilus, Caiman crocodilus fuscus* and *Crocodylus acutus*. The *Caiman genus* shows a local trade. With *C. moreletii* private researches are developing.

Honduras

The government support a management plan that have like principal goals evaluate the status of *Crocodylus acutus* in the El Cajón Dan, involving the local communities in ecotourism activities (Espinal 2005). The first captive breeding farm registered in CITES is in Honduras, but not international trade is registered in this moment.

With *Caiman crocodilus* we do not have any information regarding conservation programs.

El Salvador

Any information about conservation program with crocodiles is in this country. With *C. acutus*, one captive breeding farm is in function, but the goals probably are for conservation.

Nicaragua

With *C. acutus* no conservation program is implemented. *Caiman crocodilus fuscus* is under wild harvest, until 2005 the export quota was 10,000 skins per year, in 2006 this quota reduce to 3,000 skins and the last two year is fixed in 1,500 skins per year (http://www.cites.org/eng/resources/quotas/index.shtml).

Costa Rica

No conservation program Costa Rica implemented. Until 2000 *Caiman crocodilus* export quota is in 2,000 skins per year, but now is close this trade (http://www.cites.org/eng/resources/quotas/index.shtml). With *Crocodylus acutus*, the government implements a translocation program with conflictive animals; also they have an ecotourism program around the principal rivers.

Panama

With the species *C. acutus* and *C. crocodilus* have captive breeding program. With *C. acutus* for conservation proposes and *C. crocodilus* for commercial goals.
Caribbean

In the Caribbean, we can find 3 different species in 6 countries. The table 4 shows each country, species, programs and goals.

The status of all species in Jamaica, Haiti, Trinidad and Tobago, Dominican Republic and Puerto Rico is unknown. *Caiman crocodilus* is introduced specie in Puerto Rico and Cuba.

In the past, until 2002 conservation programs are implemented in Dominican Republic with *Crocodylus acutus* evaluation the population abundance and reproduction (Shubert & Mendez 2000 and 2002).

**Table 4.** Caribbean countries, species, programs and goals.

<table>
<thead>
<tr>
<th>Country</th>
<th>Specie</th>
<th>Program</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuba</td>
<td><em>Caiman crocodilus</em></td>
<td>Ranching</td>
<td>Trade and Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus rhombifer</em></td>
<td>Captive breeding</td>
<td>Trade and Conservation</td>
</tr>
<tr>
<td>Jamaica</td>
<td><em>Crocodylus acutus</em></td>
<td></td>
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<tr>
<td>Haiti</td>
<td><em>Crocodylus acutus</em></td>
<td></td>
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<tr>
<td>Dominican Republic</td>
<td><em>Crocodylus acutus</em></td>
<td></td>
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<tr>
<td>Puerto Rico</td>
<td><em>Caiman crocodilus</em></td>
<td></td>
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<tr>
<td>Trinidad and Tobago</td>
<td><em>Caiman crocodilus</em></td>
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</tbody>
</table>

Cuba

The Empresa Nacional para la Protección de la Flora y la Fauna (National Enterprise for the Protection of Flora and Fauna - Ministry of Agriculture) implemented the National Crocodile Program, divided in 3 sub programs, that are: a) Research and management of wild populations, b) captive management and c) environmental education (Soberon et al 2006).

Under the National Crocodile Program, are developments these researches:

1. Continuation of studies on *C. acutus* reproductive ecology and ethology, and management of crocodile nesting habitat at the Wildlife Refuge Monte Cabaniguan.
2. Follow-up monitoring of the re-introduced population of *Crocodylus rhombifer* in Lanier Swamp, Isla de la Juventud.
3. Population abundance and distribution of *C. acutus* at the Crocodile Conservation Units proposed by the Workshop American Crocodile Conservation Priorities (Gainesville 2002).
4. Genetic characterization of *C. acutus* and *C. rhombifer* Cuban populations (in collaboration with University of Habana - Faculty of Biology, WCS, Smithsonian Tropical Research Institute and Texas Technical University).
In 2008 during the CoP 13 in Bangkok, the *Crocodylus acutus* population was transferred to Appendix II, under ranching program. After the downlist the specie, the ranching program pass for different environmental success, hurricanes mostly that not permit to implement the ranching program like there wan. But the continued collecting from the wildlife and incubation in the different farms are in Cuba in 2007 with 373 hatchlings and in 2008 collected 23 nests (Regional report).

**South America**

All species are present in 12 countries, except *Crocodylus rhombifer* that endemic of Cuba. The table 5 shows for each country, the specie present, program implemented and goals. Only French Guyana and Suriname do not have any crocodile conservation program, and the *Paleosuchus trigonatus* and *P. palpebrosus* are the only species are not under conservation programs in South America countries.

**Table 5.** South America countries, species, programs and goals.

<table>
<thead>
<tr>
<th>Country</th>
<th>Specie</th>
<th>Program</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td><em>Caiman latirostris</em></td>
<td>Ranching</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Caiman yacare</em></td>
<td>Ranching</td>
<td>Trade</td>
</tr>
<tr>
<td>Bolivia</td>
<td><em>Caiman latirostris</em></td>
<td>Wild harvest, Captive breeding</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Caiman yacare</em></td>
<td>Ranching</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Melanosuchus niger</em></td>
<td>Captive breeding</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Paleosuchus palpebrosus</em></td>
<td>Wild harvest</td>
<td>Trade</td>
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<tr>
<td></td>
<td><em>Paleosuchus trigonatus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td>Brazil</td>
<td><em>Caiman crocodilus</em></td>
<td>Ranching and Captive breeding</td>
<td>Trade</td>
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<td></td>
<td><em>Caiman yacare</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Caiman latirostris</em></td>
<td>Wild harvest</td>
<td>Trade</td>
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<tr>
<td></td>
<td><em>Melanosuchus niger</em></td>
<td>Captive breeding</td>
<td>Trade</td>
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<tr>
<td></td>
<td><em>Paleosuchus palpebrosus</em></td>
<td>Wild harvest</td>
<td>Trade</td>
</tr>
<tr>
<td></td>
<td><em>Paleosuchus trigonatus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
<tr>
<td>Colombia</td>
<td><em>Caiman crocodilus</em></td>
<td>Captive breeding</td>
<td>Trade and Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Caiman crocodilus fuscus</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
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<tr>
<td></td>
<td><em>Melanosuchus niger</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
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<tr>
<td></td>
<td><em>Paleosuchus palpebrosus</em></td>
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<td>Conservation</td>
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<td><em>Paleosuchus trigonatus</em></td>
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<td>Conservation</td>
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<td></td>
<td><em>Crocodylus acutus</em></td>
<td>Captive breeding</td>
<td>Trade and Conservation</td>
</tr>
<tr>
<td></td>
<td><em>Crocodylus intermedius</em></td>
<td>Captive breeding</td>
<td>Conservation</td>
</tr>
</tbody>
</table>
Argentina

Two species we found in Argentina, *Caiman latirostris* and *Caiman yacare*, both under ranching program for commercial proposes in different Provinces; Santa Fe with *C. latirostris*, Chaco, Formosa and Corrientes with *C. latirostris* and *C. yacare*. Larriera *et al* (2008) show

<table>
<thead>
<tr>
<th>Country</th>
<th>Species</th>
<th>Activity</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecuador</td>
<td><em>Caiman crocodilus</em></td>
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<tr>
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<td><em>Melanosuchus niger</em></td>
<td>Ranching</td>
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<td><em>Paleosuchus palpebrosum</em></td>
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<td>French Guyana</td>
<td><em>Caiman crocodilus</em></td>
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<td>Trade</td>
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<td><em>Paleosuchus trigonatus</em></td>
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<td><em>Caiman yacare</em></td>
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an excellent compilation about the research, status and sustainable use of caimans in Argentina. The ranching program permit to reintroduce caimans into wildlife and from the beginning in 1991, more than 30,000 caimans of both species are reintroduced into wildlife (op. cited).

A new initiative in Formosa Province with Caiman yacare is develop, wildlife surveys (Sirosky 2004) are doing to evaluate the population status with the main goals to design a wild harvest for obtain skins and meat. The proposal is under revision.

Bolivia

In Bolivia occurs 5 species. Melanosuchus niger and Caiman latirostris had some private initiatives to determinate the population status in wildlife, with Palesuchus sp. nothing investigation was do it, and only the wild population of Caiman yacare is under a Conservation and Sustainable Use Program based in wild harvest from 1997 (Llobet 2004). This program is continually under changes, and the most recently are described by Llobet and Bello (2008). In 2004 began the reformulation of yacare program, and the principal results are: develop of monitoring protocols including habitat characterizations; protocols to evaluate the annual harvest; evaluation of ecological data that include surveys, harvest and habitats with administrative information based in a GIS tool and develop a criteria or baseline to design and apply experimental management plan by each locality (Rumiz & Llobet 2005). At this moment two management plan are implemented in indigenous land, eleven are finished and in evaluation processes by the Management Authority and one in progress and in 2007 implement the first experimental harvest (Llobet & Bello 2008)

From 2006 the Cites Administrative and Scientific Authority of Bolivia published a new resolution that permit to implement a ranching and captive breeding activities with Caiman yacare for commercial proposes (Velasco 2008).

Brazil

Is one of the most diverse crocodile country in South America with 6 species, but not all are under conservation, management or sustainable use programs. Caiman yacare is the oldest specie under captive breeding and ranching program for commercial proposes. Caiman latirostris is under captive breeding private operation in an experimental phase.

In 2003 has established a nationwide research and development programme, named Programme for Biology, Conservation and Management of Brazilian Crocodilians (Coutinho & Luz 2008). The goals are determinate the population status through surveys, estimating size structure and sex ratio, habitat characterization, reproductive biology and nesting ecology.

More recently, in CoP 14 the Melanosuchus niger population was transfer from Appendix I to Appendix II and the government would be implement a wild harvest in Sustainable Development Reserves (Ibama 2007). The main goal of this program is obtain skins and meat.
Colombia

Of all species only the *Paleosuchus* spp. is not under conservation program. *Crocodylus intermedius* Conservation plan is under revision by the Ministerio del Ambiente, Vivienda y Desarrollo Territorial (Ministry of Environmental, Housing and Territorial Development - MAVDT), at this moment the activities is a captive breeding program. *Melanosuchus niger* have also a conservation program from 1996, but not many action are made. In this moment is under review and redesign the conservation plan.

*Crocodylus acutus* the conservation program is under revision, especially the captive breeding farm relation with the conservation strategies. In other hand, the Cispata project continued implemented through the eggs collection and realizing juveniles in natural habitat, population survey, biological research and local people participation (Ulloa & Sierra 2006).

In relation with *Caiman crocodilus crocodilus* and *Caiman crocodilus fuscus*, are the two species under captive breeding program since 1980. Medrano & Gómez (2008) publishing the history of genus Caiman conservation and harvest, make emphasis in a big description of all processes regarding the use of *Caiman crocodilus fuscus*. In 2007 the MAVDT began to design a National Programs for Conservation and Sustainable Use of Crocodylia in Colombia.

Recently, two the Regional Autonomous Corporations are implementing a conservation program, Atlantico (CRA 2006) and Del Sur de Bolivar (Mercado & Palacios 2006). The main goal is the local population participation in growing hatchling for realize in wild habitat evaluation the population status and habitat characterization to design conservation plans for *C. c. fuscus*.

Ecuador

The population of *Melanosuchus niger* is in Appendix II to implement a ranching program with quota cero for commercial proposes. This program present during the time, different problems that not permit to be successful, was analyses by Hines (2002). In 2008 the ranching program is closed.

With the other species (*Caiman crocodilus*, *Crocodylus acutus*, *Paleosuchus trigonatus* and *P. palpebrosus*) only private initiatives are develop.

French Guyana

Private initiatives are develop with *Melanosuchus niger* through captive breeding programs and ecotourism activities.

Guyana

Only *Caiman crocodilus* are under a conservation program through wild harvest.
Paraguay

In 1996 began the wild harvest program with *Caiman yacare*, until 2003, year that Paraguay implemented a voluntary moratorium on the utilization of wildlife species, following recommendations from the CITES Secretariat. After this decision, the government are design a management plan for crocodiles species in the country.

Aquino & Scott (2008) present an excellent paper about the history and dynamics of crocodiles management in Paraguay, with emphasis in *Caiman yacare*, showing the mistake and propose mechanism to solve the situation.

Peru

In this country 6 crocodiles species occurs, but only have a conservation program with *Crocodylus acutus* with a captive breeding facilities in Tumbes region. This farm was under the guide by the government, but knows the manage in a local university close the facilities and the new goals would be presented in the 19 Working Meeting of CSG through 2 papers.

Uruguay

Is the minor diverse crocodile country in South America, with one specie *Caiman latirostris*. A private initiative is implemented; the farm “Criaderos de yacare Cerros Azules” began its activities 6 years ago with *Caiman latirostris*. The main goals are reproduction of the species and the reintroduction of hatchlings into wild habitat, and in the future to produce skins and meat for commercial purposes. It is a private initiative which now has Government support and permits. At this stage breeding stock consists of 20 adults, in addition to some 330 other caimans. To date they have reintroduced about 100 caimans into the wild. This program has the governmental support.

Venezuela

Only the genus *Paleosuchus* is not under a conservation program. With *Crocodylus acutus* and *Crocodylus intermedius*, the government implements the National Plan for Conservation both species (MARN 2003) jointly with different NGO’s, universities and the private sector. The main goal of both national plan for conservation is “Recovery the wild populations through eggs collection, growing in captivity for reintroduced the juveniles into natural habitats, involving farms and local people. In 18 years (1990 – 2007) 5,620 Orinoco crocodiles was realize in 14 different localities and one of them in Caño Guaritico Wildlife Refuge in Apure State, is recognize like a new population (Ayarzaguena et al 2007). The last two year the Ministry of Power Popular of Environment began to collect hatchling in two different areas to growing and reintroduced in natural habitat (Babarro in press). With American crocodile, from 1996 to 2007, 628 crocs were reintroduced in 9 natural localities.

*Caiman crocodilus* is under wildlife harvest program from 1986 and is the oldest sustainable program in South America. The annual harvest is based on the old male caimans (Class IV) longer that 1.80 total length (Velasco & De Sola 1999). The harvests on the natural populations have produced an improvement in the population characteristics, such as their abundance and structure of sizes classes, verified by continuous populations monitoring under harvests,
and comparing them with populations not harvest, which shows the sustainability (Velasco et al 2003).

**Skins production and trade**

Latin America is the region in the world that produces more skins to the international market. In 1999 the world production was estimate in 1,179,539 skins and from Latin America are 851,326, which represent the 72.14% of the total export. Now the situation is not different, the figure 1 shows the skins exported from Latin America from 1976 to 2006.

![Fig. 1. Skins exported from Latin America](image)

The tendency is to increase and shows three periods. The first between 1976 to 1983 where all programs began after the creation the Convention for International Trade of Endangered Species of Wild Fauna and Flora (CITES) and finalizing when Venezuela open the wild harvest program. The second period (1983 to 1993) the skin production is reduced had ban implemented in Paraguay and Panama y stop Colombia production. The principal countries that contributed are Guyana and Venezuela. The last period (1994 to 2006) the increase is must the captive breeding production in Colombia with *Caiman crocodilus fuscus* and lest percent Venezuela and reopen all program in the region, Paraguay with *Caiman yacare*, Panama with *C. c. fuscus*, Nicaragua with *C. crocodilus* and Brazil with *C. yacare*.

The figure 2 shows the country contribution into the international skins market in all time. Colombia is the principal country in Latin America in skin production and international market with 68.48% of total (*C. fuscus* 64.83% and *C. crocodilus* 3.66%). Venezuela occupied the 2nd place with 14.27% and so far a small group integrating by Paraguay (5.87%), Bolivia (3.70%) and Guyana (2.27%) all skins coming from wild harvest.

The country buyers is more diverse (figure 3), where Italy buy the 22.25% of Latin America production, followed by Singapore with 18.65%, where 98.67% coming from Colombia; and so far we see other country group integrate by Japan (9.35%), USA (9.29%), Mexico (8.96%), Thailand (8.61%), Germany (8.26%) and France (8.25%). Of this group Thailand and Mexico buy more skins from Colombia, the other is a mixes of all Latin America countries. The rest of production to international market is integrating 19 countries around the world.
The most important observation in this comment is that Asian market is dominated by Colombia skins, and the Europe market is it a mixture where Colombia has around the 50% of the skins sales.

The figure 5 shows the Latin America skins production by type: farms that include captive breeding and ranching systems versus wild harvest.
Three phases we observe in this figure; the first between 1976 to 1980 where all skins coming from Colombia and we estimate is a captive breeding production because in WCMC data base do not specify the origin. The second phase is dominated by wild harvest from 1981 to 1992, principally from Venezuela and Guyana, and some skins from Colombia of both sources (Captive and wild harvest). The last phase is clear dominated by Colombia captive breeding production. The wild harvest reduction is this phase is a consequence of different factors: Venezuela, Guyana and Nicaragua reduce its production and Paraguay moratorium.

In 30 year the skins market produce for Latin America 15,678,466 skins, where farms system is 10,607,435 (67.66%) and wild harvest is 5,071,032 (32.34%). This analysis does not include the skins used for domestic market.

The author tries to estimate the total incomes from the international market. But it is necessarily clarify how we do this estimation. In the case of wild harvest skins, we were based in an annual Venezuela price. Normally for the other countries with wild harvest their price is little low, between 2 to 4 US$ less. In relation of farms skins cases, we used the Colombia prices and applied to all countries.

The figure 6 shows the total net incomes and for production system. farms systems produce more money because put into the market more skins that wild harvest. In 30 year the skins market produce for Latin America 712,890,809 US$, where farms is 429,014,901 US$ (60.18%) and wild harvest is 283,875,908 US$ (39.82%). This analysis does not include the benefits for domestic market. In 2006 the net incomes was around 1,000, 442 US$, where 883,833 US$ (88.34%) from farms system and 116,609 US$ (11.66%) from wild harvest. When Argentina, Brazil and Mexico began to introduce more skins this situation would be change more drastically, because their production coming from ranching in Argentina and Brazil and captive breeding in Mexico.
ACKNOWLEDGEMENT

Many people collaborated with information and photos in the paper elaboration. Jerónimo Domínguez (Mexico), Mario Espiñal (Honduras), Juan Bolaños and Juan Sánchez (Costa Rica), Roberto Soberon (Cuba), Pablo Siroski y Walter Prado (Argentina), Catalina Gomez (Colombia), Alejandro Franulic (Bolivia), Lucy Aquino (Paraguay), Alvaro (Uruguay).

To all countries that prepare and send the Annual Cites reports. To WCMC for permit to use the trade date.

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Toward the sustainable use of the *Crocodylus acutus* for local communities in the swamps of the Cispata bay, Caribbean of Colombia

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**ABSTRACT:** the present Project sought, to formulate a pilot conservation strategy for the *Crocodylus acutus*, in the swamps of the Bay of Cispatá, old Mouth of the Río Sinú, in the Department of Córdoba-Caribbean of Colombia. With the combination of investigation activities, tracking down and monitoring, in their initial stages and with the formulation of a management plan for their later implementation, it is considered that it will be possible to cooperate to the conservation of the species, also in the local and the national level. The Program has the leadership of the Regional Autonomous Corporation of the Valleys of the Sinú and San Jorge, (CVS), and in the beginning by the “Proyecto Manglares” of the Ministry of Environment Housing and Territorial Development. Later on it has had the support of the Institute Alexander von Humboldt, FONADE, Conservation International Colombia (C.I.), Fundación Natura, Agrosoledad S.A., Zoben S.A. and Gaber S.A. with the help of these institutions and inside the activities developed between 1999 and 2008, it has stood out in the regional, national and international environment, the conformation of an association (ASOCAIMAN), integrated by a group of 18 old well-known hunters as “caimaneros” that have become the helpers in the conservation of the caiman of the Magdalena (*Crocodylus acutus*), of the Bay of Cispatá. The goal that is projected, after several investigation phases, will be based on the sustainable management of this resource, on the part of members of the local community, contemplating some of the conservation components suggested by several specialist for the crocodilians, like: (1) censuses, (2) recovery programs, (3) monitoring (4) biological Studies (5) mechanisms of caution (6) local benefits (7) agreements (8) control of the traffic, and (9) economic benefits.

**RESUMEN:** Con el presente Proyecto se pretende, formular una estrategia piloto de conservación para el *Crocodylus acutus*, en los manglares de la Bahía de Cispatá, antigua Boca del Río Sinú, en el Departamento de Córdoba-Caribe de Colombia. Con la combinación de actividades de investigación, seguimiento y monitoreo, en sus etapas iniciales y con la formulación de un plan de manejo para su implementación posterior, se considera que se podrá coadyuvar a la conservación de la especie, tanto en el ámbito local como nacional. El Programa ha sido liderado por la Corporación Autónoma Regional de los Valles del Sinú y San Jorge, (CVS), y en la parte inicial por el Proyecto Manglares del Ministerio de Ambiente Vivienda y Desarrollo Territorial. Posteriormente ha contado con el apoyo del Instituto Alexander von Humboldt, FONADE, Conservación Internacional Colombia (C.I.), Fundación Natura, Agrosoledad S.A., Zoben S.A. y Gaber S.A. Con ayuda de estas instituciones y dentro de las actividades desarrolladas entre 1999 y 2008, se ha destacado
en el ámbito regional, nacional e internacional, la conformación de una asociación (ASOCAIMAN), integrada por un grupo de 18 antiguos cazadores conocidos como "caimaneros" que se han convertido en los coadyuvadores en la conservación del caimán del magdalena o caimán aguja (*Crocodylus acutus*), de la Bahía de Cispatá. La meta que se proyecta, después de varias fases de investigación, se basará en el manejo sostenible de este recurso, por parte de miembros de la comunidad local, contemplando algunos de los componentes de conservación sugeridos por varios especialistas para los crocodilideos, como son: (1) Censos, (2) Programas de recuperación, (3) Monitoreo (4) Estudios biológicos (5) Mecanismos de precaución (6) Beneficios locales (7) Acuerdos (8) Control del trafico, y (9) Beneficios económicos.
ABSTRACT: The Colombian Environmental Ministry (MAVDT) through Resolution 1660 of 2005, mandates that the Regional Autonomous Corporation (CRA) implement Conservation Actions Plans for the Babilla (*Caiman crocodilus fuscus*).
In the jurisdiction of the South Bolivar Corporation (CSB) the most important marshland complex of the country, the “Momposina Depression”, represented by 6,036 km², wetlands divided into 11 complexes.

From November of 2007 in complex B15 the conservation plan for the species was initiated; according to the directives of the National Plan for Crocodiles Conservation in Colombia. Initially three areas were selected out of 36 identified for the zone; in April 2008 another three will be chosen. In these six regions babilla populations and habitat will be monitored so that by the end of this year we will obtain results of the crocodiles census and an estimate of the population.

Also we will execute programs of Environmental Education and Institutional Building, with a view to creating and sensitizing the communities, and to generate attitude changes. The financing of the plan is from collaboration between the environmental authority and private crocodile farms. The MAVDT will contribute 74% of the resources and the remaining 26% from money collected from farmers for quotas for repopulation.
Sustainable Use Program for *Caiman yacare* in La Estrella Swamp, Formosa Province, Argentina.

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ABSTRACT: Monitoring studies have indicated that the *Caiman yacare* population within La Estrella Swamp is abundant (>200 caimans.km⁻¹ in some places). Although there is currently no management plan in place for the species, consideration is being given to the wild harvesting of adults to produce leather and meat, and add extra value to the ecosystem. Such a program would encourage the use of the resource in a sustainable way, and provide additional income for local inhabitants. Survey methodologies for this program have been designed based on recommendations of IUCN-SSC CSG for management and use of wild populations, including night and day surveys, and questionnaires to local people. Harvesting quotas (15% of Class IV animals) will be based on monitoring. Each year, before the hunting season, the area will be survey to estimate the numbers of caimans in each size. The harvest season will be timed to occur before the reproductive season, but once the water level is reduced (September to October). The program will allow harvesting of caimans 200 cm or longer in length, but will accept up to 20% of the quota being animals 180 and 199 cm. Where meat is to be used for human consumption, hunters must provide the program supervisors the animals they harvested that night at a specific point. Animals will be then be transported in refrigerated trucks to a processing facility.
Integral use of *Caiman yacare*: driving to sustainable use in Bolivia.

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**ABSTRACT:** Since its creation, the Program for Conservation and Sustainable Use of *Caiman yacare* in Bolivia has focused in the use of leather. From 1999 to 2007 the use of 301937 individuals was authorized, from which were commercialized: 583453 flanks, 257772 tails, 17126 kg of meat and only 400 skulls. Conscious about that the lack of use of by-products that could have interesting markets, and aware about that the Management Plans are developing strategies to increase value and to obtain some by-products, we made an analysis about certain key factors, that could avoid the development of these processes: influence of market, difficulties of gathering and transportation of by-products, character of hunting (in a organizational approach), economical incentives, capabilities of negotiation, transparency in the organizations and other related to the use of illegal means. The new policies stimulate to that the benefits generated by natural resources should include a just and equitable distribution; if not, without an integral utilization local participation would be restricted, and the benefits only would be focused to a small number of actors creating gaps of gender, social status and above all, opportunities of conservation for this resource.

**RESUMEN:** Desde su creación, el Programa de Conservación y Aprovechamiento Sostenible de lagarto en Bolivia, se ha centrado el aprovechamiento del cuero. Se ha autorizado el aprovechamiento de 301937 lagartos, de los cuales se comercializaron 583453 flancos, 257772 colas, 17126 Kg de carne y sólo 400 cráneos. Concientes del desperdicio de toneladas de subproductos que podrían contar con mercados interesantes y que la ejecución de Planes de Manejo contemplan estrategias para agregar valor y obtener ciertos derivados, se realizó un análisis de los factores determinantes que podrían obstaculizar el desarrollo de estos procesos: la influencia de mercado, las posibilidades de transporte y acopio de subproductos, características de la cacería en cuanto a su organización, incentivos económicos, capacidades de negociación, de la transparencia en las organizaciones y otros relacionados a las vías ilegales de aprovechamiento. Las nuevas políticas impulsan a que los beneficios generados por los recursos naturales incluya una distribución justa y equitativa, al no existir un aprovechamiento integral, se restringe la participación local y se deja los beneficios a un número reducido de actores que forman parte de la cadena de valor creando brechas de género, de condición social y sobre todo de oportunidades de conservación para este recurso.
ABSTRACT: Since 2004 the Corporación Regional del Atlántico (CRA), develops the conservation program sustainable use and management of its wetlands. Its principal strategy is the reintroduction of thousands of babilla individuals (Caiman crocodilus fuscus), respecting the structure of the natural populations. The program covered 8 wetlands of the state (c.a. 24,000 ha) and involved 13 communities and according to the results it has adjusted, consolidating some communities, and proposing the integration of other species of the wetland to the management proposed by the CRA. The private enterprise (captive breeding) suministrated the hatchlings (13,819) and subadults (5,289). The first were delivered to 138 women of the communities, who took care of them for a year, receiving 0.30 US per each animal kept in good conditions; the second were released in the wetlands after following the appropriate protocols. The monitoring of the released specimens are carried out by the fishermen, the initial results determine a good adaptation of the individuals, established by its physical condition, growing, and rising of the nesting rates where before were scarce. Socially, the communities have appropriated of program, strengthening their sense of belonging and acceptance, of a specie which previously was unimportant or undesirable. In the future we look forward for the proper use of some of the specimens born from the previously released ones.

RESUMEN: Desde el 2004 la Corporación Autónoma Regional del Atlántico (CRA), desarrolla el programa de conservación manejo y uso sostenible de sus humedales. Su principal estrategia es la reintroducción de miles de individuos de babilla (Caiman crocodilus fuscus), respetando la estructura de las poblaciones naturales. El programa cubrió 8 humedales del departamento (c.a. 24,000 ha) e involucró a 13 comunidades y de acuerdo con los resultados se ha ajustado, consolidando algunas comunidades, y proponiendo la integración de otras especies del humedal al manejo propuesto por la CRA. La empresa privada (Zoocría) suministró los neonatos (13,819) y subadultos (5,289). Los primeros se entregaron a 138 mujeres de las comunidades quienes los cuidaron durante un año, recibiendo US 0.30 mes/animal mantenido en buenas condiciones; los segundos fueron liberados en los humedales luego de cumplir los protocolos apropiados. Los monitoreos de los ejemplares liberados son realizados por los pescadores, los resultados iniciales determinan una buena adaptación de los individuos, establecida por su condición física, crecimiento, y aumento de anidaciones donde antes eran escasas. Socialmente las comunidades se han apropiado del programa, afianzando su sentido de pertenencia y aceptación, a una especie que anteriormente les era indiferente o indeseable. En el futuro se proyecta, el aprovechamiento de algunos de los individuos nacidos de los ejemplares liberados.
INTRODUCTION

Since the year 2004 the Corporación Autónoma Regional del Atlántico (CRA), develops the conservation, sustainable use and management program in its wetlands. Its main strategy is the reinsertion of thousands of babilla individuals (*Caiman crocodilus fuscus*), coming from the repopulation quota established in the Colombian law which corresponds to the 5% of the annual production of each farm. In practice, not all of the individuals obtained in the repopulation are released, many of them were negotiated with the entrepreneurs as a previous agreement with the environmental authorities. There are several reasons for this, but they mainly correspond to the high costs of the release logistics and the characteristics of the animals in matters of the morphometrics, sex and sanity. Many of the farm animals are only males because the farms program their incubators to obtain only this sex looking forward to greater and faster growth.

The general objective of the project has been: to establish a conservation, sustainable use and management program of some wetlands in the state of Atlántico through activities that allow the organizing of the environmental offer of the system, to improve the quality of life of the communities that depend on them.

Initially there are 6 municipalities involved in the state and the activities are carried out with 13 communities in 8 wetlands.

Table 1. Municipalities, communities and wetlands where the conservation program initiated. The presence of the communities and the reached areas have a coverage wider than the 60% of the state wetlands.

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<td>Palmar de Varela</td>
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Until now there have been 14,306 individuals, 5,254 sub-adults and adults in sizes comprised between 90 and 120 cm long aiming to do a following and study the reflected adaptation in the reproductive events, and the corporal state. Additionally there were 9,052 hatchlings, in sizes comprised between 25 to 40 cm, delivered to 138 women in the community so they could rear them in concrete pens installed in the backyards of their houses. After 12 to 18
months of management the individuals were in a range between 60 to 85 cm. They were evaluated, selected and released after accomplishing the appropriated protocols. The women received US 0.30 month/animal kept in proper conditions, which provided them up to 30 US per month.

**METHODOLOGY**

The whole program was elaborated designing 4 main strategies which complemented each other so there could be a proposed management of the resources by means of the community.

1. **Strategy for the recuperation and habilitation of the wetland.**
   
a) Definition of the water bodies.

b) Identification of the main causes of the deterioration and loss of biodiversity through the application and analysis of surveys.

c) Minimization of the polluting loads poured directly to the water bodies and control of their sources, with the purpose of guaranteeing the proper quality of the hydric resources.

d) Reforestation of the tributary micro-basins and the water bodies and its cushion zones.

e) Arrange a conservation plan for the cynegetic species of the area of influence of the water bodies.

2. **Strategy of action- participation**

a) Reforestation of the tributary micro-basins of the water bodies and its cushion zones.

b) Cleaning, dismantling and recovery of the access canals in the water bodies and the contention walls.

c) Breeding of hatchlings. To develop this task several housewives from the communities were trained and organized, this is how in the backyard of every house a concrete mobile pen was installed with the capacity to house 100 individuals for ten moths.

d) Verification of the nesting areas: fishermen were trained in the recollection, transport of nests and *ex situ* management.

e) Construction and management of the incubator: this activity has not been developed yet.

f) Monitoring and following of the released individuals. Interested members of the community were trained and interviewed so they could identify, capture and measure the individuals in night journeys. The payment was established as working days.

3. **Strategy to identify the factors that cause damaging and loss of biodiversity of the studied wetlands.**

   a) Swamp characterization and its terrestrial areas.

   b) Study of the species’ population status.

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1 Design developed and approved by the experimental Project in Gambote, Bolívar. Fundación BIODIVERSA.
4. Strategy of repopulation and/or reprovision.

a) Selection of the people in charge of the hatchling breeding.
b) Construction of the needed infrastructure for the hatchling management.
c) Determination of the ecosystem’s carrying capacity.
d) Training in the individual management.
e) Morphometric and population following of the managed individuals in confining.
f) Establishment of a census and preliminary structure of the resident babilla population.
g) Establishment of the geographical origin of the individuals to release.
h) Obtaining the individuals to release, sex identification and size establishment.
i) Physical and sanitary analysis of the individuals to release.
j) Establishment of the quarantine and complementary measurements if necessary.
k) Marking of the individuals and training of the community in this activity.
l) Marking through scale cut.
m) Release and following of the individuals.

RESULTS

Animal selection criteria

The selection and marking process of the animals was done by choosing healthy individuals, those who did not present conjunctivitis, skin diseases, respiratory infections, malnutrition and malformations.

The delivered sub-adults have a size comprised in the range of 90 to 120 cm long in total and the selected hatchlings oscillated in sizes comprised between 25 and 40 cm long.

Introduction of invasive or alienigen species.

One of the mistaken alimentary politics in many countries shows in the promotion and introduction of foreign species hoping to obtain great amounts of bio-mass that help reduce hunger in its regions, using as arguments the high reproductive or growing rates of certain fish species. This is how species like the trout, salmon (Salmo spp, Onorhynchus spp), tilapias (Oreochromis spp, Sarotherodon spp, and Tilapia) perches (Perca spp) amongst other species arrived to tropical countries, species which once installed in their new habitats dedicate to compete without opponent for food, devouring the native species and becoming potential plagues that diminish the natural biodiversity in the areas, and in many occasions they cause the extinction of valuable species. In our case, we find the transplant of an endemic fish from the Orinoquía and Amazoía called cachama (Colossoma spp) which develops well in the water bodies where it’s released, because it easily replaces fruits and seeds that obtains in the flooding forest and that are its natural diet for an omnivore one. Nevertheless in the Caribbean lakes these flooding processes do not take place and the species has to feed from anything it finds which can replace its natural nourishment. In the studied wetlands we have analyzed the stomachs of some of these fish and found that their main content corresponds to the apple snail (Pomacea spp) which is an important feeding item of the babilla during its whole life, but mainly during the first months. Until now we can’t relate the presence of the cachama with the diminishing of the snail population but we can evidence their fierce appetite for this prey. The studies will establish the potential risks
of the introduction of this specie, not only for the babilla populations, but also to the Snail Kite (*Rostrhamus sociabilis*) and in general for the stability and well functioning of the wetland because the diminishing of the snail populations would ease the expansion of the aquatic vegetation (*Eichornia spp*) from which the *Pomacea* feed, accelerating the eutrophication of the wetlands.

**Released individuals**

The sex relation, temporally established amongst the released individuals, was of 1.6 males per female. During the next months the proportions to the ones found in nature, 1/1 male-female, will be adjusted.

The following information comes from the swamp San Juan de Tocagua where the greatest amount of information was found and the best understanding from the community was acquired. The captured individuals presented a range between 0 and 4.2 cm, after 74 and 183 days released (n=35), amongst this data, the males had an average growth rate of 1.76 cm and the females 0.69 cm and the total for the sample was of 0.87 cm. In general there were observed healthy animals, together with others adapted to the environment.

In relationship to the size of the nesting’s, there could be established that from a total of 20 nests collected, 16 have between 17 to 20 eggs. Which coincide with the size of the females and their age, because most of them correspond to young females, just as the number of fertile eggs per nest (n= 20), with a range of 14 to 23 fertile eggs per nest, allows to assume a good relation of sexes, because it complements with the fact that 15 nests (n=20) did not present sterile eggs.

**Nests record in San Juan de Tocagua**

1. In the year 2006 in June there was a nest reported in the swamp of Tocagua.
2. In the year 2007 and subsequently to the releases of the individuals of the conservation program, a nest was reported in June, 10 nests in July and 9 in August.
3. In the year 2008 20 nests were reported in June without counting August, September, and October to end the season, which presents us a favourable outlook to the middle-term development of a management plan of the specie by the community.

**Survival of the hatchlings delivered to the protector mothers for their care.**

In the municipality of Santa Lucía the total survival rate was of 23.8%, this can be attributed to the lack of experience of the community in the handling of the animals, situation that was solved in the other programs in Palmar de Varela and San Juan de Tocagua where the survival rate were of 80% and 89.2%, respectively.
Variation in the number of beneficiaries of the project.

The beginnings of the program were as ambitious as expected, however in the rural realities of the underdevelopment in which they struggle, with equal magnitude, traditions, unsatisfied basic needs, money in the hands of the landowners, political interests, mistakes in the law and norm expeditions, together with the indifference of the government make the development of a program that combines the theoretic expectations with the practical expected results almost impossible to accomplish. This is why in Colombia, with counted exceptions, wetlands are seen as more than potential areas to agriculture that areas destined to the preservation and the sustainable use of the biodiversity that lay there. Just as in many other regions of the planet, the wetlands are transformed into agricultural lands and then into livestock areas through a process of dryings and sedimentations done artificially by the members of the same communities that, encouraged by the landowners after offering a generally bad paid job, accomplish their objectives. The constant changes in the political environmental interests of the administrative entities of the biodiversity turn administration priorities to forgotten processes when changes appear in the directors of those entities, unless several of these variables get together with the same interests to accomplish this objective. In the case of the Corporación Regional del Atlántico (CRA), the orientation of the wetland conservation program has kept the same with a few changes since the year 2004 thanks to the firm conviction of the private enterprise (captive breeding farms) and the directors of the corporation, who have seen in the sustainable development a valuable element to achieve the welfare of the communities and improve the quality of life by the intelligent use of the biodiversity. This also resumes in an efficient social control that can become an important political capital in the take of decisions and in the continuity of the regional environmental politics.

The program initiated in the year 2004 directly benefiting 351 members of the community, in the year 2007 this number decreased to 193, and nowadays there are 150 people, from two communities being directly benefited. Some of the reasons for this decrease were mentioned above, even when the vocation of the communities also counts in this process, the closer they are to the big urban centres, the harder it is to keep the interest for the sustainable management of a biodiversity that they don’t know any longer and with the one they relate in a distant way. As a matter of fact, this evaluation was part of the job, and its initial results allowed us to redesign and cut the program in some areas and communities looking forward to strengthening others which allow, in middle-term, to serve as a convincing example to resume the processes with the more difficult communities.

One of the main conclusions of this program is the importance of the strength and the interest of the private enterprise in the accomplishment of the objectives; this can be, without doubt, the most important element of the conservation. When the government does not act, the interest of the private enterprise is decisive to achieve an alliance that can be translated in norms and fulfilment. Later the social control and other influencing elements in the conservation will appear.

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Scientific and administrative progress of the Captive Breeding Programs of *Caiman crocodilus* and *Crocodylus acutus* in Colombia.

Dirección de Ecosistemas
Ministerio de Ambiente, Vivienda y Desarrollo Territorial

**ABSTRACT:** The importance of biodiversity, its conservation, sustainable use and benefit-sharing, are guiding principles of the environmental policies of Colombia. Within this framework, it is recognize that the sustainable use of biodiversity constitutes an important strategy for the conservation of the natural heritage and for the sustainable development of local communities.

In the last two decades, a number of productive systems in *Caiman crocodilus* and *Crocodylus acutus*, have consolidated in Colombia, heightening the importance of this productive sector in the country. Taking into account the significance of the captive breeding programs of *Caiman crocodilus* and *Crocodylus acutus*, the Ministry of Environment, Housing and Territorial Development and its Research Institutes, have undertaken actions towards the improvement of the programs ensuring the sustainability of the wild populations, the generation of economic and social benefits and as well the compliance with national and international regulations regarding the production and trade of goods derived from these species.

Thus, we present the implementation progress of administrative and legal aspects that regulate the captive breeding programs of *Caiman crocodilus* and *Crocodylus acutus* in Colombia, as a joint effort of the public and private sector in Colombia.
Progress of the National Programme for Conservation and Sustainable Use of Crocodylia in Colombia

Instituto de Investigaciones de Recursos Biológicos Alexander von Humboldt

ABSTRACT: In recent years, the directions and guidelines for environmental policy in Colombia, have sought to incorporate sustainable use of components of biodiversity, recognizing that the rational use of them is a key part of a strategy of conservation and a driver of regional economies, which brings benefits to local communities. In this context, the Programme for the Conservation and Sustainable Use of Crocodylia in Colombia, provides a general framework that defines the main action lines to be undertaken by the national environmental authorities, the scientific community, the private sector, local communities and other actors committed with the sustainable use and conservation of crocodilians in Colombia, in particular with *Caiman crocodilus* and *Crocodylus acutus*. The main action lines of the Programme will be presented, covering scientific, technical, environmental, social, economic and legal aspects, among others.
Management of caiman in the Brazilian Amazon: A case study of the Mamirauá Reserve.

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ABSTRACT: The recent history of use of crocodilians in the Brazilian Amazon includes a period of widespread overexploitation for skins in the 1950s and 1960s, followed by recovery of caiman populations after the prohibition of all commercial hunting in 1967. With the increasing abundance of spectacled and black caiman in many parts of the Amazon a new phase of commercial exploitation began, this time for sale of the meat which in some areas has become an important source of income for riberinho communities. Nevertheless, hunting of caiman and the sale of their meat remains illegal in Brazil. As a first step towards the development of a legally, managed caiman hunting program, in 2004, the government of the state of Amazonas implemented an experimental harvests of caiman in the Mamirauá Sustainable Development Reserve (MSDR). The MSDR was chosen for trial management efforts because it was known to contain a large population of caiman and had been the site of basic research on caiman population biology by Da Silveira and colleagues since the mid-1990s. Now, four years since the beginning of the experimental management program, we review and evaluate this initiative both in terms of caiman management and as a potential legal economic alternative for local communities.
Caiman Nest Monitoring by Local Communities in the Piagaçu-Purus Sustainable Development Reserve, Amazonas, Brazil.

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ABSTRACT: The lower Purus River in Brazil, the site of the Piagaçu-Purus Sustainable Development Reserve (PPSDR) is likely the largest source of wild-harvested crocodilian meat in the world. We estimate that >100 tons of dried-salted caiman meat originates from this region annually. While all hunting is currently illegal, the establishment of a managed caiman harvesting program for the PPSDR is being studied by the Instituto Piagaçu and local authorities. A prerequisite for the initiation of harvest is the implementation of a monitoring program that provides useable indices of population trends. In addition to direct measures of abundance and size-class structure from night-light surveys, in 2007 we implemented a community-based program to monitor the numbers of nests in specific areas of the PPSDR. Between 26 and 29 September 2007 we trained residents of communities in the PPSDR and two other Sustainable Development Reserves to collect data on location of nests, using hand-held GPS the people to collect relevant information on caiman nests. During a subsequent ten days period, four residents of the SDR-PP searched for caiman nests in different sectors of reserve. A total of 301 nests (19% Melanosuchus niger the rest Caiman crocodilus) were encountered adjacent to 51 water bodies. In addition to nest location, nest monitors recorded information on habitat, nest size, and the presence of eggs and attending females. In addition to being a powerful monitoring tool, information on the spatial distribution of nests in the PPSDR will be important for the proposing areas of zoned usage, particularly the establishment of no- hunting zones in important nesting regions. The data gathered will be used for the elaboration of a management plan for caiman population in the PPSDR.
ABSTRACT: The “Broad-snouted Caiman” was categorized in Bolivia as critical (CR A1cd) and commercially extinct. We elaborated a Management Plan for *Caiman latirostris*, through an evaluation of the status of their wild populations during the dry seasons of 2004 and 2005. Also we conducted structured interviews to local socioeconomic actors, relating economic activities, perception and attitudes toward this species. We adjust their distribution area in the country. The average abundance was 6.17 individuals/km of side and marginal species population structure or overexploited, confirming their threat status. The meetings carried out with the governmental and socioeconomic institutions of Villamontes, Yacuiba, and Bermejo municipalities showed that the major conflict between alligator and human populations are related to accessibility and availability of water sources, due to human population's growth and has water unavailability in this arid ecosystem. Capacity building programs, for control and monitoring are presented in each municipality for this species conservation. However, this effort may not be achieved without political and economic support of departmental and municipal management, of this wildlife resource.

INTRODUCTION

The wildlife in Bolivia had and currently has a great economic value, although the real contribution of this resource to the economy is underestimated by conventional valuation systems that already lacks commercial fitness, with some exceptions as a species whose pelts are worth commercial (Ojasti 2000, Townsend 2002). The skins economic value of these species led to their indiscriminate hunting. An activity that began intensively in 30s of the twentieth century, with the hunting of alligators, as black caiman (*Melanosuchus niger*), subsequently extended to yacares (*Caiman latirostris* and *Caiman yacare*), londras (*Lontra longicaudis enudris*), cats (*Leopardus, Oncifelis, Puma* and *Panthera*) and peccaries (*Pecari tajacu tajacu* y *Tayassu pecari albirostris*) (Aparicio and Rios 2004). This process continued before General and Permanent Veda declaration in 1990 (MDSPVMARNDF-DGB 2002).

The first important reference of Bolivian caimans and yacares, comes from Medem (1983) after that, King and Videz-Roca (1989), perform the second national alligator distribution inventory of and its population structure in some localities. Ergueta and Pacheco (1990), presents a diagnosis of 5 species of crocodiles with data on their distribution and ecology.

Information on *Caiman latirostris* is restricted to general studies on the alligators in Bolivia. According Medem (1983) they were distributed as far as Pando Department, while King and
Videz-Roca (1989) reported them only in Pilcomayo River area, considering this species commercially extinct in the country. The only previous work specific reference of this species in Bolivia, is the study of their Chaco region conservation status made by Pacheco and Llobet (1998). The authors confirm their endangered status, however they consider a possible recovery in a natural way, if the anthropic pressure situation decline, and for that they proposed an Action Plan, that never been implemented. Neither generated specific process for species conservation, most on the contrary has increased the pollution of major river tributaries of the area, as Pilcomayo, Bermejo and Grande de Tarija rivers. In the area have continued but in reduced levels the trade in meat and skins into neighboring countries, generating an unquantifiable poaching.

At international level CITES, believes that this specie qualifies to be included in "Appendix I". In our country Pacheco and Aparicio (1996) categorized this species in "In Danger" category. Aparicio (2003) considered this is the most threatened species of reptile in the country and categorized as in critical condition (CR A1cd).

**STUDY AREA**

The study area is located at SE Bolivia, in Tarija department, of where they have assessed water bodies in three provinces.

![Figure 1. Localities of evaluation in Gran Chaco province, Tarija - Bolivia](image)

Gran Chaco Province, in 2004, has an area of 17,428 km² and altitudes range of 200 to 600 m.o.s.l. (Figure 1). This zone is included in Gran Chaco ecoregion Presents warm steppe
climate, with very dry and hot winters, the temperatures are between 43 °C and -7 °C. The summer rains (December to March) are torrential, reaching about 780 mm per year (Ibisch and Merida 2003, Montes de Oca 2005).

Figure 2. Evaluated Localities in Arce and O’Connor provinces, Tarija - Bolivia

Arce and O’Connor Provinces, in 2005, with altitudinal range between 180 to 550 m.o.s.l. (Figure 2). Most water bodies assessed in this area, correspond to Chaco Serrano ecoregion and only two to Gran Chaco ecoregion. This area has mesothermic hot and dry climate in winter, with annual temperatures between 20 and 24 °C. The annual rainfall range of 1000 to 2000 mm, with approximately 6 to 7 arid months per year. (Ibisch and Merida 2003, Montes de Oca 2005).

AIM

General objective

To know, the *Caiman latirostris* population status, in natural distribution areas in Tarija-Bolivia.
Specific objectives

- To determine, population abundance and population structure by size class of this specie in Tarija.
- To identify, species natural distribution areas in Tarija
- To determine, the frequency and type of use of “yacare” by local people, as well as relevant specie information (time and nesting areas, hatching time, number of eggs per clutch, etc.) through structured interviews.
- To establish, the potential distribution area of Caiman del Chaco (Caiman latirostris) as tool for identifying priority areas for their populations conservation and monitoring
- To develop, a management plan for population recovery and conservation

METHODOLOGY

Due to extensive area of study, fieldwork was conducted during dry seasons in 2004 and 2005. The first field campaign was conducted from June 10 to July 11 in 2004 in Gran Chaco province of Tarija and the second from August 24 to September 5, 2005 in Arce and O’Connor provinces of the same department.

Abundance estimation of the population

Direct counts were conducted at night, during dry season, taking advantage of animal populations concentration in water bodies, caused by low water level (Aparicio 1997, Ojeda Leon et al. 1997, Pacheco 1993, Llobet and Aparicio 1999, Rios 2004).

Under this methodology, we walked around all water bodies perimeter, preferably on moonless nights. When this was not possible, we waited dark hours in moon nights. We counted, in each water body using a rubber boat or wooden barge; both boats were driven to rowing with constant speed. With help of Maglight flashlight of 6 V we registered all found individuals along route (Godshalk 1994, Velasco and Ayarzagueña 1995, MARNR - Profauna - UCV 1996, MARNR - Profauna - UCV 1998, Llobet and Aparicio 1999, Rios 2004).

In water bodies, of where it was not possible to sail, walks were held parallel to the shore, trying to cover entire perimeter. The distance in this case depended basically on accessibility, but at least we try to cover 1Km of perimeter (Llobet Aparicio and 1999, Rios 2004).

Calculating area and perimeter of the evaluated water bodies

The water bodies were georeferenced during day, with help of Geo Positional Satellite (GPS) GARMIN 12 and its perimeter was delimited in canoe or walking around them, taking a point of georeferencing (UTM) approximately every 50 meters (Llobet and Aparicio 1999, Rios 2004). Based on this georeferencing we calculate the area of each water body (ha. of water) and its perimeter (km. from shore), using the processor maps WINDOWS Map Maker PRO VS 2.3. Efforts were made, trying to distance of georeferenced points to real shore, in the different water bodies, never ever assessed 50 cm. Not to make any correction at the time of calculating areas and perimeters.
Population Structure

To determine the size of population structure by “yacare” size, in each sighting sought greatest possible approach to estimate the total length (TL) of each individual (from the tip of the snout to the tip of the tail). If the animal’s body was not completely visible, TL was estimated by the size of his head, which is part of the body that usually is visible in the water.

With these data “yacares” were classified into one of four size categories considered for this species (A. Larriera 2004, Yacaré Project, Santa Fe - Argentina, pers.com.): Class I, up to 50 cm; Class II, 51cm to 139 cm; Class III, 140cm to 179 cm; Class IV, more than 180 cm.

When TL was not possible to estimate, the animal was registered as eyes only (EO) (Godashalk 1994, Velasco and Ayarzagueña 1995, Llobet Aparicio and 1999, Rios 2003).

Others data included

1) Environmental data: average temperature at 1 m above the body of water surface at 10cm of deep, wind speed, cloud cover and moon phase. Both the environment temperature as the water was recorded with a thermometer Oakton Temp 5 Acorn Series. The wind speed was measured with an electronic anemometer Kestrel 1000
2) Physical data of water bodies: depth, macrophytes coverage and “palizada” (remnants of trunks and branches of trees).

Interviews

The populations Caiman yacare conservation, depends of changes in attitudes and perceptions of local residents. To obtain information over practices in Caiman latirostris use and hunting customs of local people, structured interviews were conducted (Bernard 1994). The interview was applied only once every interviewed and notifying in advance the goal of the interview (Fillion 1987).

Were selected key informants in each community, usually authorities or recognized persons and respected within the community, knowledgeable of the place and environment.

The interviews guide, was developed to aboard the following topics: Relative abundance and habitat use of the species; perception and attitude towards the species; biological knowledge; and resource use.

Modeling the potential distribution of the chaco yacare

To model the potential distribution area of chaco yacare (Caiman latirostris) we used MAXENT software (Phillips et al. 2004, 2006). We used georeferenced points of counts of sites (N = 58), except those in which there was not any individual. The data were cleaned based on criteria of altitude and political limits, for which data over the 500 m above sea level and about the limits of Bolivia with Argentina and Paraguay were eliminated (n = 6).
We used layers of information with a resolution of 1 km. We worked with seven layers of environmental data that were generated in the GIS software DIVA 5.4 (BIOCLIM 1, BIOCLIM 2, BIOCLIM 3, BIOCLIM 4, BIOCLIM 12, BIOCLIM 14, and BIOCLIM 15). Other layers of information used to model the range of chaco yacare were the map of vegetation from Navarro (2007), DEM, exposure, dominant soil, herbaceous coverage, and coverage of bare soil generated in the Arc View 3.2 software.

**Data analysis**

Both the abundance and the population structure were calculated excluding individuals of first year (Class I), because at this stage of life the survival rate is about more than 20% of individuals who born, many authors do not consider it appropriate to include this class to determine the characteristics of population because the strong monthly changes that suffers (Micucci and Waller 1995, Velasco and Ayarzagueña 1995).

For the analysis of population structure we used the comparison of histograms obtained with the work of Velasco and Ayarzagueña (1995) for *Caiman crocodilus* in Venezuelan plains. Despite the limitations of this study, because it is another species of alligator, Barahona et al. (1996) and Prado (2005) used to describe population structures of *C. latirostris* and other species of alligators.

The abundance and population structure were analyzed by hydrographic sub-basin, comparing populations of yacaré in the sub-basin Pilcomayo River with populations of the sub-basin Bermejo River. Applied U of Mann-Whitney test (Siegel and Castellan 1995).

We do Spearman correlation test between data of environmental parameters considered and the abundance recorded. In the case of environmental discrete variables (moon phase and clouds) we used the Krukal-Wallis test ($a = 0.05$)

For interviews analysis a numeric code was applied to each question separately, identifying the answers in all surveys and assigning a number that varied according to how much the kind of responses, but always used the "0" when the respondent said he does not know the answer to. This was able to obtain the percentages and frequencies of responses to different questions.

**RESULTS AND DISCUSSION**

We evaluated a total of 54 water bodies of 42 belonging to the sub-basin of the Pilcomayo River, 12 in the sub-basin of the Bermejo River.

**Sub – basin of Pilcomayo River**

**Abundance**

In the sub-basin of Pilcomayo River we recorded a total of 289 individuals at 29.21 km from shore travelled, of which 137 belonged to Class I (47.40%). The total abundance of yacaré for this sub basin was 5.2 ind. / km from shore by the abundance body of water varies from 0.00 to 46.81 ind. / ind. Km travelled shore.
During the evaluation was clear preference of these reptiles for calm waters, as reported by other authors (1983 Medem, Micucci and Waller 1995), because the highest abundance values were recorded in ponds, “atajados” (dike) and artificial ponds, while that four counts in Pilcomayo River had an abundance of 0.00 ind. / km from shore.

Waller and Micucci (1993), and Prado (2000), reported the same trend in evaluations conducted in Chaco provinces and Corrientes in Argentina. These authors believe that habitat structure is responsible for this trend, since yacaré prefer to inhabit temporary water bodies, with little depth and abundant vegetation cover.

Pacheco and Llobet (1998) reported an abundance of 3.3 ind / km from shore in water bodies at the same sub-basin, a less value that found in this study. However, the validity of this comparison should be considered relative and not conclusive, that only three of 22 water bodies tested by these authors, were repeated in this study. Likewise, the covered area during field work and time of year's count was different in these two studies.

Despite the distribution areas of this species in Bolivia, would be considered as marginal, the abundance of C. latirostris found in Pilcomayo River sub-basin in Bolivia, is not very different from reported rates in regions closer to the center of its range, except for abundance recorded by Waller and Micucci (2000) (in Prado 2005) of the 30.5 ind / km from shore in the system Iberá-Argentina. However, it is necessary to mention a major difference in terms of availability and quality of habitat for Yacaré between the Argentina region and Bolivia Chaco region.

**Population Structure**

A total of 154 animals (53.29%) could not be assigned to any class size, so were registered as having eyes only (EO). This high percentage is because many of the counts were done on foot because the water was not deep enough and did not allow navigation; this made it impossible to estimate the size of various animals.

Therefore, the population structure of C. latirostris for this sub basin was calculated on the basis of 135 individuals, 64 belonged to the Class I (47.41%). The histogram shows a population that is dominated by young individuals (Figure 3).

![Figure 3. Histogram of the population structure of Caiman latirostris in Pilcomayo River sub basin in Tarija (n = 71).](image-url)
This structure shows a distribution form of type "stair", with a proportion of Class IV below expectations (<15%), according to Velasco and Ayarzagueña (1995) caused by selective hunting of adult individuals, typical of stocks subject to sustainable harvests for several years. This result is reinforced by the study of Pacheco and Llobet (1998), which also reported a population structure in the form of a "stair" with histogram that presents fall in the form of negative exponential curve, typical of populations over exploited. Attributed primarily to strong pressure from hunting on such until the 1980s (Prado 2005).

However, Bolivian Chaco would be an area near the boundary of natural distribution of this species, is likely to be marginal and population in this case the natural form of distribution histogram would be kind of "stair" without the cause of it is the removal of individuals (Gorzula 1989, Rios 2004).

Environmental data
In general environmental variables as average temperature (ETEMP), water temperature (WTEMP) and wind speed (WSPEED) during evaluations in this sub-basin were fairly stable (Table 1).

Table 1. Spearman correlation coefficients and test results for the Kruskal-Wallis analysis of the relationship between environmental variables and abundance in the sub-basin of the Pilcomayo River

<table>
<thead>
<tr>
<th>Variable</th>
<th>ETEMP</th>
<th>WTEMP</th>
<th>WSPEED</th>
<th>Vegetation coverage</th>
<th>Cloudiness</th>
<th>Moon phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance</td>
<td>R=0.188</td>
<td>R=0.006</td>
<td>R=0.335(*)</td>
<td>R=0.211</td>
<td>X² = 6.52</td>
<td>X² = 0.33</td>
</tr>
<tr>
<td></td>
<td>P=0.259</td>
<td>P=0.971</td>
<td>P=0.046</td>
<td>P=0.175</td>
<td>gl = 5</td>
<td>gl = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P = 0.26</td>
<td>P = 0.85</td>
</tr>
</tbody>
</table>

* Significative correlation

We found negative correlation between abundance of *C. latirostris* and WSPEED. Prado (2005) notes that this correlation could be explained from the fact that the movement of air masses generates waves with amplitude proportional to wind intensity and the water mirror presence of these. This fact would decrease the length of stay of yacares on surface; however this not affect the environmental variable population counts.

Interviews
We were conducted 24 structured interviews, of which 91.6% were males and 8.3% women in Yacuiba and Villamontes municipalities of Gran Chaco province, with ages ranging between 26 and 55 years. Most of them were farmer.

More than 33% of those interviewed mentioned that they had last seen *C. latirostris* 1 week ago or less (Figure 4). Furthermore, according to their perception of yacarés abundance variation in the past 10 years, most noted that currently there would be more or equal amount of yacaré making 1, 5 and 10 years ago.
Perception and attitude towards the species
Most of our interviewees (45.8%) gave to this question double response, saying that Yacaré is harmful because attacks the small livestock (goats, pigs and cows’ offspring), but felt some sympathy for the species (Figure 5). However, 92% indicated that they hunted this animal to avoid the danger of an attack, especially if found in watering – places for cattle near home.

They also noted that if it was youth or newborns they left because the infants did not represent a real risk to them or their livestock, but if it was an adult (> 140 cm) the animal elimination was the unique option.

Biological knowledge
According the interviewees yacare is founded in ponds and in artificial ponds preferably, but some said that these reptiles were equally founded in any water body (Figure 6). Coinciding with partial results obtained in field evaluations and with results by Prado (2005), Scott et al. (1990) and Waller and Micucci (1993) in studies of habitat preference in Argentina.
Figure 6. Type of *Caiman latirostris* favorites water bodies, according Gran Chaco Province informants, in Pilcomayo River sub-basin, Tarija (n = 24). The proportions are not adjusted to 100% because the respondents chose more than one option.

A total of 18 respondents (75%) were able to give some reference when asked about the time of egg-laying and hatching of them. But the answers are very diverse and even contradictory, so we do not consider reliable data provided (Table 2).

Table 2. Months of emergence of young yacarés (*C. latirostris*) according interviews in sub-basin of the Pilcomayo River in Gran Chaco province, Tarija department.

<table>
<thead>
<tr>
<th>Month</th>
<th>January</th>
<th>July</th>
<th>August</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proporción de entrevistados</td>
<td>22.2</td>
<td>11.1</td>
<td>16.7</td>
<td>5.6</td>
<td>27.8</td>
<td>16.7</td>
</tr>
</tbody>
</table>

These results show that local knowledge on reproductive aspects of *Caiman latirostris* is quite poor. Of the 18 respondents, just two referred that they had found yacare nest sometimes

**Resource using**

The most widely used part of yacaré, according to those interviewed, is fat for medicinal purposes (Figure 7), while the meat is used more as an input for the preparation of food for dogs. And the skin to draw up articles as leather crafts.

Figure 7. Parts of yacaré used by people of the Gran Chaco province, sub-basin of the Pilcomayo River in Tarija (n = 24). The proportions are not adjusted to 100% because the respondents chose more than one option.
Bermejo River Sub-basin

No records of yacare presence were prior to this study in Bermejo River sub-basin in Chaco, so the presented study data extend the range of this species in this Bolivia sub-basin

Abundance

During this sub-basin evaluations were recorded 52 individuals in 6.44 km from shore, 6 of whom belonged to Class I (11.54%). The total abundance for this sub-basin is 7.14 ind./km from shore, with an abundance of water body of 0.00 ind./km to 16.36 ind./km from shore.

The habitat availability in Bermejo River basin area is much lower than Pilcomayo River sub-basin, mainly due to strong intervention by anthropogenic effect of clearing large tracts of land for planting sugarcane and the strong contamination of water bodies as result of sugar mill activity, which removes their waste into the Rio Grande product of sugar and alcohol production.

Figure 8. Variation in the abundance of Chaco yacare in Bermejo River basin and Pilcomayo in Tarija department.

When comparing the total abundance of yacaré between sub Pilcomayo and Bermejo, through a test of U Mann-Whitney have not found a statistically significant difference (U= 185; P = 0.22; a=0.05), however the variation is more important in the Pilcomayo (Figure 8).
Population Structure
A total of 35 alligators (67.31%) could not be assigned to any size classes, so they were registered as EO. This percentage is even higher than achieved in Pilcomayo River sub-basin and is primarily due to same reason: all counts were conducted on foot because the water was not deep and did not allow navigation.

The population structure of *Caiman latirostris* in this sub-basin was calculated on the basis of 17 individuals, of which 2 (11.76%) were individuals in Class I. The structure of this population sizes shows a strong dominance of juvenile individuals Class II (n = 9; 60.00%) (Figure 9).

According to Velasco and Ayarzgueña (1995), this structure shows a form of distribution of type "stair", with a drop of negative exponential rate, caused by resource overexploitation. This structure differs of found in Pilcomayo River sub-basin that presents a linear-type fall. However, despite considering it is a marginal area of distribution of this reptile, the cause of the low proportion of adult individuals (Class III and IV) is probably result of strong negative impact of pollution and destruction of their habitat.

![Figure 9. Histogram of *Caiman latirostris* population structure in water bodies in Bermejo River sub-basin in Tarija (n = 15).](image)

Moreover, the Class I low proportion, joint with nests absence reports, the strong intervention, water pollution, and the low number of individual recorded during the counts suggest that this population is probably not reproductively active in the area, becoming a sink of wetlands and estuaries bordering Argentina, where habitats are available for the species, less intervened and polluted.

Environmental data
In general, the environmental variables as average temperature (ETEMP), and water temperature (WTEMP) during population evaluations conducted on waters bodies of this sub-basin, were fairly stable, except the wind speed (WSPEDD) with strong variations. We found a high positive correlation between WTEMP and WSPEDD (R = 0.804 (**), P = 0.005). However none of the environmental variables considered in the study showed a correlation with abundance in this area (Table 3).
Table 3. Spearman correlation coefficients and test results for the Kruskal-Wallis analysis of the relationship between environmental variables and abundance in Bermejo River sub-basin.

<table>
<thead>
<tr>
<th>Variable</th>
<th>WTEMP</th>
<th>ETEMP</th>
<th>WSPEED</th>
<th>Vegetation coverage</th>
<th>Moon phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundancia</td>
<td>R=-0.037</td>
<td>R=-0.098</td>
<td>R=-0.219</td>
<td>R=0.576</td>
<td>X&lt;sup&gt;2&lt;/sup&gt; 1.592</td>
</tr>
<tr>
<td></td>
<td>P=0.919</td>
<td>P=0.774</td>
<td>P=0.518</td>
<td>P=0.064</td>
<td>gl = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P = 0.21</td>
</tr>
</tbody>
</table>

The cloudiness variable was excluded from this analysis because all evaluations in this study area were conducted on nights completely cleared.

Interviews

Eight structured interviews were conducted in Bermejo (n = 6) and Padcaya (n = 2) municipalities in Tarija department. All those interviewed were males whose ages ranged between 15 and 55 years old. Attempts to interview women, but these refused to be interviewed saying they did not know this animal or that they had never seen.

The 50% of respondents were engaged in parallel with agriculture and cattle rising. The others were “subprefectura” or municipal authorities.

Unlike the results of interviews in Pilcomayo River sub-basin, only 50% saw them in week or less (Figure 10), with encounters with this species less frequent. Likewise when asked about their perception about the variation of *C. latirostris* abundance in the past 10 years, replied that there are now fewer yacaré individuals than 1, 5 and 10 years.

![Figure 10](image)

**Figure 10.** Time elapsed since last meeting with *C. latirostris* of the interviewees from Bermejo River sub-basin in Arce province, of the (n = 8).

Perception and attitude towards the species

In this region, apparently *Caiman latirostris* perception would be good, since 75% said it was an animal that pleased them and they believed it was an important element of occupied habitats, probably because the human population of this area is more urban (Figure 11). However, when respondents were asked to wonder if they hunted this animal or knew someone who did that in the area, 87.5% replied that people hunt for fear of these animals and to prevent family members or pets from aggressions.
Biological knowledge
As in Pilcomayo River sub-basin, those interviewed pointed out that this species was more frequently and in greater quantity in ponds (Figure 12).

The marshes were one of the lowest frequencies, contradicting reported by Prado (2005), Scot et al. (1990) and Waller and Micucci (1993). However, it is possible that accessibility and visibility falls sharply in the perception of habitat preference expressed by local residents and the abundance of these reptiles underestimates in marshes or water bodies with abundant vegetation cover.

The information on aspects of the natural history of this species was quite low, 5 of 8 respondents (63.0%) said not knowing anything related to yacare reproduction. Of 3 respondents who answered this question, 2 (67.0%) mentioned that in April offspring’s appeared in water bodies, but were contradicted by 1 interviewed (33.0%) stated that offspring’s appeared in November. None of those interviewed in this region reported the presence of nests in the area.
Resource use
Villagers interviewed reported only skin use (50.0%) and meat (50.0%).

Potential range of chaco yacare
The range of Chaco yacare in Bolivian territory has been reduced compared to the range estimated by Medem (1983) and potentially be found only in Plata Basin (Rios and Aparicio in prep.) (Figure 13).

The distribution of Chaco Yacare is restricted to Pilcomayo and Bermejo rivers, in south of Bolivia. Remain a priority to implementation of ensure population conservation programs in Pilcomayo River in Chaco region, since in this region will find the most representative range within national territory and the most abundant populations.

Figure 13. Map of the Potential *Caiman latirostris* distribution in Bolivia.

MANAGEMENT PLAN FOR *Caiman latirostris* POPULATION RECOVERY AND CONSERVATION IN TARIJA DEPARTMENT

The proposed Management Plan for population recovery and yacaré (*Caiman latirostris*) conservation will be developed in natural species distribution areas in Villamontes, Yacuiba and Carapari in the Gran Chaco province, the municipalities of Bermejo and Padcaya in Arce province and Entre Rios in O'Connor province, from Department of Tarija. Is essential social and political institutions support, while during the management plan execution in the region and economic contribution of Prefecture of Tarija.

Objectives of the Management Plan:
The overall objective of Management Plan, is to achieve recovery of Chaco yacaré wild populations (*Caiman latirostris*), with the greatest environmental, economical and social benefit.
The specific objectives to be achieved are:
- To establish, program of population recovery and to promote the species.
- Strengthen local institutions capacity for environmental conservation lie.
- To promote, understanding and appreciation of this wildlife resource at the rural and urban populations in this region through their participation in the management plan and awareness.

Programs
The management plan proposed, presents five programs and five sub programs with activities that should be implemented and developed in three years (2006 - 2009). The following is a summary description of these:

1. Management Program
This program implies that species will be subject to drivers decisions and manipulations, in terms to achieve this must combine research and conservation.

1.1. Sub evaluation program of "Yacaré" populations
For implement the program to protect and conserve during the first year (2008), the information will be used on the population abundance obtained from the different water bodies during the 2004 and 2005 prospecting. But for the next steps, should be performed their respective population assessment in 3 provinces involved in population recovery and conservation program.

The objectives of this Sub Programme are:
- To know regularly the behavior of yacares populations in relation to their structure and abundance in each municipality natural areas.
- To know regularly if in each municipality yacaré populations is increasing or decreasing.

1.2. Sub Development Program of the species
According to assessment of wild populations of this species made by the authors in 2004 and 2005, we can ensure that we can not carry out program for using without causing the disappearance of this species in the country, unless actions are undertaken to enable the increase of animals to replace those individuals who might be exploited in the future. These management measures must be implemented taking into account the environmental and socio-economic actors involved.

The objectives of this Sub Programme are:
- To increase C. latirostris population abundance in species natural distribution areas, in 6 municipalities involved in the program.
- To reduce mortality and increase the chances of C. latirostris offspring’s survival

1.3. Sub program of the species population recovery
The damaged population restoration is often the first stage of management for this eventual use. The population recovery is function of time, demands hard work and continued funding, especially in long-cycle species (Ojasti 2000), such as Chaco yacaré (Caiman latirostris).

This sub program is one of the most delicate program component and is really necessary scientific information about biological and ecological species characteristics in the area,
will start just the second year of implementation of this plan.

The objectives of this sub program are:
- To increase the species natural range in each municipality territory.
- To allow the recovery of Chaco yacaré populations in ecologically functional densities.

2. Protection and Control Program
The management of wildlife does not guarantee their availability in long term, given the economic and social conditions prevailing in the country, requiring combine actions directly related to management of species with measures to monitor the proper implementation of guidelines in this process.

The objectives of this program are:
- To ensure, compliance with the guidelines set forth in this Management Plan.
- To allow, the normal development and implementation of recovery programs, and promoting environmental awareness.
- Monitor the effect of human activity on yacare habitats and populations in each municipality.
- To control illegal hunting, illegal trade of the skins and sub products in each municipality.

3. Program for scientific research
Studies the biology of Chaco Yacare (*Caiman latirostris*) in Bolivia, not even been started. This aspect is so dramatic, in this assessment local people mentioned that this species reproduces twice a year, once every two years and even some local people mentioned that the specie reproduces all year long and there is no scientific efforts that allows give the correct answer to this question. With regard to the ecology of the species, we only have information on their distribution and abundance.

The objectives of this program are:
- To generate knowledge about biology and ecology of *Caiman latirostris* in Bolivia.
- To get scientific and technical bases to permit species conservation.

4. Monitoring Program
The goal of monitoring is to observe the progress of work according to plan and guide as the experience you get on the way.

This program, will record changes in *Caiman latirostris* populations subject to management over time, through systematized file on information provided by research projects and the respective technical reports from various sub programs and programs of Management Plan.

The objectives of this program are:
- Monitoring and evaluation of habitat extent and quality, where there is presence of the yacaré.
- Monitoring and evaluation of populations density and distribution in each municipality.
- Monitoring and evaluation of programs and sub programs proposed in this plan of conservation and population recovery.
- Have technical and scientific information - necessary to make the most effective measures for species conservation and management.
5. Training Program, teaching and environmental education

The future of species under management depends on the attitude that society and individuals involved have on the process of sustainable development. Without the participation and support of local communities, any conservation project is doomed to failure or at least is very complicated in its implementation, for this reason the training, environmental education programs are essential to achieve this support and with the other programs all of them are the instrument required to pursue the objective of the management plan.

5.1. Sub Training Program

Seeking to avoid mistakes that could commit actors related to yacares conservation in Tarija, we intend to give the necessary information, so that residents of municipalities involved may be direct participants in conservation and repopulation of *Caiman latirostris* process, strengthen their capacities to carry out management of species, which in future will enable them to make sustainable use of this resource with greatest environmental, economical and community benefit.

The objective of the Sub Program:
- To train different actors involved in Plan of Conservation and repopulation of Chaco yacaré, in technical - scientific, legal and organizational aspects, to ensure its proper development.

5.2. Sub education programs and Environmental Education

The implementation of this sub program must ensure a continuous process of transmitting information between various actors involved in preservation and promotion of *Caiman latirostris* in the region, allowing really count and timely information, to facilitate the authorities to make decisions and willingness of local residents.

The objectives of the Sub Program:
- Local residents are known to be involved directly or indirectly with the Management Plan for the Conservation and population recovery of Chaco yacaré.
- Achieve changes in local people attitude, not only with the species subject to management, but with wildlife in general, through the understanding of the importance of conservation and its usefulness in achieving sustainable development.
- To disseminate the objectives, actions and results of activities carried out within management of this species to communities of the municipalities involved in this plan directly and indirectly throughout the Department of Tarija.

CONCLUSIONS

a) It has expanded the range of yacaré (*Caiman latirostris*) in Bolivia, previously reported only for Gran Chaco province (sub-basin Pilcomayo) in Tarija department of to the provinces Arce and O'Connor in the same department (sub-basin Bermejo).

b) The abundance of population for sub Pilcomayo River is 5.2 ind. / km from shore, and for the sub- basin of the Bermejo River is 7.14 ind. / km from shore. Taking an overall average of 6.17 for the department about 6.17 ind. / km from shore traveled.

c) We did not find a variation statistically significant of the abundance of populations of
the yacaré between the two sub-basins evaluated in the department of Tarija, which it's probably because both areas are within an area of marginal range of the species. However the difference in terms of the number of individuals founded, greater product availability and quality of habitat in the basin of the Pilcomayo, suggest a difference biologically significant.

d) In both populations were found a population structure dominated by young individuals (Class II) and low proportions of adults in the Class IV, which it's probably because it is marginal populations. But in the case of Bermejo, we found a strong negative impact of anthropogenic activities on the habitat of this species.

e) Based on the abundance and population structure, found in these two areas of the department of Tarija, we note that the conservation of both yacare’s populations are seriously threatened.

f) The growth and expansion of human populations are causing conflicts between Chaco yacares and local villagers, especially use of aquatic habitats.

g) None of the climatic factors considered in this study appears to affect negatively the results of the counts.

h) The implementation of plan to population recovery and the conservation of *Caiman latirostris*, constitutes the only way to allow this species will not disappear from the national territory and in the future can make a rational use.

i) According to majority of respondents perception, the abundance of *Caiman latirostris* in Pilcomayo River region have increased over the past 10 years, whereas in Bermejo River region have declined.

j) In general, here is a good perception in both areas of study. However in Pilcomayo River region has seen a strong adults hunting activity as use practice (in some cases), control and prevention, which could adversely affect populations of this species.

k) Local knowledge on aspects of the natural history of this species is weak or nonexistent (in the case of Bermejo). That's probably because much of population of these two regions is migrant from other departments in the country, and others have long ago moved to urban centers losing contact with wild species.

l) There was not registered the presence of *Caiman yacare* in both of the sub- river basin evaluated in the department of Tarija, it is probably that in this region this species was founded in allopatry because of their greater plasticity on habitat requirements

m) The potential distribution area, of *Caiman latirostris*, in Bolivian “Chaco” are restricted to sub – basin of Pilcomayo and Bermejo rivers.


**ACKNOWLEDGMENTS**

We want to thanks to the Fundación PUMA and Conservation International – Bolivia (CI) who granted funding through the Initiative of Endangered Species (IEA) - Grants “Werner Hanagarth”. To the National Museum of Natural History (MNHN) and the Colección Boliviana de Fauna (CBF) for supporting the study. To the government institutions and municipalities in the region. Unidad Productiva y Agrícola (UPAB) – COFADENA, Federación Ganadera del Gran Chaco (FEGACHACO), la Organización Indígena de Capitanías Weenayek y Tapiete (ORCAWETA). To Dr. Alejandro Larriera y Pablo Siroski from the Yacare Project, Prov. Santa Fe, Argentina; to Ph. D. Jhon Thorbjarnarson, to Dr. Luis Fernando Pacheco and to another members from the Crocodile Specialist Group (CSG), for their comments and scientific publications provided. And to all those who in one way or another could make it possible the implementation of this study.

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ABSTRACT: Research on the ecology of the dwarf caiman, *Paleosuchus palpebrosus*, were initiated in the 1990’s in the area surrounding western Pantanal, while reproductive aspects have been studied in the Central Amazon since 2001. The main goals of the study are to evaluate the quality and problems regarding the conservation of the natural habitat in the areas surrounding the Pantanal. I found young and adult dwarf caiman and analyzed the impacts of habitat alterations on the heads of the six rivers e small rivers. The habitats visited were found to be in alarming condition, due to deforestation along the riverbanks, silting, industrial pollution, mining activities, urban sewage, human habitation, fishing and caimans poaching. Total destruction of the vegetation is being caused by agriculture, mainly soybeans and sugar cane to supply the ethanol factories. The dwarf caimans apparently resist to the pressures of habitat destruction as well as the enormous pressure of predatory hunting in these rivers in the surrounding Pantanal. However this may be due to the existence of pockets of pristine areas which act as source of individuals. The dwarf caiman could effectively act as flagship species for the conservation of the habitats and fauna to rivers surrounding the Pantanal.
Contingent Actions with Crocodilians of Chiapas, México.

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(museococodrilo@yahoo.com.mx)

ABSTRACT: Chiapas is one of the two states of Mexico that has the three species in the country (Caiman crocodilus fuscus, Crocodylus moreletii y C. acutus); however, into their distribution range cohabit with the human and it unchains different situations of negative interaction between both species. In a regular way, as part of a specific program of Crocodile Museum, there is a following and attention to such questions, using a strategy of immediate in collaboration with federal environmental instances, including a methodology of conscientization, environmental education and rescue of crocodilians. All that has promoted in lots of regions a better aware to solve these kind of events, where regularly and thanks to current reports we can attend an approximate of 80 to 100 contingent situations per year, with a success of 90% of the cases; the majority of the situations are focused to the presence of big size specimens, or occasions where human populations invades crocodilians territory and begin to appear specimens in urban areas where the community get scared, that’s why it is worth to know these kind of successful actions of conservations.

RESUMEN: Chiapas es uno de los dos estados de México que cuenta con las 3 especies del país (Caiman crocodilus fuscus, Crocodylus moreletii y C. acutus), sin embargo, dentro de sus rangos de distribución co habita con el humano y de ello se desencadenan diversas situaciones de interacción negativa entre ambas especies. De manera regular, como parte de un Programa específico del Museo Cocodrilo se da seguimiento y atención a dichos asuntos, mediante una estrategia de atención inmediata en colaboración con las instancias ambientales Federales, incluyendo una metodología de concientización, educación ambiental y rescate de cocodrilianos. Todo ello, ha promovido en muchas regiones una mejor conciencia para resolver este tipo de eventos, donde regularmente y gracias a los reportes actuales se logran atender en un promedio de 80 a 100 situaciones contingentes al año, con un éxito de hasta el 90% de los casos; en la mayor parte de estas situaciones se enfocan a presencia de ejemplares de gran tamaño, o situaciones donde la población humana ha invadido el territorio de los Cocodrilianos y comienzan a aparecer ejemplares en áreas urbanas donde asustan a las comunidades, por lo que vale la pena dar a conocer este tipo de acciones de conservación exitosas.
The reintroduction of the Cuban crocodile in Lanier Swamp (Isle of Youth, Cuba): asserts, failures and lessons.

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**ABSTRACT:** There are only two locations reported for the Cuban crocodile (*Crocodylus rhombifer*) in historic times: Zapata Swamp, in Cuba mainland and Lanier Swamp, in the Isle of Youth. Being virtually extirpated from the second location during the first half of the XX Century, the National Enterprise for the Conservation of Flora and Fauna (Ministry of Agriculture) started a restocking program in 1986, being the first step, the construction of a crocodile breeding facility: Cayo Potrero Farm, situated in the middle of Lanier Swamp. A first group of 600 individuals was released in 1994, being followed by successive introductions in the following years. Successful breeding, nesting, hatching, individual growth and dispersal among the reintroduced population have been documented by periodical monitoring carried out since 1996 up to the present. But also several negative human-originated impacts, such as poaching, have put in jeopardy the outcome of the whole operation. In this presentation we analyze, from the point of view of our experience, the importance of a correct, multi-approach planning of restocking operations, that takes into account not only biological or ecological, but also economic, educational and cultural factors of the local communities, and their possible involvement in the restocking project, their education and direct participation in the efforts and possible benefits.
The Marsh to Market Story:  
“How Sustainable Use of Crocodilians Benefits Commerce, Conservation and Communities”

Don Ashley

World trade in crocodilians has increased to more than 600,000 classic skins annually since 2004. This is 20% above the historical peak of half a million classic hides a year reached in the early 1960’s. Caiman skins lag below the historical ratio of 3 to 1 classic hides, but are nearing a million hides annually. With new management initiatives in Brazil, Bolivia and other Latin American countries at least 1.2 million caiman hides could be sustained annually by 2010.

The alligator continues to produce about 60% of the classic hide world supply, producing more than 350,000 skins a year. Louisiana now estimates the raw value of the alligator to exceed $60 million annually, with most of that value going to coastal Louisiana communities. As important, private landowners now earn more than 50% of their surface revenue (all income minus minerals, oil and gas) from the alligator, providing unprecedented value from a renewable natural resource of the marsh.

About 2000 Louisiana trappers participate in the fall harvest of 32,000 wild alligators and 55 alligator farms collect more than 350,000 eggs every summer. The economic benefit to coastal communities and economic incentives to conserve wetland habitat binds the alligator to the community culture. In turn, a community constituency respects the alligator, conserves the marsh and depends upon the annual income.

A conservative estimate puts the annual world classic raw hide value at $100 million. Tannery leather values would double this to $200 million and manufacturing of value added finished products is estimated to be at least $400 million. The retail value of finished classic products is at least $1 billion and when the market power of leading fashion brands like Hermes, Gucci Louis Vuitton, Chanel, and others are considered, the value is probably more.

The benefits to commerce through income, jobs and re-investment are relatively easy to document. The emerging benefits to wetland protection and recognition by private landowners of renewable resource values are just beginning to be realized. The greatest challenge may be to engage the manufacturing, retail and fashion house sector to fully accept their role in the sustainable use success story, particularly the opportunity to help economically sustain the trade and to further multiply community benefits -- which should include educational enhancements to rural communities.

While a $100 million a year classic raw value is a significant milestone, that value remains just 10% of a conservative $1 billion retail value. For the Marsh to Market story to successfully continue and ensure the trade remains legal, sustainable and verifiable, another chapter must follow -- certifiable trade, which will require the combined efforts of all market sectors—from the Marsh to the Market.
ABSTRACT: The Program of Commercial Use of Spectacled caiman in Venezuela is developed for 24 years, and they are characterized to present great annual variations in the harvest, the percentage of benefit on the capital inverted and in the cost of the fiscal rates. 1,393,803 caimans have been harvested and 1,354,990 has been exported. Four participant sectors in the Program are identified: Governmental, Producers, Hunters and Tanners and Traders. The Governmental sector has obtained benefits by collection to the National Treasure of 807,652 US$ and the Ministry of the Popular Power for the Environment of 11,231,524 US$. The producer sector has invested the amount of 18,034,710 US$, its income are 59,931,676 US$, which represents a 232% of the conducted investment. The tanners and traders have invested 58,404,724 US$, with income of 95,084,040 US$, which means a benefit of 63% of the investment. The hunters benefit has been of 11,979,172 US$. The registered total investment in the Program during 17 years (producer, tanners and traders) are 70,221,161 US$ and the income have been 132,714,434 US$, which means a percentage of 89% of benefit on the investment. The number of tanners and traders has varied per year in 6 to 10, the average of producers is of 329/year. The hunters we considered between 600 and 1,000 people/year. In this analysis the big importance is shown that the skins prices have by external factors to the national life, especially the wars, economic crises and the fashions. The Program of wild harvest is by its characteristics typically male, nevertheless, when new forms of use are developed, especially with the meat, the female participation will be preponderant.
Endogenous conservation of wildlife faced to the trade of crocodile organs in traditional medicine purposes in Benin (West Africa)

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ABSTRACT: The study seeks to understand the current distribution of crocodile species, the endogenous methods of their conservation and the trade of crocodile organs used in traditional medicine in Benin. 141 water-holes invading by crocodiles were visited. The 3 african crocodiles species exist in Benin: Crocodylus niloticus, Mecistops cataphractus and Osteolaemus tetraspis. Crocodylus niloticus was widely distributed (98 %). Depending on the localities, crocodiles were protected because they represent a divinity for certain some people and a totem for others. Such beliefs or customs are the grassroots of «endogenous conservation» and represent the most important method of crocodile conservation. This pact creates a relationship between crocodiles and people based on reciprocity and mutual respect.

Investigations on 33 local markets in Benin, Nigeria and Niger Republics shown that 17 organs and products of crocodile were sold: skin, muzzle, legs, bone, fat, eggs, egg’s shell, anus, dropping, teeth, bile, liver, lungs, heart, penis, stones contained in crocodile stomach and alive animal. Crocodile organs cost twice more expensive in Nigeria and Niger (P<0.05). This study shows that when wildlife becomes marketable without control local customs, beliefs could be weakened and endogenous conservation jeopardized.

Key words: Crocodile, endogenous conservation, trade, traditional medicine, Benin.
Sustainable Harvest of Wild Adult American alligators
(Alligator mississippiensis) in Florida

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ABSTRACT: Crocodilians have long generation times, high fecundity, and low egg and juvenile survival rates. Consequently, adult females have a high expected value to the population. Harvest of wild adult crocodilians has, therefore, been discouraged by conservation and wildlife trade organizations, such as the CSG and CITES. Ranching has been encouraged as the preferred low-risk option for commercial consumptive harvest of wild crocodilians. Many country and state harvest programs have embarked on capital-intensive ranching programs that have had difficulty maintaining profitability. In Florida, three American alligator (Alligator mississippiensis) management programs allow the harvest of larger alligators; nuisance alligators, private lands alligators, and alligators on public waters. We present harvest results and population trend data for harvests on public waters, which are open to the general public. During 1988-2007, adult alligators on 47 alligator management units (AMU) were intensively harvested at a target harvest rate of 6% per year. Harvest quotas were based on population estimates from 1-2 night spotlight surveys conducted each year. Actual mean estimated harvest rate for all AMUs was 5.4% of the adult population. Of 47 areas that were harvested, adult alligator populations increased on 24, remained stable on 17, and declined on 6 (Fig. 1). One area was dropped from the harvest program because it could not sustain harvests. A mean of approximately 23% of the harvest was comprised of adult-sized females during 2000-2006. Simultaneous 50% egg harvests were conducted on 24 AMUs, which also had adult harvests. Of these areas, 23 indicating stable to increasing populations of non-hatchling alligators. Public waters harvests have shifted from commercial harvests to primarily recreational harvests over the years, with each hunter now limited to a quota of two alligators. In 2007, approximately 4,300 licensed hunters harvested approximately 6,500 alligators and paid $1.3 million in fees for that privilege. These revenues are used to support alligator management and conservation in Florida. Harvest programs of large wild crocodilians have lower potential production levels than harvests for ranching, but they also have lower capitalization and operational costs, and are usually profitable if done on a commercial basis. This study, indicate that harvests of adult alligators can be sustainable. However, population monitoring needs to be conducted and regulations enforced to ensure that harvest levels are maintained within target ranges.
Effects of Hurricanes Katrina and Rita and Severe Drought Conditions on Alligator Nesting in Coastal Louisiana

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ABSTRACT: The American alligator (*Alligator mississippiensis*) occurs in a variety of habitats, with the majority of Louisiana’s population inhabiting coastal marshes. In 2005, Louisiana’s coastal alligator population generated its fourth highest nesting output. However, this high nest productivity would be followed by a tandem of devastating environmental events including: two major hurricanes and a severe drought. Due to the state’s unique topography, the residual effects of these regional storms and drought conditions caused dramatic alterations in both habitat quality and animal physiology. During summer 2006, LDWF program staff estimated by aerial survey that only 20,387 alligator nests were present in coastal marsh habitat, a dramatic decrease from the previous year’s estimate of 41,392 nests. As our alligator management program’s philosophy of sustainable utilization encompasses the inter-relationship between habitat quality, nesting output and wild harvest, program staff temporally reduced harvest quotas in several parishes which demonstrated both significant habitat damage and reduced nesting. In 2007, marked improvements in habitat quality (i.e., increased rainfall, marsh vegetation regeneration) were observed. These improved environmental conditions paired with a highly resilient alligator population led to the third best year for alligator nesting on record, with some 42,150 nests being produced in Louisiana’s coastal habitat.
Effect of Hurricane Rita and a Severe Drought on Alligators in Southwest Louisiana

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ABSTRACT: Coastal Louisiana was impacted by two major hurricanes in 2005, with Hurricane Katrina coming ashore in August closely followed by Hurricane Rita making landfall in September. The American alligator (Alligator mississippiensis) occurs in a variety of habitats statewide, with the most dense population occurring in the coastal marshes. Alligators do exist in brackish marshes, but poorly tolerate highly saline conditions and do not nest in salt marshes. We collected blood samples from a large series of alligators, to determine how the hurricane storm surge and inundation of coastal marshes with salt water affected them. We measured plasma osmolality, corticosterone (stress hormone), and electrolytes (Na, K, and Cl). The first set of blood samples were obtained within a month of Hurricane Rita and were from 11 alligators (size range 167.6 – 256.5 cm) collected at Holly Beach, Louisiana. From 8 February – 9 August 2006, another 201 alligators (size range 61.0 – 243.8 cm) were sampled on Rockefeller Wildlife Refuge. During this study, habitat conditions in Louisiana were adversely affected by the worst drought in 111 years of recorded weather data. Plasma corticosterone from the eleven alligators sampled at Holly Beach within a month of Hurricane Rita were very high, averaging 10.34 ng/ml. Plasma sodium and plasma corticosterone were strongly positively correlated with plasma osmolality in these samples. By February when we were first able to sample alligators at Rockefeller Refuge, plasma corticosterone levels were normal (0.40 ng/ml, n = 33). By early spring drought conditions were intensifying, and plasma corticosterone levels began to rise, with average levels of 3.12 ng/ml in April and 5.92 ng/ml in May. The highest corticosterone level we have ever measured (36.21 ng/ml) was recorded in an alligator caught in June, at the peak intensity of the drought; this animal had a baseline corticosterone level of 0.41 ng/ml when caught in July 2001. The severe drought had a profound negative impact on alligator nesting in coastal Louisiana in 2006, with an estimated production of only 20,387 nests as compared to 41,392 nests in 2005. Late summer rainfall in 2006 led to some dilution of high salinities (9 August salinity values 5.7 – 9.3 ppt as compared to 8.8 – 10.4 ppt on Feb 8, and 7.4 – 12.5 ppt on April 6) and alligator corticosterone levels decreased to 1.78 ng/ml; essentially back to normal levels for wild alligators. Adequate rainfall in winter 2007 led to marked improvement in habitat conditions, and 2007 was the third best year for alligator nesting on record, with some 42,315 nests being produced in the coastal zone of Louisiana. This resilient species rapidly recovered from severe environmental impacts but long term monitoring will continue.
Dr. Tirtha Man Maskey Wildlife Centre

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ABSTRACT: Dr. Tirtha Maskey is a well known name in Nepalese Conservation especially for his significant contribution to Gharial Conservation. We lost him after an unfortunate Chopper crash on 23rd September 2006.

Dr. Maskey has left behind a huge resource for present and future wildlife managers. To leave this knowledge, WWG established Dr. Maskey Wildlife Centre including a library on its office. To complete these resources, WWG has published two books which one presenting his PHD Thesis entitled: "Gharial Conservation in Nepal". This book is a scientific research entitled: "Movement and Survival of Captive Reared Gharial in the Narayani River, Nepal ". It describes technique and conservation effort to breed gharials before release it to their natural habitat and so bring this specie back from the extinction. Moreover it includes the latest presentation of Dr. Maskey in June 2006 (18th CSG meeting) entitled as "Gharial Conservation in Nepal: Results of a Population Reinforcement Program". The main objective behind publishing this book is to provide Dr. Maskey’s latest information about the Gharial conservation in Nepal.

Lastly, we believe that Dr. Maskey’s works will also be a motivation for others to carry out similar studies to save endangered species from extinction.
The Importance of Systematics in Conservation: The Nile Crocodile
(Crocodylus niloticus) As A Case Study

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ABSTRACT: As our understanding of evolution, and its impact on the ecology and population
dynamics within any given species, become more refined systematic questions become more
relevant to conservation decision making. How can we conserve a species we do not yet
recognize as a valid taxon? Similarly, how do we set conservation priorities if we do not
understand the evolutionary trajectories of, and relationships between, different populations
within a known species? Starting with its formal description in 1768, the Nile crocodile has
been a plague of taxonomic and systematic confusion. Laurenti (1768) incorrectly described
Crocodylus niloticus from illustrations of a dwarf caiman (Paleosuchus spp.) (Magnusson
1992) with a text description so vague it could equally be applied to C. palustris and C.
porosus (Anderson 1899). Geoffrey (1807) and Cuvier (1812) both examined actual specimens
from throughout Africa and described as many as five separate species from different regions
throughout the continent (Anderson 1899). Fuchs (1974) proposed 7 distinct subspecies
based on morphological characters from skins in the commercial trade. Two recent studies,
Schmitz et al. (2003) and Hekkala (2004), have reignited this controversy with molecular
systematic evidence. This preliminary molecular data suggests that Nile crocodile populations
in West Africa represent a unique lineage older than modern C. niloticus, creating not an
issue of splitting taxa but recognizing two equally valid, cryptic taxa. Here we present a
review of Nile crocodile systematics, including new molecular data, with a discussion on
the conservation implications.
The phylogeography of the yacare caiman, *Caiman yacare*, of central South America

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ABSTRACT: The yacare caiman, *Caiman yacare*, occupies wetland habitat in portions of two major river basins of central South America. The species occurs in the Amazon river basin of Bolivia and the Paraguay-Paraná river basin of Brazil, Paraguay and Argentina. It is one of the most abundant crocodylian species of the world and represents a high percentage of the world hide trade.

In this study, DNA was extracted from 211 samples taken over the entire range (Amazon, n=143; Paraguay-Paraná, n=68) and examined. Molecular analyses were performed using cytochrome b mitochondrial markers. Twenty-five haplotypes were discovered, each occurring in only one river basin (Amazon, n=16; Paraguay-Paraná, n=9). Distinct molecular compositions were found in drainages within the two basins. Results from this study may be valuable for wildlife management of sustainable harvest planning and the conservation of the species.

RESUMEN: El lagarto, *Caiman yacare*, habita humedales en porciones de las dos cuencas mayores en centro Sud América. La especie ocurre dentro de la cuenca del río Amazonas boliviano y la cuenca de los ríos Paraguay-Paraná en Brasil, Paraguay y Argentina. Es una de las especies de cocodrilianos más abundantes del mundo y representa un alto porcentaje del comercio mundial de cueros.

En este estudio, se extrajo ADN de 211 muestras tomadas de la distribución entera (Amazonas, n=143’ Paraguay-Paraná, n=68) y fueron examinadas. Se realizó análisis moleculares utilizando los marcadores mitocondrial citocromo b. Se descubrió 25 haplotipos, de los cuales ocurre únicamente en una sola cuenca (Amazonas, n=16; Paraguay-Paraná, n=9). Drenajes adentro de las dos cuencas mayores también tienen composiciones moleculares distintas. Los resultados de este estudio pueden ser útiles en el manejo de los lagartos dentro la planificación de la cosecha sostenible y la conservación de la especie.

INTRODUCTION

The yacare caiman has been subjected to large-scale commercial hunting during most of the last 50 years. Much of the exploitation in the range states of Bolivia, Brazil, Paraguay and Argentina occurred with government authorization. Little effective control existed in spite of legislation specifying limits for export quotas, minimum size, and hunting seasons. Although Brazil made all commercial exploitation of wild populations illegal in 1967, porous frontiers in all of the range states allowed free movement of wildlife products. Government officials and military personnel were frequently involved in the exploitation, complicating control efforts. CITES has imposed trade sanctions, and both Bolivia and Paraguay, the largest exporters of yacare hides, have independently suspended exports at different points in time.
All four range states have sustainable use programs in development, although none have firm biological bases for determining the harvest regions. In Bolivia, where the only functioning wild harvest currently occurs, size-class abundance data from limited surveys is the only factor employed. While adequate as a minimum measure when sufficient surveys are undertaken, additional population data would provide for more robust management. The Venezuela program placed a priority on obtaining biological data for a decade before harvest, and a self-financing program developed incorporating user fees. The under-funded program in Bolivia continues to suffer from inadequate survey personnel, lack of control of areas harvested and annual over-harvesting. Wildlife management programs are often non-existent or severely under-funded. Hides are reported to be collected clandestinely throughout the year (J. Aparicio, pers. comm.).

The following study presents the first molecular data for *Caiman yacare* populations. Information on the phylogeny, haplotype partitioning, gene flow and cryptic populations will be valuable for wildlife managers to incorporate into sustainable use planning. Detailed laboratory procedures have been omitted for simplicity.

**Sample preparation**
The fresh samples prepared for this study consisted mainly of blood or muscle. Blood samples were taken from the cervical sinus using sterile 2 cc syringes and needles (Olson *et al.* 1975) and a sample of about 1 ml was drawn and introduced into blood lysis buffer (modified from White and Densmore 1992). All of the Paraguayan samples (n=21) originated from the osteological collections in the Florida Museum of Natural History (FLMNH) at the University of Florida. All bone sample preparations were performed in a laminar flow hood to reduce the chance of cross-contamination. A Dremel MultiPro™ variable speed rotary tool was used to perforate the bone. Replicate sample tubes were made for each specimen.

All samples were obtained with proper documentation. The Bolivian authorities issued CITES export permit No. 00470 and US entry was under CITES import permit No. 816827. Argentine samples were exported with CITES permit No. 023752 and imported under US CITES permit No. 03US714329/9. Venezuelan material was obtained by FLMNH from the Venezuelan Government Wildlife Service.

DNA isolations were usually performed with a phenol-chloroform isoamyl alcohol (PCI) isolation protocol modified from Hillis *et al.* (1996) with 95% ethanol precipitation. Bone samples proved the most problematic, requiring the most time invested and generally resulting in low amounts and poor quality of the DNA extracted. Bone samples require special preparation to eliminate PCR inhibitors that may be co-isolated during extraction. A successful protocol, modified from Ye *et al.* (2004), overcame these problems. Bone samples were processed with the Qiaquick™ PCR Purification Kit with very good results. The PCR inhibitors were successfully removed with the kit.

**Sequence data**
The cytochrome (cyt) b gene was selected for intraspecific relationship analyses. The *Caiman* cyt b gene is 1150 bp long, from position 14,461 to 15,610. This is a highly variable region and of great value for phylogenetic research (Avise 2000, 2004).
The entire mitochondrial (mt) genome for a closely related *Caiman crocodilus* (Janke et al. 2001, GenBank accession number NC_002744.2) from a Venezuelan specimen has been published. This facilitated direct comparison with my PCR amplification product sequences and in the design of new primers. The *Caiman* mtDNA genome is 17,900 bp long and all further position references are relative to the Caiman mitochondrial genome of Janke et al. (2001) unless otherwise noted.

Amplifications using primers modified from Glenn et al. (1998) successfully produced 668 bp Cyb Fragment 1. A new set of cyt b primers were designed to amplify a partially overlapping fragment, Cyb Fragment 2. This new fragment is 649 bp long, with a 117 bp overlap for sequence concatenation. The reconstructed fragment was 1200 bp long, corresponding from positions 14,461 to 15,660 and represents the entire cyt b gene. Other primers were designed as needed to complete the amplifications for intransigent samples. Resulting sequences had an average of 1143 bp.

The preliminary PCR amplifications of cyt b fragments were run on an Applied Biosystems, Inc. (ABI) 377 and 3700 automated sequencers as well as Amersham MegaBACE™ 1000 96 capillary sequencers. For haplotype verification, new PCR amplification products were resequenced. Sequences were evaluated and concatenated using Sequencher 4.5. Files were then imported into PAUP 4.0b10 (Swofford 1998) for phylogenetic analyses and tree generation. Likelihood model selection was performed using MODELTEST v.3.06 (Posada and Crandall 1998). Tree support through Bayesian inference was accomplished using MrBayes v.3.1.1 (Huelsenbeck and Ronquist 2001; Ronquist and Huelsenbeck 2003). TCS v. 1.21 software (Clement et al. 2000) was used to create haplotype genealogy networks by implementing the “statistical parsimony” algorithm described by Templeton et al. (1992). Arlequin v. 3.0 (Excoffier et al. 2005) was used for AMOVA analyses, genetic distance measurements, and Mantel tests.

**RESULTS**

Cytochrome b sequences for each of the 214 samples were evaluated using Sequencher 4.5. Some samples were re-amplified as necessary for error-free final sequences. The concatenated sequences, averaging 1143 bp, were compared and analyzed to determine haplotypes. New haplotypes were analyzed with maximum parsimony (MP), maximum likelihood (ML) and minimum evolution (ME) comparisons for associations with other haplotypes. A conservative approach was taken in establishing haplotypes and samples were reamplified and sequenced repeatedly.

The evolving group of haplotypes was consistently re-analyzed, especially the 12 ‘singleton’ haplotypes represented by only 1 individual. Haplotype trees were constructed and one step associations were carefully analyzed to verify differences. Upon final haplotype assignment, the group was assembled into a contig in Sequencher 4.5 and imported to Paup v.4.0b10. Additional analyses were performed with Arlequin v.3.0, as well as DNAsp v.4.10.4 (Rozas et al. 2003). As the haplotype group was assembled, the sample sequence data set was repeatedly compared and assigned as needed. Twenty-five cytochrome b haplotypes were finally determined.
Figure 1. River drainage divisions used for segregating samples from the Amazon (northern) distribution of *Caiman yacare*. B = río Beni, M = río Mamoré, SM = río San Miguel, P = río Paraguá.

Analysis began by assessing the haplotypes as one group. The samples, and also the haplotypes as seen below, were split into two groups representing the two major distribution areas (north and south) (see Fig. 1). These were further divided into ‘populations’, taking into consideration the sampling localities and hydrogeographic topography. Although the yacare caiman is not principally a riverine crocodylian, they are always present even in the largest rivers. River systems are assumed to be an important conduit for migration and resulting gene flow and are used here to help define boundaries for the analyses. The Amazon distribution (northern) was divided into 4 main drainages: the río Beni, río Mamoré, río San Miguel and río Paraguá.

The Paraguay-Paraná (southern) distribution represents a very different, linear topology and was divided into two portions (See Fig. 2). It has been noted in molecular studies of fish that genetic diversity generally increases downstream, especially when taking into account additive functions of major tributaries. In the southern distribution of *Caiman yacare*, the río Pilcomayo is a major tributary with very large populations along its considerable length (~700 km). With this in mind, the arbitrary division was placed just upriver of the union the río Pilcomayo and the río Paraguay.
After all sample haplotypes were determined, the samples were assigned and a drainage distribution table was constructed (see Table 1). Of the 214 samples, 16 haplotypes are distributed in the northern distribution and 9 in the southern distribution. There is a complete division of haplotypes with none shared in both distributions. A comparison of all haplotypes (1197 bp) revealed 23 polymorphic sites with 10 singleton variable sites and 12 parsimony informative sites. A total of 1063 invariable sites were detected and, as a result of different primer sets and inconsistent success in amplification, 112 sites had missing data.

The haplotypes trees were constructed using PAUP 4.10b with MP, ME and ML evolutionary models without resolving all haplotype associations. Haplotypes always segregated between the two distribution basins with none shared, but the internal topologies varied and many branches had poor bootstrap support (see Figure 3). Maximum parsimony (MP) analyses used heuristic searches starting with stepwise addition trees and replicated 100 times. Branch swapping was performed by the tree-bisection-reconnection (TBR) method. While 98 MP trees were constructed with the identical scores, they had high concordance on the main branch arrangements and differed mainly on tip associations, especially within the southern distribution (see Figure 3).

This becomes evident when a comparison is made between the 2 distributions with this 1161 base data set. The northern distribution (16 cyt b haplotypes, mean 1155 base length) has 7 variable parsimony uninformative sites with 7 parsimony informative sites. The mean

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**Figure 2.** River drainage division used for segregating samples from the río Paraguay-Paraná (southern) distribution of *Caiman yacare*. Py = río Paraguay, Pa = río Paraná. Note length and location of western tributary río Pilcomayo.
frequency base compositions are 30.3% A, 25.4% T, 34.2% C, and 10.1% G. The southern distribution (9 cyt b haplotypes, mean 1151 base length) has 9 variable parsimony uninformative sites with only 2 parsimony informative sites. The mean frequency base compositions are 30.2% A, 25.2% T, 34.3% C, and 10.3% G. These data show an under-representation of guanine as described for the mitochondrial genome by Zhang and Hewitt (1996).

Table 1. Distribution of 25 cytochrome b haplotypes for Caiman yacare. No haplotypes detected are shared among basins. Locality for original haplotype specimens: Bo=Bolivia, Pa=Paraguay.

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<th>Paragua</th>
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The Tamura and Nei model (TrN+I) of evolution was selected using Modeltest 3.06 for ML analyses. Excess transitions, unequal nucleotide frequencies and a variation of substitution rate among different sites are taken into account in this model. In addition, the proportion of invariable sites (+I) is used in the calculation. Employing the likelihood test ratio (LTR), a molecular clock model was compared and accepted, and a phylogram tree, rooted at the C. latirostris split at 24 mya, was constructed and measured. Results show that the haplotype divergence time between basins is relatively recent and is estimated at ~1.5 mya and subsequent within basin radiation of populations occurred in the last 500,000 years. This follows a similar pattern seen for Caiman crocodilus cytochrome b sequences, with the
divergence between the Amazon and Orinoco basins occurring at ~2.75 mya and within basin radiation occurring during the last million years (see Godshalk, this volume).

Figure 3. Maximum parsimony (MP) tree for 25 cytochrome b haplotypes of *Caiman yacare* rooted with *Caiman crocodilus*. Number above branch refers to mutational steps, number below refers to percentage consensus of 98 equally parsimonious trees. (length=158, CI=0.918). Bracket A = Amazon basin, northern distribution, P = Paraguay-Paraná basin, southern distribution. Haplotypes are unique to each distribution. Abbreviations: Cc_REF (Caiman crocodilus reference sequence), Cy_ (C. yacare plus haplotype number).

As many haplotypes differ with single mutational steps, haplotypes trees could not be easily resolved using bootstrap values. A haplotype network was constructed using TCS v.2.1.1 to better understand the phylogeny. A 15 single mutational step difference occurs between the 2 most distant haplotypes in the network. Within both North and South haplotype networks, a 7 mutational step difference occurs between the most distant haplotypes (see Fig. 4). While some haplotype reticulations remain unresolved, the overall pattern and distinction between basins are clear. The separation between basin clades is 2 or 3 mutational steps depending on the reticulation.
Results from an Analysis of Molecular Variance (AMOVA) (Excoffier et al., 1992) implemented in Arlequin v3.0 (Excoffier et al. 2005) added information on the distribution and separation of haplotypes: 72.4% of the variation was attributed between the 2 basins, 7.7% of variation was attributed between populations within the basins, and 19.9% of the variation was attributed to within population differences. The pairwise distance method Fst value between basins was 0.7576, significant at the p < 0.001 level.

Within the northern distribution, two common haplotypes account for 76.2% of the 143 samples from the basin (Cy_03=51%, Cy_04=25.2%). Private haplotypes (i.e. occurring in only one population) were detected in all 4 populations of the Amazon distribution. A similar situation exists in the southern distribution. Two common haplotypes account for 75.7% of the 66 samples from the basin (Cy_19=40.9%, Cy_15=34.8%). Private haplotypes were also detected in both populations of the southern distribution. An AMOVA analysis on the drainage populations provides additional information on within and between basin comparisons (see Table 2).
Table 2. Analysis of $F_{st}$ values for populations of *Caiman yacare*. Top set: Population pairwise distance $F_{st}$ values, Bottom set: Matrix of significant $F_{st}$ values, $p < 0.05$.

<table>
<thead>
<tr>
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<th>Mamoré</th>
<th>San Miguel</th>
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Pairwise distance comparisons were made within and between all populations and a matrix was constructed using Arlequin 3.0 (Excoffier et al. 2005). A corrected average pairwise difference was also computed (see Table 3).

Table 3. Average pairwise distances for populations of *Caiman yacare*. Above the diagonal: average number of pairwise differences between populations ($\pi_{XY}$). Diagonal elements: average number of pairwise differences within population ($\pi_X$). Below diagonal: corrected average pairwise difference ($\pi_{XY}-(\pi_X + \pi_Y)/2$).

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A Mantel test was implemented by Arlequin v.3.0 to test the correlation between genetic pairwise distance $F_{st}$ values and riverine distances between populations. A positive correlation was determined ($r=0.6962$) and was established through a permutation test (2000 permutations) and was significant at the $p<0.01$ level. Spatial autocorrelations are significant following the $F_{st}$ values given in Table 2, using the distance matrix constructed for the test (see Table 5).
DISCUSSION

Populations of *Caiman yacare* are subject to strong pressures from legal harvest as well as low level poaching. Thousands of adult animals are culled annually from wild populations in Bolivia. The harvest program has been temporarily suspended in Paraguay but preparations are being made to resume. Yet surprisingly, little information has been accumulated about the biology of the yacare caiman. Much of what is known comes from the Brazilian Pantanal where conditions are unique and wild harvest is not permitted. However, wildlife managers must incorporate all relevant information in order to make informed decisions regarding sustainable use of this species.

Data generated from this study underscore the potential and the limitations of molecular information. These data compliment knowledge on the biology of the species. From the mtDNA sequence data, derived from matrilineal inheritance, a distinct split is seen between the North and South haplotype distributions (see Table 3, Figure 3). Results from the Analysis of Molecular Variance (AMOVA) attributes 72.4% of the variation between the two distributions.

Considering the sample localities and overall sample size, shared haplotypes would likely have been detected. Of the 214 animals sampled for this study, 22 caiman were from the Bolivian Pantanal. This is close to the Amazon basin boundary, an area of potential mixing between the North and South distributions. Additionally, 9 samples were from northern Paraguay along the main río Paraguay corridor, relatively close to another potential mixing area. These data suggest that the geographic separation of the río Amazon basin (Northern distribution) and the ríos Paraguay-Paraná basin may be a significant barrier for migration of females.

Large adult male caiman establish breeding areas which are defended against competing males. These dominant male patrol their area and aggressively exclude not only reproductive adult males, but also sub-adults (Thorbjarnarson 1991, 1993; Coutinho 2000). Studies on seasonal movements show that while caiman are displaced by the rigors of the intense wet and dry season regime, their net movement is generally not great. Adult females, however, show less movement and the adult males respond to this by establishing territories relatively close to the dry season refugia. In this manner, sub adult males are forced further away from the dry season habitat (Thorjarnarson 1991, 1993).

The genealogy network graphically displays the division between haplotype groups of the two major distributions (see Figure 4). A minimum of 5 evolutionary steps separate the two haplotype groups. Most relationships of within group haplotypes are separated by single evolutionary step. Although some relationships between haplotypes cannot be resolved by transition-transversion analyses and lead to multiple pathways, these reticulations do not disrupt the overall structure of the 2 group networks.

The effect of the large basin haplotype division is emphasized by the relative within group uniformity. The $F_{st}$ values for cytochrome b haplotypes indicate that while some geographic structuring is evident, the río Beni, the río Mamoré and río San Miguel populations are not significantly different from each other (see Table 4). This is understandable given the topography and environments resulting from periodic wet season flooding. Annual flooding
events often negate drainage boundaries and large-scale pooling, particularly acute approaching river junctions, frequently extend hundreds of km$^2$. This region is covered with isolated lakes and ponds of various sizes that may serve as ‘stepping stones’ for gene flow between river drainages that provide much shorter distances than linear riverine mileage would imply.

Ephemeral streams crossing the open savannas may also serve as genetic conduits. These conditions of seasonally coalescing waterbodies, permanent lakes and intermittent streams are common but found to a lesser degree in the eastern region of río San Miguel. For this reason, F$_{st}$ values are slightly higher than Bení or Mamoré values but still not significant at the p <0.05 level. I collected 74 samples from the río San Miguel population and similarities detected in samples from both the río Bení (N=20) and río Mamoré (N=29) populations reflect the fact that they are largely subsets of the San Miguel population.

This is not appear to be the case with the río Paraguá population (N=20). The geography of the area has isolated the river to a greater degree than the other three populations mentioned above. The F$_{st}$ values indicate the distinction although this is primarily due to the presence of 2 unique haplotypes.

In a comparison of F$_{st1}$ values and average pairwise distances, it can be observed that the greatest similarity for populations within the Northern distribution is with the nearest geographic neighbor (see Tables 4 and 5).

For the Southern distribution, the río Paraguáy population is significantly different from the Paraná population at p <0.05 level (see Tables 4 and 5). In the linear hydro-geographic setting of this distribution, there are no consistent short-cut conduits for gene flow outside of the main river corridors as seen on the flooded savannas of Bolivia. In this sense, riverine and straightline distances are essentially the same.

Results of a Mantel test also confirms structuring according to river geography. There is a positive correlation of isolation by distance. These data indicate important processes of haplotype distribution among the populations. Movements by female caiman are sufficient to distribute common mtDNA haplotypes across large areas, but restricted enough for the evolution and establishment of geographically isolated haplotypes.

It has been shown that phylogeographic patterns that are shared by sympatric or co-distributed species may shed light on a common historic biogeography (Avise 2000). In this manner, comparative molecular analyses for the sympatric crocodylian species may help the understanding of the development of the Amazon. Numerous vertebrate species are common to both the Amazon and Paraguay river basins but no comparative studies have yet been undertaken. Further investigation into the molecular patterns exhibited by these species may assist in reconstructing the geographic histories that until now have proved elusive.

**Conservation Genetics** – Genetic information is serving an increasing role in conservation biology. New techniques have been developed that produce more data, more accurately in less time and for less money than previously imagined. The utility of the resulting data depends on the unique situation of species in question. For example, genetic profiling is crucial for work with endangered species when considering captive breeding, re-introduction programs or in population viability modeling. This, however, is not the case with *Caiman*
yacare. The yacare caiman, along with the common caiman, *C. crocodilus*, are perhaps the two most numerous of crocodylian species. Conservation genetics have a much different role to play in the management of abundant populations. Data generated from the analyses in this study as documented above will have impact in the following areas:

**Taxonomic clarification** – Conservation efforts can become focused when taxonomic uncertainties are resolved. Daugherty *et al.* (1990) observed that accurate taxonomies “are not irrelevant abstractions, but the essential foundations of conservation practice”. *Caiman yacare* is now regarded by some researchers as a subspecies of the common caiman. This unwarranted convention has been adopted by some authors since Werner (1933) first referred to the yacare caiman as *Caiman crocodilus yacare*. Apparently, this is based only on superficial similarity rather than biological objectivity and is counter to the rules of the International Commission of Zoological Nomenclature. The data presented above emphasizes the position of *C. yacare* as a species. This presents no legal ramifications as CITES, the US Fish and Wildlife Service, the European Union and all the range states (Argentina, Bolivia, Brazil, and Paraguay) have previously regarded *C. yacare* as a species in their laws and regulations.

The unexpected results regarding the genetic distance as described with the *Caiman crocodilus fuscus* haplotype (see Godshalk, this volume) must be resolved through further study. Review of the biogeographic history suggests comparable reproductive separation from the Orinoco basin populations of *Caiman crocodilus*. This may lead to a new species designation for the Central American populations, now considered *C. c. chiapasius*. Resolving the identity for the Pacific drainage populations from Colombia, also considered *C. c. chiapasius*, is also necessary but very difficult given the political situation there.

There remains the uncertain identity of populations from the Caribbean drainages of northern Colombia and western Venezuela. Genetic analyses of these *C. c. fuscus (sensu stricto)* populations would help complete the genetic mosaic of this wide ranging group. This could be undertaken with the collaboration of Colombian and Venezuelan colleagues. A taxonomic change for these latter populations might entail legal repercussions, as Colombian hide exports from farming operations in the region are very large (>500,000/yr, Velasco and de Sola 2005) and the regulations have been in place for over 15 years.

Data presented in Godshalk (this volume) show significant genetic distance between the Orinoco and Amazon populations of *C. crocodilus*. Reproductive isolation is complete owing to geographic separation and the processes toward separate speciation continue. Further investigations are required to reveal the extent of separation and clarify the taxonomic status.

**Genetic diversity** – Wildlife species are typically characterized according to the genetic diversity detected within and between the various subpopulations. Appropriate species management will seek to quantify and maintain a broad level of natural heterozygosity. Relative heterozygosity levels should be maintained to avoid inbreeding or bottlenecks. The results of this study show that the populations of *C. yacare* show a relatively high degree of genetic diversity compared to non-piscine vertebrates. Large population numbers remaining in the range states have maintained high numbers of haplotypes for cytochrome *b*. No indications of inbreeding depression or reduction in heterozygosity due to population bottlenecks were detected as measured by $F_{is}$ values (data not shown).
As this species is subject to commercial exploitation that selectively eliminates large adult males, wildlife managers will need to periodically monitor the genetic diversity, drift or reduction in heterozygosity. Controversy exists over this type of harvest strategy, especially in a species where dominant males represent a disproportionate segment of the breeding population. Continual removal of the largest members, and potentially a large segment of the breeding alpha male population, may ultimately cause an unfavorable genetic drift.

**Characterizing movements** – Effective wildlife management requires knowledge of species movements. Biological investigations can yield direct information on movements at a certain scale. Genetic data can give insight to movement on a much different scales. As described above, the cytochrome b data reveal that female yacare caiman do not appear to cross the barrier between the Amazon and Paraguay-Paraná river basins with enough regularity to establish haplotypes that are shared between basins. This result was unanticipated, although movements by females are generally less than males. This barrier may not impede migration of males, however, resulting in the lack of distinct segregation of microsatellite alleles (data not shown). This movement would be very difficult to quantify by other methods. Further studies will be necessary if wildlife managers want more fine scale movement data.

While traditional F-statistics and other genetic metrics produce migration indices, often expressed as Nm values, wildlife managers must be aware of the inherent limitations. These data are directly related to, and limited by, the quality and quantity of the source data. Information on the actual migration numbers per generation, and implications to the study populations, are usually not clear. For example, the genetic contribution of 10 migrants per generation from the río Paraguá to the Pantanal area, with local effective populations (Ne) in the millions, would likely be insignificant. Introduced alleles and haplotypes would be subject to lineage sorting and genetic swamping by the sheer magnitude of numbers. The situation is very different for an endangered species where the Ne is low and the relative genetic contribution of each migrant is higher.

**Reserve design** – Molecular data can be incorporated in future reserve design and modification of existing protected areas. These wetlands must be interspersed over a large area to form buffer zones for general recuperation in the event of over harvesting. Especially important to keep in mind are areas such as the río Paraguá where unique haplotypes and alleles are found. The present study should be considered only preliminary as important areas, such as the western río Madre de Díos, southern Mamoré, eastern Iténez, eastern Pantanal and Pilcomayo were not surveyed at all.

Natural corridors must be maintained for continued gene flow. This does not pose a problem in the near future for Bolivia and Paraguay where the land use in the primary habitat is for extensive cattle ranching. Rapid development in Brazilian Pantanal and northern Argentina gives cause for concern. Conversion to large-scale agriculture is a growing problem with reduction of habitat and contamination with herbicides, fertilizers and pesticides. There is also a growing potential for large-scale habitat disruption if the proposed waterway (Hidrovía) from the Brazil to the Atlantic is approved and constructed.

A good example of a positive improvement to reserve design comes from Bolivia. Noel Kempff Mercado National Park is located on the Brazilian Shield along the río Paraguá. It includes important catchment basins and ecosystems on the east side of the river but the
previous park boundary basically paralleled the río Paraguá was but set back several kilometers. Recent legislation increased the Park holdings to include the main river corridor and protect the connectivity of affluents to the main river. This improvement may imply potential protection for unique *C. yacare* populations described in this study from the río Paraguá drainage.

**Evaluating translocations** – Given the large numbers in wild *Caiman yacare* populations, translocations do not appear necessary in the near future. However, unforeseen events leading to local extirpation through poaching or contamination might necessitate re-introductions in selected areas. Very low population levels may also lead to inbreeding depression.

Genetic profiling of the translocation stocks would be advised for maintenance of prior diversity. Fortunately, yacare hides are currently of relatively low value and hunting ceases at a certain “catch per unit effort” threshold. Typically, when this occurs a large population of sub-adults and juveniles remain. Due to young age and small size at sexual maturity, *Caiman yacare* and *C. crocodilus* populations rebound relatively quickly without outside assistance. Some are reproductive at about 1 m total length.

With many of the larger crocodylian species, both size and time to maturity work against them. In those species, many individuals attain a valuable size and are killed before they reach the reproductive age/size class. Quite often sympatric *Caiman* species move into the habitat previously occupied by the extirpated species, making additional hurdles to recovery. These are typically the species requiring translocations.

**Forensics** – The field of wildlife forensics has moved forward quickly with the advances in molecular techniques. Data from this study give authorities the ability to identify raw *Caiman yacare* hides from those of common caiman with certainty. This segregation by visual means requires comparison of whole flanks and is imprecise at best.

If future harvest zones are to be monitored, haplotype data could be used to give an indication for the area of origin. The border between Paraguay and Bolivia has been notoriously porous with wildlife products passing in both directions. The distinction of Bolivian Amazon versus the Paraguayan haplotypes is clear as shown in this study. The only zone of ambiguity would come from caiman originating in the Bolivian Pantanal.

The next step will be to develop molecular protocols for working with tanned hides and manufactured products. Unfortunately, the normal procedures for fresh tissue are rendered useless once the hide has been subjected to the chemical treatments of tanning. As many hides are processed to the chrome tan or “crust” stage before international shipment, sensitive molecular inspection is circumvented. Once these technical problems are overcome, many of the current difficulties of hide identification and product origin can be resolved. CITES regulations have greatly reduced the current volume of illegal crocodylian hides on the world market, but stricter controls resulting from new tools can further reduce that portion. Genetic information from studies such as this will be collected and implemented as new techniques are developed.
CONCLUSIONS

1) *Caiman yacare* is a distinct Evolutionarily Significant Unit (ESU). It was originally described as a full species and has a distribution with nearly complete reproduction separation from the closely related common caiman, *Caiman crocodilus*. Comparison with Amazon *C. crocodilus* sequences shows genetic separation with no apparent influence from *C. yacare* migration downstream.

2) *Caiman yacare* can be identified from every other crocodylian species, including *Caiman crocodilus* and subspecies, by comparison of cytochrome b or 16S sequences.

3) The Brazilian Shield, which forms most of the northern boundary and causes the río Madera constriction, is an effective barrier to upstream migration of *C. crocodilus* from the north. While hybridization is possible at the very limited areas of contact between the two species, there has been no detectable genetic introgression. Analyses from this study show distinct genetic separation and significant genetic distance between them.

4) The 25 *Caiman yacare* cytochrome b haplotypes are divided between the two main distribution areas, río Amazon and río Paraguay-Paraná, with no haplotypes shared between the two. This indicates that there is no effective migration of females between these two populations.

5) *Caiman yacare* populations are weakly structured in relation to the pattern of river drainages within their distribution. This is shown in analyses for both mtDNA sequences and microsatellite allele frequencies. While microsatellite allele frequencies differ according to geography, all loci are shared by all populations.

LITERATURE CITED


**Did Schmidt just scratch the surface? Resolution on the taxonomy, phylogeography and population structure of the African dwarf crocodile**

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**ABSTRACT:** The taxonomy of the African dwarf crocodile (genus *Osteolaemus*) has been disputed since a novel morphotype was discovered in the early 20th Century. Because this poorly-known reptile is widely hunted throughout the forests of Central and West Africa, resolving the existence and extent of taxonomic units has important management and conservation implications. A lack of molecular data from individuals of known origin and disagreement on diagnostic morphological characters have hindered attempts to settle one of the last remaining taxonomic questions in the Crocodylia. We have resolved this debate by sequencing three mitochondrial and two nuclear genes using a large sample of dwarf crocodiles from known localities across major drainage basins of forested Africa. Concordant results from Bayesian, maximum likelihood, maximum parsimony and population aggregation analytical methods (PAA) reveal three highly distinct clades with a Congo Basin form as basal to sister lineages from the Ogooué Basin and West Africa. Corrected genetic distances between clades ranged from 0.2-0.6% in nuclear fragments and as much as 16.2% in mitochondrial COI. Population aggregation, using fixed and alternate character (nucleotide) states to cluster or divide populations, recovered 232 such molecular characters in 4286 bp of sequence data and unambiguously aggregated populations into their respective geographic clade. Private haplotypes in all five gene fragments provide further support for the independent evolution of three dwarf crocodile lineages. Several morphological characters coincide with our phylogenetic analyses to distinguish crocodiles in the Congo Basin from Ogooué Basin and West African forms, but no fixed morphological differences have yet been documented between the latter two regions. This study highlights the importance of using widespread taxon sampling and a multiple evidence approach to diagnose species boundaries and reveal the existence of cryptic diversity.

NB: Submitted for publication May, 2008 to *Molecular Phylogenetics and Evolution* under the title: **Species-level diversification of African dwarf crocodiles (Genus Osteolaemus): a geographic and molecular phylogenetic perspective.**
The first genetic linkage map for the saltwater crocodile
(Crocodylus porosus)

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ABSTRACT: Genetic maps currently exist for many commercially as well as evolutionary important species. In this study we presents the first genetic-linkage map for the Saltwater Crocodile (Crocodylus porosus), and indeed the first for the Class Reptilia. We constructed male, female and sex-averaged linkage maps for C. porosus using a total of 189 microsatellite DNA markers typed for between 83 and 482 individuals from between five and ten families obtained from Darwin Crocodile Farm, NT Australia. We identified 12 linkage groups (LG) with LG sizes ranging from two to 53 loci. The overall map consists of 161 loci, while 28 markers still remain unlinked. LG are currently being physically anchored to chromosomes (2n=34) using Fluourescent In Situ Hybridisation (FISH) methods. The current linkage map confirms that female crocodiles have extraordinarily higher rates of recombination than males, with overall map lengths of 1636.5 cM and 275.2 cM respectively. This uncommonly large difference in recombination rates is one of the largest reported for a vertebrate species. This first genetic map lays the framework for further mapping analyses, with QTL mapping of economically and evolutionarily important traits currently underway in the saltwater crocodile.

INTRODUCTION

Genetic linkage maps currently exist for many commercially important species and are essential research tools for the mapping of economically, as well as evolutionary important traits. Dense genetic maps necessary for the accurate mapping of quantitative trait loci (QTL) require many polymorphic markers spaced evenly across the genome. Microsatellites are ideal markers for genetic mapping in many species, as they are relatively frequent throughout eukaryote genomes, co-dominant, hyper-variable, and are often highly informative within pedigrees. In a recent paper by Miles et al. (2008a), 253 novel polymorphic microsatellites were identified and evaluated for the saltwater crocodile (Crocodylus porosus). These markers were generated for the purpose of constructing a genetic linkage map. Evidence of genetic linkage between microsatellites was previously reported in crocodilians by Isberg et al. (2006). However, to our knowledge, no genetic map for a crocodilian, or any other member of the Class Reptilia, has thus far been reported. Herein we report the first microsatellite-based genetic linkage map for the saltwater crocodile (Crocodylus porosus),

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and indeed for any other reptilian. Currently, linkage groups (LG) are being physically anchored to *C. porosus* chromosomes (2n=34) via fluorescent *in-situ* hybridization (FISH) methods, and we expect the final anchored genetic linkage map to be completed in late 2008. The existing linkage map confirms that female crocodiles have extraordinarily higher rates of recombination than males (Isberg *et al.* 2006), with a ratio of female recombination versus male recombination of 5.95, the second highest ratio reported for any vertebrate species. The recent generation of a crocodilian genetic linkage map has also made it possible to perform systematic searches for individual loci affecting quantitative traits of economic importance in farmed Australian saltwater crocodiles. Whole-genome QTL scans are currently underway at Darwin Crocodile Farm and the University of Sydney.

**METHODS**

**The ‘Porosus’ mapping population**

The Porosus resource is a two-generation pedigree originating from Darwin Crocodile Farm, NT, Australia. This commercial population consists of a total of 482 individuals from ten full-sib families, with clutches from 2005-2007. Family sizes ranged widely with numbers ranging from 13 to 89 individuals. This resource can be sub-divided into two separate resources: the *linkage mapping resource* and the *QTL mapping resource*. Microsatellite genotype data from each resource was analysed using the software Cervus 3.0 (Kalinowski *et al.* 2007) to confirm parentage and pedigree integrity. Parentage analysis was conducted using a typing error rate of 0.01 and a strict confidence interval of 95%.

**Linkage Mapping Resource**

The linkage mapping resource originally consisted of 96 individuals from six full-sib families, but was later culled to 83 individuals from five full-sib families due to the incorrect parentage assignment for one clutch. Family cohorts were selected from 2007 offspring only, and family sizes ranging from 14 to 18 individuals. This resource was typed for 189 loci with the ensuing data used to construct the framework linkage map.

**QTL Mapping Resource**

Additional genotype data arising from subsequent QTL scans was incorporated into the final linkage map construction to bolster statistical support for the map order. This QTL mapping resource consisted of 482 individuals from ten full-sib families (some of which overlapped with the linkage resource families), with clutches taken from 2005, 2006 and 2007, where possible. The additional individuals were genotyped for 82 microsatellites selected for their even distribution across the framework linkage map.

**DNA extraction**

DNA was isolated from whole blood samples using a modified phenol-chloroform extraction protocol adapted from Sambrook *et al.* (1989). The DNA resource is available upon request for those who wish to contribute further to the crocodilian genetic linkage map.
Microsatellite genotyping

189 microsatellites were mapped in this study, and PCR conditions for these markers are described in Miles et al. (2008a). CAG-universal primers were labeled with either VIC, 6-FAM or NED fluorescent dyes. PCR amplicons for each of the respective panels were pooled (VIC, 6-Fam and NED) and analysed on an ABI 3130xl automated DNA sequencer. Raw genotype data was imported into Genemapper version 4.0 (Applied Biosystems) for genotype analysis. Genotypes for each microsatellite loci were scored, exported then compiled into a single data set via a custom BioPython script for linkage analyses.

Linkage Map Construction

Cri-Map v2.4 was used to perform linkage analyses and map construction for *C. porosus* (Green, 1990). Although many modern and more user friendly programs are available, none seem to have the same flexibility that enables Cri-Map to infer phase of (unsampled) parental generations (assuming we call the sampled generations F1 and F2) and enable linkage analysis with simple two-generation pedigrees. Genotype datasets for the two mapping resources were combined using the MERGE option in CRI-MAP. Markers were then sorted into LGs by TWOPOINT analysis with a threshold LOD ≥ 3.0, and later ordered within these groups using the BUILD multipoint analyses. LOD ≥ 2.0 was chosen as the minimum statistical support criterion for ascertaining locus order within LGs using the multipoint BUILD function. Loci that could not be confidently placed within the map order at the minimum LOD ≥ 2.0 were later added using the function ALL, which places loci in the most likely map position with the greatest statistical support. The function, FLIPS6, was later used to verify the final locus order of adjacent loci within LGs, ensuring the order with the greatest statistical support was retained. Centi-Morgan (cM) map distances were calculated using the Kosambi mapping function within CRI-MAP.

Physical Mapping

In conjunction with the construction of the linkage map, a bacterial artificial chromosome (BAC) library was established at Mississippi Genome Exploration Laboratory (MGEL), Mississippi State University, USA, with 2.8x coverage of the *C. porosus* genome. At the University of Sydney and South Eastern Area Laboratory Services, BAC filters were screened with P32-labeled overgo probes designed from microsatellite loci already mapped to the terminal ends of LGs. BAC clones identified to contain mapped microsatellites will be fluorescently labeled with FITC and Spectrum Red (Vysis) fluorochromes using nick translation, and then hybridized onto *C. porosus* metaphase preparations via fluorescent in-situ hybridization (FISH) methods. The physical mapping of the terminal loci will enable the anchoring and orientation of LGs to *C. porosus* chromosomes. Further refinement of the standard G-banded *Crocodylus porosus* karyotype was also carried out, including the production of a chromosome ideogram with band allocation providing a standardized reference for chromosomal locations.
RESULTS

Of the 189 microsatellites incorporated in the analyses, 161 loci were assigned to 12 LG, with 28 loci remaining unassigned. These LG comprise from two to 53 loci. Additional markers and perhaps additional informative meioses may be required to incorporate these unassigned microsatellites into the map. Initial mapping attempts revealed that the total length of the sex-averaged recombination map was 800.4 cM, with the sex-specific maps for male and female being 275.2 cM and 1636.5 cM respectively. These results show that the difference in recombination fraction between sexes was uncommonly high, almost six times higher in the female than that of the male. Idiograms for the respective maps are not presented here. However, comprehensive map illustrations will be reported upon completion of the physically anchored map. Preliminary results for the FISH mapping are presented in figure 1, and are described in the Dalzell et al. (2008).

Figure 1 Fluorescent in-situ hybridization (FISH) of fosmid clones to C.porosus chromosomes. Preliminary work towards the FISH mapping of BAC clones to anchor linkage map.

DISCUSSION

This paper described the first genetic linkage map for a crocodilian, and indeed for any other reptilian species. The present crocodilian map revealed an uncommonly large difference in the recombination frequencies between sexes, and apart from maps reported for some fish species (Coimbra et al. 2003; Moen et al. 2004), this is the greatest disparity yet reported for a vertebrate species. This phenomenon of differential recombination frequency is not uncommon. However, as previously reported by Moen et al. (2004), the ratio between recombination rates usually lies between 1.0 and 2.0, as evident in some of the most comprehensive linkage maps for vertebrates (Gyapay et al. 1994; Archibald et al. 1995; Dietrich et al. 1996). The reasons for these differences in recombination frequency are
Currently unknown. Sex-specific recombination rates have typically invoked an involvement of the sex chromosomes, with the heterogametic sex having the least recombination (with exceptions). However, crocodilians exhibit temperature dependent sex (TDS) determination (Lang et al. 1994), thus the high degree of heterochiasmy presumably relates to other major differences in the processes of male and female meioses. This is an area for further investigation.

Although the current map does incorporate 161 microsatellites, a large number of markers remain unmapped due to their lack of linkage to other markers. These unlinked markers indicate that the true map length is likely to be larger than that covered by the current sex-specific and sex averaged maps, which are relatively small for a vertebrate. Genome coverage will be better assessed following the physically mapping of LG terminal loci, which will not only anchor the map, but also will reveal the extent of chromosomal coverage for each of the respective LG. Additional markers, and/or additional informative meioses, will likely be required for the incorporation of the currently unlinked microsatellites into the existing map. However, as reported by Shedlock et al. (2007), the low levels of repetitive sequence that exist in non-avian reptiles could limit the saturation of a crocodilian linkage map with microsatellites alone. For this reason, the identification and mapping of single nucleotide polymorphism (SNP) markers will likely be required for the generation of saturated genome-wide linkage map. The current microsatellite-based linkage map for *C. porosus* serves as a framework for the future mapping of SNPs and other markers in the effort to generate a dense genetic map for the crocodilian.

A high density genetic linkage map is the first step towards the identification of loci contributing to genetic variance in economically and evolutionary important traits in crocodilians. The current *C. porosus* map, whilst only of medium density, has already facilitated systematic searches for QTL in Australian farmed saltwater crocodiles. Preliminary results from the first QTL scans in a crocodilian were presented by Miles et al. (2008b), and we expect more extensive results to be reported shortly.

This crocodilian linkage map will also facilitate comparative mapping and evolutionary studies in crocodilians and other closely related reptiles. The microsatellites isolated and mapped may also serve as a bridge for comparative mapping efforts, as microsatellites exhibit high levels of cross-amplification success in many species, including crocodilians (Dever et al. 2002; Fitzsimmons et al. 2002; Zucoloto et al. 2006; Miles et al. 2008c). For this reason, 82 of the microsatellites mapped in this study were also evaluated for their amplification success in 18 other non-source species of crocodilian, the results of which are presented in a recent paper by Miles et al. (2008c). It is hoped that in addition to providing the first genetic map for a crocodilian, this marker resource will provide polymorphic markers for several crocodilian species previously lacking informative genetic markers.

REFERENCES


Green, P., Falls, K. and Crooks, S. (1990). Documentation for CRIMAP, version 2.4. Washington University School of Medicine, St. Louis, Missouri USA.


Development of Microsatellite Markers for Siamese Crocodile
(*Crocodylus siamensis*)

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4 Department of Microbiology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.
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6 Department of Zoology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.

**ABSTRACT:** New Microsatellite markers were developed for Siamese Crocodile (*Crocodylus siamensis*) by constructing a library for microsatellite DNA. Construction and characterization of the library are described in the present study. Twenty microsatellite markers were developed from a (AC)\textsuperscript{15} enriched microsatellite DNA library. Among the twenty microsatellite loci, ten (50%) were polymorphic, whereas the rest were monomorphic (with two to four alleles per locus). The microsatellite sequences obtained could be classified structurally into perfect repeats (80%) and imperfect repeats (20%). No incomplete repeat type was observed. These markers were tested in five individuals of the same species and these tests resulted in twenty new microsatellites markers for *C. siamensis*. Low number of alleles (1-4 alleles) with an average of 1.7 alleles per locus was observed. The average length of uninterrupted repeats from the selected clones was 12.3.

**INTRODUCTION**

The Siamese crocodile (*Crocodylus siamensis*) is a critically endangered species of freshwater crocodiles. It was previously distributed throughout Southeast Asia. However, Thailand has extensive crocodile farms of *C. siamensis* and *C. porosus* breeds. Unintentional hybridization is often a more serious problem of conservation concern because it can occur undetected, particularly if hybrids do not have distinguishing morphological features. However, intentional hybridization could become a concern, if mixed species populations become the source for reintroduction efforts. In this case, hybridization may have dramatic effects for native endangered species e.g. Siamese crocodiles, if human-induce introductions arise from the population consisting a few or all hybrid offspring (Allendorf et al., 2001).

In addition, developing a plan for preventing such hybridization for the Siamese crocodiles is limited since clear observation is rarely. Clear observation is rarely possible because mating occurs in the water and often involves groups of males and females which are difficult to differentiate (Lang, 1989). Even if a female is observed to be mounted by more than one
male (Davis et al., 2000), it is unclear whether multiple males successfully copulate and inseminate her, resulting in fertilized eggs. Such observations have led to the supposition that female crocodiles may produce clutches of progenies by multiple males. Hybrids can be difficult to distinguish based on morphology, thus there is a need to develop molecular techniques to identify species status of individuals considered for release into the wild and to establish captive breeding programs for conservation.

Microsatellites have been the genetic tool of choice for DNA based parentage systems due to their highly polymorphic nature and have been employed for refined estimating of kinship and parentage (Bruford and Wayne, 1993) in many organisms including crocodiles (Glenn et al., 1998; Davis et al., 2000). They are nuclear markers that consist of short tandem repeats, usually 1-5 bp in length, such as (AC)n or (ATT)n (Beckmann and Weber, 1992). They are found approximately every 10 kb in the eukaryotic genome and their repeat arrays are generally no longer than 300 bps (Stallings et al., 1991). Polymorphism arises through variation in the number of repeat units present, possibly owing to slipped-strand mispairing (Schlötterer and Tautz, 1992). Variation at microsatellite loci can be assayed by PCR amplification using primers complementary to unique sequences flanking specific repetitive arrays, followed by electrophoretic sizing of the PCR products (Tautz, 1989).

In the current study, microsatellite primers were developed to compare population genetic structure in crocodilian families (Glenn et al., 1996; FitzSimmons et al., 2001). Several sets of primers have been designed for three other species of Crocodylus (including the Cuban crocodile, C. rhombifer, the salt-water crocodile, C. porosus and the Australian freshwater crocodile, C. johnsoni). However, within this genus, most tests of cross-species PCR amplification indicated the presence of homologous microsatellite loci that were variable (FitzSimmons et al., 2001). Herein, we describe the development of new microsatellite DNA primers for the C. siamensis. This is an important first step that should help to establish conservation strategies and contribute to an understanding of the structure of wild, remnant populations for this species.

MATERIALS AND METHODS

Sample collection and DNA extraction: Whole blood (5ml) was collected without injury to individual from an anterior dorsal sinus of a live caught wild Siamese Crocodile. The sample was kept on ice and sent to laboratory for DNA extraction and used for constructing a microsatellite library. In addition, five individuals of the same species were selected from the Sriracha breeding farm. Blood samples were collected as indicated above for the analysis of designed microsatellite primers.

Genomic DNA was digested with Taq I, in a final volume of 100 µl that composed of 10 µl of 10x Taq I buffer, 0.1 U/µl BSA, 0.25 U/µl of Taq I, and 1µ g/µl of genomic DNA. The mixture was incubated at 65°C for at least five hours or overnight. Digested DNA was run on a 0.8% agarose gel with ethidium bromide and visualized under ultraviolet (UV). DNA fragments with an average size of 500 to 1000 bps were isolated from agarose gel and purified by using QIAquick spin column (QIAGEN) followed by ethanol precipitation. This isolated DNA fragments were ligated into the Cla I site pBluescript II KS+ (Takara) and transformed into fresh competent XL1-Blue supercompetent cells (Strategene) by heat shocking. Transformed cells were grown up overnight on LB agar plates containing 50 µg/ml
ampicillin with Xgal and IPTG. Recombinant colonies were transferred onto Hybond nylon membranes (Amersham, Sydney) and followed by hybridizing with synthetic oligonucleotide microsatellite probe d(AC)15. Prehybridization and hybridization were carried out at 42°C in 6x SSC (from a 20x stock = 3M NaCl, 0.3 M sodium citrate), 5x denhardt reagent (from a 50x stock = 1% BSA fraction V, 1% Ficoll and 1% polyvinylpropylene) and 0.1% SDS. After hybridization, it was washed twice (30 min) in a 6x SSC, 0.1% SDS solution. Filters were screened for microsatellite repeated by using Gene-Images random primer labelling kit (Amersham Pharmacia Biotech) and exposed to X-ray film. After alignment to autoradiography images, positive colonies were selected and a recombinant plasmid was isolated by using alkaline preparation and screened for recombinants DNA by restriction enzyme. The potentially positive recombinants were sequenced automatically (Fluorescent dye method, Applied Biosystems).

**Primer design and genotyping:** Primer pairs were designed to amplify the flanking regions of selected microsatellites using the program Genetyx software (GENETYX software development Co. Ltd., Tokyo, Japan). Primers were about 18-24 bp in length, with calculated annealing temperatures of 50-65°C with a maximum 4°C difference between each pair, and no primer dimer of hairpin formation. In the genotyping, DNA samples from 5 Siamese Crocodiles were amplified in a 25 ul final volume of 1x PCR buffer (20 mM Tris-HCl, pH 8.4; 50 mM KCl), 1.5 mM MgCl2, 0.2 mM each dNTP, 0.4 mM of each primer, 0.02 U/µl. Taq DNA polymerase, and 25 ng of DNA. The amplified conditions are started with denaturing step of 94°C for 3 min and followed by 35 cycles of 94°C for 1 min, the appropriate annealing temperature for 1 min, and amplification at 72°C for 1 min. Products were stored at 4°C until ready to be analyzed and scored. The alleles of the microsatellite primers were detected in 6% denaturing polyacrylamide gel electrophoresis and their expected sizes were compared with standard size of φ x HinfI. The program Kodak 1D Digital Science V. 3.0.2: Scientific Imaging System (Eastman Kodak Company, New Haven, CT) was used for analyses of scientific images.

**RESULTS AND DISCUSSION**

Total 215 clones of transformant were constructed and hybridized with d(AC)15 probe. It was found that 59 clones or 27.44% of total clones with tandem repeat nucleotide were recognized and selected. From these positive clones, 30 of them (50.7% of total d(AC)15 positive clones) were selected for DNA sequencing. The sequencing result gave only 22 clones that can be selected to design primer. The other eight clones cannot be studied further due to inadequate lengths of flanking sequence. Thirty-two microsatellite primers were designed from 22 positive clones and only 20 of these provided reliable amplifications (Table 1). The DNA sequences of the cloned alleles were submitted to Genbank (accession numbers EF413033-EF413054). The microsatellite polymorphism in the farm population of Siamese Crocodiles has been analysed by SDS-PAGE. Low number of alleles (1-4 alleles) with an average of 1.7 alleles per locus was observed (Table 1). The average length of uninterrupted repeats from the selected clones was 12.3. Ten (50% of total microsatellite primers) of the 20 microsatellite loci were polymorphic. Information of all primers designed, including repeat motif, expected size, observed sizes, PCR conditions, and other characteristics, is presented in Table 1 and the illustrated of loci markers CS-4, CS-5 and CS-21 are presented in Figure 1.
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<th>Locus (GenBank accession no.)</th>
<th>Primer: (5' --&gt; 3')</th>
<th>Length</th>
<th>%GC</th>
<th>TM</th>
<th>Repeats</th>
<th>Expected size (bp)</th>
<th>Observed allele size range (bp)</th>
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</table>
A total of 20 microsatellite loci were structural analysis as indicated by Weber (1990) and 16 loci exhibited perfect microsatellite motifs without any interruption in the repeats, whereas 4 loci contained compound microsatellite repeats with a run of CA or GT repeats. No imperfect repeat locus was observed in the study.

The enrichment procedure that we employed was successful. The number of microsatellite library obtained in our study was di-nucleotide repeats which are common in Crocodylidae and Alligatoridae as previously reported by Glenn et al. (1998) for A. mississippiensis, FitzSimmons et al. (2001) for C. porosus and C. johnstoni, and Zucoloto et al. (2002) for Caiman latirostris.

Regarding to the former, captive colonies could be more efficiently managed by establishing individual pedigrees that would help to keep inbreeding coefficient as low as possible. With respect to the latter, genetic studies of the behavioral ecology of remnant populations will allow assessment of mating systems and dispersal patterns of wild individuals, helping researchers to understand how the remnant populations use the landscape.

In future studies, we will further characterize the primers obtained by verifying segregation and heterozygosity. The development of these new microsatellite markers significantly increases our capability to assess the diversity of C. siamensis in Thailand. These new markers will improve exclusion power for maternity tests and the resolution of parentage identification among wild individuals in C. siamensis.

**ACKNOWLEDGEMENTS**

This research is supported by Public-Private Technology Development and Transfer Center, and Center of Agricultural Biotechnology, Kasetsart University, Kamphaeng Saen Campus, Nakon Pathom.
LITERATURE CITED


Using Microsatellites to Describe Hybridization Between *Crocodylus acutus* and *Crocodylus moreletii* in the Yucatan Peninsula

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**ABSTRACT:** We tested for hybridization among wild populations of American crocodile (*C. acutus*) and Morelet’s crocodile (*C. moreletii*) in the Yucatan peninsula by using Bayesian assignment tests based on microsatellite data compared to mitochondrial and morphological assignments. Skin clips from 83 individuals were taken for genetic identification, and a total of 32 individuals (38.6%) exhibited some evidence of ancestral admixture by combined morphological, mitochondrial and microsatellite analyses. The majority of hybrids were classified as F2 hybrids and backcrosses to *C. moreletii*. Most of the introgression occurs in two national biosphere reserves located on the northern and eastern coasts of the Yucatan Peninsula. Preliminary tests did not find a significant decrease in hybridity across three life stages, thus far indicating a low level of selection against hybrids. Model-based analyses on multilocus genotypes of pure individuals returned little geographic partitioning in both *C. acutus* and *C. moreletii*. 
Cryptic species as a frame on use and conservation of Crocodylus acutus.

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ABSTRACT: Resolving taxonomic incongruence and delimiting regional management units for the genus Crocodylus in the Neotropics is currently one of the most relevant conservation and management issues for crocodile specialists. The small sample size used to establish New World Crocodylus morphological and molecular systematics has limited the understanding of the evolutionary process and has left out many undescribed cryptic species. Using mtDNA sequences form cytochrome oxidase I (COI) and cytochrome b (Cyt b) and 7 microsatellites designed by Fitzsimmons we challenged the paradigm that Crocodylus acutus is a single wide ranging species. Our findings will have a significant impact on American crocodile conservation and management plan since we can recognize at least five Evolutionarily Significant Units that should be managed as fully independent entities in order to maintain genetic biodiversity that will high productivity in captive populations and long term survivor of the taxa.

RESUMEN: Resolver las incongruencias taxonómicas y delimitar las unidades regionales de manejo y conservación para las especies del género Crocodylus en el Neotrópico es actualmente uno de los aspectos más relevantes para los especialistas en cocodrilos. El pequeño numero de muestras utilizadas en los estudios de sistemática morfológica y molecular de los cocodrilos del Nuevo Mundo a limitado el entendimiento del proceso evolutivo del grupo y a impedido el reconocimiento de muchas especies cripticas. Usando un amplio numero de muestras y secuencias de dos generes mitocondriales, citocromo oxidasa I (COI) y citicromo b (Cyt b) y 7 microsatélites diseñados por Fitzsimmons, nosotros decidimos evaluar el paradigma que Crocodylus acutus es una sola especie de amplia distribución. Los resultados de esta investigación tendrán un impacto significativo en el plan de conservación y manejo de los cocodrilos americanos porque el estudio recupera por lo menos cinco diferentes Unidades Evolutivas Significativas que deberían ser manejadas como unidades totalmente independientes para mantener la diversidad genética que promueva una mejor y más alta producción en cautiverio y la sobrevivencia del grupo a largo plazo.
Genetic characterization of Cuban populations of *Crocodylus* (Crocodylia: Crocodilidae): *C. rhombifer*, *C. acutus* and suspected hybrids using mitochondria and microsatellite markers.

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ABSTRACT: *Crocodylus rhombifer* has the smallest natural distribution of any species in the order Crocodylia (400-500 km²) and is one of the world’s most endangered crocodilians. In the Cuban Archipelago, this endemic species coexists with the American crocodile (*Crocodylus acutus*). These two species readily hybridize both in the wild and in captivity. In this study, mitochondrial DNA sequences and microsatellites loci were evaluated as tools to characterize genetically wild-caught individuals. Seventy-three samples were taken from three locations on Cuban archipelago: two in Zapata Swamp for *C. rhombifer* and suspected hybrids and the remaining in Birama Swamp for *C. acutus*. Genetic diversity from the *C. acutus* population in terms of observed heterocigosity (Ho=0.59) was higher than other populations inside the genus. On the other hand, the comparisons per pair of samples revealed significant genetic differentiation based on $F_{ST}$ ($F_{ST}=0.338$, $p=0.05$). Sequences analysis revealed *C. rhombifer* and suspected hybrids had the same haplotype, suggesting that all suspected hybrid samples represented crosses between female *C. rhombifer* and male *C. acutus*. Finally, the Cuban *C. acutus* haplotype was more closely related to the Cuban *C. rhombifer* haplotype than to the Mesoamerican *C. acutus* haplotype, suggesting a possible status species specific different to the current considered.
Development of Innate Immunity in Juvenile American Alligators

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ABSTRACT: Previous results in our laboratory indicated that hatchling alligators do not exhibit serum complement-mediated innate immune activity, but develop this activity during their first year. Thirty five alligators, from seven different wild clutches, were housed indoors (30°C) and fed ad libitum for approximately 2 months. Half of the alligators were then moved to outdoor tanks, while the other half remained indoors, such that animals from each clutch were represented in both groups. Blood was collected from each alligator at various times during their first year. Early results have indicated that alligators kept outside develop immunity much earlier than those housed indoors. Furthermore, immunity developed during the winter months when activity levels were low and nutritional intake was nonexistent. These results indicate that factors other than optimal metabolic temperature and growth may have an influence on the development of immunity. In addition, we observed clutch effects. Alligators from clutch #6 housed indoors developed immunity earlier than other alligators housed under the same conditions. Likewise, alligators in clutch #6 exhibited the highest mean immune activity relative to other groups in the outdoor environment. These results suggest that captive breeding programs for crocodilians might be able to utilize immune parameters as a selectable trait.
ABSTRACT: In a previous study we showed that captive adult alligators inadvertently fed lead pellets had extremely high lead concentrations in liver, kidney and bone, but had no obvious signs of pathology (Lance et al. 2006). Conversely, similar incidental lead ingestion in captive juvenile alligators on a commercial farm led to some mortality (Camus et al. 1998). To investigate the effect of lead consumption on juvenile alligators we force-fed five groups of eight juvenile alligators (body weight 1.8 to 4.8 kg) lead pellets in gelatin capsules at doses of 0, 0.25, 0.50, 1.0, and 2.0 g/kg body weight. Blood samples were collected before treatment and at two, four and six weeks and analyzed for lead concentrations and ALAD (aminolevulinic acid dehydratase) activity. ALAD activity depression is used to monitor lead exposure in humans. Alligators were monitored for three months following treatment. We could detect no differences in growth rates among treatments during the three months. The lowest dose tested, 0.25 g/kg body weight, caused a significant depression of ALAD activity (~90%) in whole blood at two weeks post treatment. Blood lead concentrations remained elevated throughout the sampling period and showed a significant correlation with ALAD activity depression (p < 0.01).

Alligator blood ALAD appears to be as sensitive to lead poisoning as other vertebrates, but no effect of lead on appetite and growth could be detected.

Differential Protein Expression of Alligator Leukocytes Induced by Injection of Bacterial Lipopolysaccharide

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ABSTRACT: Blood was collected from juvenile American alligators prior to, and 24 hours after intraperitoneal injection of bacterial lipopolysaccharide (LPS). The leukocytes were isolated from each sample, and the protein was extracted. The samples were analyzed by Two Dimensional Difference In-Gel Electrophoresis (2D-DIGE) to determine changes in protein expression upon LPS injection. The results indicated that the expression of several proteins was increased upon LPS treatment, while the expression of several others decreased. The quantitative increases and decreases were determined by digital densitometry. Fourteen proteins of interest were picked from the two dimensional gel and subjected to MALDI-MS/MS to acquire partial peptide sequence data. These peptide sequences were compared to those within the Entrez National Institutes of Health website protein sequence database to determine the identity of each protein. The identity and function of these alligator leukocyte proteins will be discussed.
Characterizations of serum complement activity of Broad-Snouted Caiman (*Caiman latirostris*)

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**ABSTRACT:** Immunity to infection is mediated by two general systems: acquired (or adaptive) and innate (or natural). Such systems have evolved and diversified in response to many factors, principally to the environment in which organism lives. Crocodilians exhibit aggressive social behaviors, and frequently serious wounds, including loss of entire limbs, resulting from these conflicts. Despite these serious injuries, they usually show no signs of infection.

Several recent findings in the field of immunology have reinforced the importance of examining functional features of immune systems in a variety of organisms. These immune features, such as the serum complement system, have been identified in crocodilians. Those findings could be related in high resistance to infections. This study was conducted to detect and characterize the concentration-, temperature-, and time-dependent serum complement activity of *Caiman latirostris.*
INTRODUCTION

The Chlamydia outbreak occurred in the Darwin region of Australia between June and August 2006.

Two farms experienced high morbidity/mortality during the outbreak in 2-6 month old juveniles. One farm had 96% loss and the other 29% loss. Total mortality >3000 deaths. Two further farms experienced low morbidity disease in 1-3 year old animals. During the outbreak, farms observed signs of severe infections both in the eyes and throat of animals. Animals were unable to see, eat or swallow in severe infections.

Samples from the eyes and throat, tested positive for Chlamydia by PCR. Chlamydia not known cause but Chlamydia was detected in a high number of animals.

In total sixty animals were post mortem and gross lesions were observed in the form of Severe conjunctivitis, Fibrinous oropharyngitis and Occasional cloacitis.

Severe conjunctivitis consisted of fibrin and mycoid discharge young animals (Figure 1) and in older animals of 1-3 year age class, the third eyelid sealed induces blindness. (Figure 2)
Fibrinous oropharyngitis consisted of redness in the throat due to inflammation (Figure 3) and a mass of fibrin build up (Figure 4) which caused asphyxiation. In the early stages of infection the mass of fibrin build up prevented the animal from eating or swallowing. In older animals nodules were also seen. The nodules formed due to the aggregation of lymphocytes cells. (Figure 5)