ASOCIACIÓN CHELONIA MONOGRAPHS
Volume V

Natural History and Conservation of the Orinoco Crocodile (*Crocodylus intermedius*) in Colombia

M. Merchán (Ed.), A. Castro, M. Cárdenas, R. Antelo & F. Gómez

Chelonia

FDB
FONDS DE DOTATION POUR LA BIODIVERSITÉ

LACOSTE

Corporinoquia
Por una Región Viva

Natural History and Conservation of the Orinoco crocodile (*Crocodylus intermedius* Graves, 1819) in Colombia

Publisher: Asociación Chelonia.

First Edition: February, 2012.
ISBN: 978-84-615-8223-5.
Legal deposit: M-15547-2012.
Printed by: PUBLIEQUIPO.

José Ayarzagüena during field work in the Pantanal of Bolivia, 2006. © A. Rodríguez-Williams.

The authors dedicate this book to the memory of Dr. José Ayarzagüena Sanz (Madrid, 1952 – Madrid, 2011), a renowned biologist who dedicated much of his life to the conservation of the Orinoco crocodile and promoting the sustainable use of the natural resources of the Venezuelan Llanos.

Asociación Chelonia

Accord entre Corporinoquia et Chelonia: «pour sauver la vie»

Les accords ont pour objectif initial de recourir aux ressources institutionnelles dans le but d´effectuer des projets en commun. L´accord obtenu entre Corporinoquia et l´Association Chelonia, concrétisé l´année dernière, a permis, comme première réussite concernant la recherché appliquée, la présente monographie qui comprend le travail d´actualisation des informations sur la distribution du crocodile de l´Orinoque. Les résultats confirment les menaces qui pèsent sur les écosystèmes dans la Région. Cette espèce, magnifique et imposante, se trouve alors dans une profonde crise qui peut conduire à son extinction dans le milieu naturel. Ce risque d´extinction est également confirmé par les avertissements émis par le Plan National de Conservation du Crocodile de l´Orinoque. Cela signifierait une perte incalculable pour le patrimoine de la biodiversité colombienne. Les facteurs qui déterminent la diminution de l´espèce dans l´Orinoque se réfèrent à l´action humaine, de part la pression directe de l´exploitation des ressources de la chaine trophique comme les poissons, la détérioration de la richesse de biodiversité du réseau hydrique ou par la croissante tendance de pollution et dégradation des écosystèmes et ressources naturelles au sein de l´habitat de l´espèce. Corporinoquia est consciente qu´au sein de l´Orinoque, la transformation systématique des écosystèmes naturels, la pollution du secteur productif agricole et pétrolier dans les sols et l´eau, et l´extraction indiscriminée de poissons pour le commerce en ville, mènent au bord de la faillite, l´ensemble de la chaine trophique. Par conséquent, la faible présence du crocodile de l´Orinoque indique une diminution générale de la santé des écosystèmes et de l´environnement régional. C´est la raison pour laquelle, on comprend que le travail institutionnel de Corporinoquia doit renforcer les efforts de conservation des espèces et des ressources naturelles, avec une perspective écosystémique – territoriale, qui commence par une adéquate planification environnementale et socioculturelle du développement économique. Cependant, les efforts de planification environnementale et territoriale, et les autres fonctions propres de l´autorité environnementale, se voient limités par la capacité institutionnelle pour couvrir efficacement la totalité du territoire de juridiction et promouvoir une gestion environnementale axée vers la durabilité.

Il est urgent, qu´au niveau national et international, les ressources de recherche et de conservation des espèces symboles telles que le crocodile de l´Orinoque, le cerf de Virginie, l´ours à lunettes, le puma et le jaguar, augmentent. Dans ce sens, le renforcement institutionnel de la gestion environnementale intégrale dans l´Orinoque est le facteur primordial pour atteindre les objectifs régionaux de la conservation et du développement durable, optimisant le travail coordonné avec les autres organismes publics de l´Etat constitués par le Système National Environnemental (SINA) de Colombie, spécialement les mairies et autres autorités publics ; avec la complémentarité et l´équité dans l´investissement public de l´Etat et des organisations privées de conservation. La gestion environnementale de l´Orinoque doit réviser et orienter, évidemment, les actions des corporations productives qui transforment constamment le territoire, tout comme les communautés locales urbaines, agricoles et indigènes, en renforçant leurs organisations et corporations afin de consolider les interlocuteurs institutionnels qui représentent leur intérêt groupé et permettent de générer des accords de conservation et usage durable des ressources naturelles inaliénables pour les communautés et les producteurs. La participation dans la Région des autres acteurs comme les associations internationales de recherche et de gestion environnementale comme Chelonia, entre autres, est aussi fondamentale pour obtenir un processus durable de conservation de la biodiversité et des écosystèmes représentatifs de l´Orinoque. De cette manière, la présente monographie doit être le pas initial pour consolider des accords, de plus grande envergure, qui permettent la conservation effective du crocodile de l´Orinoque, dans des écosystèmes sains. C´est pourquoi, nous continuerons, en travaillant avec Chelonia et d´autres organismes nationaux qui se consacrent à la conservation, d´identifier les actions et stratégies pour la mise en place de projets concrèts de conservation et d´usage durable qui permettent la récupération des populations du crocodile de l´Orinoque. Nous devons maintenant, urgemment, former un nouveau panorama d´actions coordonnées entre l´Autorité Environnementale Régionale, les organisations internationales de recherche et de conservation et le SIRA dans l´Orinoque pour pouvoir maintenir l´état sanitaire de nos écosystèmes et «Pour sauver la Vie», comme souligne notre devise corporative.

Projet de Conservation de Crocodile de L´Orinoque en Colombie.
Corporinoquia.

Agreement between Corporinoquia and Chelonia: "To Save Life"

The agreements have the initial objective of uniting institutional resources to achieve common goals. The agreement established in 2010 between Corporinoquia and the Asociación Chelonia has achieved the current monograph as a first goal in the applied research field, including updated information on the distribution range of the Orinoco crocodile. The outcomes confirm the threats on the region's ecosystems. This magnificent and breathtaking species is suffering from a deep decline, which can lead to its extinction in its natural habitats, just as the National Plan for the Orinoco Crocodile Conservation had warned. This disappearance would represent an invaluable loss in the wealth of Colombian biodiversity.

The factors that determine the Orinoco crocodile's decline in the Orinoquia are related to human action, either by direct pressure from the use of the natural resources of its food web, like fish, the deterioration of the biodiversity in the water systems, or by the increasing contamination and degradation of the ecosystems and natural resources that form its habitats.

Corporinoquia is aware of the systematic transformations occurring in the natural ecosystems, of water and soil contamination from agriculture and oil production, and of the indiscriminate exploitation of fish for commercialization in the cities. These factors are leading to the collapse on the entire food web. Therefore, the scarce presence of the Orinoco crocodile indicates a general decrease in ecosystems' health and the regional environment. Because of this, it is understandable that Corporinoquia's institutional work must strengthen the efforts in conservation of the species and the natural resources from an ecosystem and territorial perspective, including suitable environmental and sociocultural planning for economic development.

However, the labors of environmental and territorial planning, as well the functions of the environmental authority, are limited by institutional ability to act efficiently for the entire jurisdiction and to promote sustainable environmental management. Therefore, merging resources for research and conservation of iconic species such as the Orinoco crocodile, the white-tailed deer, the spectacled bear, the puma and the jaguar, is urgent on a national and international level.

As such, institutional strengthening for comprehensive environmental management in the Orinoquia is the prime factor in achieving regional conservation and sustainable development objectives, optimizing the coordinated work of the State public entities that form the National Environmental System (Sistema Nacional Ambiental - SINA) of Colombia, especially that of the municipalities and the departmental governments. This all comes from a perspective of complementarity and equity in the investments of the public state entities and private conservation organizations.

The environmental management of the Orinoquia must review and guide, of course, the actions of the producers or companies that constantly transform the territory, as well as that of the local urban, rural and indigenous communities, strengthening their organization and association to consolidate institutional interlocutors who represent their communal interests and allow for the creation of agreements on the conservation and sustainable use of the natural resources.

The participation in the region of other actors, such as the international organizations that work on conservation and environmental management like Chelonia, among others, is also fundamental to achieve a process for the conservation of biodiversity and the representative ecosystems of the Orinoquia.

This monograph is an initial step to achieve ever important agreements that allow for the effective conservation of the Orinoco crocodile in healthy ecosystems. For this reason, we will continue working with Chelonia and other national organizations dedicated to conservation, in the identification of conservation and sustainable use actions, strategies and projects that allow the recovery of the Orinoco crocodile populations.

We must now, urgently, create a new panorama based on cooperative action among the Regional Environmental Authority, the national and international research and conservation organizations, and the SIRA (Water Regional Information System) in the Orinoquia to maintain the health of our ecosystems and "To Save Life", as our corporate slogan says.

Orinoco Crocodile Conservation Project in Colombia
Corporinoquia

INDEX

1.- Introduction

Manuel Merchán Fornelino

This work forms part of the activities of the "Conservation of the Orinoco Crocodile (*Crocodylus intermedius*) in the Eastern Llanos of Colombia" project, funded by the Fundación Biodiversidad of the Ministry of Environment and Rural and Marine Affairs of Spain, Fonds de Dotation pour la Biodiversité-FDB (France) through its Save Your Logo program, and the Lacoste apparel company. It also joins the Asociación Chelonia's monograph series on the projects that it has been carrying out for nearly fifteen years in Europe, Latin America and Africa.

Though the early beginnings of Chelonia were confined to the Community of Madrid, in large part due to the fact that it was founded in the Spanish capital, initiatives soon emerged in Andalucía, Castilla La Mancha and Castilla y León, designed, during those early years, to evaluate the impact of human activities on native populations of amphibians and reptiles. This ran parallel to the creation in 2006 of the Association's offices in those three autonomous communities, as well as in Castilla La Mancha, Castilla y León, Galicia, Asturias, Aragón, Extremadura and Cantabria.

In 2006, besides opening offices across the country, the resolution to begin activities fostering development cooperation and biodiversity conservation outside Spanish territory was approved by the Board of Directors. While specific actions and collaboration with South American organizations had been progressing, it was only at this point that dedicated administrative and logistical structures were put in place for these activities, including registration with the Spanish Agency of International Cooperation for Development (AECID) and with the international cooperation agencies of Andalucía, Extremadura, Cataluña, Galicia and Valencia. With this administrative foundation, Chelonia's different offices throughout Spain began to submit project proposals for Nicaragua, Paraguay, Uruguay and Colombia.

The actual genesis of the project, which includes the publication of this book, began in August 2009 in the city of Bogotá, during an informal meeting between two of the co-authors, Miguel Cárdenas and Manuel Merchán, with representatives from universities and nonprofit organizations. In these gatherings, the conservation status of the Orinoco crocodile's wild populations in Colombia was discussed, as well as the political situation in Venezuela and the degree of influence this might have on Venezuelan populations of the species, including expropriations that had taken place in previous years.

Subsequently, a pre-proposal was drafted and submitted for evaluation by the Board of Directors of the Asociación Chelonia in Madrid, receiving unanimous approval just over a month later, together with a firm commitment to pitch for funding of a conservation project for the species in the Eastern Llanos of Colombia. In September of 2009, progress was made on agreements with the Colombian organizations – Corporation of Natural Protected Areas (ANP) and Foundation for Forest Conservation and Development (CDF). With the helping hand of Jesús Henao Sarmiento, these became Chelonia's first and essential supporting institutions in the country in developing the proposal for the Orinoco crocodile.

The final push for the project occurred three months later, in November of 2009, when the Fundación Biodiversidad (under the authority of the Ministry of Environment and Rural and Marine Affairs) officially approved the proposal submitted two months earlier, thus allowing the conservation project to be launched in early 2010. The first official presentation ceremony took place in Madrid, with the assistance of the Director of the Foundation, Ana Leiva. Chelonia´s base of operations was set up in Bogotá, from where the project would be coordinated. During the first half of 2010, agreements were signed with the Autonomous Regional Corporation of the Orinoquia (Corporinoquia) which supported the project in its entirety, providing essential support, mainly in field work, technical and legal consultancy and cartographic documentation.

At the same time, while the work in the Llanos was getting under way, Chelonia established contact with the French foundation Fonds de Dotation pour la Biodiversité (FDB), which, several months later, expressed its interest in taking an active part in the project through its "Save Your Logo " program, involving the Lacoste company, as part of its brand policy of contributing to the conservation of endangered crocodiles, caimans, alligators and gavials around the planet. In May 2010, senior staff from the FDB Foundation, accompanied by a Lacoste delegation led by the company´s President, Mr. Michel Lacoste, traveled to Colombia for a follow up visit. During this visit, a reception was held at the French Embassy in Bogotá, an expedition was made through the Meta River area, and visits were made to Los Ocarros Biopark and the Roberto Franco Station (National University of Colombia). In addition, a detailed presentation of the overall project was made for all the delegates from Lacoste, FDB Foundation and Los Ocarros Biopark.

In the month of June, in Paris, the final agreements were signed between FDB and Asociación Chelonia, agreeing to carry out the project over a three-year period. The agreement included the identification and assessment of wild crocodile populations, as well as tasks of awareness-raising and outreach. At the end of 2010, in Madrid, the Fundación Biodiversidad ratified its support of the project until the end of 2011, thus allowing for long-term planning of the work to be carried out in Colombia and Europe, including the publication of this book.

Conservation of the Orinoco Crocodile Today

The irrational exploitation of natural resources and the loss of biodiversity are global problems, but are particularly severe in tropical regions. The extinction of life forms has accelerated dramatically in recent decades, and sadly many species are now under very serious threat. The Orinoco crocodile is undoubtedly one of these species. Included by the International Union for Conservation of Nature (IUCN) in the category of “Critically Endangered”, the Orinoco crocodile has experienced a sharp decline since the 1930s. The species’ now scant populations require specific conservation measures throughout their areas of distribution in the Llanos of the Orinoco basin in Venezuela and Colombia.

Conservation work with critically endangered species is often complex and never exempt from high levels of uncertainty. In these endeavors, numerous factors critically influence both the methodology to be used and the possibilities of success to be anticipated. In the case of the Orinoco crocodile, difficulties -and with them uncertainties- are grand.

This is a species with a widespread and well-defined geographical distribution concentrated in the Orinoco basin in Venezuela and Colombia. The seasonality of the ecosystems the crocodiles live in -the flood plains of the Orinoco– is both advantageous and harmful to the study of the species. The lack of rainfall and consequent low water levels during the dry season (from approximately December to April) force aquatic animals to concentrate in dwindling bodies of water, something which undoubtedly eases the detection of the species in these conditions. However, the same seasonality turns the plains into an inland sea of thousands of square kilometers during the rainy season, making the detection of highly aquatic species, including our target species, almost impossible. There are some subtle differences with regards to this, as stated in Chapter 6 of this book on examining crocodile locating techniques, although all locating techniques, including those with indirect methods (such as ocular reflex or identifying prints or droppings), are hampered by the seasonality in this species’ habitat.

Currently, the greatest setback in successfully identifying wild Orinoco crocodiles is the species’ extremely low population density. Recorded densities several decades ago were increasingly low due to hunting, but, as detailed in Chapter 5, the main reason for the decline in hunting of the species was the difficulty in actually finding individuals. Unfortunately, this low population density is also a major problem for researchers when defining the conservation status of the species.

On the plus side, there is a solid and firm legislation in Colombia regarding the conservation of the species (see Chapter 4), though its application may at times be complicated due to external factors like inaccessibility to certain areas because of public policy issues. However, the existence of an initiative such as the National Program for the Conservation of the Orinoco Crocodile, as a space that brings together all the Colombian institutions involved in the conservation of the species, guarantees to a large extent the greatly needed debate regarding the initiatives to be taken as well as their subsequent implementation.

On the Authors and the Work

This book focuses on the biology, distribution and conservation of the Orinoco crocodile in Colombia. However, given the distribution of the species in Colombia and Venezuela, it became necessary to include content related to the latter country to properly explain certain issues, especially those regarding its conservation. Also, since this book has sought to maintain the vernacular names used in the Colombian Llanos when referring to the fauna, flora, geographical characteristics or traditional uses, a glossary has been included at the end to allow for a better understanding. In any case, to address any doubts the reader may have, the scientific names of species mentioned in the text and the citations of authors who have referred to them have been kept, and can be found in the Bibliography.

All the authors of this work have participated as Chelonia staff at some stage of the project, and have contributed according to their specialty. Biology related content, the details of the 2010 and early 2011 expeditions in Colombia and the glossary were elaborated by Antonio Castro Casal, a biology graduate with extensive field experience in the development natural resource conservation programs in several South American countries. The chapters on habitat and distribution and legislation were developed by Miguel Andrés Cárdenas-Torres, a forest engineer from Colombia with a thorough understanding of the geography of his country and of the legislation related to its natural resources.

Rafael Antelo Albertos, Doctor of biology and author of the chapter on conversation, has worked for over five years on conservation programs of the Orinoco crocodile in Venezuela and knows firsthand the species' overall situation. And finally, Fernando Gómez Velasco, a naturalist and tracking techniques expert, prepared the chapter which details all aspects related to locating the species in its natural environment.

This book, as part of the conservation project carried out by the Asociación Chelonia in Colombia since 2010, is presented as yet another contribution to the work of the public and private entities working to ensure the conservation of the Orinoco crocodile in the Orinoco basin.

2.- Biology and Behavior of the Orinoco Crocodile (*Crocodylus intermedius*)

Antonio Castro Casal

2.1. Size and Growth

The "Caimán Llanero", or Orinoco crocodile, is one of the largest and most endangered crocodiles on the planet. This species is estimated to reach a maximum length of approximately seven meters, according to those who were professional crocodile hunters (Medem, 1981). Humboldt and Bonpland (1826) left records of a large Orinoco crocodile encountered on his travels through the Apure River in 1880: *"At about four in the afternoon we stopped to measure a dead crocodile on the beach, it was 16 feet 8 inches [508 cm] long; and M. Bonpland found another one a few days later (it was male) that reached 22 feet 3 inches [678 cm]"*. Donoso (1966) cites the description Fray Jacinto de Carvajal made on his trip through the Apure River in 1618, which mentions a 25 foot long crocodile that corresponded to 696 cm (according to the author the Castilian foot (27.85 cm) was the measurement used). Today, in the few and sparse wild populations still present, the largest individuals rarely exceed a total length of 4.50 m.

Crocodiles can reach a considerable longevity. American alligators (*Alligator mississippiensis*) can live 70 years old in captivity, but in the wild they are believed to not exceed 50 years of age (Woodward *et al*., 1995). Medem (1983) mentions a female crocodile found in a house in San Fernando de Apure (Venezuela) on April 30, 1972 that measured approximately 350 cm in length and was 46 years old. In 1981, Medem received news that it was still alive. It finally died in 1992 at the age of 66 (Antelo, pers. comm.).

Medem (1981) cites three color phases which agrees with observations by Colombian plainsmen: yellow, with light shades on the back and sides; butterfly-like, with grayish-green and blackish spots on the back; and black, with dark grey or black on the back and sides, which is considered a melanic phase. In Venezuela, only the yellow and black phases are apparent (Godshalk and Sosa, 1978; Medem, 1983). In the Colombian Llanos, the "black crocodile or caiman" is considered a different species or breed to the Orinoco crocodile, based on differences in size, color and behavior. The "black crocodile or caiman" is considered to be larger, very dark and more aggressive; it does not bask on beaches and attacks its prey

Adult specimen of *C. intermedius* photographed in the Bioparque Los Ocarros, Villavicencio (Meta). February 2011. © CHELONIA/F. Gómez

Adult specimens of *C. intermedius* photographed in the Bioparque Los Ocarros, Villavicencio (Meta). February 2011. © CHELONIA/F. Gómez only from under the water. Antelo (2008) makes a similar observation with respect to crocodiles in the Venezuelan Llanos. The color, as discussed above, can vary as some individuals are much darker. The size and the behavior of these crocodiles appear to contribute to the legend around them.

To simplify the study of population structure and habitat use in crocodilians, size classes have been defined by stages related to biological changes during development. For *C. intermedius,* at least two methods of classification by size have been established, as shown in the following table:

	LT (cm)	Stage	Authors
Class I	X < 60	Newborn	Ayarzagüena and
Class II	60 < X > 250	Sub-adult	Castroviejo (2008)
Class III	250 < X > 350	♀♀and♂♂ Adult	Antelo (2008)
Class IV	X > 350	♂♂Adult	

Class I	X < 60	Newborn	
Class II	60 < X > 120	Juvenile	Seijas (1998)
Class III	120 < X > 180	Juvenile	Seijas and Chávez
Class IV	180 < X > 240	Sub-adult	(2000)
Class V	X > 240	Adult	

Table 1. Size classes established for *C. intermedius*.

Both methods correlate sexual maturity with the attainment of very similar lengths (250 and 240 cm respectively). The first method uses the interval between 250 and 350 cm to differentiate all mature females and part of the population´s mature males, as it considers all individuals of Class IV, from 350 cm and up, to be male. The largest recorded female reached a total length of 363 cm (Antelo, 2008 and Antelo *et al*. 2010). The second method however does not take into account sexual differentiation with regards to size and also establishes two classes in the juvenile stage.

2.2.- Habitat

Medem (1981 and 1983) mentions that adult individuals live mainly in pools of large rivers and deep lagoons during seasons when the water level is low, spending the winter in lagoons connected to rivers or in their meanders. Medem also identifies two annual migrations; one takes place in summer from lagoons to rivers, and the other in winter, from rivers to lagoons. He points out that juvenile individuals live in wells, lagoons and swamps of calm waters covered by floating vegetation. Adults driven there by pressure from increasing hunting would also use these habitats. Humboldt and Bonpland (1826) gathered knowledge from the indigenous people while travelling around the Orinoco and commented, "[...] *the Indians assured us that the young crocodiles preferred to live in narrower swamps and rivers, and that they especially gathered in gorges* [...]". Bonilla and Barahona (1999), regarding the population located in the department of Arauca, agreed that during the summer specimens can be found in meanders or near them, which can be "sections of the river" (Ele River) or wells (Cravo Norte River) that maintain their water while other areas dry up.

Thorbjarnarson (1987) found that crocodiles prefer the bends of the Capanaparo River (Venezuela), and to a lesser extent, currents immediately around islands in the river. During the breeding season in the Capanaparo River, adult individuals concentrate in the main channel of the river in areas deeper than 3 m. Individuals were also located in oxbow lakes shaped by old meanders (called "madreviejas", also referred to as former riverbeds) connected to the main channel (Thorbjarnarson and Hernández, 1993b).

According to Llobet (2002) in the Capanaparo River (Venezuela), crocodiles larger than 60 cm (juveniles, sub-adults and adults) prefer sloping beach areas with descents inferior to 30° that are barren or with herbaceous vegetation, both in seasons of low and high water levels. Adults and sub-adults prefer to position themselves in deep areas away from the banks (open water), and juveniles in areas of the river where parts of the bed are also exposed (inter-phase earth-water). This use of the habitat coincides with Thorbjarnarson (1987) regarding the Capanaparo River and Ávila-Manjón (2008) regarding the Cojedes River, both in Venezuela.

In the El Frío Biological Station (Venezuela), Antelo (2008) points out that during the dry season adults concentrate in the deeper areas of gorges and meandering rivers that have large bends and maintain a depth of over 2 m throughout the summer. He also mentions the congregation of individuals from October onwards in lagoons that maintain their water levels throughout the dry season (coinciding with Medem, 1981) and, coinciding with information gathered from local fishermen, the use of small shallow pools and floodplain lakes which are isolated from the main water course, and retain plenty of fish, in summer. Furthermore, Antelo coincides with other authors on the use by adult individuals of open water, while sub-adults occupy the shores. He also points out that adults begin to gradually disperse at the start of the rainy season in search of new aquatic habitats formed by the rains, using smaller tributaries as pathways through the savanna. This confirms what Medem (1981) pointed out in Colombia. This also coincides with the information obtained from local villagers and fishermen of the Meta River, indicating that adult crocodiles can be found in the main course of the river during the summer, which is also the breeding and reproductive season and when suitable beaches for nesting appear, while in winter they disperse and are found in streams and lakes that connect with the river.

According to Antelo (2008), radio-monitored sub-adults released in El Frío Biological Station often prefer habitats covered by aquatic vegetation which they use to protect themselves. Muñoz and Thorbjarnarson (2000) point out that radio-monitored sub-adult crocodiles released in the Capanaparo River (Venezuela) were mostly observed in shallow waters near shores- in the dry season near beaches without vegetation and during the rainy season, among partially submerged vegetation. All agree on the permanence of sub-adults in the same area throughout the year. Hatchlings usually occupy areas near the nests where they were born, where waters are calm and covered by aquatic or riparian vegetation (Thorbjarnarson and Hernández 1993b; Barahona and Bonilla, 1999; Llobet, 2002; Antelo, 2008).

In the dry season, when the water level is low, adult and sub-adult crocodiles can use caves or natural "cover", initially flooded, in the cliffs or river banks. They widen them by digging into them (Medem, 1981; Colvée, 1999; Antelo, 2008), using their snouts and front legs and making vigorous movements with their body and tail to create currents that help remove the sediments (Thorbjarnarson, 1987). These caves can also be dug into the ground or under tree roots in places without gullies (Antelo, 2008). In Colombia, the use of caves has been observed in the Arauca, Casanare and Capanaparo rivers (Medem, 1981); Godshalk and Sosa (1978) point out the existence of caves carved entirely by the animals. The reason for using these caves or lairs is not yet well known, however they could be used as daytime refuges during the dry season (Thorbjarnarson, 1987; Antelo, 2008).

Aestivation in the Orinoco crocodile does not seem to take place to-date. However, Humboldt and Bonpland (1826) refer to it in 1800: *"These monstrous*

Adult specimen of *C. intermedius* photographed in the Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/A. Castro

Skull of *C. intermedius* photographed in the Orinoco Hotel, Puerto Carreño (Vichada). March 2011. © CHELONIA/A. Castro

Lateral view of the ocular region of an adult individual of *C. intermedius.* Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/M. A. Cárdenas

Dorsal view of the ocular region and skull roof of an adult individual of *C. intermedius.* Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/M. A. Cárdenas *reptiles have multiplied in such a way, that throughout the course of the river we have always had five or six within sight. However, when the waters of the Apure rose, hundreds of crocodiles were observed covered in mud from the savannah.*" In addition, they state: "[...] *It was dry mud, which had covered the crocodile in that state of lethargy, or summer dream, and in which many of the species had lain during the absence of rain in the Llanos. The noise of men and horses, perhaps the smell of the dog, had made the crocodile reappear. In the shelter built on the edge of the pond, and flooded during part of the year, the crocodile had undoubtedly entered, during the flooding of the savannah, through the same opening through which it had been seen to exit*".

Historically, the most suitable habitat for the species is thought to be major rivers (Ayarzagüena, 1988) with white waters of the lowland plains (Thorbjarnarson, 1987; Thorbjarnarson and Hernández, 1992). The clear-water rivers formed in the savannas (Cinaruco, Vichada), smaller than those that emerge from the mountains, also were or are habitats of the Orinoco crocodile, although they appear to contain lower densities (Thorbjarnarson, 1987). Although several authors point out the ideal conditions of these rivers, populations existed and have been found in habitats close to the foothills (Ramo and Busto, 1986), in the Caura River, an Orinoco tributary of dark waters and granite bed (Franz *et al*., 1985; Thorbjarnarson, 1987), in the Ventuari River, a clear water tributary of the Orinoco which drains the eastern part of the Amazonas Department (Venezuela), and in reservoirs, such as the Venezuelan Camatagua and Guárico (Thorbjarnarson, 1987; Seijas and Meza, 1994).

The two individuals observed by team members of the Asociación Chelonia in December 2010 and February 2011 in the Vichada River occupied a narrow river bend with a sloping beach (35-40°) located on the right margin. Both shores have riparian vegetation of the gallery forest. The individuals were observed both during the day and at night, but only in the water. The individual observed in December 2010, with high water levels, was located at noon and in the afternoon in an area near the ravine of the right bank, a few meters downstream from the beach. On the other hand, the individual observed in February 2011, in low waters, was located preferably in the middle of the water channel, during the day and at night, and showed a tendency to move towards the shore opposite to the beach (left bank). The different use of the area was probably due to the different water levels during the two seasons.

On the other hand, the stretch of the Meta River for which there is information regarding the presence of the species does not have sharp bends, though it seems to be deep even during periods of low water. In this season, the area has large beaches with varying slopes and no vegetation. The white sand beaches are situated on both banks of the river and on islands located in its channels. On the edge of the right bank, a rock formation emerges during this season which, according to the information provided by a local fisherman of the area, the Orinoco crocodile uses to bask in the sun.

2.3.- Patterns of Thermoregulation

Crocodilian body temperature depends on the environmental temperature, as their low metabolic rate cannot generate the heat needed (Grigg and Seebacher, 2000) to maintain their body temperature within an optimum functional range.

Basking behavior is proven to be a process that regulates body temperature, and which is complemented by the movement of individuals between land and water (Grigg *et al*., 1998). In *Crocodylus johnstoni*, a medium-sized Australian crocodile, there are indications of two thermoregulation patterns: one in which individuals alternate periods of sunlight on the ground with periods in the water to lower their body temperature, and another in which crocodiles do not leave the water, keeping their body temperature balanced with that of the water throughout the day (Seebacher and Grigg, 1997). On the other hand, *Crocodylus porosus*, one of the largest sized crocodile species in the world, has a very defined seasonality; in winter they spend the night in the water and the day on land, while in summer, they remain in the water during the day and only come ashore at night. All this suggests that patterns of thermoregulation are correlated with the body mass volume, as the range of body temperatures during the day decreases with increasing body size (Grigg and Seebacher, 2000).

While basking, different crocodilian species keep their mouths open ("mouth gaping") at varying degrees. This mechanism is believed to regulate the temperature of the head, so it heats up more slowly through water loss by evaporation from oral mucosa (Spotila *et al*., 1977; Grigg and Seebacher, 2000). Physiologically, regulation of body temperature is defined by different mechanisms such as the level of blood flowing through the body surface, heart rate (Grigg and Alchin, 1976; Franklin and Seebacher, 2003), "mouth gaping" (Spotila *et al*., 1977) and metabolic acclimatization (Grigg and Seebacher, 2000).

Regarding the Orinoco crocodile observations made by Antelo (2008) in Apure (Venezuela) indicate the existence of two daily periods of sunlight during the dry season: one in the morning between 09:00 and 12:00, when the air temperature exceeds the water´s, with a peak from 11:00 to 12:00; and another between 16:00 and 17:00. However, during the rainy season, the period of sunlight is more widespread throughout the day, possibly due to a lesser variation of the air´s temperature. This author registers most basking to occur during the month of April.

Ramo and Busto (1984) coincide with Antelo on the existence of two periods of basking each day during the dry season in the Tucupido River (Venezuela), with a maximum of two daily periods. The first period lasts from 10:00 to 11:00, and the second -less intense- occurs at 16:00. This behavior matches the bimodal pattern of thermoregulation of the Nile crocodile (*Crocodylus niloticus*) in Zimbabwe (Loveridge, 1984) and that of the spectacled caiman (*C. crocodilus*) in the Venezuelan Llanos (Ayarzagüena, 1983; Castroviejo *et al*., 2008), although it differs from the mono-modal pattern of the saltwater crocodile (*Crocodylus porosus*) (Grigg and Seebacher, 2000).

Thorbjarnarson (1987) indicates *C. intermedius’* preference to bask on sandbanks of the Capanaro River (Venezuela) beaches and estimates that over 20% of the population of crocodiles over 2 m long bask between 08:30 and 11:00. On the other hand, Barahona and Bonilla (1999) indicate that within the Orinoco crocodile population present in the department of Arauca (Colombia), they only observed one male basking on land, though its tail was in the water. This occurred between 15:00 and 16:00 on three consecutive days in the dry season. During the remainder of the observation period, the individuals stayed in the water, sticking out their heads or their entire dorsal area or remaining submerged. They also point out the presence of traces revealing that individuals came out at night or during early morning hours. They do not, however, believe that this is related to thermoregulation, but rather that it is stalking a potential prey. The different patterns of behavior with respect to other populations of the species appear in this case to be due to human disturbances.

Indeed, human presence, coupled with the Orinoco crocodile’s distrust or caution, could be changing its “natural” patterns of thermoregulation, which were not observed during the dry season (December 2010 and February 2011) in individuals in the Vichada River (Colombia) that remained floating or submerged in the water while observers were present. Although two trails of two individuals were found on the beaches indicating that they were basking, they

Spectacled caimans (*C. crocodilus*) basking on a beach in the El Frío Biological Station, Apure (Venezuela). May 2007. © J. M. Galán

Adult female photographed in the caño Macanillal, El Frío Biological Station, Apure (Venezuela). May 2008. © M.Rivas were not observed doing so. Moreover, some individuals of the species are believed to be present in the well of La Vorágine (Meta River between La Primavera and Aguaverde; Vichada Department), although they were not seen nor were traces located during sampling (November 2010 to March 2011). This may indicate that its basking activity decreased due to human presence and activity. The information gathered from local fishermen confirmed the observation of individuals basking on the area beaches during the summer, although there are no estimates of frequency or time periods. Basking activity may also be affected during the rainy season, as fewer suitable sites are available as many beaches or sandbars remained submerged (Antelo, 2008).

In summary, the Orinoco crocodile´s pattern of daily basking appears to be clearly bimodal in the summer or dry season, taking place in the morning and afternoon, while in the winter or rainy season this bimodal pattern is mitigated by the greater uniformity of air temperature (Antelo, 2008).

2.4.- Diet and Predation Behaviors

Crocodiles are opportunistic predators that adapt their diet to the availability of prey and its ontogenetic development (Cott, 1961, Jackson *et al*., 1974; Webb *et al*., 1982; Pérez and Velasco, 2002). Ancient travelers described their eating habits, such as Joseph Luis de Cisneros (1764): "[...] *when they catch their prey, they shake their head as if it were a mastiff; they are fast in the race, they feed off fish and turtles in the river; if they hunt a four-legged prey, they dive to the bottom with him, and at night they go out onto the beach to eat it;* [...]".

The diet of juvenile individuals under 80 cm long described by Seijas (1998) for the Cojedes River (Venezuela), included: water beetles from the Belostomatidae, Hydrophilidae and Dytiscidae families, terrestrial insects such as beetles of the Carabidae and Scarabaeidae families, grasshoppers, moths, a wasp, crabs (*Poppiano dentata*), shrimp (*Macrobium* sp.), snails (*Thiara* sp.) rodents of the Cricetidae family, frogs of the Leptodactylidae family, a bird and a snake (*Leptodeira annulata*) as well as fish of the Doradidae family.

Blohm (1948) describes the consumption of the head and legs of "young Orinoco turtles" between 8 and 12 cm in length by a young Orinoco crocodile, 82 cm long, in a tank with water and sand. During the procedure, it first drowned the chelonian, then dragged it out of the water and banged it against a rock. Medem (1981), meanwhile, described the stomach content of 11 specimens collected in the Arairi, Güejar and Cuminía rivers (department of Meta, Colombia) in 1955/56. Mainly found were remnants of leather fish (*Pimelodus clarias, Pimelodella chagresi, Sorubim lima*), as well as of capybara (*Hydrochoerus hydrochaeris*), agouti (*Dasyprocta* sp.) and cormorant (*Phalacrocorax brasilianus*). He also mentions observing predation on turtles of the genera *Podocnemis* and *Phrynops*. Also mentioned is the capture of "sardines", which swim by crocodiles resting in shallow water. The crocodile takes advantage of the situation by pushing them towards its mouth with an arched movement of the tail. Donoso (1966), apart from mentioning the capybara, agouti, cormorants and turtles, also includes the spectacled caiman (*Caiman crocodilus*) and its own offspring as part of the diet. Antelo (2008) also describes a case of cannibalism.

Inhabitants of the Llanos commonly tell stories of crocodile attacks on horses and cattle on the stepping stones used to cross the rivers during the long journeys undertaken to move the herds. Medem (1981) describes how horses and cattle are captured -they are seized by the muzzle or one of their front legs and are dragged into the water to be drowned-, and cites the observation of a crocodile with a cow's head in its mouth, swimming in the Meta River near the town of Santa Rosalía (Vichada Department). Humboldt and Bonpland (1826) acknowledge predation on horses: "*Horses that roam the savannah during that period [of high waters], and are unable to climb up small elevations, hundreds of them perish: mares can be seen swimming with their colts during part of the day to feed on the grass, of which only the tips come above the water. They are chased by crocodiles, and on their legs can often be seen signals left by the teeth of carnivorous reptile*".

The information that exists on the nutrition of *C. intermedius* sub-adults and adults shows a greater proportion of fish in their diet (Seijas, 1998). However, they prey on different groups of vertebrates such as capybaras (Antelo, 2008) and iguanas (Ramo and Busto, 1984) and also act as scavengers, taking advantage of domestic or wild mammals (Medem, 1981) such as capybaras (Antelo, 2008). Humboldt and Bonpland (1826) also mention capybaras as part of the Orinoco crocodile´s diet: "*The crocodiles of the Apure feed mainly off capybaras which live in groups of 50 to 60 individuals* [...]".

Man may occasionally have been among its prey. Gumilla (1791) mentions that "*it just happened to learn to prey upon human flesh*" and describes three situations in which the Orinoco crocodile should be feared: during the breeding sea-

Adult specimen of *C. intermedius*. Some individuals present an especially narrow snout. Roberto Franco Tropical Biology Station, National University of Colombia, Villavicencio (Meta) January 2010. © CHELONIA/M. Merchán

Adult of *C. intermedius* feeding on a capybara (*Hydrochoerus hydrochaeris*) in the La Ramera Lagoon, El Frío Biological Station, Apure (Venezuela). July 2006. © M. Camacho son, when it is guarding the nest, or when it is caring for newborns. Medem (1981) described three cases of attacks on humans by *C. intermedius*.

Humboldt and Bonpland (1826), when describing their trip through the Orinoco around Angostura, narrate: "*When the water rises a lot, the banks are inundated and what happens is that reckless men are victims of crocodiles. These animals, due to the structure of their larynx, hyoid bone and ripples in the tongue, can grab their prey underwater, but not swallow it; the animal can usually be found eating its prey on a beach just hours after the event takes place. The number of individuals that die annually, victims of their recklessness and of the ferocity of the reptiles, is much greater than what is believed in Europe, especially among populations where the surrounding land is often flooded. The same crocodiles remain in one spot for a long time, and each year become more daring if by chance they develop a liking to the taste of human flesh. What´s more, their boldness is such that it is very hard to kill them. The bullet does not penetrate through their skin and the blow is not deadly unless it reaches straight into its large mouth or under the armpit. Indians who barely know of the use of firearms, attack crocodiles with spears after they are hooked on crooked irons, baited with meat and tied to a tree. They do not approach the individual however until it has given up trying to get rid of the iron embedded in its upper jaw*".

Very little information is available on predatory behavior and hunting techniques in the wild. The existing information is mainly made up of specific observations recorded by ancient travelers exploring the Orinoco bann, as well as Federico Medem who began investigating the species in the 1950's, and of observations (Antelo, 2008) recently carried out on the population at the El Frío Biological Station (Apure, Venezuela).

Cardona (1964) cites Calzadilla Valdés ("Por los Llanos del Apure" meaning "Through the Llanos of the Apure"), who described the presence of Orinoco crocodiles on heron nesting grounds "Vuelta Mala". They captured the herons set down as traps by hunters who then seized them by beating them with paddles (oars) and pushing them with rods.

Medem (1981) mentions that the Orinoco crocodile can detect prey 300 m away and describes various hunting techniques:

- Once prey is located, the individual moves in the opposite direction, diving and reappearing suddenly where it had detected the prey. By striking its tail, it propels medium-sized prey into its mouth, such as “saíno” or white-collared peccary (*Pecari tajacu*) and the “cafuche” or white-lipped peccary (*Tayassu peccary*), “venado” or white-tailed deer (*Odocoileus virginianus*), “soche” or grey brocket (*Mazama gouazoupira*), “chigüiro” or capybara (*Hydrochoerus hydrochaeris*), dogs or pigs.

- Smaller sized animals captured directly with the mouth, such the “lapa” or lowland paca (*Agouti paca*), “picure”, “ñeque” or agouti (*Dasyprocta* sp. and *Myioprocta* sp.), ducks, cormorants or chickens, who after being caught are repeatedly beaten against the ground or surface of the water until they are left completely immobilized.

- Hunting of fish in the air (*Pseudoplatystoma* sp.) when they are “driven” out of the water in an attempt to escape. Antelo (2008) cites unsuccessful attempts by newborn and juvenile crocodiles to capture dragonflies and passerines in the air.

- Hunting by waiting for “sardinas” in shallow waters of riverbanks or lagoons, with the crocodile’s back sticking out of the water. Schools of fish approach the motionless animal to feed off organisms on its scales, at which time the crocodile arches very suddenly and uses its tail to push fish towards its mouth.

- Hunting by regurgitating an oily substance that attracts “sardinas”. The individual stays put with its mouth open, waiting for the right moment to close it and catch the fish. Medem observed regurgitation in captivity and assumes that it must also be done in the wild to capture “sardinas”, comparable to the American crocodile’s (*Crocodylus acutus*) use of this technique.

Antelo (2008) cites several hunting classes and techniques:

“In shallow waters, adult individuals lean head and tail towards the bottom, leaving part of their trunk above the surface of the water, forming an inverted U and doing forward-backward and lateral movements with the aim of catching fish, perhaps terminating by stretching the body underwater. The crocodile approaches, with its dorsal area hovering over the water surface, perpendicular to the shore, resting its chin on it and slowly turning its tail, forming a semi-circular barrier with its body and the shore where the fish are then trapped. The crocodile tries to catch them by turning its open mouth in an inward motion. At the start and at the end of the rainy season, crocodiles take advantage of the rapidly flowing currents along

the dikes; they wait with their mouth open for fish to flow along the stream, catching their prey at exactly the right moment. The effectiveness observed was almost 100%." Antelo also describes underwater hunting of fish and mammals; although exactly how they are captured is not known, he did record the individual emerging to the surface with its prey. In two cases, the preys were sub-adult capybaras (*H. hydrochaeris*).

Antelo (2008) also confirms the scavenging tendencies of the Orinoco crocodile described by Medem (1981), who gathered testimonials, though not proven, of collective hunting of capybara and fish through cornering techniques.

2.5.- Survival and Mortality Factors

A wide variety of factors can affect the survival of crocodilians, especially during the early stages of development from the egg stage to the first year of life (Pérez and Rodríguez, 2005). Environmental factors such as temperature variations, moisture-desiccation variations, and abrupt changes in water levels of rivers that can flood nests on the surface and underground, can affect the viability of the eggs. Furthermore, both eggs and newborns are threatened by different species of animals that feed on them or which can accidentally cause the eggs to break. This means, generally, that a very low percentage of individuals survive and reach adulthood. Ayarzagüena (1983) recorded the loss of eggs in spectacled caimans (*C. crocodilus*) in the Apure Llanos (Venezuela) due to a predation rate of almost 80% and a survival rate of only 23.1% in the first five months of life.

For *C. intermedius,* there are few records of egg loss caused by nest flooding, perhaps because they usually nest on beaches or banks when water levels are still falling and the eggs hatch when water level is at its minimum or at the start of its annual rise. Chávez (2002) indicates that some nests are flooded by the uncontrolled management of the lock gates in the Cojedes Norte River (Venezuela). González-Fernández (1995) points out a loss of six nests out of 27 (22.2%) with only one caused by floods.

Predation is the primary cause of mortality among Orinoco crocodile eggs. Based on data from El Frío Biological Station (Venezuela), Antelo (2008) indicates that in 2004, 81% of the nests were preyed, and only 40% in 2005. The total record of preyed nests from 2004 to 2006 shows that 27 (60%) of 45 monitored posts were totally or partially preyed upon. The "mato", "lobo pollero" or gold tegu (*Tupinambis teguixin*) was identified as the main predator. Other predators include the "oso palmero" or giant anteater (*Myrmecophaga tridactyla*) and the "caricare" or northern-crested caracara (*Caracara cheriway*) who takes advantage of eggs that have been dug out by other predators. Antelo also mentions that the "terecay" or yellow-spotted Amazon river turtle (*Podocnemis unifilis*), and other female crocodiles, may break some eggs as they lay them in the same place. Chávez (2002) points to turtles of the *Podocnemis* genus, iguanas (*Iguana iguana*) and *Anolis*-type lizards as factors that can negatively affect the egg viability. Medem (1958, 1981) cites the gold tegu, "gallinazo" or black vulture (*Coragyps atratus*) and grey fox (*Cerdocyon thous*) as predators of crocodile eggs. Colvée (1999) adds the green ameiva (*Ameiva ameiva*) to the list of potential predators.

Many species prey upon newborns. Humboldt and Bonpland (1826) describe a joint attack by "zamuros" or turkey vultures (*Cathartes aura*) on a group of young. Medem (1981), mentions the ocelot (*Leopardus* sp.), the jabiru (*Jabiru mycteria*), raptors -without specifying which type-, the striped catfish (*Pseudoplatystoma fasciatum*, *P. tigrinum*), the goliath catfish (*Brachyplatystoma filamentosum*, *B. vaillantii*), ox (*Pseudopimelodus albomarginatus*, *P. raninus*) and red-tailed catfish (*Phractocephalus hemiliopterus*) as being the main predators of small sized younglings. Antelo (2008) offers an overview of neonate predators that include the caracara (*Caracara cheriway*), the "chiriguare" or yellow-headed caracara (*Milvago chimachima*) and the tiger heron (*Tigrisoma lineatum*). Among potential predators he includes piranhas (*Serrasalmus* spp.), the giant otter or "perro de agua" (*Pteronura brasiliensis*) and the "babilla" or spectacled caiman (*C. crocodilus*). Though there is no recorded information of this kind of predation on the Orinoco crocodile, Seijas (1998 and 2000) does register predation of this species on American crocodile hatchlings (*Crocodylus acutus*), so it may also prey on the Orinoco, as Thorbjarnarson points out (1987). Godshalk and Sosa (1978) explain that the Genera *Jabiru*, *Euxenura* (currently *Ciconia*) and *Ardea* are diurnal predators and that the *Felis* (currently *Leopardus*) and *Procyon* Genera are mainly nocturnal.

An additional cause of neonatal death is the lack of female participation in opening the nest. This prevents hatchlings from being able to pass to the exterior due to the weight and amount of sand on them. Antelo (2008) registered the case of a nest with two live neonates inside, between 7 and 10 days old, left unopened by the mother at a depth of 45 cm. He also refers to another case in which he found a newborn hatching from the egg while another seven were dead and

Adult of *C. intermedius* feeding in the Bioparque Los Ocarros, Villavicencio (Meta). May 2010. © CHELONIA/M. Merchán

Manuel Merchán photographed beside a 4.05 m long adult male of *C. intermedius* in the El Frío Biological Station, Apure (Venezuela). May 2006. © P. Mejía decaying. He therefore concludes that, for the offspring to survive hatching correctly, it is vital that the mother opens the nest.

The capture of hatchlings by man for commercialization or simple possession must also, coupled with the high rates of mortality and predation previously mentioned, hinder the recovery of wild populations. Bonilla and Barahona (1999) indicate that it is a very common practice in the town of Cravo Norte (Arauca Department), pointing out that between 1994 and 1995 at least 17 offspring were collected in that region. Human predation is also mentioned by Llobet (2002) regarding the Capanaparo River (Venezuela) population.

Gumilla (1791) and Godshalk and Sosa (1978) refer to the "tigre" or jaguar (*Panthera onca*) and the "güío" or anaconda (*Eunectes murinus*) as predators of sub-adults. Cannibalism of the wild crocodile is also cited by Antelo (2008) when the radio-transmitter signal carried by a sub-adult was located inside an adult female. Different species of wild crocodilians generally present a high mortality rate in newborns and juveniles. Thorbjarnarson (1987) estimates a mortality rate of 91% to 95% during their first two years of life of Orinoco crocodiles of the Capanaparo River (Venezuela).

There is little information on the causes of death in adults and even less of predation on them. Mankind must be their major cause of mortality (Antelo, 2008). This author reported the attack and death of a male caused by another in captivity, and mentions the vulnerability of some individuals to drowning through accidental entanglement in fishing nets. This cause of death was also pointed out by Thorbjarnarson (1987) and Bonilla and Barahona (1999) among the crocodile population of the department of Arauca (Colombia), and by the Asociación Chelonia team in the Meta River based on information provided by fishermen.

Historically, commercial hunting for the crocodile skin trade, which began in the early twentieth century, and gained intensity between 1929 and 1934 (Medem, 1981), has been the greatest cause of mortality among adults and sub-adults. This author also mentions crocodile hunting to feed the native populations when fishing became less effective, mainly in winter, something which Gumilla (1791) had already picked up on: "[...] *the Otomac and Guam Indians, who use their meat as sustenance, especially in the winter and with the rising of the river, when fishing is rather pointless* [...]". Thorbjarnarson (1987) also mentions commercial trading, not only of hatchlings, but of adults too, some of which are purchased by rangers in the State of Apure (Venezuela). Currently, intentional or premeditated killing is thought to be justified because of the species' danger to man and domestic animals, and its unproven negative influence on the fish abundance. This mortality must also reduce the number of adults that still survive and which, along with predation, natural mortality and habitat destruction, prevent the recovery of wild populations. Finally, we must take into account, though little information is available, the possibility of death caused by illnesses, whether natural, due to contamination or other factors resulting from human activities.

Egg Predators	**Common Name**	**Source**
REPTILES		
Tupinambis teguixin	Gold tegu	Medem (1958, 1981, 1983); Donoso (1966); Godshalk (1982); Colvée (1999); Antelo (2008
BIRDS		
Caracara cheriway	Caracara	Antelo (2008)
Coragyps atratus	Black vulture	Medem (1958, 1981); Donoso (1966)
MAMMALS		
Myrmecophaga tridactyla	Giant anteater	Antelo (2008)
Cerdocyon thous	Forest fox	Medem (1981, 1983); Godshalk (1982); Colvée (1999);
Potential Egg Predators	**Common Name**	**Source**
REPTILES		
Ameiva ameiva	Green ameiva	Colvée (1999)
Podocnemis unifilis	Yellow-spotted river turtle	Antelo (2008); Chávez (2002); Seijas (1998)
Iguana iguana	Green iguana	Antelo (2008); Chávez (2002)
Crocodylus intermedius	Orinoco crocodile	Ayarzagüena (1987); Antelo (2008)
Predators of Hatchlings	**Common Name**	**Source**
FISH		
Pseudoplatystoma fasciatum	Barred shovelnose catfish	Medem (1981)
Pseudoplatystoma tigrinum	Tiger shovelnose catfish	Medem (1981)
Brachyplatystoma filamentosum	Goliath catfish	Medem (1981)
Brachyplatystoma vaillantii	Goliath catfish	Medem (1981)

Adult female Orinoco crocodile defending its litter in front of the observer in the Ramera Lagoon, El Frío Biological Station, Apure (Venezuela). May 2004. © R. Antelo

Orinoco crocodile nest on the shore of the La Ramera Lagoon, El Frío Biological Station, Apure (Venezuela). February 2005. © R. Antelo.

Phractocephalus hemiliopterus	Red-tailed catfish	Medem (1981)
Pseudopimelodus albomarginatus	Catfish	Medem (1981)
Pseudopimelodus raninus	Catfish	Medem (1981)
BIRDS		
Tigrisoma lineatum	Tiger heron	Ayarzagüena (pers. comm.) in Antelo (2008)
Ardea cocoi	Cocoi heron	Godshalk and Sosa (1978); Medem (1983); Colvée (1999)
Ciconia maguari	Maguari stork	Godshalk and Sosa (1978)
Mycteria americana	Wood stork	Medem (1983)
Jabiru mycteria	Jabiru	Godshalk and Sosa (1978); Medem (1981)
Cathartes aura	Turkey vulture	Humboldt and Bonpland (1826)
Coragyps atratus	Black vulture	Medem (1958, 1983); Colvée (1999)
Caracara cheriway	Northern caracara	Antelo (2008)
Milvago chimachima	Yellow-headed caracara	Antelo (2008)
MAMMALS		
Procyon cancrivorus	Crab-eating raccoon	Godshalk and Sosa (1978); Colvée (1999)
Leopardus sp.	Ocelot	Godshalk and Sosa (1978); Medem (1981)
Potential Predators of Hatchlings	**Common Name**	**Source**
FISH		
Pygocentrus cariba	Piranha	Lasso (pers. comm.) in Antelo (2008)
Serrasalmus altuvei	Piranha	Lasso (pers. comm.) in Antelo (2008)
Serrasalmus elongatus	Piranha	Lasso (pers. comm.) in Antelo (2008)
Serrasalmus irritans	Piranha	Lasso (pers. comm.) in Antelo (2008)
Serrasalmus mediane	Piranha	Lasso (pers. comm.) in Antelo (2008)
Serrasalmus rhombeus	Piranha	Lasso (pers. comm.) in Antelo (2008)
Hoplias malabaricus	Wolf fish	Lasso (pers. comm.) in Antelo (2008)
Hydrolycus armatus	Payara	Lasso (pers. comm.) in Antelo (2008)
Ageneiosus brevifilis	Guyana slopehead fish	Lasso (pers. comm.) in Antelo (2008)
Leiarius longibarbis	Planet catfish	Lasso (pers. comm.) in Antelo (2008)

Pseudoplatystoma orinocoense	Barred shovelnose catfish	Lasso (pers. comm.) in Antelo (2008)
Pseudoplatystoma metaense	Barred shovelnose catfish	Lasso (pers. comm.) in Antelo (2008)
REPTILES		
Caiman crocodilus	Spectacled caiman	Seijas (1998); Antelo (2008)
BIRDS		
Egretta alba	Great egret	González-Fernández (1995); Colvée (1999)
MAMMALS		
Pteronura brasiliensis	Giant otter	Antelo (2008)
Predators of Sub-adults	**Common Name**	**Source**
REPTILES		
Eunectes murinus	Anaconda	Gumilla (1791); Medem (1981); Antelo (2008)
Crocodylus intermedius	Orinoco crocodile	Antelo (2008)
MAMMALS		
Panthera onca	Jaguar	Gumilla (1791); Godshalk and Sosa (1978); Medem (1981); Antelo (2008)

Table 2. List of species that prey on or affect (directly or potentially) the survival of the Orinoco crocodile.

2.6.- Reproduction

Sexual Maturity

The most efficient method to confirm sexual maturity in crocodilians is to check the development status of the gonads, which involves sacrificing the animals. This technique is obviously not feasible in a species that is in critical danger of extinction.

Medem (1981) describes a male in captivity having reached sexual maturity when it was approximately 13 years old and its total length stretched to 265 cm, though he mentions another older male with a total length of 300 cm that had not yet reached maturity. Thorbjarnarson (1987), from information gathered on animals in captivity and taking into account similarity in growth rates among captive and wild individuals, indicates that sexual maturity in females is reached at a total length of 240-260 cm, and at an age between 7 and 10 years. Males, in turn, are considered to be sexually mature at 300 cm in length and at an age between 9 and 12. Despite these estimates, a copulation attempt of a 273 cm male and mating behavior in a male of 285 cm (Thorbjarnarson and Hernández, 1993a) were recorded in captivity. These authors determined the total length of nesting females along the Capanaparo River (Venezuela) from the traces left near the nest, deducing that the shortest female reached 266 cm, while most were between 275 and 325 cm. In captivity (Hato Masaguaral), the shortest nesting female was 250 cm long.

According to this data and the size classes used by Rivas and Owens (2002), one can conclude that the approximate length needed to reach sexual maturity is between 240 and 260 cm, though there are cases where sexual maturity has been reached at lesser total lengths and others that have required further growth.

The difference between the data on sexual maturity for this species, both in individuals in captivity and in the wild, is caused by the crocodilian´s dependence on habitat quality (Lance, 2003) and, therefore, on environmental conditions and the availability of resources, which may delay or accelerate growth and sexual maturity. It has been proven that under ideal conditions of captivity, crocodilians grow faster and reach sexual maturity earlier than under natural conditions (Joanen and McNeese, 1986; Rivas and Owens, 2002).

Among American crocodiles (*C. acutus*), the female is estimated to sexually mature before males (Ogden, 1978; De la Ossa and Sampedro, 2002). The phylogenetic proximity of this species to *C. intermedius* suggests that these females could also mature earlier, though no data justifies this belief. However, Colvée (1999) indicates that, based on comparative behavior observations related to the size of adults and sub-adults, the limit for sexual maturity of males could be a total length of 200 cm and for females of 250 cm. The same author notes that verifying sexual maturity through behavioral observation does not provide accuracy, especially in males, because the state of some sexually mature males might possibly remain unexpressed due to exclusion from mating activity by other dominant males.

Specimen of *C. intermedius* recently hatched, photographed in the incubator room of the El Frío Biological Station, Apure (Venezuela). May 2006. © CHELONIA/M. Merchán

Specimen of *C. intermedius* recently hatched in the La Ramera Lagoon, El Frío Biological Station, Apure (Venezuela). May 2008. © R. Antelo

Hatchling of *C. intermedius* photographed in the Roberto Franco Tropical Biology Station, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán

Hatchlings photographed in shallow waters of Caño Macanillal, El Frío Biological Station, Apure (Venezuela). May 2008. © M. Rivas

Territoriality, Courtship and Copulation

The Orinoco crocodile possesses a certain degree of gregariousness, establishing territories mainly during periods of courtship and copulation. In the wild, males tend to occupy deep areas of water, and simultaneously share one or more females (Medem, 1981; Thorbjarnarson and Hernández, 1993b). In the latter, a separation from 1.5 to 8 km between groups in the Capanaparo River (Venezuela) was registered. For his part, Medem (1981) clarifies that adults stake individual claims on 2 km stretches in the upper part of the Capanaro River (Colombia).

In captivity, crocodiles are not aggressive when they reach their new site, but once they consider it their territory, they apply different mechanisms to defend themselves or intimidate others (Medem, 1981; Lugo 1995). According to Colvée (1999), in Agropecuaria Puerto Miranda (Venezuela), the larger males are more aggressive and establish larger territories to access a greater number of females. However, interaction occurs following the development of ethological guidelines, producing few cases of physical assault. Still, Antelo (2008) points out the death of one male caused by the attack of another male whose total length was 4 m, after breaking the fence that separated them in the El Frío Biological Station (Venezuela).

The period of territoriality and courtship usually occurs between October and December, with more activity taking place in October and November (Medem, 1981; Thorbjarnarson and Hernández, 1993b; Colvée, 1999; Antelo, 2008), although cases have been registered of individuals in captivity that started practicing patterns of territoriality and courtship from mid-June, in August and in September (Gumilla, 1791; Medem, 1981; Lugo, 1995; Colvée, 1999). In captivity, dominant males prefer courting larger females than smaller ones (Colvée, 1999).

Territoriality and courtship-copulation behaviors are characterized by a series of guidelines that include the use of audio, visual, tactile and olfactory channels (Thorbjarnarson and Hernández, 1993b; Colvée, 1999). Territorial and mating behaviors are normally related, though there are deployments that do both, so they are sometimes difficult to separate (Colvée, 1999). These behavior patterns establish reproduction territories from other males and attract females (Antelo, 2008), and follow a sequence that is described generically in the table below, based on descriptions given by Medem (1981), Thorbjarnarson and Hernández (1993b), Colvée (1999), Antelo

(2008) and from our own observations. Initially the male, in the water, exposes the dorsal surface of its head, body and tail (dorsal buoy), and then raises its head and tail in an arched position (arched tail) and moves it from side to side (tail wag). Subsequently, a) it raises its head**,** letting its jaw hit the surface of the water, closing its mouth as it does so (headslap), and later lifts the head and lets out a series of roars, or b) issues a series of roars (previously or alternatively letting out sub-audible vibrations or snapping its jaw), then hits the jaw against the surface of the water (headslap). It then shows only the nostrils, eyes and Skuff roof (head buoy) [variation: it stays afloat with its body inflated], while exhaling through the mouth, causing bubbling as it goes underwater (immersion).

Medem (1981)	Thorbjarnarson and Hernández (1993b)	Colvée (1999)	Antelo (2008)	This investigation
-	Dorsal buoy	Dorsal buoy	-	Dorsal buoy
-	Occasional vibrations	Occasional vibrations	-	-
Arched tail	Arched tail	Arched tail	Arched tail	Arched tail
-	Tailwag	Tailwag	-	Tailwag
-	-	-	-	Jawclap
Roars (1-4)	Headslap (2)	Headslap	Vibrations and snores	Roars (1)
Headslap (1-2)	Roars (2-4)	Roars (3-8)	Headslap (1-3)	Headslap (1)
-	Dorsal buoy	Inflated body	Dorsal buoy	Dorsal buoy
-	Bubbling	-	Bubbling	Bubbling
Immersion (and swimming in circles)	-	-	-	Immersion

Table 3. Development of sequences of territoriality-mating behavior according to different sources.

According to Thorbjarnarson and Hernández (1993b) and Antelo (2008), courtship begins when male and female approach each other and perform actions that may include: sub-audible vibrations, swimming in circles, rubbing of noses and jaws, placing of the female´s head on the muzzle, Skuff roof or nucal region of the male, female´s jaw rubbing the neck, back or pelvic region of the male, hissing and bubbling, immersions and emersions. Later, usually under water, the male slides over the side of the female, until they are facing each other and perform intercourse, while they alternatively emerge and submerge.

Colvée (1999) explains that either the female or male may initiate courtship. The female initiates courtship by approaching the male and lifting its head to expose its throat. They then rub against each other, swimming in circles and shoving along, to which the male responds by lifting its tail, grunting and producing bubbles. The male begins by lifting its head and inflating its body; it can lift its tail and head simultaneously or clap its jaw against the surface of the water, initiating the process of intercourse, sometimes by emitting sub-audible vibrations. Mating takes place usually between October and December (Thorbjarnarson and Hernández, 1993b; Antelo, 2008), though it has been recorded during the month of September (Lugo, 1995; Colvée, 1999).

Nesting

The nesting season occurs in the dry season when water levels drop enough so that beaches and sandbars emerge. Medem (1981) points out that the nesting season is from early January to early February. Thorbjarnarson and Hernández (1993a) observed nesting peaks in late January and early February of 1987, 1991 and 1992. Variation in the nesting season may be due to the dynamics and hydrological cycle of the rivers where the different populations are located, considering the availability of high nesting places (Thorbjarnarson, 1987), and the rain cycles (Ramo *et al*., 1992).

The Orinoco crocodile nests on substrates, normally sandy, into which it usually digs a round hole with its hind feet. The depth depends on the size of the female, as it has been proven that the longer the body, the greater the length of the limb and therefore, the deeper the nest (Colvée, 1999; Antelo, 2008 and 2010). Usually, nests are set up on sandy beaches with moderate to steep slopes or in sandy banks with steep slopes, which are close to riparian, shrubby or herbaceous vegetation (Thorbjarnarson, 1987; Thorbjarnarson and Hernández, 1993a; Barahona and Bonilla, 1999, Llobet, 2002). Antelo (2008 and 2010) indicates the presence of two nests in embankments of more compact substrate at El Frío Biological Station (Venezuela). Here it was proven that in places with no sandy substrate, females can use a pile of sand

Sub-adult individuals of *C. intermedius* photographed in the Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán

Hatchlings of *C. intermedius* photographed in the Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán

(1,5-2 m^3) created by humans to make their nests (also used by turtles, iguanas and lizards). In these artificial beaches, 69 females nested from 2003 to 2007. In the absence of sandy substrates, Orinoco crocodiles can nest on other substrates, such as the clayey-rocky soil of the Camatagua reservoir (Blohm, 1982; Medem, 1983; Thorbjarnarson and Hernández, 1993a), or on organic surfaces of "caño" Rabanal (Guárico River) and the Pao River, in the State of Cojedes (Thorbjarnarson, 1987). In captivity, they take advantage of artificial sand facilities. Medem (1981) cites, but did not observe, a case of nest-making in a palisade containing 43 eggs, as a mound of leaves and plant materials in the high Ariporo River (department of Casanare, Colombia).

Females in the wild and in captivity start to excavate in beaches and banks several weeks or days before oviposition, and usually at night (Thorbjarnarson and Hernández 1993b, Lugo, 1995; Colvée, 1999; Antelo, 2008). These excavations are carried out to evaluate the potential nesting site and type of substrate. The nest excavation process is usually nocturnal. The female sits on the chosen spot and starts digging and pushing the sand away with its hind legs and tail. The process takes between 1.2 and 2 hours. It then places its cloacae over the hole and oviposition begins; the animal keeps its head up, mouth slightly open and hind legs extended and close to the body. Busto *et al*. (1992) points out that the hind limbs can sometimes stay inside the nest hole during the entire process. Oviposition can last between 50 and 73 minutes. After laying its last egg, the female covers the hole applying a reciprocating movement of its hindlegs. Finally, she walks over the nest to compact the sand (Thorbjarnarson and Hernández, 1993b).

The depth of the nest is usually measured on two different levels: the distance between the surface and the first layer of eggs, and the distance between the surface and bottom of the nest, once all the eggs have been removed. According to data gathered from 19 nests measured by Colvée (1999), the depth to the first layer of eggs varies from 20 to 33 cm, while the total depth of the nest is between 36 and 51 cm. This author found a positive correlation between the total depth of the nest and the total length of the female, so it is believed that larger females, with longer hind legs, dig deeper nests.

Source	Place	Depth I (cm)	SD	Depth II (cm)	SD	Nº nests measured
Medem (1981)	Guaviare	27,00	-	43,00	-	1
Ardila *et al*. (1999)	Roberto Franco Station of Tropical Biology	20,6	-	57,00	-	1
Thorbjarnarson and Hernández (1993a)	Capanaparo	30,70	7,1	46,10	7,2	36
Colvée (1999)	P. Miranda	27,47	4,40	42,79	4,93	19
Antelo (2008 and 2010)	El Frío Biological Station	26,35	7,9	42,63	9,71	31-34*
Espinosa (2010)	Cojedes	17,78	8,9	35,62	7,0	10-8**
Ramo *et al*. (1992)	Unellez	27,50***	-	42,50***	-	5

Table 4. Average depth to the first layer of eggs (Depth I) and to the bottom of the nest (Depth II) according to data from above mentioned sources. SD: standard deviation.
* Depth I: average based on 31 measured nests, and Depth II average based on 34 nests.
** Depth I: average based on 10 measured nests and Depth II average based on 8 nests.
*** As there is no further data, the average of the range quoted by the authors has been applied.

Generally, females in the wild take into account the contiguity of a deep part of the river (well or pond) when selecting the area in which to place the nest. This can provide greater security and proximity when monitoring and caring for the nest (Thorbjarnarson and Hernández, 1993a). This has also been confirmed by the Asociación Chelonia team in the Vichada River (Colombia).

There have been several cases in which females choose the same beach to nest, and even nest very close to or over one another, creating a possible risk of egg loss for the first female (Ayarzagüena, 1987; Colvée, 1999; Chávez, 2000 and 2002; Antelo, 2008). Reasons for this behavior are unclear. One hypothesis is the search for greater protection of the nest. Assuming that the female who nests second is younger and smaller in size, she would be seeking the greater protection afforded by the proximity of a larger female. Another reason could be that due to the lack of beaches suitable for nesting, they must be shared (this is probably the reason when it happens in captivity or in habitats with few nesting sites).

It is also believed that a female possesses a degree of loyalty to its nesting site in the wild, laying its eggs in the same place over several years (Medem, 1981; Thorbjarnarson and Hernández, 1993a). Information gathered from villagers and fishermen of the Vichada and Meta river areas (Colombia) indicates

Adult individual of *C. intermedius* photographed in Caño Macanillal, El Frío Biological Station, Apure (Venezuela). May 2008. © M. Rivas

Juvenile of *C. intermedius* released in Caño Macanillal as part of the Orinoco Crocodile Conservation Program of the El Frío Biological Station, Apure (Venezuela). May 2006. © P. Mejía that the same female uses one particular beach year after year, coinciding with the above.

The number of eggs, according to different sources consulted, can vary, reaching approximately 20 to 60, although there are cases with very few eggs and others revealing up to 70-80 eggs. The data analyzed shows an average of 40 eggs.

Source	Place	Eggs (nº)	Average	% Fertility	Incubation days
Thorbjarnarson and Hernández (1993a)	Capanaparo	14-65	38,6	94,4	74-93 (n)
Ayarzagüena (1987)	Cojedes	13-52	38,5	-	-
Seijas (1994 and 1995)	Unellez	31-52	40,9	-	78-107 (a)
Lugo (1995) and Ramírez-Perilla and Urbano (2002)	Roberto Franco Station of Tropical Biology	14-50	36,2	76,8	85-122 (a)
Jiménez-Oraá *et al*. (2007)	Manipire	30-66	43,9	-	-
Ramo *et al.* (1992)	Unellez	37-52	43	-	78-85 (a)
Thorbjarnarson and Hernández (1993a)	Masaguaral	6-47	30,7	50,1	70-95 (a)
Colvée (1999)	P. Miranda	25-54	39,4	23,6	87-92 (a)
Antelo (2008 and 2010)	El Frío Biological Station	20-59	41,2	75,4	75-103 (a)

Table 5. Range of number and average of eggs, from several nests and different populations of *C. intermedius*. (n) Natural incubation. (a) Artificial incubation.

Larger sized crocodilian species produce larger and more eggs (greater in quantity and total mass laid) than smaller ones. Also, on an intraspecific level, there is a tendency for larger females to present higher fertility rates than smaller ones, as fertility is demonstrated by the size of the lay and the frequency of reproduction (Thorbjarnarson, 1996).

The incubation period is also quite variable. Most of the registered data comes from artificial incubation and records it as lasting between 74 and 103 days, though there are records of up to 122 days (Table 5). In wild nests of the Capanaparo River (Venezuela), the incubation period lasted between 74 and 93 days (Thorbjarnarson and Hernández, 1993a), and 81 days (Antelo *et al*., 2010) in a nest located in the El Frío Biological Station (Venezuela).

Hatching

Hatching and birth occurs towards the end of the dry season and the beginning of the rainy season when water levels are minimal or rivers begin to rise. The data analyzed indicates that birth, both in captivity and in the wild, occurs between late March and mid-May, taking into account the different populations of Colombia and Venezuela.

There seems to be a slight lag between laying and hatching times among different populations. Due to this variability, Thorbjarnarson (1987) established 3 categories based on the nesting-hatching season: early, intermediate and late nesting.

	Hatching Period	Rivers and/or Breeding Stations
Early nesting	From mid to late March	Meta, Vichada, Casanare, Cravo Norte rivers and tributaries (Colombia); Caura River and Unellez Breeding Station (Venezuela)
Intermediate nesting	From early to late April	Orinoco River
Late nesting	From late April to early May	Capanaparo and Cojedes rivers, "caño" Guaritico – El Frío Biological Station

Table 6. Classification according to egg hatching periods (based on Thorbjarnarson, 1987).

Current Colombian populations for which information exists, both wild and in captivity, would fall into the early nesting category, as well as Unellez's (Venezuela), perhaps because it is located close to the foothills where the rains begin earlier than in areas of the low plains (Ramo *et al.*, 1992).

Source	Location	Nesting Period	Nesting Peak	Hatching Period
In the wild				
Medem (1981)	Colombia	From early January to early February	-	From early March to late April
Ayarzagüena (1987)	Cojedes	From late January to late February	-	-
Thorbjarnarson and Hernández (1993a)	Capanaparo	-	From late January to early February	From mid to late April
Seijas (1998 and 2000); Seijas and Chávez (2002)	Cojedes	From mid- January to mid-February	From late January to early February	From mid-April to early May
Llobet (2002)	Capanaparo	-	From mid to late January	From mid-April to early May
Ávila-Manjón (2008)	Cojedes	From late January to early February	From late January to early February	From mid-April to early May

Antelo (2008 and 2010)	El Frío Biological Station	From late January to early March	From early to mid-February	From mid-April to late May
In captivity				
Lugo (1995); Ramírez-Perilla and Urbano (2002)	Roberto Franco Station of Tropical Biology	From late December to early January	-	From late March to late April*
Ramo *et al.* (1992)	Unellez	From late December to early January	-	Late March
Thorbjarnarson and Hernández (1993a)	Masaguaral	From early February to late March	From mid to late February	May
Colvée (1999)	P. Miranda	From late January to early March	Mid-February	-

Table 7. Nesting and hatching periods in different populations of *C. intermedius*, in the wild and in captivity. * Estimated from incubation period data gathered by the authors.

The total length of the newborns, according to data from different populations, varies between 25 and 33.20 cm, with an approximate average of 28 cm. The weight reveals great variation and was found to be between 48 and 99.8 g (Table 8).

Source	Location	Length (cm)	Min L	Max L	Weight (g)	Min weight	Max weight	Nº measured offspring
Ramírez-Perilla and Urbano (2002)	Roberto Franco Station of Tropical Biology	28,05	27,00	28,70	77,45	62,50	84,50	35
Ardila *et al.* (1999)	Roberto Franco Station of Tropical Biology	26,87	26,00	28,60	86,26	67,20	99,80	14
Ramo *et al.* (1992)	Unellez	28,46	27,00	30,00	69,72	62,00	75,00	45
Colvée (1999)	P. Miranda	27,66	25,85	28,45	67,42	51,25	76,78	180
Antelo (2008)	El Frío Biological Station	28,60	25,00	33,20	66,90	48,00	87,50	-

Table 8. Average, minimum and maximum total lengths (in cm) and average, minimum and maximum weight (in g) of neonates born in captivity.

During the hatching process, neonates emit a vocal message directed at the mother from within the egg, so they can be helped out of the nest. The female tends to visit the nest, usually at night, several days before the eggs hatch (Thorbjarnarson and Hernández, 1993b; Antelo, 2008). The female usually accompanies the hatching process. It begins with the forelimbs excavating the nest, while the hind limbs separate the excavated material. The female may stop at intervals, resting its throat on the substrate or backing up to place its nose in the semi-excavated opening of the nest. The female snorts during the excavation, and is usually answered by vigorous grunts from the neonates. Once the newborns are out of the eggs, the female puts them into the pouch of its mouth by moving it sideways. The female then transports them to shore and releases them into the water amongst emerging vegetation (Thorbjarnarson and Hernández, 1993b).

Antelo (2008) recorded a nest opening in at least two stages carried out on different days, which seems to suggest that, just as in artificially incubated eggs, not all neonates in the same nest are born on the same day. The mother would open the nest and transfer the infants on more than one occasion, according to the time of hatching.

Parental Care

Females guard the nest, usually remaining near it in the water. In the wild, Antelo (2008) describes a behavior made up patterns of staying in the water, showing only nostrils, eyes and skull roof, to moving on to show the entire dorsal region (head, trunk and tail) and then diving into the water. Very rarely did females show signs of intimidation, inflating their body and taking short paces forward, shaking the tail, while emitting a growl.

Bibliographic information shows that in captivity females develop more aggressive defense behaviors towards man. This includes showing its inflated body from the water, emitting hissing sounds, making a bubbling effect and, when humans are just a few meters from the nest, violently exiting the water towards the nest and staying close to it (Colvée, 1999). In this behavior, Antelo (2008) also includes jaw snapping, violent tail movements, and staying permanently over the nest until the humans withdraw. Females continue to look after the nest even if the eggs have been taken from it, although, for the most part, they seem to diminish the intensity of the protection as the incubation period advances (Colvée, 1999; Antelo, 2008).

Lugo (1995) reports that the Orinoco crocodiles of the Roberto Franco Station of Tropical Biology (Meta Department) recognize their feeders and allow them to come close without displaying bullying behavior (though the sex is not specified, nor whether the behavior varies if the individual is guarding a nest). However, in front of strangers they show intimidation patterns such as inflating the body and hissing, biting occasionally or violently entering the water.

In 2010, the Asociación Chelonia team visited the Wisirare Ecopark, located about 15 km from Orocué (department of Casanare, Colombia), where 9 specimens of the Orinoco crocodile are kept (7 females and 2 males). It was discovered that individuals do not show any kind of aggressive or intimidating behavior in the presence of observers. In August, the crocodiles responded to the caregiver's call by approaching the gate, without any feeding motivation. In November, without the presence of the caregiver and during the mating season, they did not show any sort of threatening territorial behavior.

Females in the wild show defensive and variable caring behaviors, ranging from individuals that do not watch the nest or do not do so during the whole incubation period, to individuals who are not aggressive while their eggs were taken, to females who, even if they help their young open the nest, do not take care of them once hatched (Antelo, 2008). Defensive behavior whilst in captivity, when in the presence of animals - potential predators of eggs near the nest - is seen through a violent burst towards the potential predator, emitting a strong growl with the mouth closed and remaining in or near the nest for several minutes (Colvée, 1999). In the wild, they seem to have the same behavior, although they also snap their jaws (Antelo, 2008). Regarding intraspecific interactions, the female defends the nest from the water against the approach of another female or male. In this case, defensive interactions are more intense with males (Colvée, 1999).

Antelo (2008) points out the repairing of partially emptied and later predated nests, after observing that these nests still contained eggs and had been again covered with sand, and after verifying the presence of adult crocodile footprints on it.

Newborns are usually kept near the mother in a group along shores where plenty of vegetation surrounds the nest (Thorbjarnarson and Hernández, 1993b; Seijas, 1998; Seijas and Chávez, 2002; Antelo, 2008). Gumilla (1791) had already mentioned groups of hatchlings that were defended by adults: "[...] *Third, when* *they are out of the shell, the little caimans hustle together close to the banks, swimming along the water´s edge and their parents remain within view. And during this time and the other two periods [courtship and nesting], they use up their insatiable energy and, furiously charging, firing at the same time an intolerable musk, which stuns all senses;* [...]".

Newborns in the wild and in captivity take the opportunity to bask on the mother's head or back (Thorbjarnarson and Hernández, 1993b). Defending the infants in the presence of humans involves carrying out a series of actions from the water such as inflating the body, hissing and groaning and snapping the jaw. If discomfort continues, the female may react by violently getting out of the water, galloping, snapping her jaw and beating her tail (Antelo, 2008). Hatchlings remain under the mother's care for a while before dispersing and becoming independent. Thorbjarnarson and Hernández (1993b) indicate a stay of up to eight weeks in the Capanaparo River, three weeks in the Tucupido River and four weeks in the Camatagua reservoir (all in Venezuela). In captivity (Hato Masaguaral, Venezuela), they pointed out that the infants began dispersing on nocturnal hours during the fourth week, but in the mornings they again gathered near the nest. This situation lasted 3.5 months, until they were removed from the site. Antelo (2008) notes a 2-3 month stay with the mother in the El Frío Biological Station, indicating a recorded maximum of 103 days.

3.- Habitat and Distribution

Miguel Andrés Cárdenas-Torres

3.1. The Orinoco Llanos

The Great Orinoco basin covers an area of 991,588 km^2 distributed between Colombia (347,165 km^2) and Venezuela (644,423 km^2), comprising 34.5% of the territory of Colombia and 70.6% of that of Venezuela (Domínguez, 1998, Correa *et al.*, 2006). The basin covers the eco-region of the Orinoco Llanos and shares territories to the east with Venezuela and the mountain range of the Guiana Shield. The basin´s western boundary is delineated by Colombia´s Oriental Cordillera, which reaches altitudes of well over 3,500 m.a.s.l. in some points.

This particular eco-region of the Orinoco Llanos spreads over 500,000 km^2, bounded by the Andean foothills to the west, the Macarena Range and the Guaviare River to the southwest, the Coastal Cordillera to the north and the Guiana Shield to the southeast. It is considered to be a region of authentic savannas, in great part floodable (Sarmiento, 1983; Antelo, 2008; Rosales *et al.*, 2010).

From an administrative point of view, the Orinoco basin area in Colombia comprises the departments of Arauca, Casanare, Meta, Vichada, Guaviare, Vaupés, Guainía, Boyacá, Cundinamarca, Santander, Norte de Santander and part of the Capital District. In Colombia it is also known as the region of the Oriental Llanos. In Venezuela, it covers the following States: Amazonas, Bolívar, Apure, Táchira, Mérida, Trujillo, Barinas, Portuguesa, Lara, Yaracuy, Cojedes, Carabobo, Aragua, Guárico, Anzoátegui, Monagas and Delta Amacuro.

The Orinoco River's source is in the Parima Range (Venezuela) and it flows about 250 km in an east-west direction to the point where the Casiquiare joins the Negro River (a tributary of Amazonas River) and later converges with the Macava River. It begins its middle course when it later joins the Guaviare River, continuing north to the Meta River mouth. It then immediately bends east until it merges with the Apure River, where the lower Orinoco begins and then continues to the Orinoco Delta or Amacuro Delta, which has 12 main channels, a multitude of smaller courses and a maximum width of approximately 300 km (Domínguez, 1998).

Aerial view of the Metica River, upstream from Puerto López (Meta). © CHELONIA/M. Merchán

Emerged beach on the shores of Caño La Hermosa (Casanare). November 2010. © CHELONIA/A. Castro

Orinoco Llanos in Colombia and Venezuela

The location of the southern boundary of the Llanos, situated within the Eastern Llanos of Colombia, is matter of debate. Some authors say that the southern boundary is the Guaviare River, while others hold that the boundary lies instead at the Inírida River, a tributary of the Guaviare River which runs almost parallel to it, but more to the south in a northeasterly direction before bending north in its last stretch before its mouth. Still other authors like Hernández (2002) and von Hildebrand *et al*. (2002) believe that the southwestern boundary of the Llanos (northwest of the Amazonia) is marked by the Ariari River and the Guaviare River right to its middle course, crossing to the Vichada River to its mouth in the Orinoco. This demarcation places some of the rivers of the Orinoco basin within the Amazonia bioregion. The characteristics of the tropical rainforests in these areas are more closely related to the Amazonian type than to the Llanos one.

According to Sarmiento (1983), the Llanos are divided into four main regions:

- Foothill savannas – They border the foothills of the Eastern Cordillera and the Coastal Cordillera and are characterized by large alluvial fans and a system of alluvial terraces.

- High plains - Located in two different areas separated by a tectonic depression: the first, between the Meta and Guaviare rivers (Colombia), extending towards the Cinaruco River (southern Venezuela), and the second on both sides of the lower course of the Orinoco River (Venezuela), with an undulating or rugged morphology caused by the Orinoco tributaries' valleys.

- Alluvial floodplains – They occupy a large area among foothill savannas and high plains, represented by non-floodable sandy banks that follow the rivers courses, where gallery forests or seasonal savanna woodlands or pastures and hyperseasonal silty savannas are distributed among successive sandy banks, covered by pastureland or palm trees. Their lower areas are characterized by marshland vegetation and permanent swamps.

- Aeolian plains - They form a continuous belt that follows the upper course of the Meta River through to the Cinaruco River, with small patches edging into the high plains. This belt is characterized by the presence of extensive dune fields with little or no wooded areas.

3.2.- The Eastern Llanos of Colombia

It is necessary to differentiate the Eastern Llanos of Colombia from the Colombian Orinoquia area, as confusion can arise when applying these terms which are often both used as synonyms. The Orinoquia includes the Eastern Llanos area, spanning the high, medium altitude and low areas of the Eastern Cordillera, La Macarena Range and a transitional area between Orinoquia and Amazonia. The Western Llanos correspond to the plain that lies between the Andean foothills of the Eastern Cordillera and the Orinoco River as its respective western and eastern boundaries, with the Arauca River to the north and the Guaviare River and La Macarena Range to the south, reaching altitudes from approximately 60 to 300 m.a.s.l.

The Colombian Orinoquia, covering about 350,000 km^2, occupies approximately one third of the country´s continental surface area (IGAC, 1999). According to Molano (1998), the area covered by the Orinoco's hydrographic basin in Colombia contains landscape units other than plains such as:

- Andean-Orinoco Sub-region: includes the high, medium-altitude and low lands of Colombia´s Eastern Cordillera, comprising, with their corresponding moorland biomes, Andean and sub-Andean forests extending from the moorland level up to 800 m, and foothills which develop from the 1,000-800 to 200 m.a.s.l. and are characterized by the presence of dense vegetation.

- Sub-region of the Oriental Llanos: they extend from the Arauca, Capanaparo and Meta rivers in the northeastern area, to the Guayabero and Guaviare rivers in the southeast, close to La Macarena Range. A series of fault lines in the Andean foothills and the Guiana Shield created the Llanos. A southeast-northwest fault line divides the region of the plains into two: the eastern region, more elevated to the south of the Meta River, which runs along the course of the fault line; and the western area, north of the Meta River, currently experiencing subsidence. As a result, large areas of the Arauca, Casanare and Meta departments undergo flood dynamics.

- Orinoquia-Amazonia Transitional Sub-region: covers a large area south of the Vichada River characterized by high plains, an ecotone between the Orinoco savanna area and the Amazon forest.

- Sub-region of the “Andén Orinoqués”: a strip of land located on the left bank of the Orinoco River between the towns of Puerto Inírida and Puerto Carreño, characterized by residual high plains with some protruding rocky outcrops.

- La Macarena Range Sub-region: an area of special biological interest made up of a series of landscapes and structures surrounding a mountain core related to the Guiana Shield which is of Precambrian origin and located in the southwestern area of the Orinoquia. The National Park of La Macarena Range is located in this sub-region; it was established in 1971 and has an area of 630,000 ha.

According to Molano’s description (1988) there are different sub-units within the sub-region of the Eastern Llanos:

- Llanos of wetlands and overflows: quite large surface areas characterized by the presence of savannas and forests located mainly on the left bank of the Meta River. Within the Meta, Vichada, Casanare and Arauca departments this type of plain is evident in a large depression area which continues on into the State of Apure (Venezuela). In this area of subsidence, the rivers

Group of water birds on a shore of the Meta River. November 2010. © CHELONIA/R. Antelo

Gallery forest on the margins of the Vichada River (Vichada). December 2010. © CHELONIA/A. Castro that begin at the foothills and go through them become highly meandering and sinuous, forming many dried-up river beds with occasional stagnant water bodies coming out on to a lower savanna region and there feeding marshes, swamps and pools. Subsequently, water-courses lacking a set direction join together in small channels that develop into sizeable rivers flowing into the Meta River or its major tributaries. It should be noted that the Arauca, Casanare, Meta and Vichada rivers have an overflow area of about 97,870 ha, in addition to their 16,600 ha of wetlands.

- Non-floodable savannas: area located on the east (right bank) of the tectonic fault line over which the Meta River runs –known as the High Plain– which is divided into two units: first, the flat High Plain south of the Meta River which extends over a large part of the Vichada Department. Its surface is composed of fine sediments that are brought by the wind and make up fields of dunes that are intersected by small valleys of gallery forests and swamps. The other unit is the broken High Plain, located immediately to the south of the flat High Plain in the Meta and Vichada departments, which displays a hilly landscape cut by valleys and basins with different sized reliefs.

Taking into account the topographic, geological and hydrological characteristics, some consider the Colombian Eastern Llanos ecoregion to be made up of the Oriental Llanos, the “Andén Orinoqués” and the transitional Orinoquia-Amazonia sub-regions, even though the latter does not present clearly defined boundaries and, according to some authors, is defined applying different criteria.

From a biogeographic and ecological point of view, Hernández (in Defler and Palacios, 2002) suggests that the northern boundary of the Amazonia is not located on the central-eastern part of the Guaviare River, saying that it extends beyond this river to the north, occupying “the eastern portion of the Vichada Department, towards the Orinoco margins and the southern portion of this department, south of the Vichada River, the southeastern part of the Meta Department, the wide stretch of gallery forest on the left bank of the Guaviare River (Meta Department) and the entire region surrounding La Macarena”. However, this portion of land is part of the Orinoquia basin.

3.3.- Biogeographic Regions

The study of the existing biogeographic units in the area that are covered by the sub-regions of the Oriental Llanos in Colombia allows us to understand the presence, distribution and evolution of different biotic elements per territorial unit, which conform to the factors (climate, geological, geomorphological, human, etc.) and the availability of resources (nutrients, water resources, habitat, etc..) that characterize each unit in the region, and which are grouped according to similarities in their composition and structure.

The first test classifying the biogeographic units of Colombia was carried out by Chapman (1917) with its application being mainly the identification of birds. He described the area corresponding to the hot thermal floor as a tropical zone; he described the warm floor as being subtropical, and the cold floor as equivalent to its temperate zone and moorland, recognizing the existence of an area covered with snow distributed very locally (Hernández *et al.*, 1992).

According to the proposal made by Hernández *et al*. (1992), these biogeographic units are classified by Biogeographic Provinces, which in turn are subdivided into Biogeographic Districts. For the area of the Orinoco Llanos in Colombia, the unit called the Biogeographic Province of the Orinoquia was established. It recognizes six preliminary units: Arauca-Apure District, Casanare District, "Sabanas Altas" District, Maipures District, Casanare-Arauca Foothill District, and Meta Foothill District. However, the three units that make up the Llanos correspond to the following:

- Arauca–Apure and Casanare districts: characterized by savannas and gallery forests that continue well into the State of Apure (Venezuela). The boundary between these two districts is difficult to establish.

- "Sabanas Altas" District: characterized by savannas with older and poorer lands, south of the Meta River.

- Maipures District: complex mosaic of savannas in the eastern part of the Vichada Department.

Natural Regions

In Colombia, the area corresponding to the Orinoco Llanos forms part of the natural region of the Orinoquia (also commonly known as the Eastern Llanos), which has an extension of around 350,000 km^2. This region is made up of enormous extensions of natural savannas, foothills and floodable areas due to the

“Caño” on a flooded savanna, Palmarito Casanare Natural Reserve (Casanare). August 2010. © CHELONIA/M. Merchán

Dawn in the Meta River. December 2010. © CHELONIA/F. Gómez numerous currents that drain towards the Orinoco River in a southeasterly direction. Regarding the vast drainage network that originates on the eastern flank of the Colombian Eastern Cordillera, it is worth highlighting that the main rivers are the Arauca, Casanare, Meta and Guaviare, along with others of great importance such as the Tomo, Bita, Vichada, Guainía, Tuparro, Inírida and Cinaruco.

According to the IGAC (2001), the Orinoquia region is classified into seven natural sub-regions: Meta River plains, Orinoco River plains, Meta-Guaviare River plains, marshlands of the Arauca River, Llanos Foothills, Foothills Overflood Plains and La Macarena Range. Of these, the first four are included in the study on the Orinoco Llanos:

- Meta River Plains: they extend over the eastern areas of the Casanare and Arauca departments, through the western part of the Vichada Department and the extreme northeastern part of the Meta Department, with a prolongation towards the south following the Manacacías River.

- Orinoco River Plains: stretch of territory on the left bank of the Orinoco River, which extends to the final stretches of the sub-basins of the rivers that flow into it, from Puerto Carreño on the north to the mouth of the Guaviare River on the south.

- Meta-Guaviare rivers Plains: includes rolling plains south of Villavicencio that reach the Guaviare River (natural southern boundaries); in an easterly front this natural region ends in a wedge on the Guaviare River close to Guyana. The most representative forest ecosystems are made up of natural grasslands, while the climate is slightly humid compared to other sub-regions

- Arauca River marshlands: this sub-region is limited to a portion of the floodable areas of the Arauca River in the Colombia-Venezuela border region. As for the Colombian plains, the area is located within the jurisdiction of the Arauca and Arauquita municipalities, on the banks of the Arauca and Cinaruro rivers.

Hydrography

The hydrographic network of the Orinoco Llanos is influenced by the presence of a varied system of waterways that originate on the eastern side of the

Colombian Eastern Cordillera, draining its waters in an easterly direction towards a vast plain with moderately undulating landscapes and large plains of natural savannas that are typical of this region of the country, and which make up a large percentage of the Orinoco territory. This geomorphological condition is eminently flat with a ground composition developed through sedimentation of Quaternary deposits; it has formed a landscape of low hills, meandering rivers, large gallery forests and floodable savannas that are home to a large part of the national biodiversity. These conditions allow the Orinoco Llanos to present a continuous water supply, providing large amounts to flow to the main stream (Orinoco River) and numerous benefits to riverine populations in terms of fishing, navigation and crops irrigation in some cases.

Various authors have estimated that the Orinoco River maintains an average annual flow of 36,000 m^3/s, making it the third mightiest river in the world, following the Amazon River and the Zaire River (Milliman and Meade, 1983, cited by Cressa *et al*., 1993 and IGAC, 1999).

From its source in the Parima Range (Venezuela), the Orinoco River continues south of the Guiana Mountain Mass, skirting this geological structure in a northerly direction and running approximately 2,140 km to the Atlantic Ocean. According to Correa *et al.* (2006), the Orinoco basin in Colombia is made up of 13 primary basins classified from north to south: Arauca, Meta, Bita, Dagua-Mesetas, Tomo, Tuparro, Vichada, Zama, Matavén, Ajota, Guaviare, Inírida and Atabapo. Their main features are as follows:

- Arauca River basin: formed by the river of the same name, its source is located on the borders of the Santander and Boyacá (Colombia) departments and it is approximately 1,000 kilometers long. The Arauca River is the natural frontier between Colombia and Venezuela on a stretch of about 250 km. It presents high sedimentation levels and a somewhat undefined flow. Its main tributaries are the Cobaría, Bojabá, Colorado and Tocancías rivers (IGAC, 1999). Its basin occupies a total of 16.124 km^2 within Colombian territory.

- Meta River basin: the Meta River springs from the Eastern Cordillera. Its channel is wide with a small drop in altitude as it traverses the plateau, reaching a total length of 1,142 km (of which 730 km are navigable). Over its course, numerous tributaries originating from the highest plains flow into it; during the rainy season there are great floods due to the large volumes of sediments which are transported and deposited there. Its main tributaries are the Metica, Humea, Camoa, Humadea, Guamal, Acacías, Negro, Ocoa and Guatiquía, Guacavía, Upía, Cusiana, Cravo Sur, Pauto, Manacacías, Ariporo and Casanare (IGAC, 1999). This hydrographic basin spans over 107,032 km^2 (Correa *et al.*, 2006).

- Bita River basin: compared to other tributaries of the Orinoco, this is one of the smallest with an area of 8,070 km^2. The origin of the Bita River follows that of other gorges born in the high plain and it empties into the Orinoco River at Puerto Carreño.

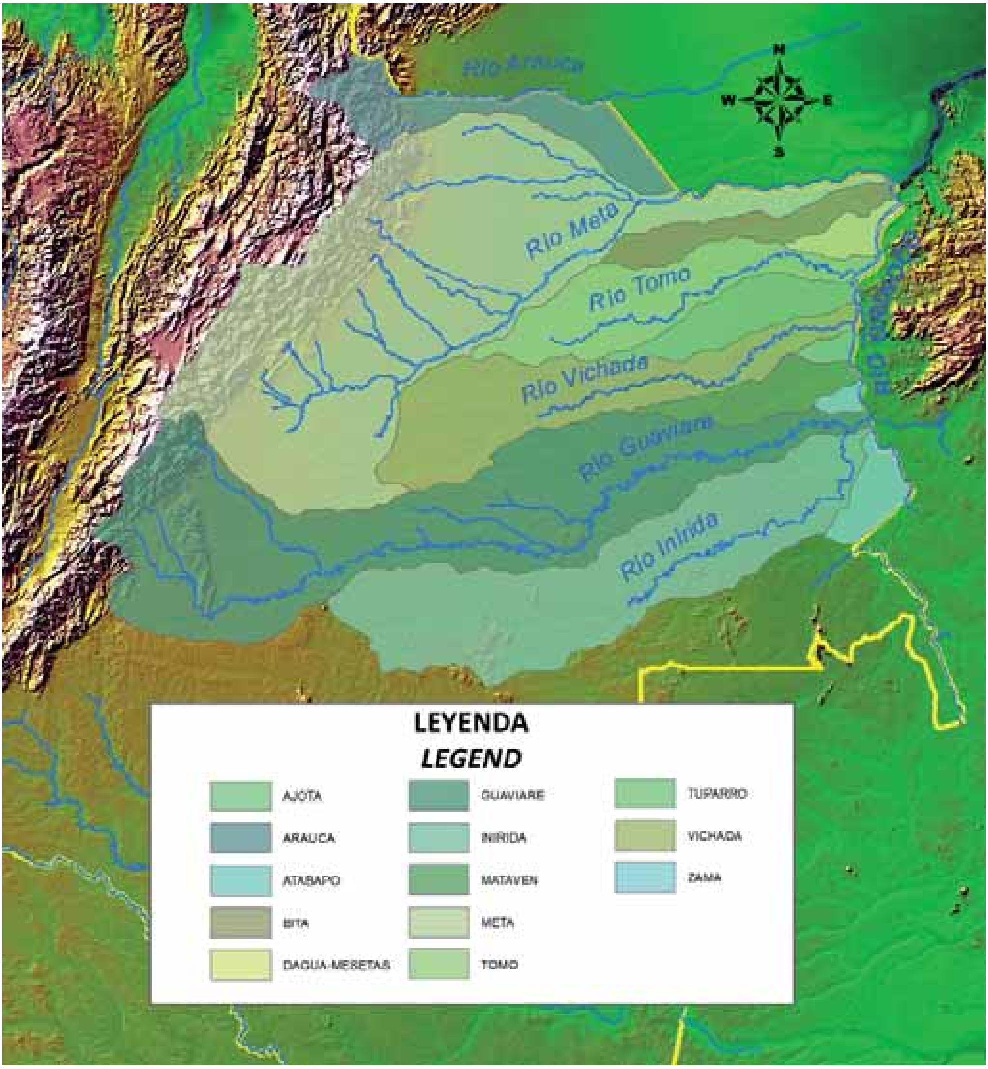
- "Caños" Dagua-Mesetas basin: just like the Bita River basin, it has one of the smallest surface areas, containing the "caños" Dagua and Meseta, which are not connected, each flowing directly into the Orinoco River. This basin is estimated to have an area of 3,632 km^2.

- Tomo River basin: the area of this basin is 20,383 km^2 and forms part of the floodable plains and permanent lagoons within the geomorphological typologies characteristic of the Orinoquia. The river that gives it its name originates in the area of the Carimagua lagoon and is approximately 600 km in length.

- Tuparro River basin: along with the Tomo River basin, it is part of the territories that are currently considered to be within the boundaries of the El Tuparro Natural National Park, where there are significant areas of natural forest and where much of the biodiversity of the Orinoco basin is contained. It has an area of 11,320 km^2 (Correa *et al.,* 2006).

- Vichada River basin: the Vichada River springs from the confluence of the Planas and Tillavá rivers in the Meta Department, flowing for approximately 680 km. This basin is part of the Amazonia-Orinoquia transition zone, with the influence of the strip that distinguishes the respective forest and natural grasslands ecosystems. The main tributaries are the Muco River and the "caños" Ariba and Mayoragua (IGAC, 1999). The basin has an approximate area of 26,013 km^2 (Correa *et al.*, 2006).

- Zama River basin: the basin with the smallest surface area of all the tributaries of the Orinoco River in Colombian territory, with just 763 km^2 (Correa *et al.*, 2006).



Hydrographical basins in the Colombian Orinoquia

- "Caño" Matavén basin: formed by the winding "caño" Matavén, of dark waters and small tributaries. It covers an area of 9,150 km^2 (Correa *et al.,* 2006) between the small basins of Ajota and Zama. It is located in the southeastern region of the Cumaribo municipality (Vichada Department), in the Amazonia-Orinoquia transition zones which contain a wide diversity of habitats.

- Ajota River basin: it is a small and independent course of water that makes up a 1,064 km^2 basin (Correa *et al.*, 2006) that flows into the Orinoco River.

- Guaviare River basin: the Guaviare River has a length of approximately 1,380 km and is formed from the confluence of the Guayabero River, which receives water from the Duda and Ariari rivers, Eastern Cordillera of Colombia, right at the foothills of La Macarena Range (IGAC, 1999). Its main tributaries are “caño” Jabón, the Siare and Iteviare rivers, the Amanavén channel that collects water from several gorges, “caño” Minisiare and the Inírida River, which flows into the Guaviare near the mouth of the latter in the Orinoco. This basin, according to Correa *et al.* (2006), occupies an area of approximately 84,352 km^2.

- Atabapo River basin: dark water river located on the border of Colombia and Venezuela. Its basin in the region of the Orinoquia covers an area of approximately 4,852 km^2 and drains its waters directly into the Guaviare River, near its mouth with the Orinoco, close to the town of San Fernando de Atabapo (Guainía Department).

- Inírida River basin: has an area of 53,771.15 km^2 (Correa *et al.*, 2006); the Inírida River runs more or less parallel to the Guaviare River, bending north on its last stretch to merge with it where the town with the same name as its basin is located.

Basin	Area (km^2)
Arauca	16,124
Meta	107,032
Bita	8,070
Dagua-Mesetas	3,632
Tomo	20,383
Tuparro	11,320
Vichada	26,013
Zama	763
Matavén	9,150
Ajota	1,064
Guaviare	84,352
Atabapo	4,852
Inírida	53,771

TABLE 9. Surface area of the sub-basins that make up the Orinoco River basin.

Climatology

The climate of the Orinoco Llanos is highly influenced by the movements of the Intertropical Confluence Zone (ITCZ), where southeasterly and northeasterly trade winds collide. These winds are masses of warm air laden with moisture, so that wherever they pass they cause cyclonic or rainy weather. However, when they retreat they generate relatively drier anticyclonic weather.

The ITCZ (Lessman and Eslava, 1985) is a part of the atmosphere where two masses of air converge at a low relative pressure. It is parallel to the Equator and placed between two nuclei of high atmospheric pressure. This area, and the masses of air that flow into it, moves with regards to the Equator following the movement of the sun, with a 5 to 6 week delay and an average latitudinal width of approximately 20° in Africa, 30° in Asia and 15° in South America.

The pressure difference between the high pressure nuclei and the ITCZ creates horizontal air movements from the Tropics to the Equator. These go off course due to the rotation of the earth and eventually blow from the northeast in the north sector and from the southeast in the south. The areas not under the influence of the ITCZ at a given period are subject to the effects of relatively dry and stable air masses, and generally enjoy relatively dry and sunny weather. However, if they are under the influence of the ITCZ, the sky will be cloudy with abundant rains; sometimes turbulent and/or thermal dynamics originate that cause strong convection processes (rising air), water vapor condensation (when cooled by the rise) and precipitation. In Colombia, the ITCZ fluctuates from around 0° latitude during January-February and 10° north, an extreme position which can be reached in July-August.

The climate in the Llanos is very seasonally unimodal, but there is a gradient of variation in the average annual precipitation which decreases from the western region (2,700 mm) towards the east (800 mm) (López *et al*., 2005). Following the limits suggested by Hernández *et al*. (1992), the Colombian Llanos are in a latitudinal belt that lies between 07° 06' and 02° 34' N, in its widest point, covering an area of tropical and also partially equatorial climate, where temperatures vary uniformly throughout the year between 24 and 28 degrees Celsius (IDEAM, 2005). Higher temperatures are recorded in January and February and the lowest temperatures appear from May to September. The annual average relative humidity is between 60-80%, except in the Puerto

Dawn in the Meta River. December 2010. © CHELONIA/F. Gómez

Aerial view of the Metica River, where habitat transformation for human use can be observed (Meta). May 2010. © CHELONIA/M. Merchán

To the south of the Meta River, the floodable plains are substituted by a high plains landscape. December 2010. © CHELONIA/A. Castro

Sandy beach emerged from the Cravo Sur River (Casanare). November 2010. © CHELONIA/A. Castro

Carreño area where it varies between 50% and 80% (IDEAM, 2005). Evaporation presents a monomodal regime, registering the highest values during the months of December and March. In the central and eastern regions of the plains, values between 1,500 and 1,700 mm can be reached each year. Rainfall is also monomodal, with a wet season that lasts primarily during the months of April and November, and a dry season that continues during December and March. The popular name for these periods does not match the name of the latitudinal position, as during the rainy season it is referred to as "winter", taking place in the summer months of the northern hemisphere. The dry season is referred to as "summer", taking place during the winter months of the northern hemisphere (Domínguez, 1998). Annual evapotranspiration levels vary from around 1,000 to 1,200 mm, with some areas reaching 1,400-1,600 mm in the north of the Arauca Department and in an area surrounding Puerto Carreño (IDEAM, 2005).

In 1999, the IGAC identified 13 bioclimatic units in the Orinoquia through the ORAM (Orinoquia-Amazonia) project. For this project, it combined and carried out equivalences between the Koeppen climate classification system (which involves vegetation and climate factors), the Thornthwaite (involving evapotranspiration factors) and Caldas-Lang's, to which other photo-interpretable elements were added such as the influences of human activity, winds and mesorelief.

The result of the aforementioned exercise showed the following classification of life zones for the Colombian Orinoquia: Humid Tropical Forest (HMF), Dry Tropical Forest (DTF), Very Humid Tropical Forest (VHTF), Humid Premontane Forest (HPF), Very Humid Premontane Forest (VHPF), Very Humid Premontane Forest (VHPF) – Warm transitional zone, Dry Premontane Forest (DPF), Very Humid Low Montane Forest (VHLMF), Low Montane Rainforest (LMRF), Montane Rainforest (MRF), Very Humid Montane Forest (VHMF), Rainy Subalpine Moorland (RSAM) – Warm transitional zone, and Subalpine Moorland (SAM) – Warm transitional zone.

According to the IGAC's ecological letter (1977), the Dry Tropical Forest (DTF) of the Llanos extends through the eastern part of the Arauca and Casanare departments and the northwestern part of Vichada. The Humid Premontane Forest (HPF) covers a strip that surrounds the Dry Tropical Forest to the west and to the south. It includes the central part of the Arauca and Casanare departments, the northeast corner of the Meta Department, and penetrates a strip of Vichada that follows the course of the Tomo River, moving north towards the Meta River on the east side of La Venturosa. The Humid Tropical Forest (HTF) is a stretch that spreads into the western part of the Humid Premontane Forest (HPF), occupying the western part of the Arauca and Casanare departments, spilling over into the department of Meta up to an altitude of approximately 300 m, entering southern Vichada and northern Guainía to occupy a stretch situated between the Vichada and Guaviare rivers, and running north along the west bank of the Orinoco River. The Very Humid Premontane Forest (VHPF) is distributed along the western part of the plains of the Arauca Department between altitudes of 200 and 250 m.a.s.l., ascending into the Casanare and Meta departments at an altitude of nearly 500 m. It reappears in Casanare, near the city of Yopal, and extends into the Meta Department where it expands and surrounds La Macarena Range at altitudes varying from 500 to 1.000 m.a.s.l.

Geomorphology and Soils

This region of the Orinoco Llanos comprises a vast plain composed mainly of sediments of Tertiary and Quaternary origin, with an average width of 500 km but reaching over 700 km in some parts, and covering an extension of over 1,500 km from the Inírida River to the Amacuro Delta (Domínguez, 1998).

The Eastern Llanos arise from a gradual filling of sediments from the erosion of the Eastern Cordillera. The oldest layer of sediments is an alluvial strip layer which extended to the Orinoco; the sediments closest to the Cordillera are sand and gravel, while the more clayey sediments were deposited to the east (Goosen, 1971). The eastern side of the Llanos also received sediments from the erosion of the Guiana Shield, forming the "Andén Orinoqués" (Villarreal and Maldonado, 2007), distinguishing this sub-region from the Llanos.

Accordingly, the area of study is composed of rocks from the Guiana Shield which extends in a northerly direction from the Orinoco River to the fault line of the Meta River, and westwards to the base of the Eastern Cordillera. North of the Meta River fault line takes in the base of the Arauca and Casanare plains, which are bound to the west by the Guaicáramo fault line (Correa *et al.*, 2006). On a stratigraphic level, the oldest alluvial layer of the Llanos dates back to the early or middle Pleistocene, and stretched from the Orinoco River to the Eastern Cordillera. The sedimentary material near the Cordillera, particularly in Arauca and Casanare, is rocky and sandy, gradually turning clayey towards the east (Goosen, 1971).

According to the Geological Map of Colombia (Ingeominas, 2007), the departments of Arauca and Casanare and the northwestern corner of the Meta Department are covered by Quaternary alluvial deposits (deposited by streams that lose their capacity to load materials), spanning the banks of the Manacacías, Meta and other main rivers of the Llanos. South of the Meta River, there is a stretch of Quaternary terrace deposits (horizontal or almost horizontal land formations resulting from alluvial accumulation). North of the Meta River, there are several insular formations made up of dune Quaternary deposits (deposits of sand caused by wind). The eastern and southern parts of the Vichada Department and most of the Meta Department, along with the southern boundary near the Guaviare River, are covered with Miocene continental sedimentary rocks. In the eastern part of the Vichada Department, near the course of the Orinoco River, there are some small patches of Mesoproterozoic plutonic rock. Along the foothill formations, fan-shaped Quaternary deposits (accumulations of sediment in conical or alluvial fan currents) can be found; they are more abundant in the vicinity of Villavicencio.

According to the Geological Map of the ORAM project (IGAC, 1999), the eastern parts of the Arauca and Casanare departments are composed of wind-influenced alluvial plains made of medium grade sand of variable thickness which are often covered by a thin layer of very fine sand and silt brought by the wind. The area of north and west Arauca and western Casanare is characterized by the presence of floodplains composed of gravel and pebbles embedded in a sandy loam matrix. The major rivers' stream banks in these departments are characterized by yellow sand and gravel terraces cemented by secondary iron, floodplains with basal sand, sandy shale and fine superior sand, just like today's beaches are formed by materials of different compounds (from silt to sand with fine gravel). Areas of ancient terraces can be found on the outer part of these formations, following the same course. The baseline and outer edge is composed of gravels, sands and shales, with thicknesses varying from just a few centimeters to sixty meters. The Casanare Department is dotted with sandy dunes islands. The larger ones are located in the northeastern area, with longitudinal sand dune composed of very fine quartz sand and silt, with

Flooded savanna with dispersed forests in the Palmarito Casanare Natural Reserve. August 2010. © CHELONIA/A. Castro

Rocky hill of the Guiana shield in the savanna near Puerto Carreño (Vichada). March 2011. © CHELONIA/A. Castro estimated thicknesses up to 30 m, and lengths of more than 20 km and 2 km wide. Some of these dune fields are in the southeastern part of Arauca and Vichada near the border with the latter department. In the western areas of Arauca, Casanare and Meta, foothill formations of alluvial fans can be found, composed of blocks and gravels embedded in a sandy loam matrix, locally clayey. This formation is larger and more continuous on the eastern side near Villavicencio (Meta). Most of the plains in Meta and Vichada are covered by sand at the edge of the shield, composed of coarse and medium grained quartzitic that can reach a thickness of 30 m. Discontinuous formations of Parguaza granite can be found in the eastern area of Vichada, following the course of the Orinoco River. They are made of relatively homogeneous igneous rock that has orbicular feldspar in its composition and which is exhibited in the form of rounded hills and steep slopes. A tertiary sedimentary formation of the Amazonia is found in the southern part of Vichada, between the Vichada and Guaviare rivers and southeastern Meta, where white, red, and purple sands predominate with yellowish tones.

The lifting of the Eastern Cordillera was accompanied by the sedimentation process which created different landscapes - depending on the tectonic activity - categorized as: high plains, foothill plains, outflow plains and aeolian plains. The high plains can be divided taking into account the processes and stages that gave them origin: structural highplains (sedimentation, horizontal stratification, tectonic uplift) and residual highplains (erosion and leveling). Outflow and aeolian plains are in depressions of active subsidence and foothill plains are divided into tectonic foothill plains (old), depositional (younger) and current flood plains (IGAC, 1999). The Eastern Llanos form part of the Physiographic Province of the Orinoquia sedimentation mega-basin.

The physiographic province is divided, following IGAC’s classification (1999), into several sub-provinces: a) Tectonized foothills of Arauca, Casanare and Cundinamarca, b) Low plains of the floodable parts of the Orinoquia in Arauca and Casanare, c) High plains of non-floodable parts of the Orinoquia (Meta-Vichada), d) La Macarena Range, and e) the Shield of Vichada, Guainía and Vaupés (although this sub-province is considered to belong to the Guiana Craton Physiographic Province, which is almost absent in Colombia, so it is not considered as part of the natural divisions of the country). The sub-provinces indicated in point b, c and e are primarily considered to be within the Eastern Llanos.

Low floodplains of the Orinoquia in Arauca and Casanare

a) Alluvial plain of outflow with a slight aeolian influence: made up of high and low terraces that present medium to coarse-grained soils in advanced stages of weathering, and slow to medium drainage. In turn, these terraces are divided into different types of landscapes:

- Mid and low altitude terraces: located between the Upía and Cravo Norte rivers, forming flat or convex belts between parallel rivers and streams, with moderate drainage and surface aeolian influence.
- Low terraces and high alluvial plains with some wind influence: directly associated with the previous ones, with flat-concave surfaces and slow and moderate drainage.
- Dams, meadows and lowlands, with active alluvial outflows resulting from subsidence: distributed between the Arauca and Upía rivers in slightly sloped terrains that present a certain geographical heterogeneity.
- Terraces and meadows of rapid to moderately slow drainage: located between the Arauca and Casanare rivers, covering areas that range from 25 to 75 km from west to east. With a slightly wavy morphology, its relief is flat with a slight easterly inclination.
- Wide and flat-bottomed depression, very floodable with slow drainage: between “caño” Canaral and the Arauca River.

b) Aeolian plain with fine to medium sand grains: they form a wide and continuous strip of wind layers and dunes that continue on from where the previous plains and the alluvial plain of the Meta River culminate. The soils have developed from fine sands, silts and clays. They differ in several minor landscapes:

- Fields of longitudinal dunes (sandbanks): primarily found in the northwestern bank of the Meta River, forming small dune fields created from sediments deposited by trade winds.
- Continuous aeolian-deposited layers accumulated on levees and depressions: occupy large areas with an almost flat relief, formed from the deposit of silt sediments and aeolian sands on the alluvial overflow plains. They extend from the Venezuelan border to the Cravo Sur River and present slow drainage.
- Discontinuous aeolian layers accumulated in dams, dikes and depressions: associated with more elevated surfaces than the previous landscape, they present moderate to slow drainage consisting of sands, clays and silts.

- Aeolian layers and fields of sedimented dunes on flat-concave surfaces of an ancient alluvial high plain: form slightly elevated blocks with a slight tilt towards the east and are located between the Venezuelan border and the mouth of the Meta and Casanare Rivers, with moderate to slow drainage.

c) Lower floodplains of Orinoco River with intermediate waters and a meandering regime: their soils are medium to fine grained, with slow to very slow drainage, originated from heterogeneous alluvial sediments. Various landscapes make up the set:

- Floodable flatlands of major rivers: with a flat relief, they are subject to permanent flooding and the inundating of meadows and narrow fertile highlands.
- Low and mid-altitude alluvial terraces: areas, usually small in size, associated with floodable flatlands.
- Low alluvial plains and erosional valleys: narrow gently sloping stretches of land associated with floodable flatlands that make up various levels of terraces.
- High alluvial terraces: narrow strips of land that occupy a small area surrounded by slopes of up to 20 m, presenting moderate to slow drainage.

High non-floodable plains of the Orinoquia (Meta-Vichada)

They are a set of high plains, glacis and terraces with varying degrees of dissections, ranging from the area south of the Meta River to the floodplain of the Vichada and Guaviare rivers. The different landscapes that compose it are:

a) Structural-erosional high plains with varying degrees of dissection: high plains located south-east of the Meta and Metica rivers and north of the Vichada River, that can be seen as flat or uneven forms. The soils are of moderate to rapid drainage and are very acidic with low to very low fertility rates.

- Flat to slightly undulating structural surfaces.
- Flat to high concave surfaces.
- Erosional surfaces and locally structured, slightly undulating.
- Erosional structural surfaces lifted by vertical tectonic movements in blocks of undulating and uneven micro-basins.
- Major escarpments, hillsides and high erosional-structural slopes.

b) Residual high plain of the Shield:

Savanna with termite nests on the shore of the Vichada River. February 2011. © CHELONIA/F. Gómez

Flooded savanna near the Pauto River (Casanare). November 2010. © CHELONIA/A. Castro

Gallery forests in the low Vichada River basin (Vichada). December 2010. © CHELONIA/A. Castro

Sandy beach with steep slope. Pozo Caimán, Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

- Structural flat watershed areas in sandy areas.
- Flat-concave watershed areas.
- Erosional slopes, moderately undulating, with wide inter-undulating glacis.

c) Depositional-erosional high plain:

- Slightly dissected glacis, locally associated with high and mid-terraces.
- Structural high to low terraces, with mixed influences (alluvial-colluvial).
- Narrow erosional valleys.
- Continuous and locally discontinuous aeolian layers.

d) Lower floodplains of the Orinoquia with intermediate waters, with a meandering regime and partial structural control, with some local aeolian influence:

- Currently floodable flat plain together with low and mid-terraces.
- Mid and upper terraces.
- Low valleys.

Shield of Vichada, Guainía and Vaupés

a) Hilly residual relief with low structural highlands:

- Naquén, Caranacoa and Traira Highlands.
- Hillrocks and tabular hills in rhyodacitic and andesitic lavas.
- Hills and rounded hills.

b) Leveling surfaces with structural control in the igneous-metamorphic Mitú complex.

- Flat motions and concave planes.
- Surfaces with inselbergs, pediplains, hills and residual elevations.
- Rolling hillsides that slope into the valleys.
- Locally sloped pediplains with wide undulations.
- Homogeneous kidney-shaped peneplain.
- Plain of rolling motions.
- Sloped pediplains with strong undulations.
- Rolling hills with complex igneous-sedimentary ripples.

- Torrents and pediplains located in floodable plains, migmatites and gneiss, overlaid with Paleozoic-Tertiary sediments and Quaternary alluvial deposits.

The soils of the Orinoquia high plains are considered to be of high evolutionary degree, unlike those located in mountain areas that are influenced by volcanic ash and are subjected to mass removal processes, making them considerably younger. They are represented by Ultisols and Oxisols, which correspond to highly evolved soils (especially the latter), related to moist and wet climates and a defined precipitation season.

In the savanna areas of high plains, where seasonal climates are very marked, such conditions act directly on Plio-Pleistocene sediments. Different degrees of dissection can be observed, displaying red and yellowish soils in natural grasslands, with little vegetation. Sediments significantly altered by the seasonality that prevails over long periods of time can be found below. Particularly in the departments of Casanare and Arauca, where floodplains prevail, soils develop over Quaternary sediments. Here the environment constitutes an important role in forming ferrous compounds that cause gray colors to appear as they are subjected to defined flooding.

Accordingly, the floodable Orinoquia, characterized by alluvial and aeolian plains, often develops soils directly influenced by either their seasonal weather conditions (1,800 to 2,500 mm of precipitation in Casanare and 1,532 mm in Arauca, and an average temperature of 27ºC in both departments) or by flooding, especially when referring to poorly drained low lands with higher percentages of organic carbon (1-2%, except for “Psamments”) when compared to soils of the high plains (0.5 - 1%). The phenomena of reduction and oxide-reduction establish the fundamental processes and characteristics of its soils (“Endoaquepts”, “Endoaquults”) (IGAC, 1986 and 1993). Areas with wind coatings experience very little soil development (different “Psamments”). “Dystrudepts” are abundant throughout the sub-region (Malagón, 2003a and 2003b).

In summary, the soils of the Orinoquia high plain are those with the highest degree of evolution in the country, dominated by the typology of the different Oxisols (“Haplustox”, 19.6% and “Hapludox”, 14.5%) and to a much lesser extent, of Ultisols (“Kandiudults” 1.7% “Hapludults” 0.9% “Endoaquults” 0.8% “Paleudults”, 0.6%). Floodable Orinoquia shows advanced stages of alteration

View of the Manacacías River beside the Mururito Natural Reserve (Meta). December 2010. © CHELONIA/A. Castro

Guiana shield rocky formation in the Orinoco River near Puerto Carreño (Vichada). March 2011. © CHELONIA/A. Castro

Sandy beaches and margins are indispensable for *C. intermedius* reproduction. Guachiría River (Casanare). November 2010. © CHELONIA/A. Castro

Gallery forest on the margins of the Caño Gandul (Casanare). November 2010. © CHELONIA/A. Castro (quartz, kaolinite, intergrades, mica) more related to the products they deposit than the genesis of the soil, but less evolved soil types (Entisols and Inceptisols) with Ultisols and very few Alfisols in Arauca, as a result of specific evolutionary processes. The prototypes of maximum evolution are the “Endoaquults” (15.8%), with “Haplaquox” (3.4%) and very few “Endoaqualfs”. Hydromorphic conditions and aeolian-covered coatings explain this typology, which is the opposite of the high plain where old sediments, the period of evolution and climatic seasonality are responsible.

3.4.- Biological Medium: Flora

The Orinoco basin is home to a range of incredible and uniquely rich ecosystems in terms of flora and fauna taxa present, as it is represented by different hypsometric levels that determine different environments for organisms to establish and adapt. Much of the basin’s richness is also due to tectonic events that occurred in the Miocene period, which led to the lifting of the Eastern Cordillera. Some populations that were left isolated managed to adapt and evolve in specific environments, favoring the emergence of new species and of permanent contributions of trans-Andean, Amazonian and Guianese biotic elements.

As part of this distribution, Molano (1998) cites the Pleistocene refuges, jungle enclaves marginal to the savannas, Andes and Guiana Shield. The baseline jungle of the Eastern Cordillera (800-2,200 m) is considered to be of great importance to the Orinoquia. It is a point of confluence of Sub-Andean and equatorial elements, and the Imeri shelter (high Negro-Guainía River) and Guianese and Amazonian biota. The latter corresponds to the jungle located at the source of the Orinoco River and on the Amacuro Delta. The distribution of deserts, savannas and forests was modified following the last glaciations, when the desert biome disappeared and the Orinoco Llanos remained covered by forests and savannas. These plains serve as routes, corridors and as areas of dispersion and expansion of species from surrounding forest ecosystems and provide refuge for wildlife that live in forests and savannas. This series of processes gave way to the different landforms and environments that can be seen today in the Orinoco Llanos, allowing us to appreciate the natural wealth of the region. This wealth, in turn, is a result of the exchange of biotic elements from different ecotones which evolved in the Orinoco Llanos’ different ecosystems.

Numerous and extensive studies on vegetation have been developed by research groups, universities, NGOs, private companies and environmental authorities in the different physiographic units of the Orinoco basin. However, despite great efforts to deepen knowledge of the region's flora, there are still information gaps given the magnitude of the area of study, the complexity of the ecosystems, the logistical difficulties of travel and field work in areas of strategic importance, and the magnitude of the work carried out.

In an effort to understand the conservation status and biodiversity of the plant resources of the Orinoco Llanos and to establish the current state of the ecosystems, a series of field trips and technical-scientific identification surveys are being developed within the framework of the Orinoco crocodile (*Crocodylus intermedius)* conservation project. It has been possible to establish the quantity and quality of the more favorable habitats guaranteeing stability and maintenance for the species' wild populations. Some components of the flora have been identified, associated with ecosystems in places that have registered the existence of *C. intermedius*.

All of this information has been entered into databases and listings of flora species collected by official bodies, environmental authorities and private entities that participate in studies in the region, with particular emphasis on those carried out on the ecosystems corresponding to the sub-region of the Llanos, home to *C. intermedius*. There is specific information on distribution areas for the species, a valuable element for planning future restoration and conservation actions.

Savanna Types of the Orinoco Llanos

The savanna areas constitute one of the major ecosystems characterizing the Orinoco Llanos and are part of the renowned "plains landscape" in Colombia and Venezuela. The main flora elements that make up these areas are communities of grasses and cyperaceaes in a layer with abundant herbaceous species, some of them known as *Axonopus affinis, A. purpusii, A. compressus Andropogon selloanus, Digitaria sanguinalis, Paspalum chaffanjonii, Leersia hexandra, Panicum laxum, Luziola pittieri, Paspalum plicatulum, Reimarochloa acuta* and *Paratheria prostrata*. In the upper strata, some of the most representative species that reach a height of more than 50 cm

Low vegetation on a lagoon adjacent to the Mesetas River (Vichada). March 2011. © CHELONIA/A. Castro

Savanna "caño" in the La Aurora Natural Reserve. October 2010. © CHELONIA/A. Castro are *Hymenachne amplexicaulis, H. donacifolia, Luziola spruceana, Sporobolus indicus, Trachypogon vestitus, Andropogon bicornis, Axonopus anceps, Imperata contracta, junceum Panicum, Paspalum fasciculatum* and *Sorghastrum parviflorum.*

Studies conducted by the Alexander von Humboldt Institute (2007) in El Tuparro Natural National Park have defined some substantial differences in the types of vegetation found in the savanna ecosystems, depending mainly on the soil's moisture content (drainage conditions). Savannas are classified into well-drained soils dominated by *Heteropogon contortus* and *Paspalum pectinatum*, transitional savannas on moist soils in the presence of *Drosera sessilifolia* and *D. cayennensis* and dominated by *Bulbostylis lanata and Syngonanthus* sp., and savannas with pastureland on wet soils, dominated by *Bulbostylis* sp. and *Caraipa llanorum*. The first type of savanna is associated with the landscape of the "well-drained savannas covered by aeolian sand" (seasonal savannas because they experience a stress period caused by drought). The other two types of savannas are associated with the "badly drained savannas of depression relief covered by aeolian sands" and the hyper-seasonal savanna, usually associated with a lack woody element except for certain types of palm.

Forest Types of the Orinoco Llanos

The high forests of the plains of the Arauca River, are known to have 3-4 layers of woody vegetation. The largest layer contains samples over 28 m high, the presence of palms is low, and large-sized grass such as "guadua" (*Guadua angustifolia*) is generally not found. In a lower layer of under-growth, there is a type of herbaceous vegetation present, characteristic of wetlands. However, these areas are not flooded nor do they have the structure of reservoirs. In this type of forest one can find representative species such as *Manilkara bidentata, Pseudolmedia laevigata, Socratea durissima, Symplocos amplifolia, Cecropia peltata* and *Heliconia bihai.*

In the Orinoco floodplain region, there is an ecosystem known as "gallery forest" or riparian forest, which is one of the most representatives of this part of the country. It is related to the geomorphological conditions of plains (with hardly any slope), where rivers, streams and other bodies of water shape the landscape and determine the existence and development of these ecosystems. By definition, a riparian area is one that surrounds a body of water, which is why these forests grow on the banks of rivers, streams, lakes and even around wetlands. This type of ecosystem is usually very rich in plant and animal species due to the humidity and the variety of food they contain. They therefore constitute important areas for conservation, not only that of water resources but also that of the related biodiversity. They also serve as corridors to facilitate connectivity between forest fragments.

In some cases, riparian forests may have a flood regime, determining the existence of a certain type of vegetation; those that do not flood present a different structure and composition. Some writers classify them as floodable riparian seasonal forests and non-floodable riparian forests, respectively. In the first case, the vegetation has an average tree layer ranging between 13 and 15 m high, though some samples can exceed 20 m. In these phreatophyte forest areas, forests grow on the stream banks and the water courses favor a greater availability of moisture during drought period. Here, the trees reach a higher altitude and are characterized by the presence of *Mauritia flexuosa, Vismia angusta* and herbaceous species such as *Hyptis* sp. and *Xyris* sp. In most places, one can also find graminoid wetland vegetation.

Non-floodable riparian forests have a tree layer with heights ranging over 20 m, with both evergreen and deciduous species. In the undergrowth lianas, epiphytes and large herbs are abundant, as well as palms, *Oenocarpus bataua* or the “milpesos” palm, a species with a wide distribution in the Orinoco basin, stands out. The most representative species of this type of forest include: *Calophyllum brasiliense, Enterolobium cyclocarpum, Garcinia floribunda, American Genipa, Socratea exorrhiza, Phenakospermum guianense, Guadua angustifolia* and *Norantea guianensis.*

In both cases, the importance of riparian forests for the conservation of the Orinoco crocodile is mainly in the habitat that it provides the species during different stages of its life cycle, including beach sites for nesting, shelter for newborns, shelter from natural predators, and rest areas for adults. In more open areas of the plains, it is common to find forests that have a lower tree structure, ranging from 8 to 12 m high, low population density and thin stems. There, the vegetation is hydro-tropophic and dominated by deciduous species that lose their leaves during the dry season, when palms are frequent, lianas are sometimes present, and they are sometimes associated with grasses. The most representative species for this type of forest are *Clusia loranthacea, Clusia columnaris, Aristida* sp. and *Schizachyrium* cf. *brevifolium.* The structure and composition of these forests is heavily conditioned by the influence of man and his activities, often having to do with areas of livestock, and they are developed as relict forest in areas not permitted for different use.

Endangered Flora

According to information obtained from the study carried out by Lasso *et al.,* (2010), in the Orinoco basin area, plant richness includes 8,273 species (of which 996 are endemic), accounting for more than 50% of the country's flora (Table 10).

Family	Species	Threat Category	Global Distribution	DEPT.
Chrysobalanaceae	*Hirtella maguirei*	CR	Colombia	Meta
	Hirtella adenophora	VU	Colombia	Meta
	Hirtella vesiculosa	VU	Brazil? Colombia	Guiana
Lecythidaceae	*Eschweilera cabrerana*	EN	Colombia	Meta
Acanthaceae	*Aphelandra schieferae*	VU	Colombia	Meta
Asteraceae	*Espeletia tapirophila*	VU	Colombia	Meta
	Libanothamnus tamanus	VU	Colombia	Arauca
	Diplostephium fosbergii	NT	Colombia	Meta
Orquidaceae	*Restrepia metae*	VU	Colombia	Meta
Zamiaceae	*Zamia melanorrhachis*	LC	Colombia	Meta

Table 10. Endemic species of the Colombian Orinoquia. Abbreviations: CR= Critically Endangered. EN= Endangered. VU= Vulnerable. NT= Near Threatened. LC= Less Concern. Source : Adapted from Lasso *et al.*, 2010.

3.5.- Biological Environment: Fauna

From a bio-geographical point of view, the wildlife that lives in the Orinoco basin is the result of the exchange and migration of biotic elements that have trans-Andean, Amazonian and Guianese origins. The organisms are evolutionarily specialized to the conditions of the different biotopes that characterize the sub-regions of the basin. It also depends on hypsometric variables, which affect the richness of the fauna which itself is related to altitudinal levels, resource availability and the quality of habitat.

Fish

In 2006, 424 fish species were known to inhabit the Colombian Orinoco basin, while on the Venezuelan side the figure reached 835. Today we know that there are over 1000 species of freshwater fish in the Orinoco basin, due mainly to the large number and diversity of aquatic environments such as white water, clear and black rivers, lagoons, dry river beds with stagnant water lakes, flooded savannas and forests, among others.

However, Orinoquia's various ecosystems are experiencing alterations due to human activities which seriously threaten their conservation, especially in terms of pollution, overfishing, mining and oil industries, etc. Another important and disturbing factor affecting fish populations is related to deforestation, as many species obtain their food from the forest (Marrero *et al.*, 1997, points out that nearly 57% of fish food in "moriche" palms comes from the terrestrial biotope).

There is also a large number of species of commercial interest: *Mylossoma duriventre Pygocentrus cariba, Semaprochilodus laticeps, Hoplias malabaricus, Brachyplatystoma filamentosum, B. vaillanti, B. juruense, B. platynema, B. rousseauxii, Hemisorubim platyrhynchos, Phractocephalus hemiliopterus, Liposarcus multiradiatus, Hydrolycus tatauaia, Pseudodoras niger, Hoplosternum littorale, Leiarius marmoratus, Pseudopimelodus apurensis, Pseudoplatystoma metaense, P. orinocoense, Sorubimichthys planiceps, Colossoma macropomum, Mylossoma aureum, Piaractus brachypomus, Prochilodus mariae, Curimata cerasina, Hydrolycus armatus, Calophysus macropterus, Megalonema platycephalum* and *Zungaro zungaro* (Lasso *et al.*, 2010).

Amphibians and Reptiles

The environmental characteristics found in the Orinoco basin have given rise to different ecosystems that can provide for the establishment and development of amphibian and reptile populations which adapt to the conditions of these environments. Their richness depends on the availability of resources, food, habitat and the moisture regime present in essentially every environment. Thus, they become "indicator species" for the quantity, quality and conservation status of the different environments.

A total of 266 amphibian species can be found in the Orinoco basin, 256 of which belong to the Anura Order. Within the anurans, 15 families are represented: Hylidae, Strabomantidae, Aromobatidae, Leptodactylidae, Centrolenidae, Bufonidae, Hemiphractidae, Microhilidae, Leiuperidae, Dendrobatidae, Pipidae, Eleutherodactylidae, Ceratophryidae and Ranidae.

With respect to reptiles, a total of 290 species have been identified, with 16 species of freshwater turtles (Chelidae, Podocnemididae, Testudinidae, Geomydidae and Kinosternidae families), 5 amphisbaenids species, 77 lizards (gecko and Policrotidae mainly), 177 species of snakes (Colubrids, Vipers and Elapids predominate) and four species of crocodilians (Alligatoridae and Crocodylidae families).

Birds

The group of birds is one of the richest and most diverse taxa in the region of the Orinoquia, where 1,200 species are estimated to be found from the plains to the low savanna areas shared between Colombia and Venezuela. However, effort is required to obtain more knowledge on this group, including researching biology and distribution throughout the Orinoco Llanos of Colombia. Studies already carried out in Colombia have shown limitations when accessing all the ecosystems. These efforts would allow an estimation of the real biological potential of birds and more effective conservation.

Regarding endemism, 18 species, grouped into five orders and 11 families have been detected in the Colombian plains: Tinamiformes (Tinamidae family; 1 species), Apodiformes (Trochilidae family; 4 species), Albuliformes (Galbulidae family; 1 species; and Bucconidae family; 1 species), Piciformes (Picidae family; 2

Ray (*Potamotrygon* sp.) captured by local inhabitants, Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

Hypostomus sp. captured by local fishermen in the Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

View of the head of a “payara” (*Hydrolicus scomberoides*) captured by local fishermen in the Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

Giant toad (*Rhinella marina*). August 2009. © CHELONIA/M. Merchán

Toad (*Rhinella granulosa*) in a pond near Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

Hatchling of red-footed tortoise (*Chelonoidis carbonaria*) photographed in January 2010. © CHELONIA/M. Merchán

Detail of the head of an adult red-footed tortoise (*Chelonoidis carbonaria*) photographed in the Corporinoquia facilities in Yopal (Casanare). August 2010. © CHELONIA/M. Merchán

South American river turtle (*Podocnemis expansa*) photographed in the Bioparque Los Ocarros, Villavicencio (Meta). May 2010. © CHELONIA/M. Merchán

Sub-adult individual of savanna side-necked turtle (*Podocnemis vogli*). El Frío Biological Station, Apure (Venezuela). © CHELONIA/M. Merchán

Adult specimens of savanna side-necked turtle (*P. vogli*), basking in a seasonal pond along the road from Yopal to Orocué (Casanare). August 2010. © CHELONIA/M. Merchán

Colombian tegu (*Tupinambis teguixin*) photographed in the Bojonawi Natural Reserve (Vichada). March 2011. © CHELONIA/A. Castro

Iguana (*Iguana iguana*) photographed on the right margin of the medium course of the Meta River. December 2010. © CHELONIA/F. Gómez

Green anaconda (*Eunectes murinus*) sheltered in a land crack in the La Aurora Natural Reserve (Casanare). February 2011. © CHELONIA/M. Merchán

Adult spectacled caiman (*Caiman crocodilus*) on the shore of an artificial pond in the Palmarito Casanare Natural Reserve (Casanare). August 2010. © CHELONIA/M. Garcés

Detail of the head of a juvenile spectacled caiman (*Caiman crocodilus*) on a shore of the Meta River (Casanare) photographed during a nocturnal survey. March 2011. © CHELONIA/A. Castro

Group of water birds in a flooded savanna. Roseate spoonbill (*Platalea ajaja*), wood stork (*Mycteria americana*), cattle egret (*Bulbucus ibis*), great egret (*Ardea alba*) and great blue heron (*Ardea herodias*) can be observed. Yopal – Orocué Road (Casanare). August 2010. © CHELONIA/M. Garcés

Group of water birds. Among them we can observe cattle egret (*Bulbucus ibis*), southern lapwing (*Vanellus chilensis*) and scarlet ibis (*Eudocimus ruber*). Yopal – Orocué Road (Casanare). August 2010. © CHELONIA/M. Garcés

Roseate spoonbill (*Platalea ajaja*) in a flooded savanna. Yopal–Orocué Road (Casanare). August 2010. © CHELONIA/M. Garcés

Scarlet ibis (*Eudocimus ruber*) in a flooded savanna. Yopal–Orocué Road (Casanare). August 2010. © CHELONIA/M. Garcés

Jacana (*Jacana jacana*) in a flooded savanna in the Palmarito Casanare Natural Reserve (Casanare). August 2010. © CHELONIA/M. Garcés species, and Passeriformes with Furnariidae families (2 species), Thamnophilidae (1 species), Tyrannidae (2 species), Vireonidae (1 species), Thraupidae (2 species) and Parulidae (1 species).

Mammals

In terms of conservation biology, the taxa of mammals is greatly important for understanding the dynamics of succession in the ecosystems of the Orinoco basin and for representing indicators of environmental dynamics, the transformation of the territory and the alteration of natural spaces. One of the main problems in the conservation of large mammals in the area is the fragmentation of ecosystems, as these animals require spaces large enough to maintain their populations and to reproduce. Such fragmentation is a common denominator in the Orinoco Llanos, especially in how their ecosystems have been culturally transformed to develop productive activities such as livestock and agriculture.

Studies carried out in the Orinoquia differ in the number of mammal species identified: the World Bank provides a total of 210, Alberico *et al.* (2000) estimates 167. The most representative records correspond to La Macarena Range, where the group of bats and small rodents reaches approximately 100 species.

As for the group of primates, records indicate about 16 species, corresponding to the following genera: *Saguinus* (3 species), *Saimiri* (2 species), *Aotus* (3 species), *Lagothrix* (2 species), *Callicebus* (2 species) and other genera with just one species each: *Cebus apella, Alouatta seniculus, Ateles belzebuth* and *Cacajao melanocephalus.*

The so-called capybara (*Hydrochoerus hydrochaeris*) is among the most emblematic species of the Orinoco Llanos, represented in Colombia and Venezuela by the subspecies *H. h. hydrochaeris*. The capybara is the largest rodent in the world, its habits are strongly linked to the waterways and its social behavior is complex. It is an enormously important source of protein, which is also why it has been heavily hunted in its areas of distribution.

Other species of aquatic mammals characteristic of the region are the Amazon River dolphins (*Inia geoffrensis*) of the Iniidae family, the manatee (*Trichechus manatus*) of the Trichechidae family, otters (*Pteronura brasiliensis* and *Lontra*

Jabiru (*Jabiru mycteria*) in a flooded savanna. Yopal–Orocué Road (Casanare). August 2010. © CHELONIA/M. Garcés

Large-billed tern (*Phaetusa simplex*) in the surrounding area of Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

Ringed kingfisher chick (*Megaceryle torquata*) on the shore of the "caño" Gandul (Casanare). November 2010. © CHELONIA/R. Antelo

Scarlet macaw (*Ara macao*). August 2009. © CHELONIA/M. Merchán

Hoatzin (*Opisthocomus hoazin*) on the shore of the Cravo Sur River (Casanare). August 2010. © CHELONIA/M. Garcés.

Savanna hawk (*Buteogallus meridionalis*). Casanare. August 2010. © CHELONIA/M. Garcés

Crested caracara (*Caracara cheriway*). Casanare. August 2010. © CHELONIA/M. Garcés

Lesser yellow-headed vulture (*Cathartes burrovianus*). Casanare. August 2010. © CHELONIA/M. Garcés.

Capybaras (*Hydrochoerus hydrochaeris*) lying beside spectacled caimans (*Caiman crocodilus*). Palmarito Casanare Natural Reserve (Casanare). September 2010. © CHELONIA/M. Garcés

Pink river dolphin (*Inia geoffrensis*) in Meta river waters. March 2011. © CHELONIA/A. Castro

Southern tamandua (*Tamandua tetradactyla*) in the Bioparque Los Ocarros, Villavicencio (Meta). February 2011. © CHELONIA/F. Gómez

White-tailed female deer (*Odocoileus virginianus*) photographed in the Bioparque Los Ocarros, Villavicencio (Meta). February 2011. © CHELONIA/F. Gómez

Adult lowland tapir (*Tapirus terrestris*). Bioparque Los Ocarros, Villavicencio (Meta). February 2011. © CHELONIA/F. Gómez

Giant otters (*Pteronura brasiliensis*) in the Chire Nuevo River, La Aurora Natural Reserve (Casanare). February 2011. © CHELONIA/A. Castro *longicaudis*) of the Mustelidae family and the water opossum (*Chironectes minimus*) of the Didelphidae family.

3.6.- Human, Environment and Socioeconomic Study

A socioeconomic study was conducted to find out the actual social and economic situation of the population living in the Orinoco crocodile´s (*Crocodylus intermedius)* distribution areas, especially in the Meta, Casanare, Arauca and Vichada departments, and to identify the human population's main features to plan conservation actions for the crocodile species. To fulfill this objective, data and statistics provided by the National Bureau of Statistics (Colombian DANE) from a survey conducted in 2005 were used, as were the Territorial Management Plans (Colombian POT) and literature which describes the settlement history and other cultural elements of the Colombian Orinoquia.

Geographic-Administrative Aspects

The department of Meta has a surface area of 85,635 km^2. Its capital city is Villavicencio. It is bordered in the north by the departments of Cundinamarca and Casanare, the department of Vichada to the east, Caquetá and Guaviare to the south, and Huila, Cundinamarca and Caquetá to the west.

The department of Casanare has a surface area of 44,640 km^2. Its capital city is Yopal. To the north it borders the department of Arauca, Vichada to the east, Meta to the south, and Cundinamarca and Boyacá to the west.

The department of Arauca (its capital is the city of the same name) has a surface area of 23,818 km^2. To the north and east it borders the Republic of Venezuela, to the south the departments of Vichada and Casanare, and to the west the Department of Boyacá.

The department of Vichada has a total surface area of 100,242 km^2. The capital city is Puerto Carreño. To the north it borders the Colombian departments of Casanare and Arauca, to the north and east the Republic of Venezuela, to the south the department of Guainía and Guaviare, and to the west the department of Meta.

Young puma (*Puma concolor*). January 2010. © CHELONIA/O. Sanz

Adult and juvenile Colombian red howler monkey (*Alouatta seniculus*) in a gallery forest. La Aurora Natural Reserve (Casanare). February 2011. © CHELONIA/A. Castro

Demographic Aspects

The information obtained on population levels in individual departments in the study area of the Colombian Orinoquia gives an estimated total of 1,192,686 inhabitants, which is equivalent to about 2.78% of the total population of Colombia per the 2005 census. The highest population percentages can be found in the below-40 year old range. According to the rate of aging, there are 14 people over 65 for every 100 children and young persons under the age of 15.

Age Range	Total Population	%
0 - 4	133,490	11.192
5 - 9	138,311	11.597
10 - 14	139,169	11.668
15 - 19	117,594	9.860
20 - 24	105,121	8.814
25 - 29	95,459	8.004
30 - 34	86,896	7.286
35 - 39	82,595	6.925
40 - 44	72,865	6.109
45 - 49	58,708	4.922
50 - 54	44,167	3.703
55 - 59	34,721	2.911
60 - 64	26,318	2.207
65 - 69	22,268	1.867
70 - 74	15,846	1.329
75 - 79	10,249	0.859
80 - 84	5,314	0.445
85 - 89	2,593	0.217
90 - 94	785	0.066
95 - 99	175	0.012
100 - 104	29	0.0024
105 - 110	10	0.0008
111 - 115	3	0.0003
Total	**1,192,686**	**100.00**

Table 11. Population based on age range

The Meta Department has the highest population with a total of 713,772 inhabitants, corresponding to 59.85% of the total in the area studied. This is mainly due to the proximity of this department to the center of the country, particularly to the city of Bogotá, allowing for a permanent economic and commercial exchange as well as the promotion of market dynamics that facilitate the settlement of the population in this region of the Orinoco. The same occurs with the department of Casanare, which, like Meta, is located in an area of foothills where communication with the center of the country is more efficient.

Department	Total Population	%
Meta	713,772	59.85
Casanare	281,294	23.58
Arauca	153,028	12.83
Vichada	44,592	3.74
Total	**1,192,686**	**100.00**

Table 12. Population by department

Department	Total Population	Surface Area (km^2)	Population Density
Meta	713,772	85,635	8
Casanare	281,294	44,640	6
Arauca	153,028	23,818	6
Vichada	44,592	10,242	4
Total	**1,192,686**	**164,335**	**7**

Table 13. Population density by department

In the study area, 60.74% of the population is within the working age range, totaling 724,444 people throughout the four departments, proving a good amount of manpower in the region.

Department	PWA	%
Meta	440,355	60.79
Casanare	168,596	23.27

Arauca	91,403	12.62
Vichada	24,090	3.33
Total	**724,444**	**100.00**

Table 14. People of working age

Most of the Working Age Population (WAP) can be found in the department of Meta, with over 60% and a total of 440,355 people, followed by 23.27% in the department of Casanare, 12.62% in Arauca and 3.33% in Vichada. The results indicate that the percentage of the total population for each of these departments is directly proportional to the WAP.

Regarding the distribution of population by gender, the data produced by the 2005 DANE census allow us to establish a roughly even proportion between men and women, with the male population reaching a slightly higher percentage of 50.68% compared to 49.32% for females.

Socioeconomic Aspects

The overall economy of the region is represented by extensive livestock in savanna areas, and technified agriculture for temporary and permanent crops in the foothills. Oil exploitation activities in Arauca, Casanare and Meta are an important economic sector, representing the national economy's main source of exports and income. It has led to the development of road infrastructure and services in these departments and the creation of numerous jobs. Unfortunately, it is also one of the main threats to the conservation of lowland habitats in general, and to *C. intermedius* in particular, due to the heavy transformation of ecosystems required for the extraction of hydrocarbon.

Meta

Livestock is a primary sector among the main economic activities of the Meta Department, with an approximate 4,522.5 ha used for grazing. Agriculture holds a strong place in the department´s economy, considering that about 198,726.2 ha are involved in this type of production. Permanent, transitional and annual crops are represented by rice, African palm oil,

“Llaneros” preparing horses to swim across a branch of the Meta River. Santa Rosalía port (Vichada). November 2010. © CHELONIA/A. Castro

Cowboys crossing the horses through the course of the Ariporo River. La Aurora Natural Reserve (Casanare). October 2010. © CHELONIA/A. Castro banana, corn, cocoa, citrus and other fruits. Another important sector is the development of fish farming - where a large amount of product meets local and national market demands - through fishing in the main streams and breeding species of catfish, tilefish, “bocachico” and “cachama”, among others. Aquaculture production is estimated to produce 4,367 tons per year. Finally, oil extraction plays an extremely important role in the department of Meta where, according to “Empresa Colombiana de Petróleos” (Ecopetrol), it ranks second in oil production with an average of 120,000 barrels a day.

Secondary sectors of the department´s economy include the mining industry and refining of palm oil, rice threshing, metalwork activities and construction products.

The tertiary sector mainly includes ecotourism activities in the Orotoy and Acacías rivers, the Samarcanda Lake and the Guacavía River in Cumaral. Ecotourism also plays a role in the savanna landscapes, the Yucao, Meta and Manacacías rivers in Puerto Gaitán, and as in the geographic center of Colombia, which is a place highly frequented by domestic and foreign tourists, located in the municipality of Puerto López. In San Juan de Arama, tourism is concentrated in the following areas: Santo Domingo Falls, Peñas Blancas Balcony, Quebrada Honda Falls, Tablazo, Indio Acostado, Las Marcelas and Negra Lagoons, and the City of Stone. Ecotourism is also developed in the national protected areas in Meta, specifically in some parts of the National Parks of Sumapaz, La Macarena Range, Tinigua, Chingaza and Cordillera Los Picachos.

Casanare

Historically, the department of Casanare is known for maintaining an economy based on livestock and rice farming, mainly in the municipalities of Aguazul and Yopal. Cattle farming is the main economic activity of the population, in terms of both jobs and income. In this department, agricultural activities include the production of permanent, transitional and annual crops which, combined, occupy an area of about 74,247.6 ha.

Currently, Casanare´s main economic item comes from royalties generated by the oil sector, positioning the department as the top producer nationwide. Its oil prosperity came about in the nineties, the decade in which the Cusiana and Cupiagua oil fields were discovered; oil export capacity was thus increased by exploiting 30 wells located in the lowlands of the foothill. Furthermore, there are gold, manganese, phosphorus, and nickel mines. However, there is a shortfall in Casanare´s trade balance due to the high volume of imports, which are influenced by materials and machinery that oil companies require.

The third sector of Casanare´s economy is represented by outdoor activities and ecotourism, which mainly take place in the municipalities of Yopal (La Calabaza Path, La Tablona, La Niata and La Guatoca gullies), Aguazul and Maní (Natural Reserve of the Tinije Lagoon, San Miguel Cliffs in the Unete and Charte rivers), La Salina and Sácama (El Cocuy Natural National Park), Maní (Cusiana River and Straits of Bocachico) and Villanueva ("caños" Aguaclara and Arietes).

Arauca

With regards to the oil industry, the department of Arauca became noted for its volume of oil exports in the 1980's due to the discovery of the "caño" Limón well which was at that time the most important in Colombian history with reserves of 1.2 billion barrels. Livestock activities play an important role within the department, covering a total of 1,873.330 ha, with focus placed on breeding, raising and fattening of cattle. Commercialization is aimed at the towns of Puerto López, Bucaramanga and Cúcuta. Areas of permanent and annual crops reach 4,680 ha, represented by cocoa, banana, yucca, rice, conventional maize, coffee, sugarcane, beans and fruit trees, as well as industrial crops such as African palm, sorghum, soy, sesame and machined dry rice. Another important item is fishing and the harvesting of species such as catfish, "bocachico" and "tambaquí", which are marketed locally and distributed in Cúcuta, Bucaramanga, Ibagué, Cali and Bogotá.

Industry is mainly based on the production of food products, beverages and decoration workshops, while the trade sector has its strength in the towns bordering Venezuela. The tourism sector is concentrated in enclaves such as the Mirador Murgas Ecological Reserve, Piquetierra Lagoon, La Guerrera Lagoon, Los Morichales Park and Colorada Lagoon, among others.

Vichada

The primary sector for the department of Vichada's economy is mainly based on livestock, commerce and more modestly, locally consumed agriculture (mainly cotton, corn and banana). Livestock is very extensive and characterized by cattle production in all grassland areas, particularly in the municipality of La Primavera. Fishing is also an important part of the economy; approximately 30 varieties of ornamental fish are marketed and destined for Bogotá and foreign trade.

The industrial sector is represented by the production of leather handicrafts, garment manufacturing and processing of household products from rattan fiber or "chiquichiqui" fiber or "cumare" palm (*Leopoldinia piassaba*).

Tourism is booming, and focused on three main aspects: ecotourism; in areas such as El Tuparro Natural National Park; scientific tourism, for example in El Merey Experimental Farm or Las Gaviotas Technology Development Center (Cumaribo) and ethnographic tourism, especially in the Matavén Jungle Reserve where high ethnic diversity is represented by Sikuani, Piapoco, Piaroa, Puinave and Kurripaco communities. This area is located in the municipality of Cumaribo.

Cultural aspects of the Colombian Orinoquia

The traditions and customs of the inhabitants of Orinoquia are not very different among the four departments. In fact, many traditions are shared with regions of the Venezuelan plains. Its people engage mainly in cattle breeding, using the horse as a working tool par excellence, and making it one of the most distinctive marks of the Llanos culture.

Given the environmental conditions of the region -characterized by high temperatures and the almost permanent influence of the sun for much of the day- the hat has become one of the most widely used accessories for the worker of the plains, having, over the years, become a cultural icon. The traditional dance is the "joropo" and costumes worn to practice it recall those used in cattle raising. This is a cultural expression of the pioneering work of the plains, i.e. man-horse-cattle, and is manifested in celebrations and festivities. The rhythm, typical of the plains,

Cowboys on horseback through the flooded savannas of the La Aurora Natural Reserve (Casanare). October 2010. © CHELONIA/A. Castro

"Coleo" championship (traditional festival from the Llanos) in Puerto López (Meta). May 2010. © CHELONIA/M. Merchán dates back to the mid-nineteenth century when large plantations and cattle ranches celebrated religious holidays, sang the renowned "galerones" and danced the waltz and "vals vueltiao" which over time became the "joropo". The musical instruments used for the "joropo" are typical of the region and include the harp, the "cuatro" (meaning "four", which derives its name from the number of strings), the mandolin and the maracas.

4.- An Overview of the Legal Instruments Relevant to Orinoco Crocodile Conservation in Colombia

Miguel Andrés Cárdenas-Torres

Colombia's natural resources, including its biodiversity, are in a troublesome situation due to the increasing pressure of human populations, particularly with regards to the transformation of highly sensitive ecosystems for the purpose of carrying out unsustainable production activities. This process harms wildlife populations, increasingly restricted to remaining forest lands, and adversely affecting conservation at the local level.

The situation was particularly serious from the thirties to the sixties for the Orinoco crocodile (*Crocodylus intermedius*). Thanks to the efforts of the Colombian government and Autonomous Regional Corporations, various legal instruments have been created to control the decline of this emblematic species in the wild.

4.1.- Legal Background

Biodiversity conservation has been a topic of increasing importance in international policies for sustainable development. In the year 2000, the Millennium Development Goals of the United Nations were formulated and signed by 192 countries. The goals were to be achieved by 2015, and considerable emphasis was given to the relationship between man and nature, and specific commitments were made to fight against the extinction of species and conserve biodiversity as world heritage.

From the standpoint of international law, some experts agree that natural resource management with a conservationist approach had its beginnings in the Convention on Biological Diversity (CDB), signed under the framework of the Earth Summit in Rio de Janeiro (Brazil) in 1992. This agreement defined guidelines with new criteria that leaned towards globalization, and was more stringent from the viewpoint of making information available, as well as incorporating requirements to safeguard critical resources such as water, land and forests. These commitments were ratified by Colombia through Bill 165 of 1994. Article 8 of the CDB establishes that the contracting parties draw up guidelines for the selection, establishment and management of protected areas or regions that require special measures to conserve their biological diversity. It also establishes that the State is responsible for the rehabilitation and restoration of degraded ecosystems and that it will promote the recovery of threatened species through, among other things, the development and implementation of plans or other management strategies.

However, three decades ago, the international community was already searching for mechanisms to allow governments to coordinate and cooperate in combating illegal wildlife trade, one of the most critical factors contributing to the extinction and decline of wildlife. In 1963, members of the International Union for Conservation of Nature (IUCN) drafted the "Convention on International Trade in Endangered Species of Fauna and Flora (CITES)", the final text of which was finally agreed upon at a meeting with representatives from 80 countries in Washington D.C. in 1973. CITES entered into force mid-1975, and currently has been ratified by 175 countries.

CITES operates according to the legislation of each signatory country. In the case of Colombia, CITES was approved by Law 17 of 1981. Subsequently, the Colombian CITES Administrative Authority and its functions were established through Decree 1401 of May 27, 1997. CITES has three Appendices or lists of species (I, II and III) depending on their degree of trade regulation. Appendix I is the most restrictive, banning international trade of the species concerned, except when carried out for scientific research purposes. In its latest update of October 14, 2010, CITES contracting parties kept the Orinoco crocodile in Appendix I.

The species was also declared by Colombia´s Ministry of Environment to be "In Danger of Extinction" in 1997. In 2010, through the Resolution 383, the species is considered as "Critically Endangered". IUCN still includes this species in the category of "Critically Endangered", and has it classified as the most endangered crocodile and one of the twelve most endangered vertebrates on the planet.

Agreement	Colombian Law that Endorses the Agreement
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Law 17 of 1981, Decree 1401 of 1997
Convention for the Protection of World Cultural and Natural Heritage	Law 45 of 1983
Vienna Convention for the Protection of the Ozone layer	Law 30 of 1990
Agreement of the 1992 Rio Earth Summit, Agenda 21 Convention on Biological Diversity	Principles were incorporated into Article 1 of Law 99 of 1993 Law 165 of 1994
Convention for the Protection of New Plant Varieties	Law 243 of 1995
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal	Law 253 of 1996
RAMSAR Convention on Wetlands of International Importance, especially waterfowl habitats	Law 357 of 1997

Table 15. International environmental agreements signed by Colombia

4.2.- Regulatory Tools

Under the provisions of the Political Constitution of Colombia of 1991, it is the State´s duty to guarantee the protection of natural resources, and it therefore must establish policies and regulatory tools that permit their appropriate use and management while achieving the sustainable development of human communities. For this, Article 2 of the "Carta Magna" considers it the State´s essential responsibility to serve the community, promote general prosperity and ensure the effectiveness of the principles, rights and duties established in the Constitution, facilitate popular participation in decisions that affect the people in the economic, political, administrative and cultural aspects of the nation, defend national independence, maintain territorial integrity, and ensure peaceful coexistence and stability. Through Articles 79 and 80, the State must ensure the protection of the diversity and integrity of the environment, preserve areas of special ecological importance and boost education in order to achieve these objectives. It must also plan the management and exploitation of natural resources so as to enable their sustainable development, conservation, restoration or replacement.

The National Institute of Natural Resources (INDERENA), formalized by Decree-Law 2460 of 1968, was created as a public institution under the authority of the Ministry of Agriculture. The agricultural sector was restructured through its functions of protecting and regulating the use and exploitation of renewable natural resources nationwide. At the same time, many decrees and resolutions led to the creation of Autonomous Regional and Sustainable Development Corporations. Some of these took over the functions of INDERENA, the entity that had been responsible for implementing the provisions of the Natural Resources Code (Decree Law 2811 of 1974) and which had also acted as advisor to the National Government on matters of environmental policy. With the provisions of Article 133 of Decree 501 of 1989, INDERENA´s objective became helping elevate the quality of life of the Colombian population and the sustainable development of agricultural sector through environmental protection, research, administration, conservation, preservation, management and the promotion of renewable natural resources in the country.

Law 23 of 1973 formalized the Code of Natural Resources and Environmental Protection, which was later standardized by Decree Law 2811, as a response to the need for a regulatory tool that organized the use, conservation and improvement of renewable natural resources. Act 2811 addresses international environmental issues, and in Articles 10 and 11, it establishes the need to manage habitats and species common in neighboring countries in order to prevent or solve environmental problems and regulate the use of shared natural resources.

Afterwards, the Presidency of the Republic issued Decree 1608 of 1978, which essentially regulates part of the National Code of Renewable Natural Resources and Environmental Protection and Law 23 of 1973 on wildlife. Article 5 states that the protection standards outlined in statutes relating to non-maritime waters, hydro-biological resources, flora and the marine environment shall apply to the group of crocodilians, as well as other groups of species that partly depend on the aquatic environment to maintain their life cycle. However, until the enactment of Act 99 of 1993, the guidelines reflected in the Code of Natural Resources were carried out by the former INDERENA; functions were subsequently left in the hands of the Ministry of Environment and other official institutions.

Law 99 of 1993 constituted an important landmark in the country's environmental policy, as it abolished INDERENA, leading to the creation of the Ministry of Environment and the research institutes: Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), the José Benito Vives De Andréis Institute for Marine and Coastal Studies (INVEMAR), the Alexander von Humboldt Research Institute of Biological Resources (IAvH), Amazonian Institute of Scientific Investigations (SINCHI) and the John von Neumann Pacific Environmental Research Institute (IIAP). Of these, the Humboldt Institute (IAvH) is responsible for providing scientific information to the Ministry of Environment with regards to policies related to biological resources, including the conservation and management of *C. intermedius.*

The same Law 99 of 1993 establishes the standards and administrative structure of the Autonomous Regional Corporations, defined in Article 23 as *"...legally-constituted public corporate bodies, integrated by local authorities whose characteristics geographically make up one ecosystem or form one geopolitical, biogeographic or hydrogeographic unit, endowed with administrative and financial autonomy, their own assets and legal framework, legally obligated to administer, within the area of their jurisdiction, the environment and renewable natural resources and to work for sustainable development in accordance with the laws and policies of the Ministry of Environment"*. The responsibility for regional action on habitats and populations *in situ* and *ex situ* of *C. intermedius* falls on two Autonomous Regional Corporations: Regional Autonomous Corporation of La Macarena (Cormacarena) and the Regional Autonomous Corporation of the Orinoquia (Corporinoquia). The first covers the Meta Department, while the second is responsible for territories within the departments of Arauca, Casanare and Vichada. Finally, the Act organizing the National Environmental System (SINA), made up of the research institutes, regional autonomous corporations and other public and private entities, created the National Environment Council. This includes representatives from the Ministries of Environment, Agriculture, Health, Economic Development, Mines and Energy, Education, Public Works and Transportation, National Defense and Foreign Trade, as well as representatives from a range of government agencies related to environmental issues, government delegates, municipalities, indigenous and Afro-Colombian communities, unions of agricultural and livestock producers, forestry, mining, industry, exporters, environment and academia-related NGOs.

Law 165 of 1994 approved the Convention on Biological Diversity, signed in Rio de Janeiro on June 5, 1992, in Colombia. Its main objectives are the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of the genetic resources through adequate access to those resources and through the appropriate transfer of relevant technologies. Commitments were also signed in the presence of the General Secretary of the United Nations to identify and carry out regular monitoring of the ecosystems or habitats that contain species declared endemic or in danger of extinction. In 1995, the National Environmental Council (created by Law 99 of 1993 and regulated by Decree 1867 of August 3, 1994), approved the Policy on National Biodiversity which was elaborated by the Ministry of Environment and the National Planning Department with the support of the IAvH. Its intention was to reflect the Convention on Biological Diversity (Act 165 of 1994), identifying the bodies responsible for managing biodiversity in the country, the areas of action and the corresponding strategies: conservation (through the Protected Areas System for implementing conservation measures), knowledge (characterization of the biodiversity in those areas) and use (sustainable management systems). With this, the conservation strategy aims to provide the right tools and establish guidelines for natural resources managers in Colombia to reduce the processes and activities that cause biodiversity loss. The supervising authorities (Ministry of Environment, Regional Autonomous Corporations (CAR), National Customs, the Public Prosecutor and Attorney) take on significant importance in preventing trade of endangered species, as set out in CITES, thus providing an instrument for the conservation of *C. intermedius,* and in minimizing the impact of illegal trade.

Wildlife Policy, as enacted by the Ministry of Environment in October 1997 and approved by the National Environmental Council that same year, sought to create the necessary conditions for the use and sustainable exploitation of wildlife as a biodiversity conservation strategy and a socio-economic alternative for the country's development, ensuring both the permanence and functionality of natural populations and the ecosystems they inhabit. Among the issues it sets out that are of importance to the management of the Orinoco crocodile, is the need to retrieve and manage populations of endangered species and consolidate knowledge about wildlife. In 2002, the Ministry of Environment presented the "National Program for the Conservation of the Orinoco crocodile (*Crocodylus intermedius*)," which was developed by Ministry specialists, the Alexander von Humboldt Institute of Biological Resources Research and the National University of Colombia. The Program prioritized actions to be implemented for the conservation of the species, both *ex* and *in situ*, including specific goals such as the recovery of eggs and hatchlings, the building of facilities with an approximate area of 1,200 m^2 to release 2,500 individuals, the identification of potential habitats for reintroduction, the definition of a protocol for this reintroduction, the monitoring of reintroduced populations, and the exchange of specimens between Colombia and Venezuela. From an administrative point of view, the National Program sets out instrumental actions with institutional, financial, communication, environmental education and research components.

A year later the Ministry of Environment was dissolved and the current Ministry of Environment, Housing and Territorial Development (MAVDT) was set up, organized by Decree 216 of February 2003. Later, the Biodiversity Action Plan of the Orinoco basin (2005-2015) was drawn up by the new MAVDT and an interdisciplinary team consisting of representatives from environmental institutions in Colombia. It formulated the themes, strategies, programs and tools needed to manage biodiversity in that part of the country. *C. intermedius* was considered one of the "focal species" in the planning, with a specific program focused on improving knowledge on its population, composition, structure and functional dynamics.

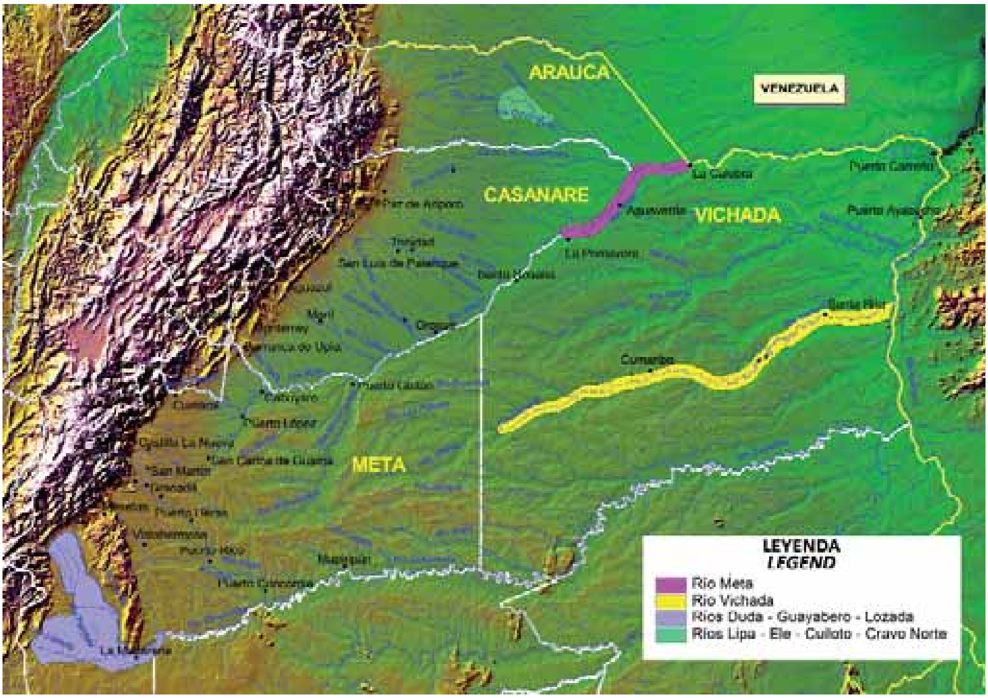
The Regional Autonomous Corporation of the Orinoquia (Corporinoquia), which has jurisdiction over three of the four departments in which *C. intermedius* populations are distributed, has the status of an official entity and formulates its own land use and natural resource planning through the Regional Environmental Management Plan (PGAR). The current PGAR (2002-2012) establishes how to cover the "protection of ecosystems and regulation of natural resources" within its plan of action, including programs which directly influence the conservation and management of *C. intermedius*, such as the *"Conservation and restoration of ecosystems and strategic eco-regions*" designed to identify and report strategic conservation and restoration areas through a "regional ecological structure plan" that promotes a future network of nature reserves. Furthermore, the "Implementation of the programmed lines of the Biodiversity Plan" focuses on developing conservation actions, including *in situ* measures through the protected area system, by reducing the processes and activities that cause loss or damage to biodiversity, recovering degraded ecosystems and threatened species, and increasing knowledge and sustainable use of the natural heritage.

5.- Conservation

Rafael Antelo Albertos

In the year 1800, the Prussian explorer, geographer and naturalist Alexander von Humboldt, referring to the Orinoco crocodile, said: *"It is unlikely that a country in which a maze of countless rivers allows groups of animals to move from the eastern slopes of the Andes, through the Meta and Apure rivers, to the coasts of Spanish Guiana, will ever be free of crocodiles. All that will result from an encroaching civilization is that these animals will become more apprehensive and more determined to escape"*. This statement is one of the few inaccuracies committed by the famous author, but it highlights the extraordinary historical abundance of this species which, as this chapter reveals, is in serious threat of extinction today.

5.1.- Historical Data and Censuses



Relict distribution areas of the Orinoco crocodile in Colombia

The Orinoco crocodile caught the attention of chroniclers and explorers of the region of Los Llanos, who throughout the nineteenth and twentieth century described the abundant caiman populations in the region's waterways. Humboldt (1800), Paéz (1868), Gallegos (1928) and Calzadilla (1940) made the following observations: *"In this intermediate terrain (referring to the beaches) we can see crocodiles, often in groups of 8 or 10, lying on the sand, motionless... lying next to each other"; "These reptiles have multiplied in such a way that all along the river we have always had five or six within sight. However, due to the weather we began to notice the rising of the Apure River, and in consequence hundreds of crocodiles were buried in the mud of the savannah."; "Further below the mouth of the Arauca, crocodiles appeared in greater numbers than they had up until then..."; "When you walk along the banks of the Portuguesa, you can see these large lizards gathered in groups of six or more, basking in the sun near the water..."; "Like all those in the plains, that gorge was a breeding place of Caimans who had bitten other animals and caused them to drown…".*

Both before and after the colonial period, indigenous European and "mestizo" populations hunted crocodiles to prevent attacks or to use some part of their bodies for food, medicine, magic or religion. The Otomac, Guano and Yaruro Indians ate the meat and eggs, while people from the Llanos prepared remedies for sprains and horse skin diseases with crocodile fat. Creoles and natives were convinced that crocodile tusks were an antidote for poison, especially if extracted on Good Friday (Gumilla, 1741, De Cisneros, 1764; Codazzi, 1841; Páez, 1868). This selective hunting did not have a severe effect on the dense populations of crocodiles, partly due to low human densities, but also because these uses were sporadic and they were large market demand.

In 1929 commercial hunting of the Orinoco crocodile (Mondolfi, 1965) began in Venezuela and Colombia, ultimately leading to a near complete extinction of the species. Hunting developed to satisfy high international demand for crocodilian skins, and leather industries found a seemingly inexhaustible gold mine in the region of the Llanos, a habitat exclusive to the *C. intermedius*. The Orinoco crocodile's skin is considered 'classic' (Velasco, pers. comm.) because its ventral side is not very rigid, making it easy to work. This, coupled with the large size of the specimen, made it one of the most prized in the world; which helps explain the intense hunting pressure on the species.

With few exceptions, Orinoco crocodile hunting was carried out at night from light wooden boats, locally referred to as "curiaras" (indigenous boats made from one tree). The crew consisted of three men -the skipper on the stern leading the way, the harpooner on the bow who carried a lantern and harpoon, and a third man who helped beat and kill the crocodile. They dazzled their prey with flashlights and approached close enough to launch and drive the harpoon into its neck. Pulling hard on the rope attached to the harpoon, they drew the specimen onto the boat where, with much effort, they killed it with the blow of an axe to the head. The dead specimens were deposited on the shores of rivers and gorges, where men removed their skins during the day and transported them to distribution centers (see review on hunting techniques in Antelo, 2008).

This activity constituted a great economic importance in the region and peaked at the start of the 1930's, continuing into the 60's when the shortage of raw material led to the lucrative business's collapse (Mondolfi, 1965). Crocodile hunting was carried out unsustainably- seasons and extraction fees weren't respected and males and females, young and old were hunted indiscriminately. This behavior resulted from the lack of regulation of hunting activity. The limited data that is available regarding the number of individuals hunted during this period reinforces the information provided by chroniclers on the abundance of crocodiles in the region. During an initial period of four years, 850,000 crocodile skins were exported from Venezuela alone, and from 1930 to 1931 between 3,000 and 4,000 skins per day (Calzadilla, 1940, Medem, 1983) were sold in San Fernando de Apure (Venezuela), one of the three distribution centers. It is estimated that in Colombia at least 235,200-254,000 skins were obtained during the entire hunting period (Medem, 1981); in the 1940's specifically about 154,000 specimens were killed in the Meta River and its tributaries and another 40,000-50,000 in the Guayabero and Guaviare rivers (Blohm, 1973). With this information in mind, Thorbjarnarson (1987) and Antelo (2008) calculated that the total population of Orinoco crocodiles before the start of commercial hunting ranged between 2 to 3 million specimens respectively. These quantities are considered conservative.

Medem (1958) was the first researcher to warn about the critical situation of the species, carrying out the first censuses of the *C. intermedius* populations in Colombia from 1974 to 1975. The results could not have been more disappointing, as only 280 individuals were observed in an area of 252,530 km^2 (Table 16). The maximum total Colombian population was estimated at 780 specimens (Medem, 1981).

Adult female of *C. intermedius*. La Terraza Fish Station, Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. A. Cárdenas

Adult female of *C. intermedius*. La Terraza Fish Station, Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán

Detail of the head of an adult female of *C. intermedius*. La Terraza Fish Station, Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán

Adult Orinoco crocodile. Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

Department	Nº of Crocodile Observed
Arauca	180
Casanare	49
Meta	14
Vichada	37
Total	**280**

Table 16. Distribution of crocodiles observed by Medem in the censuses of 1974 and 1975 in the departments of Colombia.

Between 1994 and 1996, the Roberto Franco Station of Tropical Biology (Villavicencio, Meta Department) conducted a second national census, covering 70% of the distribution area of *C. intermedius* in the departments of Arauca, Casanare, Guaviare, Guainía, Meta and Vichada. The results showed a further decline in the number of crocodiles, as a total of only 34 were observed, four of which were sub-adults. A total of 127 individuals were estimated to be in 70% of the distribution range (Rodríguez, 2002). During this study, four areas were found to have residual populations and other areas contained isolated specimens: 1.- Ele, Cuiloto, Cravo Norte and Lipa rivers, 50 specimens estimated; 2.- Santo Domingo, Duda, Lozada and Alto Guayabero rivers, 25 individuals estimated; 3.- Meta River, between La Primavera and La Culebra, 15 specimens estimated; 4.- Vichada River, 15 individuals estimated.

A new census conducted in the department of Arauca in the years 2000 and 2001 confirmed the importance of the residual population made up of the Ele, Lipa and Cravo Norte rivers, where 24 specimens were observed, 54 were estimated and 11 nests were found (Ardila *et al*., 2002). The last census carried out in Colombia before those presented in this book was carried out by personnel of the Roberto Franco Tropical Biology Station in the Duda and Guayabero rivers, where 12 individuals were observed besides seven nesting places, with a population estimate of about 46 specimens (Ardila *et al*., 2002; Velasco *et al*., 2002).

In Venezuela, the first census of the Orinoco crocodile was carried out in 1978. Over 3,500 km of rivers were covered and 253 individuals were observed (Godshalk, 1982). Based on this first census, more detailed studies were subsequently conducted in areas where crocodiles had previously been observed (Thorbjarnarson, 1987; Ayarzagüena, 1990). In the hydrological system of the Cojedes River, the total population estimated in the year 2000 was 547 individuals (Seijas and Chávez, 2000), while in the Capanaparo River the size of the estimated population was 443 in 1987 (Thorbjarnarson, 1987) and at least 536 in 2002 (Llobet and Seijas, 2002). These two are the largest populations that survived the commercial hunting period. However, remains of other populations of some importance were found in Venezuela, such as that discovered in 1982 in the Caura River, where 69 individuals were observed (Franz *et al*. 1982), and the one in the Tucupido reservoir where 11 individuals were accounted for in 1993 (Seijas and Meza, 1994). There were 30 specimens distributed in different areas of the Manapire River and it was discovered that at least 10 females reproduced between 2000 and 2005 (Jiménez-Oraá, 2002; Jiménez-Oraá *et al*., 2007).

One of the populations with the greatest potential is located in the El Frío Biological Station (EBF) and the neighboring Caño Guaritico Wildlife Refuge (Apure State, Venezuela), where a population of 400 specimens and 31 breeding females were estimated in 2007 (Antelo, 2008). This population was formed exclusively, as detailed below, by specimens bred in captivity and later introduced into the natural environment. However, the EBF was expropriated by the Venezuelan government in 2009 and the future of its crocodile population remains uncertain. Recent works published on the situation of the Orinoco crocodile populations in Venezuela point to a decline in the number of specimens in both the Cojedes and Capanaparo rivers, although no new estimates on population sizes have been made (Mena *et al*., 2010; Seijas *et al*., 2010).

In summary, and assuming no significant changes have taken place since the last censuses, we can estimate that the total number of Orinoco crocodiles amounts to approximately 1,700 individuals, over 1,500 of which are found in Venezuela and the rest in Colombia.

5.2.- Conservation Programs in Venezuela

The first initiatives to conserve the species were carried out even before the results of the first nationwide census were known, as the virtual disappearance of the Orinoco crocodile from the ecosystems of the Llanos became evident. El Frío Biological Station was the first institution to develop a captive breeding program in 1977. This initiative was quickly copied by the Fundo Masaguaral (1984), the Ezequiel Zamora National Experimental University of the Western Llanos (UNELLEZ) in 1985, Agropecuaria Puerto Miranda in the 1990's and later by

FUDECI in 2000, with the opening of a crocodile breeding Center in Puerto Ayacucho.

The operation of these breeding centers is justified by the high mortality rates of crocodiles during incubation, birth and the first years of life in the wild. In these centers, captive and wild crocodile eggs are incubated and specimens are kept from birth until they reach a size of at least 80 cm in length. At this size, the crocodiles have a greater chance of survival as there are fewer natural predators in the areas they inhabit.

Several documents were simultaneously published that embodied the different strategies proposed to help the recovery of *C. intermedius*. These works and the applied conservation strategies resulted from the consensus of different international institutions and NGOs such as the Crocodile Specialist Group of Venezuela (GECV), The Foundation for the Defense of Nature (FUDENA), FUDECI, World Wildlife Fund (WWF), Asociación Amigos de Doñana, La Salle Foundation, UNELLEZ, the Ministry of the Environment of Venezuela and individuals such as Mr. Thomas Blomh. Thus, in 1993, the *Plan of action for the survival of the Orinoco crocodile in Venezuela* (1994-1999) was developed; the Ministry of Environment established the *Strategic Plan for the survival of the Orinoco crocodile* in 1994 and the *Population and habitat viability assessment workshop* (PHVA) was organized in 1996. These documents (FUDENA, 1993; PROFAUNA, 1994 and Arteaga *et al.*, 1997) stress, inter alia, the need to enhance captive breeding of the species and to form new populations, or enhance those already existing, with specimens bred in captivity.

El Frío Biological Station (EBF) and Caño Guaritico Fauna Refuge (RFSCG)

In the late 1980s, there were three captive breeding centers housing a significant number of Orinoco crocodiles. Most of the animals were born on the breeding farms, while some had been caught in the Cojedes River and taken into captivity to increase the genetic variability of the captive population, thus enhancing their chances of survival (Ayarzagüena, 1990). In 1989, the Decree 2702 was published, and the Caño Guaritico Wildlife Refuge, Fish Reserve and Protection Zone set up and designated as the pilot area for the introduction of the species kept in captivity, among other things. This area was chosen because it formed part of the historical distribution area of *C. intermedius;* it represented optimal habitat for the development of the species: sandy beaches suitable for reproduction, abundant food in the form of fish, low human density, and most

The biologist Rafael Antelo collecting eggs of a wild Orinoco crocodile to incubate them under controlled conditions as part of the Orinoco Crocodile Conservation Program, El Frío Biological Station, Apure (Venezuela). February 2006. © CHELONIA/J. M. Arcos

Sub-adult *C. intermedius*. Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán importantly, the committed support of land owners within the Refuge. It is worth pointing out that the Orinoco crocodile has a total length of over 5 m and is perceived by local people as a dangerous species to humans and pets; this is why social issues had to be taken into consideration when releasing specimens back into their natural environment. Similarly, a 58 km stretch of the Refuge adjoin the El Frío Biological Station (EBF), a private protected area of 80,000 ha, played a key role as described below in the local recovery of the species. However, when the Refuge was set up, the local crocodile population was already extinct and the main challenge was to form a new population from specimens in captivity.

The first introduction of crocodiles into the natural environment took place in April of 1990 in the EBF, in "caño" Macanillal, a body of water belonging to the "caño" Guaritico hydrological network. After that, the crocodile releases in the Refuge and the EBF became a routine activity until 2010. According to data provided by Velasco, in 2007 the total number of individuals introduced to the area amounted to 2,380; 1,333 were released in the Refuge, 916 in the EBF and the rest in other places such as El Cedral Farm (69) or "caño" Garza (62).

The first indication of reproduction in wild specimens was found in 1996, again in the EBF and through a study carried out during the 2006 and 2007 dry seasons; a new Orinoco crocodile population of about 400 specimens was confirmed, including a minimum of 30 breeding females, most of which were present in the EBF. This proved to be a complete success in the global conservation of herpetofauna, because for the first time a stable population of crocodilians bred exclusively in captivity had been formed (Antelo, 2008). It is worth pointing out that many people and public, private, national and international institutions contributed to this objective and thanks to their close collaboration, made this achievement in Orinoco crocodile conservation possible. It is also worth highlighting the importance of private properties in the conservation of ecosystems of the plains and their species, exemplified by the case of the EBF private land ownership. In April 2009, the EBF was expropriated by the Venezuelan government and, to date, the continuity of the conservation program as well as the future of the crocodiles there is still uncertain. Similarly, the breeding farm run by FUDECI in Puerto Ayacucho has closed its doors, and Agropecuaria Puerto Miranda is experiencing administrative problems. However, two new breeding centers joined the efforts of conserving the species in Venezuela: SINCOR in the State of Anzoátegui and the Biological Station of Rancho Grande, in the State of Aragua. Currently, both centers breed newborns captured in the Cojedes, Manapire and Capanaparo rivers.

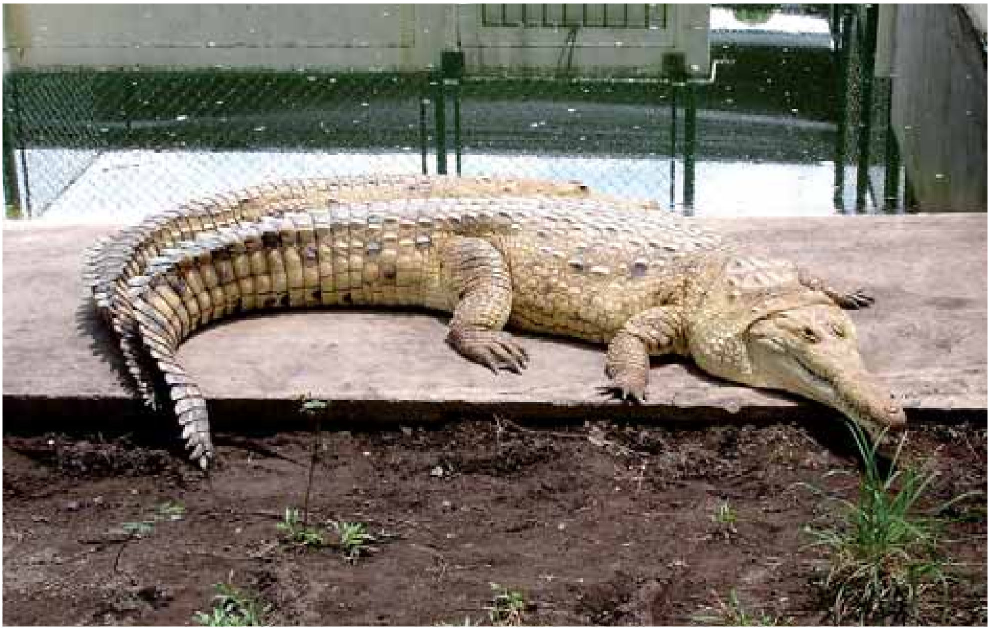
Up to 2010, a total of 7,419 Orinoco crocodiles were released in Venezuela (Velasco pers. comm.) marking a world record. Of these, 2,661 individuals were released in the EBF and RFSCG, 1,803 specimens were introduced or released in the Aguaro-Guariquito National Park (State of Guárico), 990 individuals in the Santos Luzardo National Park (Capanaparo River, State of Apure), 686 into the Cojedes River, 375 in the "Esteros de Camaguán" Wildlife Refuge (RFSEC), and 311 specimens released into the Tortuga Arrau Wildlife Refuge (RFSTA). However, to date there has only been a notable population increase in the EBF and RFSCG.

5.3.- Conservation Programs in Colombia

Orinoco crocodile conservation activities in Colombia have been centralized in the Roberto Franco Station of Tropical Biology (Meta Department) under the authority of the National University of Colombia, since Federico Medem settled the first pair of crocodiles there in 1970 (Ramírez and Urbano, 2002). From thereon, the number of animals kept in captivity at the Station has increased, through new acquisitions from donations, from the confiscation by INDERENA of 19 individuals in 1994, or through breeding by parents already in captivity. The first nesting took place in 1986, but due to nutritional deficiencies in the parents and other factors, the eggs failed to hatch that year or the following. In 1988, the breeding adults' diet was adapted to increase reproductive efficiency, and in 1991 the first births took place, continuing until 1995. That same year, 36 specimens were taken to the Yamato Foundation in Puerto Gaitán (Meta Department) in an attempt to reduce the population density of crocodiles in the EBTRF and to expand the captive breeding program. Four specimens were also brought to the Secretary of Agriculture of Casanare, and two more were given to Mr. Rito Segovia for safekeeping in El Maní, department of Casanare (Ramírez and Urbano, 2002).

In 1998, in light of the results obtained in the censuses carried out in the Colombian Orinoquia, the Ministry of Environment developed the *National Program for the Conservation of the Orinoco Crocodile* in collaboration with the Alexander von Humboldt Institute and the National University of Colombia. Its general objective was *"to prevent the extinction of the Orinoco crocodile* -Crocodylus intermedius- *in Colombia and promote its recovery in its national area of distribution, thus contributing to long-term conservation of the*

Hatchlings *C. intermedius*. Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán



Adult *C. intermedius*. Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/M. Merchán *species, integrating it into the regional economic and cultural systems"*. The first phase of this program, for which a minimum duration of 10 years was anticipated, included six specific actions:

1 .- Recovery of eggs and newborns.
2.- Implementation of 1,200 m^2 of infrastructure for the release of 2,500 individuals.
3.- Identification of potential habitats for reintroduction.
4.- Definition of protocol of reintroduction.
5.- Monitoring of reintroduced populations.
6.- International exchange.

In the year 2000, a series of awareness-raising and expansion activities were carried out in seven city centers of the Colombian Orinoquia region and attended by over 300 people. The aim was to promote the National Program for the Conservation of the "Caimán Llanero" and assess, through enquiries, the local population's knowledge of this endangered species. One of the most important results of this initiative was that 87% of those surveyed said they would like their town to take the lead in the conservation of the Orinoco crocodile (Ramírez, 2000).

In 2004, the size of the Colombian ex-situ population totaled 117 specimens, 70 of which were in the EBTRF, 26 in the Yamato Foundation, 8 in Wisirare Park (Casanare Department), 7 at the Piscilago Zoo (department of Cundinamarca), 5 in Los Ocarros Biopark (Meta Department) and 1 on private property in the town of Maní (Casanare Department). Of these, 36 were male, 69 female and 12 of unknown sex. Seventeen females nested that same year, with a total of 332 eggs that failed to hatch (Maldonado, 2005). In a span of three years, the number of captive specimens in Colombia increased significantly, nearly doubling from the aforementioned 117 crocodiles to 220 (Seijas *et al.*, 2010). To date, the EBTRF watches over about 300 specimens. Approximately 200 of them have reached the appropriate size to be introduced into the wild (Ardila, pers. comm.). Thus, the captive population was greater than the wild population, according to estimates from studies conducted between 1994-1996 and 2000-2001. Since mid-2008, the EBTRF, in collaboration with Cormacarena, Corporinoquia and the Ecosystem Management of the Ministry of Environment, initiated a series of studies to determine the status of wild populations and to identify suitable areas for reintroduction. For the moment, suitable areas have been found in the department of Arauca and others are being evaluated in Casanare (Seijas *et al.*, 2010). Furthermore, since January 2010, the Asociación Chelonia has worked

Adult *C. intermedius* photographed in the Bioparque Los Ocarros, Villavicencio (Meta). May 2010. © CHELONIA/M. Merchán

Adult *C. intermedius* in the Roberto Franco Station of Tropical Biology, National University of Colombia, Villavicencio (Meta). January 2010. © CHELONIA/O. Sanz with Corporinoquia, the Corporation of Natural Protected Areas, the Forest Conservation and Development Foundation, and the Palmarito-Casanare Foundation, to evaluate appropriate release areas in the departments of Casanare and Vichada.

5.4.- Conservation Proposals in Colombia

- Update the information on the size of wild populations through a new census of the areas sampled in the 1990's and early 2000's.

- Consolidate the improvements registered in captive breeding: bearing in mind the recovery of the species in its natural environment, it is necessary to have constant reproduction of juveniles that may be reintroduced annually to strengthen existing populations or establish new ones in historic areas of distribution.

- Begin the task of collecting wild eggs and newborns: in line with previous proposals, this activity would increase hatching rates and encourage the survival of a greater number of individuals, which in turn would increase the number of crocodiles available for reintroduction each year while also promoting genetic diversity. This task should include the participation of local populations that could receive financial aid for their cooperation.

- Define one or more areas for the introduction of captive-bred individuals: this activity was partially initiated in the 1990's and is currently being carried out by various institutions (EBTRF, Corporinoquia, Asociación Chelonia, Palmarito-Casanare Foundation). It has not yet focused on reintroduction campaigns.

- Establish new captive breeding farms, given that current centers are at their capacity limit. It is necessary to open new spaces for the management of this species within the Orinoco crocodile's area of distribution.

- Continue local public awareness actions for the conservation of the species in the medium term: although efforts have been made with regards to this, awareness activities must be continuously maintained in the medium term to ensure active participation of the population. The inclusion of other threatened species in the awareness process is also desirable.

6.- Tracking Techniques in the Study of the Orinoco Crocodile in Colombia

Fernando Gómez Velasco

6.1.- Introduction

Tracking is the term applied to the set of techniques used to locate an animal by observing its footprints or other traces. A skilled tracker is not only able to follow footprints, but also use them to discern what the animal has done, where it has gone, what it was doing at that moment, how long the print has been there, and sometimes, even distinguish the size, weight and other characteristics of the animal. Tracking entails having a thorough knowledge of wildlife, behavior and needs, habitat, weather conditions, trophic (food) resources and even human-induced activities in the area. In addition, if tracking means following or locating species which are potentially dangerous to man, as is the case of crocodiles, one must also possess knowledge of the norms and recommendations which must be met without exception. If the tracking area is the habitat of potentially dangerous species, it will be necessary to have an escape route or a previously established safe place to minimize risks. Knowledge of how the animal would react and its level of aggressiveness toward man is the best risk prevention.

Another essential factor in a good tracker is ethics; the animal's activity cycle must never be altered to cause stress. The point is to enter the environment whilst only minimally modifying its natural conditions. When traces are observed in areas with fauna, observation time must be as short as possible, or even postponed if judged necessary. When working with protected species, non-intervention is not only a question of ethics, it is also a matter of legal implications.

There are plenty of traces to be considered in crocodile tracking, but the most outstanding are tracks, trails, nests, debris and excrements. The traces not only reveal the presence of the species, but also sometimes offer detailed information on the individual such as its sex, age, health status or the presence of amputations or malformations.

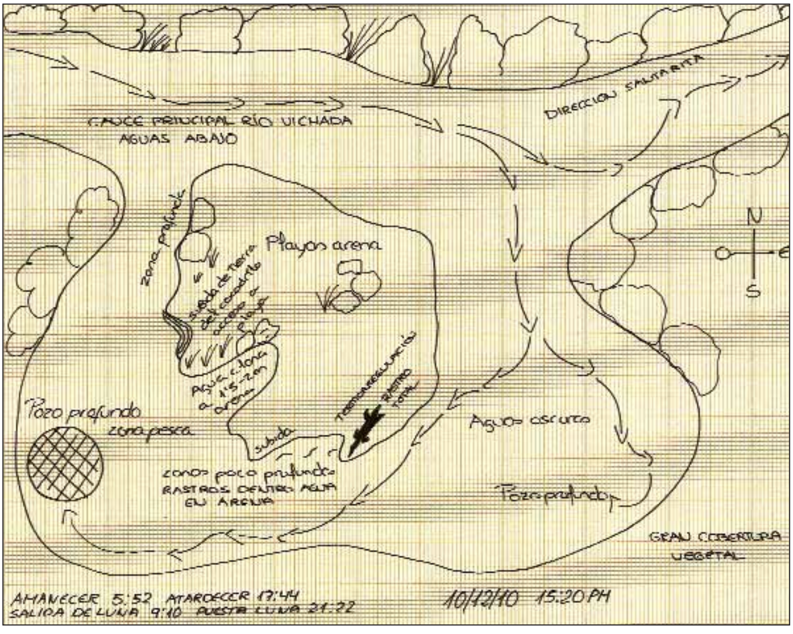
Among the different types of tracking, here we will rely primarily on "basic tracking". It is usually carried out in perfect terrain, where footprints and other

Orinoco crocodile photographed in the wild in February 2011 in Pozo Caimán, Vichada River (Vichada). © CHELONIA/F. Gómez

Detail of the front foot of a spectacled caiman (*C. crocodilus*). December 2010. © CHELONIA/F. Gómez

Detail of the hind foot of a spectacled caiman (*C. crocodilus*). December 2010. © CHELONIA/F. Gómez

Identification diagram of a crocodile trail on a sandy beach. December 2010. © CHELONIA/F. Gómez



Field annotations of a *C. intermedius* trail in the Vichada River (Vichada).
© CHELONIA/F. Gómez

marks can be clearly seen, especially in areas lacking vegetation like beaches. There is also “speculative tracking”, for example when an animal crosses an area of dense vegetation. In this case, we would have to draw conclusions on where it moved without seeing actual traces on the ground.

6.2.- Interpretation of Tracks

We must follow a set of rules to carry out operative and effective tracking and ensure our objectives are achieved:

- Widen our scope of vision (peripheral vision)
- Read-along (view in front of the feet)
- Carry out a conceptual filter – What are we looking for?

To correctly interpret crocodile traces, we have to understand the hydrographic characteristics of the area, the characteristics of the sand, exposure to the sun and the circadian rhythm of other species. We must also consider how crocodiles move in the water, how they exit from it, how they move on to beaches, how they position themselves to bask in the sun, at what distance from the water they do, what their hourly needs are, what range of temperatures they withstand, and what level of human intervention exists in the area. Knowing about how other species sharing habitat with our target species interact, as well as their trophic or territorial needs, leads to a better understanding of the tracks.

Traces of the target species will rarely be alone; this is why it is vital to distinguish those produced by our target species from those by other species, when the trails were made, which are animal-made and which are not, and how they interact in the time and place. All trails must be interpreted according to three levels for a correct reading. According to José María Galán, these levels are based on reading the trace from the print itself, the details of its surrounding area and other adjacent traces, and the interaction between them.

Types of Interpretation (according to J. M. Galán)

- Close readings

Location of subtle details that define the trail. It provides us with initial data on the species (number of fingers, claw marks, shape of the pads, marks produced by the tail or other parts, etc.).

- Contextual reading

The objective is to answer the question: *Where is the trail situated?* Without knowing its context, the trace is ambiguous and this complicates the interpretation of the trail.

- Ecological reading

An attempt to answer the question: *How does the trail interact with others?*

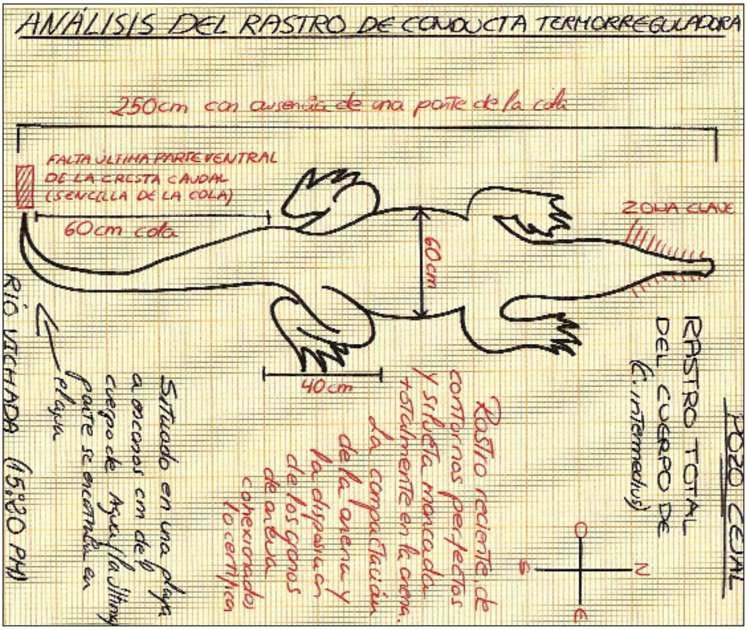
Technical Aspects of the Analysis and Classification of Tracks

Parts of a track

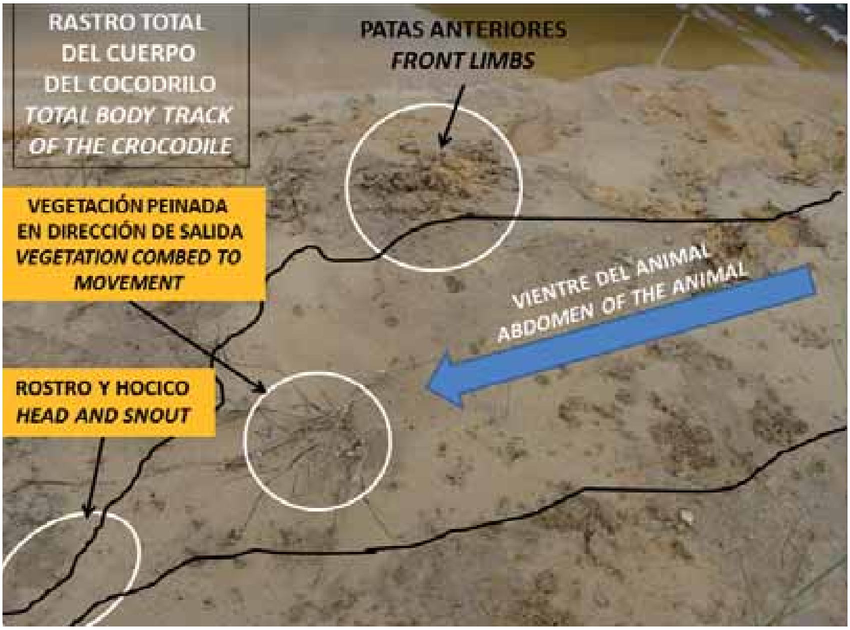
When a track is marked on the ground, the heel slides over it, leaves a mark in the ground and lifts out. No track is made perpendicular to the ground, it is always made at an angle, either when stepping in or out. The lighter the substrate, the greater the distortion of the print that one can see. Most people do not read the real print; they just read the horizontal cut (the total print), which does not provide the true meaning of the real track.

Classification of tracks

- Clear track: The footprint can be clearly seen with all digits on the ground. It occurs 5% of the time and requires a perfect ground (river banks of mud or silt, for example).
- Track of average reading: part of the print can be seen, usually the front part with clear edges or borders.
- Track of complex reading: the shape of the footprint is seen with difficulty, usually with deformations (common in shallow sandy soils, for example).
- Interpretational track: very hard to visualize; all that can be seen are edges or just a faint pressing on the ground.
- Ghost track: one we cannot see though we have just been following its trail; edges may be marked in the sand or just as a faint pressing on the vegetation.



Field annotations of a *C. intermedius* trail in the Vichada River (Vichada). © CHELONIA/F. Gómez



Identification diagram of a crocodile trail on a sandy beach. © CHELONIA/F. Gómez

Topography of the track

When any print is produced, it generates two types of very sharp reliefs: depressions and ridges. The former are the result of the force exerted by the animal on the substrate, resulting in its collapse. For the latter, pressure causes the substrate to flow upward between the animal´s paws, creating ridges between the toes.

Dating the Tracks

Dating footprints is very closely tied to physical factors (rain, snow, wind, humidity and temperature), anthropological factors (level of human intervention on the habitat) and biological factors of the target species itself.

Issues in the dating of tracks

- A print is a very rare event in time that temporarily alters the substrate on which it was produced.
- During the course of the print´s life, the altered substrate will tend to recover its initial state.
- The deterioration of the print is greater as time passes.
- A print that steps over another is always the more recent one.

Elements such as rain and humidity help the correct dating of tracks. Some soil insects, worms and even birds are useful as they have very defined activity moments during the day or night, helping to determine the approximate time at which the track was produced. Other elements, such as manure and urine, can also be helpful.

Analysis of Tracks in Terms of Locomotive Behaviors

Analysis of the different ways that a species moves provides valuable information about its life and habits. The activities of crocodiles in terms of the type of movement observed are classified as follows:

- Paced movement on foot: the arrangement of the hind limb prints slightly overlap those of the front. The track is slightly distorted. This type of step indicates that the animal carried out a non-stressful activity, such as going into or getting out of water, or changing its location under the sun on firm land. When an animal is stressed it tends to use a more rapid pace, in which the steps of the hind limbs overlap more with those of the front.

- Moving by galloping: the tracks of the hind limbs may be found ahead of the foreleg marks. The greater the animal´s speed, the more the hind leg prints will overtake the front ones. This movement is often used in defensive behavior. In this situation, the driving force rests on the hind limbs. When the animal charges against a potential source of threat, it may also use its tail to propel itself forward, leaving a very clear print on the ground, even in shallow water.

- Impulsive jump-start: the animal adopts a start-off position and rests its hind or front legs firmly on the ground. The front legs relax and the hindquarters, tail and hind legs define the driving force with the help of its claws. This behavior leaves behind a trail with a big distance for take-off, strong compression on the ground and a deeper claw mark than in normal movements. The tail leaves a clear mark in the place where it took off and diminishes as it approaches the water. This trail may appear to lead toward the water or occasionally in another safe direction, such as a landfill, a pile of branches, a fallen tree, and so on.

- Taking off to attack: normally this type of response is caused by a stimulus, which triggers a speedy exit out of the water as a response propelled by the hind legs, tail and in some cases even a jump off the hindquarters. If the animal is in the water, the load causes water to splash towards the shore in the direction of travel, and as a result of it a deformed and expanded footprint can be observed where only the claws are defined.

- Jump: it is created by the propulsion of the hindquarters and tail; a crocodile is able to drive itself out of the water and rise three meters vertically above the surface.

6.3.- Crocodile Locating Techniques

The techniques used to locate crocodiles can be classified into two major groups:

- Direct methodology: direct observation of individuals, in or out of the water. Locating the habitats of the species beforehand is essential, as it is to know its preferences and thoroughly knowing the area, animal life and human pressure, and the characteristics of the rivers in the area, including the presence of deep wells and sandy beaches for nesting.

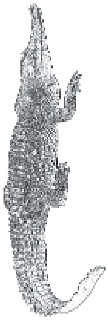
- Indirect methodology: finding signs of presence, such as tracks, droppings, nests and remains of eggs, or remains of individuals. The interpretation and dating of tracks play a fundamental role, as well as does the knowledge of anatomy and morphology of the species, of other crocodilians of the area, and of indicators of the presence or absence of other species such as *Tupinambis teguixin, Iguana iguana, Inia geoffrensis* and *Podocnemis* sp.

Behavioral Aspects

Knowledge of the species' behavior is essential for the interpretation of trails identified in the field. If a crocodile is spotted in the distance and it has its entire body on the sand, we can deduce that it has spent little time exposed to the sun and, therefore, its flight or defensive response will be slower. If instead the animal has its head raised, it has probably reached a high temperature and does not need to expose its entire body. If we find an animal with its mouth open, it will quickly move towards the water as its body temperature will be higher. Good interpretation provides an effective approach.

Crocodiles need to keep warm during the first few hours of the day to make up for heat lost throughout the night. With the increase in body temperature, the animal's physiological processes such as digestion speed up. After warming up, the animal can either return to the water or open its mouth to cool down. When the animal positions itself to regulate its temperature on a beach, it can rest its head on the sand or raise it. According to field observations, crocodilians on beaches with steep slopes tend to hold their heads up, possibly to better observe their surrounding environment.

The history of the area, in terms of human pressure, will mark the behavior of animals. In an area where crocodiles are not hunted, they will often adopt more relaxed positions by stretching out and placing their head on the sand. On the other hand, in areas where hunting is intense, animals tend to take on defensive positions such as keeping their head up and hind



Identification diagram of a crocodile trail on a sandy and muddy substrate. © CHELONIA/F. Gómez

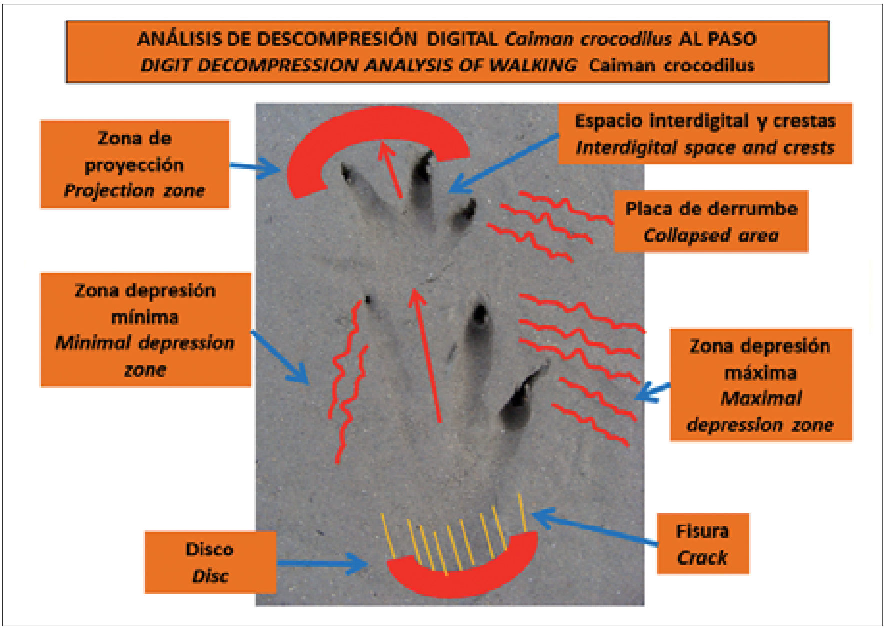


Diagram of a decompression analysis of a *C. crocodilus* footprint. © CHELONIA/F. Gómez limbs positioned completely on the ground to enable a rapid charge to the water. Also, the position will change depending on the water, as individuals from pressured areas will choose isolated areas that allow a quick getaway into the water.

Defensive behaviors instigated by human pressure are very important with the Orinoco crocodile. They can be highlighted by measuring the distance from the animal trail to the water's edge and the direction the animal took in terms of the body of water or the direction of the current. Knowledge of the ethology of the species is therefore vital when diagnosing the presence of tracks.

Anatomical Factors

Crocodilians use pulmonary respiration which enables them to remain under water for long periods of time. When a crocodile submerges, its pulse is reduced from 40 to 3 heartbeats per minute. In terms of thermoregulation, they spend the night hunting in aquatic environments, conditioned both by the temperature and the activities of potential prey. At night, the water is warmer than the earth (which loses the heat accumulated during the day faster), with maximum ground/water temperature differences when the sun sets. When the sun rises, the ground warms up and reptiles take the opportunity to raise their body temperature as well. They expose a side of their body towards the sun's rays to quickly warm that side; the accumulated heat spreads out evenly and increases the temperature of body areas not exposed to sun. At the same time, superficial blood transports heat inside the body. When the sun sets and the sand cools down, the animal usually moves, leaving a surface with an elevated temperature.

The forelegs of crocodiles are made up of five short non-webbed fingers (sometimes described as slightly webbed). The hind legs have four toes which are longer than those on the forelegs but, unlike them, they are webbed, making propulsion in the water easier. There is a remarkable difference between both pairs of extremities, with the forelegs measuring approximately 11 cm in length and the rear legs 25 cm. The footprints of each limb are easily differentiated, as the forelegs have a circular section and the hind legs are on the whole more elongated. Also, the hind legs are more than twice as long. In a trail, the hind legs will be close to the crocodile´s tail and almost always above or behind the forelegs.

A full print, i.e. when the entire body of the animal appears marked in the sand (usually when thermoregulation activity is carried out), is useful for estimating the size of the individual, and thus sometimes identifies the species and even sex of the animal.

Locating by Ocular Reflex and Nocturnal Counts

The eyes of a crocodile reflect light in the dark when lit up by lights or reflectors because of the presence of "tapetum lucidum" in their retina. This reflex helps identify crocodiles' eyes, which have a characteristic green color, and is very useful when locating them at night. It enables the counting of individuals and the differentiation of species; in the case of *C. intermedius*, the eyes reflect a bright bluish-green color, allowing them to be distinguished from the reddish-orange color that characterizes *C. crocodilus*.

The use of light sources also helps establish the position of crocodiles; they remain dazzled and keep still while the light points towards their eyes, even if the observer approaches. Depending on the type of light (its strength, inclination and focal distance), the reflection caused can result in various colors, which may sometimes complicate the identification of the species. Therefore, to eliminate doubts it is advisable to get as close as possible, focus on the animal, and observe the skull roof and muzzle to confirm the species and body size.

This system is used along a flowing current of water. In wide streams it is convenient to "beat" one shore and then the next, and to do so against the flow of the current so as to avoid duplication when counting or estimating abundance, as alarmed crocodiles will choose a route in the direction of the current to facilitate their escape. In nocturnal counts, the process is to focus on one area and follow it in a straight line to achieve a complete sweep. For example, one line can be a beach, other the shore and another, the body of water.

One thing that must always be taken into account is that the disposition of the individuals is not always longitudinal to the axis of the water. Sometimes, if the animals are placed transversely, they do not reflect light. It is therefore advisable to move in the direction in which the animal is moving and refocus backwards to see animals that have changed their position and will reflect light.

To ensure the traceability of species such as the Orinoco crocodile, work should be carried out during the dry season, when the animals are concentrated in bodies of water. The recommended peak time of activity is between 22:00 and 02:00. The crocodiles move in different ways depending on the structure of the vegetation on the shores and beaches and the current of the main body of water. It can be done on foot or horse, by using a 4x4 vehicle, or on a boat with or without motor. The advantage of using motor-powered boats is that they have electric power available, allowing for the use of long-range lights like halogen or neon (50,000-200,000 bulbs), as well as speed and ease of approach. The estimated speed should be 10 to 15 km/h for "flying" type boats with 15, 25 or 40 hp engines, which allows sampling to be done over larger areas. Finally, nocturnal conditions, such as the lunar phase, and weather conditions like rain or fog are important, as are other characteristics like the width of the body of water, vegetation on the shore, floating, submerged or emergent vegetation, backwaters, fallen logs, sinuous curves, big beaches or other features that influence the location of individuals at night.

Use of Calls

Calls are very useful for locating crocodiles, as certain sounds stimulate the animal response and even leads to them approach the place where the call originated. According to our own experiences, crocodiles respond efficiently to three types of sounds:

- Striking a plank or oar on the water: the animal emerges and pokes its head partially or completely out of the water. Aggressive patterns have been observed, with the animal opening its mouth, emitting grunts and hitting its head against the water.

- Infant claim (distress call): calls similar to those produced by offspring during the hatching process and the first few weeks of life. The animal emerges and pokes its head partially or completely above the surface of the water; sometimes the behaviour mentioned in the previous case can be observed.

- Male claim: emission of a husky growl. The animal will approach, maintaining a 10-15 m distance in clear exploration mode.

Trail of *C. intermedius* located in El Cejal in December 2010, along the low course of the Vichada River (Vichada). © CHELONIA/F. Gómez

Trail of *C. intermedius* located in El Cejal in December 2010, along the low course of the Vichada River (Vichada). © CHELONIA/F. Gómez

Trail of *C. intermedius* in the El Cejal Beach, Vichada River (Vichada). December 2010. © CHELONIA/F. Gómez

Ventral dragging trail of *C. intermedius* made when the individual came up the beach, El Cejal, Vichada River (Vichada). © CHELONIA/F. Gómez

6.4.- Tracking of *C. intermedius* in Colombia

From the end of October to the end of January, depending on the year's climate conditions, sand beaches and mud banks begin to appear on the Vichada and Meta rivers. This allows crocodiles to sunbathe so they can thermo-regulate, and develop behavior patterns of territoriality, mating and nesting.

The type of sand that makes up these beaches and the compression of materials under the effects of water pressure during long periods create the perfect ground to read and interpret tracks. In rare species like the Orinoco crocodile they become an excellent working tool for population characterization fieldwork.

Zoning of Trails

The little vegetation on riverbanks with beaches provides for excellent ground observation, especially during the dry season. On the other hand, during the rainy season the river covers beaches and layers of vegetation, and it either reaches the river bank or floods it.

Assuming that studies are carried out during the dry season, two types of substrates are considered for the observation of quality tracks: sand and mud.

- Sandy areas: sand has special characteristics that help the quality of the tracks, mainly because all of the details will be marked, albeit tenuously, and we can follow a trail efficiently and for a long time if the beach presents the appropriate size and conditions. A drawback however is that the print on sand has a very short "life", as wind plays a major role in the durability of the trail. With a light wind, the grains disperse or separate, breaking the outline of the print or adding new material to it. The result is a deformed print or one which is hard to identify. If, on the other hand, the wind is stronger, the print´s life is shortened.

All tracks tend to recover their horizontal plane, and this process is very quick in the sand, due to its limited depth and compression. The amount of moisture in the sand is vital, as more moisture means more cohesion of the sand grains and therefore more durability and fewer deformities caused by weather conditions.

Crocodile prints in sand produced early in the morning have a greater compression due, firstly, to moisture deposited by animal body parts when coming out of the water, and secondly, because of the humidity at dawn. Therefore, a trail made at night or early in the morning will have a clear outline and shape. Its color will be clearer, crisper and darker, mainly because of the moisture that pulls the grains of sand together while maintaining the original shape of the footprint. As the morning progresses and the sun shines on the print, it loses moisture and the sand grains separate and disintegrate, so that the trail is distorted, losing its original contours, and becoming more blurred and undulated.

- Areas of mud: the characteristics of this substrate allow us to observe deep tracks, with a well-defined outline and a long life due to its stable structure, compression and water content. In mud, the disappearing process of footprints is long compared to sand; the deeper the compression on the ground, the longer it takes to recover its horizontal plain.

Mud is perfect for reading figures and any malformation or distinguishing feature is quickly highlighted. The only possible drawback of this substrate is that the actual size of the footprint may be modified if the mud is too deep or the water level too high. This would cause the shapes to expand or be dragged in the direction of travel, something which must be taken into account when drawing conclusions on the animals that have produced the trails and their sizes. We must not forget that the faster the animal travels, the bigger the footprint's deformation, and mud can be misleading when observing the deformed tracks, especially the fingers.

Reading trails in this environment will vary depending on the way the crocodile moves about. If it moves "in step", the track will be perfectly marked as this movement is not abrupt and the strength exerted on the land is not great; all details will be visible. If the type of movement is a "galloping" action, as the speed increases so does the compression force from the drive, and the effects on the mud will also increase; an important deformation will be produced. When it moves into this substrate, clay particles adhere to the body parts and they move around, appearing on the next footprint or beside it.

Footprints and tails mark well on this substrate, and the imprint will last a long time. Higher humidity and lower temperatures ensure the imprint will last even longer. In the case of large and heavy individuals, the trace of the body on the ground will be observed and if it is dragged, its path on the ground will be seen perfectly.

Trail of tail, footprints and dragging surface of a *C. intermedius*; several trails of iguana can be observed over the crocodile trail. El Cejal, Vichada River (Vichada). December 2010. © CHELONIA/A. Castro

Spectacled caiman (*C. crocodilus*) excrement. © J. M. Galán

Trail from the sandy slope to the water on the beach of Pozo Caimán, Vichada River (Vichada). February 2011. © CHELONIA/M. Garcés

Jesús Artahona examining the remains of a *C. intermedius* nest preyed upon by a Colombian tegu (*Tupinambis teguixin*). El Frío Biological Station, Apure (Venezuela). May 2007. © J. M. Galán

Parallel trails of two individuals of *C. crocodilus* on a beach of the Meta River. December 2010. © CHELONIA/F. Gómez

Evidence of the Presence of *C. intermedius*: Out of the Water

Evidence usually arises from 9 o'clock in the morning, when thermoregulatory behaviors begin, taking advantage of the rising ambient temperature above the water.

- Full or partial body print:
The individual gets out of the water and leaves a print of its full body (head to tail) on the beach or shore, or that of the body part that is on the sand with its tail remaining in the water. This posture is usually thermoregulatory behavior. When over 60% of the body is exposed, the animal is considered to be warming up (Seebacher *et al*., 1999).

- Prints of forelegs and hind legs:
Fore and hind leg prints can be seen in soils of compact structure, as they are the body parts which exert the maximum amount of pressure onto the ground.

- Tail trail:
This occurs as the crocodile leaves or enters the water or when it moves along the beach. The tail trail usually appears twisted due to its position. It is very common to find incomplete traces of a tail. When young animals (not heavy) move along beaches or shores, they lift their entire body except for the last section of the tail, which is dragged along the substrate. The larger the animal, the larger the trace of the tail, because more of it will be dragged, even from its base at the cloacae level.

- Trails coming in and out of the water to an area of thermoregulation: They are trails represented by sand or compressed mud with materials dragged on it. When they are new, one can appreciate the water that drips from the body of the individual.

- Trails of the individual coming in and out of the nest:
Lanes of sand or mud paths that mark a journey from the water to the nest and vice versa, with good visibility from the water to the nest to make monitoring easier.

- Water over ground with cohesive sand grains:
This is seen when the animal that just came out to bathe in the sun reacts to a stimulus and quickly goes back into the water. On the beach, trails of water

remain, dripping from the crocodile's body, with grains of sand held together by the crushing of its belly.

When crocodiles are frightened or suddenly attracted to stimuli, they are capable of lifting their belly off the ground. The younger the specimen, the sooner it will adopt this behavior because of its distrust and fear, and due to its small size and intimidating power, which both increase with age. When animals lie on inclined planes such as slopes, they prefer sliding into the water abruptly on their bellies.

In general, younger individuals who have not reached sexual maturity (especially males) tolerate each other without any major problems in common areas of hunting and basking, creating characteristic traces of many trails. On the contrary, adult trails generally appear on their own on the best beaches with the best hunting areas. If there is a beach with a fallen tree that provides shade, the area will usually be occupied by a large specimen. Thermoregulatory activity is very important and the larger individuals assert their strength to occupy the best spaces.

Evidence of the Presence of *C. intermedius*: in the Water

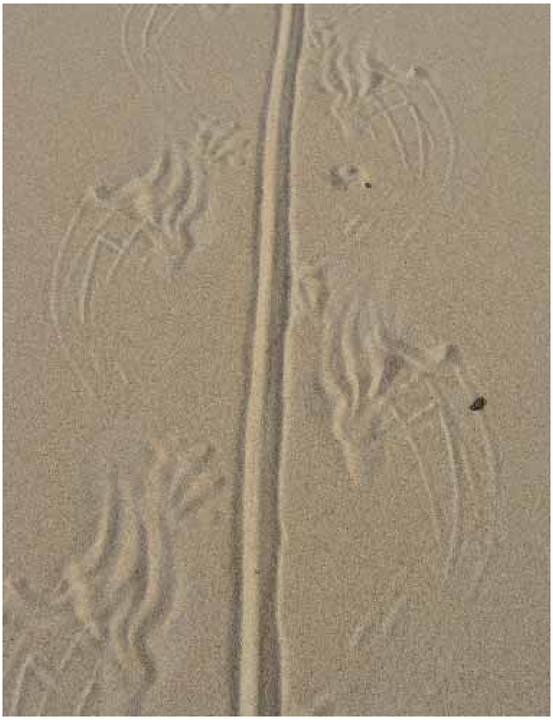
- Sunken sand-trails and tail marks in the direction of movement:

They are sandy areas which are observed under water and adjacent to the shore, on which the animal drags part of its body and tail when coming out of the water. In areas where the slopes are steep, they are seen as sunken areas. From the water's edge the different coloration of these paths can be distinguished from the rest of the background. The undulating movement of the tail produces a series of winding ridges that go towards the shore where the animal has set its exit, or sometimes it produces straighter lines when dragging its tail into the water. These trails have a short life and can only be seen on the shore.

- Particles on the surface and dark colored water:

When the animal goes into or out of the water, it stirs up the bottom of shallow areas, which momentarily muddies the water. Furthermore, sand particles attached to the belly of the animal tend to remain suspended from it when it drags itself on to the beach.

Detail of the hind footprint of a spectacled caiman (*C. crocodilus*). December 2010. © CHELONIA/F. Gómez



Trail of an iguana (*Iguana iguana*) running on a sandy beach of the Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

Trail of *Iguana iguana* walking on a muddy substrate. February 2011. © CHELONIA/F. Gómez

Footprints of a river turtle (*Podocnemis* sp.) on a sandy beach of the Vichada River (Vichada). December 2010. © CHELONIA/F. Gómez

- Small ripples from waves:

These occur when the animal enters or leaves the water on a beach with no slope. When the animal accesses the water from a slope these ripples are larger. They will be larger in cases of larger animals.

- Large ripples on the surface:

The animal is on the surface and plunges abruptly, beating its tail when the body is already under the surface.

- Circle-shaped bubbles on the surface:

This is when the animal has just dipped into the water and is at the bottom, not moving. If there are waves without bubbles, they usually correspond to the surface motion or Amazonian River dolphins (*Inia geoffrensis*).

- Bubbles on the surface with an elliptical shape:

They occur when the animal dives and moves slowly along the bottom. In these cases, we must take into account the characteristics of the body of water, as with strong currents the observation is more complicated.

Other Indications of Presence

- Nests:

Recent, abandoned, buried or unearthed.

- Eggs:

Hatched, abandoned or eaten. Crocodile eggs are preyed upon by numerous species, so it is not uncommon to find traces of them.

- Human intervention:

The plundering or total destruction of the nest and its eggs can be certified through the presence of human footprints on the ground with or without shoes, as well as with the mark of the stick they tend to carry beside the footprints. The nest appears in the shape of a bowl, characteristic of the species but with the soil stirred about in one or several of its sides.

- Remains of the animal:

They can range from skeletal remains (skulls, ribs, vertebrae, etc.) to bits of skin to whole decomposing specimens.

- Excrements:

Very difficult to locate, as they have weak structures and are usually deposited in the water. Structure and composition is very similar to that produced by the spectacled caiman (*Caiman crocodilus*). They can appear both on sandy beaches as well as rocky soils, which give the excrement a longer life and make it more detectable to the observer.

- Caves or cover:

They are used as refuges in moments of peak solar intensity (between 12:00 and 15:00). The entrance is usually circular and found in banks and slopes. In the rainy season, it is under water. They appear above water when the flow of the river is lower during the dry season. On some occasions, if drought is severe enough, the opening may be too high up, forcing individuals to build a new one closer to the water surface. If there are no slopes on the shore they can make the caves under tree roots.

Footprints of an amphibian (likely *Rhinella*) on a sandy substrate. December 2010. © CHELONIA/F. Gómez

Footprints of the front leg (right) and hind leg (left) of a capybara (*Hydrochoerus hydrochaeris*). Beach of the Meta River. December 2010. © CHELONIA/F. Gómez

Fresh excrements of capybara (*Hydrochoerus hydrochaeris*). Shore of the Meta River. December 2010. © CHELONIA/F. Gómez

Recent footprint of a crab-eating raccoon (*Procyon cancrivorus*). © CHELONIA/M. Merchán

7.- "Orinoco Crocodile Project 2010 / 2011" Expeditions

Antonio Castro Casal

7.1.- Precedents for the Distribution of the Orinoco Crocodile in Colombia

The Orinoco crocodile was declared a species "in danger of extinction" in Colombian territory, through Resolution No. 676 of the Ministry of Environment of July 21, 1997 and is considered a Critically Endangered Species (CR) by the International Union for Conservation of Nature (IUCN). This status is defined by the following criteria: a) reduction of population in its area of distribution, extent of occurrence or quality of habitat (A1c), and b) population estimated to be under 250 adult individuals and severely fragmented (C2a).

According to Medem (1958), its area of distribution in Colombia formed part of the basin of the Arauca, Casanare, Meta, Guaviare and Vichada rivers, reaching as far west to the lower Duda River, making a total area of 252,530 km^2. Therefore, its historical limits of distribution in Colombia would be Arauca and Meta rivers to the north, the Duda-Guayabero River system to the southwest, the Orinoco River up to its confluence with the Atabapo River to the east and the Guaviare River to the south. Medem (1981) stated that it was very abundant before the mid-thirties in the Arauca, Casanare and Meta rivers, with a lower abundance in the Vichada and Guayabero-Guaviare rivers due to the presence of "raudales" (rapid waters caused by outcrops in rocks) of the Orinoco (Atures and Maipures).

Three national protected areas exist in what is the historic distribution range of the species in Colombia. One is the Tinigua Natural National Park, located in the south-western region of the Meta Department between the La Macarena Range and the Andean foothills, crossed by the Guayabero River and delimited to the east by the Duda River. The Natural National Park of La Macarena Range is another, neighboring the Tinigua Natural National Park, with which it shares a natural boundary through the Duda River, which then joins the Guayabero to form the Guaviare River. Finally, there is El Tuparro Natural National Park, located in the central-eastern region of the Vichada Department. Furthermore, in this historical area of distribution there are seven Natural Reserves recognized by the Ministry of Environment, Housing and Territorial Development; six of them are located in the department of Casanare and one in the Vichada Department.

Spectacled caiman (*C. crocodilus*) photographed during a flight over the Palmarito Casanare Natural Reserve (Casanare). August 2010. © CHELONIA/M. Garcés

Adult spectacled caiman (*C. crocodilus*) basking on a steep slope beach on the shore of the “caño” La Hermosa (Casanare). November 2010. © CHELONIA/R. Antelo

Bi-motor airplane used for the flights over the Palmarito Casanare Natural Reserve and its adjacent areas. © CHELONIA/R. Antelo

Fieldwork in Pozo Caimán, Vichada River (Vichada). December 2010. © CHELONIA/A. Castro

The Palmarito-Casanare, San Pablo and El Boral reserves, located in the municipality of Orocué (Casanare Department), between the Cravo Sur River to the west, the Meta River to the south and “caño” Guirripa to the east, make up a combined area of more than 23,000 ha. Close to these, Las Malvinas Natural Reserve, also within the municipality of Orocué, is located in the microbasin of “caño” Duya. North of the Casanare department is La Aurora, in the municipality of Hato Corozal, within the Ariporo River basin, and La Esmeralda, in the municipality of Paz de Ariporo. The Villa Myriam Reserve is in Cumaribo (Vichada Department). Additionally, at the shores of the Orinoco is the private Bojonawi Natural Reserve within the El Tuparro Biosphere Reserve.

7.2.- Sampling and Logistics Methodology

Sampling conducted by Asociación Chelonia in 2010 and the first half of 2011 was focused on the departments of Casanare and Vichada, especially in the basins of the Meta and Vichada Rivers. Updating the available information was done at a bibliographical level and by contacting people and institutions that participate or have participated in activities related to the conservation and the research of the Orinoco crocodile.

Data collection was carried out in the field in various places of the Casanare and Vichada departments. During these trips, contact was made with many people and organizations, both public and private, and information was gathered from people who have or have had direct contact with the environment where the species is or was distributed, mainly fishermen and residents of riverine villages. The regions to be visited to verify the presence of individuals of the species in the wild was planned jointly with the Regional Autonomous Corporation of the Orinoquia (Corporinoquia), taking into account the latest research and information on the distribution of the species. Different means of transport were used to carry out field visits, sampling and analysis of the plains’ ecosystems, as well as reconnaissance and evaluation of possible sites and habitats where captive-bred individuals could be introduced in the future. Various aerial itineraries were made, covering the areas of the Palmarito-Casanare, San Pablo and El Boral Nature Reserves, as well as a large area of the Cravo Sur and Meta rivers. The flights were made on two types of aircrafts. One was the “trike”, a delta wing and rear-engine two-seater with a metallic structure for the pilot and passenger. The second was the “Air Cam”, a twin-engine aircraft capable of carrying the pilot and two companions, with wings located on top of the plane and the engines in the rear of the wings, providing a wider field of vision. Both aircrafts allow flights at low altitudes and slow speeds, although the "trike" provides optimal conditions for locating and observing medium/large sized species.

"Bongo" type boats between 8 and 10 m long with a metal hull and 40 hp outboard engines were used for trips and surveys conducted along the Meta River, its gorges and tributary rivers. Additionally, another boat with an aluminum hull of about 5 m and 25 hp outboard motor was used. For the Vichada River trips, a 7 m long boat with a fiberglass hull and 40 hp outboard motor was used. To cross the Orinoco River, a 10 m long metallic "bongo" type boat with a 25 hp outboard motor was used. To go through smaller tributaries, row boats, fiberglass kayak type and wooden canoe-style boats were used. When prospecting the terrain, 8x50 binoculars were used along with the following global positioning devices: Garmin GPS map CSx60, Oregon 450 and eTtrex Venture. During nocturnal reconnaissance, the following instruments used were: 2 spotlights of 2 million cd, a reflector 1 million cd with a 12V battery connection and/or motor, long range flashlights of 500 lumens, and headlamps.

For data collection during nocturnal counts, a chart model was designed. Ayarzagüena's size system to group samples of the spectacled caiman (*Caiman crocodilus*) that were detected while counting was used, applying four size classes (1983), described by Velasco and Ayarzagüena (1995):

Class	Total length (cm)	State
Class I	X < 50	Neonates
Class II	50 < X > 120	Subadults
Class III	120 < X > 180	♀♀ and ♂♂ Adults
Class IV	X > 180	♂♂ Adults

Table 17. Size classes in *Caiman crocodilus* (Ayarzagüena, 1983).

Different sections of the Meta River were explored during the months of August, September, November and December of 2010 and in March of 2011. The Cravo Sur River was prospected in the months of August, September and November 2010. "Caño" Canacabare (a tributary of the Cravo Sur River), Guanapalo, Gandul, Yatea, Guachiría and La Hermosa (tributaries of the Meta River) were examined in November 2010. The Vichada River and some of its smaller tributaries and adjacent lagoons were explored in December 2010 and February 2011. The Palmarito-Casanare and San Pablo Nature Reserves, were explored in August, September and November 2010. In the last month, studies were extended to El Boral Reserve. La Aurora Natural Reserve and its waterways were explored in October 2010 and February 2011. The stretch of the Orinoco River between Puerto Carreño and the area where "Isla del Pato" is located, El Pañuelo lagoon of the Bojonawi Reserve, as well as specific points of the Dagua and Mesetas rivers, were prospected in March 2011.

7.3.- Results of Sampling: Meta River Basin

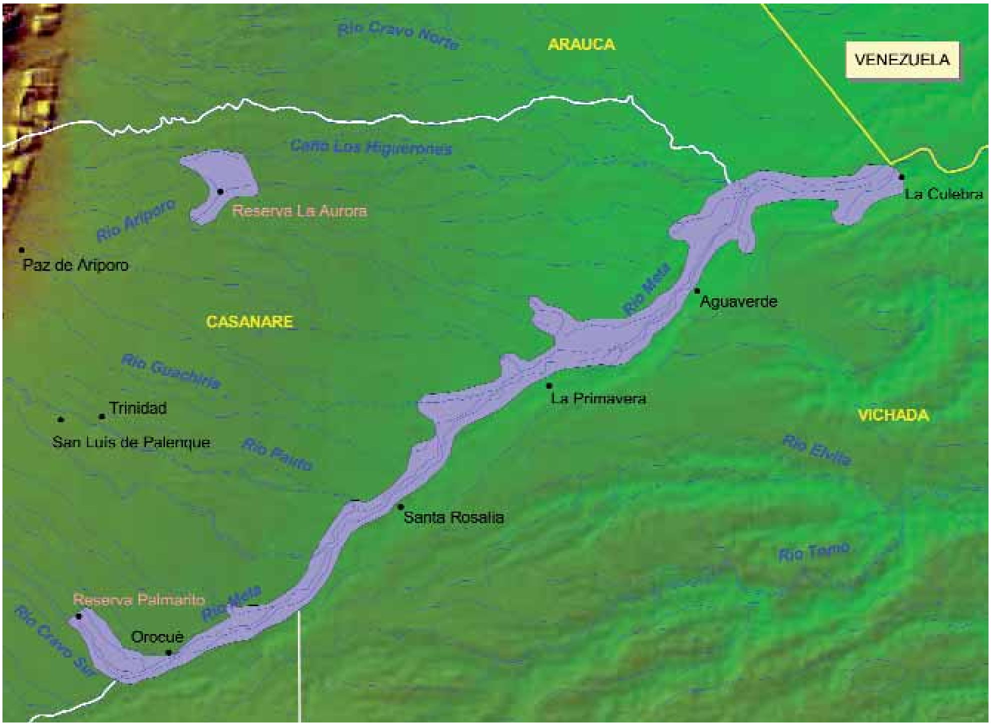
The Meta River basin covers an area of 107,032.32 km^2, equivalent to 30.83% of the Orinoquia (Correa *et al*., 2006). This basin is formed by important subbasins such as those of the Casanare, Ariporo, Cravo Sur, Pauto, Cusiana, Upía, Manacacías Rivers, and covers the entire department of Casanare, the south and central regions of the department of Arauca and the northern part of the Meta Department. In this basin the following bodies of water were sampled:

Cravo Sur River

This course, which has its source in the foothills near Yopal (Casanare Department) was sampled through waterways in daylight hours from the mouth of "caño" Canacabare (04° 50' 37.11" N; 71° 41' 50.68" W) and its confluence with the Meta River (04° 41' 20.86" N; 71° 31' 54.13" W) on three occasions, two of them on boats with outboard engines. The Cravo Sur River has a mildly meandering course, but possesses many white sandy beaches with ecological conditions that seem to be adequate crocodile habitats. In the dry season the waters subside, impeding navigation with outboard motor boats. Landowners and inhabitants of its shores normally travel it on boats with outboard engines, whenever the depth of water allows them to. Its mouth in the Meta River is relatively close to the town of Orocué (about 26 km away). On terrains near its course there are oil exploitations and African palm oil cultivations. There are also three Nature Reserves on the left riverbank, which occupy about 26 km of the shores. No traces or signs of the presence of the species were found while prospecting.

A nocturnal count at a speed of 10-15 km/h was carried out in its waters in November 2010, downstream from the mouth of the "caño" Canacabare to the port of the Palmarito-Casanare Natural Reserve, illuminating both shores. Following the observation of the reflection of crocodilian eyes, speed was reduced to approach the dazzled individual, determine the species and assign a size class. Twenty-two caimans identified over the 7.27 km explored, 11 of Class I, 2 of Class II, 1 of Class IV and 8 which could not be assigned a size class (a density of 3 individuals / km).

"Caño" Canacabare: narrow, somewhat meandering flow of the Cravo Sur River, surrounded by gallery forest. It was prospected during the month of November. It was chosen because of information collected from a local villager regarding the possible presence of a specimen in its waters. It was explored upstream from its confluence with the Cravo Sur in afternoon hours while there still was natural light, until it began to get dark. From the area known as "Brisas del Mare Mare" (04º 49' 41.0'' N; 71º 44' 57.0'' W), the exploration and nocturnal count began downstream, with a waning moon, calm winds and clear skies. Twelve km of its course were explored downstream and 54 spectacled caimans were iden-



Surveyed area in the Meta River by the, the Asociación Chelonia tified; 18 of Class I, 11 of Class II, 16 of Class III, 7 of Class IV and 2 could not be assigned a size class (a density of 4.5 individuals / km).

Meta River

A white water course that has its source in the Eastern Cordillera; it has a wide channel and a slight slope in the plain, reaching a total length of 1,142 km (of which 730 are navigable) and receiving input from numerous tributaries that cross the Llanos (IGAC, 1999). There are many islands and when the water level lowers, a large number of beaches and sandbars appear which make it difficult to navigate. It is intense for most of the year, as it is an important communication channel between the different populations that are located on or near its shores. Commercial fishing is widely practiced in these waters, mainly in the summer when the water level is low and fish are more concentrated. The width of its *bank* and flow make it a non-meandering river with very wide bends. This, coupled with the many islands that dot its course, makes the area sampled very large and complicates the possible location of individuals of the target species. The waves, caused by winds on the surface of the river, also make it difficult to locate individuals in the water.

Stretch 1: Mouth of the Cravo Sur River – Mouth of "caño" Duya

Area sampled in daylight hours during the month of August by a 5 m long boat with a fiberglass hull and a 40 hp Yamaha motor, covering a distance of 66.3 km. The high water level left beaches with very little sand. Neither traces nor presence of the species were detected. This stretch contains dense boat movement due to the position of the town of Orocué on the river´s shore (04° 47' 34.12" N; 71° 20' 04.39" O).

Stretch 2: Orocué – Mouth of "caño" Picapico

Stretch prospected from the municipal seat of Orocué (04° 47' 34.12" N; 71° 20' 04.39" W), department of Casanare, to an area about 60 km downstream from the port of the municipal seat of La Primavera, Vichada Department, during the month of November and also covering several sections of the streams that flow into its channel, as described below. This section was sampled by means of a 10 m long metal-hulled bongo type boat with a 40 hp Yamaha engine, and occasional stops were made in the towns of Santa Rosalía (05° 08' 36.50" N; 70° 51' 31.00" W) and La Primavera (05° 29' 25.02" N; 70° 24' 31.51" W), from where the nearby gorges identified by the information provided by residents and local fishermen were visited. A total of 234.6 km of the Meta River were explored downstream in daylight hours, examining banks and beaches in search of traces or indications of the target species, and interviewing villagers and fishermen in communities, villages and camps along the banks. The same section was explored upstream, but faster. No traces or observations of the species were located during the exploration.

Different people from different villages and camps of the Meta riverbanks mention a large well in the deepest part of the river known as La Vorágine (05° 40’ 58.63” N; 70° 04’ 47.51” W) as one of the most favorable areas for locating the Orinoco crocodile. A stop was made in this area, situated about 60 km downstream from the port of La Primavera to conduct a more thorough examination, though no records of individuals or traces of the species were recorded. A camp of fishermen of the area, on the river´s left bank, was visited to interview its inhabitants who confirmed the presence of crocodiles in the area, but pointed out that their observation could be difficult due to the high water levels of 2010, as beaches where they tend to be had not yet emerged. Another fisherman, 9.80 km downstream from the previous camp, confirmed the presence of a female that spawned annually in a nearby beach which was covered by water at the time, saying that indigenous Guahibos returning from Puerto Carreño knew the area and used to collect the eggs from that beach.

“Caño” Guanapalo

This is a narrow and meandering body of water bordered by gallery forest, with areas open to the plain that flow into the Meta River from its left bank. It has beaches suitable for crocodile nesting known locally as “poyatas”, some of which are fairly steep. Important livestock farming activities take place on its banks. It was prospected from its point of confluence with the Meta River (05° 03’ 13.86” N, 70° 59’ 31.64” W), following its course 44.8 km (05° 00’ 39.50” N, 71° 12’ 13.03” W) upstream during afternoon hours, until sunset. Several individuals of the “terecay” turtle (*Podocnemis unifilis*), and “galápaga” *(Podocnemis vogli)* were observed basking on logs on its shores.

Once it became dark, an exploration and nocturnal count were carried out from the place mentioned above, under a growing lunar phase with calm winds and few clouds in the bongo type vessel with a 40 hp Yamaha motor. The trip downstream with the engine running was carried out at a speed of 10-15 km/h, with an overall average speed of 11.4 km/h. In the lower part of the tributary in an area where the pilot assured that the Orinoco crocodile was likely to be, the engine was turned off

The biologist Antonio Castro during survey work in Pozo Caimán, Vichada River (Vichada). December 2010. © CHELONIA/F. Gómez

Flight on a trike, Palmarito Casanare Natural Reserve (Casanare). © CHELONIA/R. Antelo

Flooded savanna bordered by a floodable forest in the Palmarito Casanare Natural Reserve. September 2010. © CHELONIA/M. A. Cárdenas

Adult spectacled caiman. Casanare Expedition. August 2010. © CHELONIA/M. A. Cárdenas to reduce noise and the boat moved along with the current and the use of a paddle. During the 44.8 km long nocturnal exploration, 21 Class I spectacled caimans were identified, 15 Class II, 44 Class III, 12 of Class IV and 57 were not assigned a size class, making a total of 149 (density of 3.32 caimans/km). The large number of caimans not assigned a size class was due to the fact that the boat could not approach the individuals in the stretch where it moved with the engine turned off. Despite these efforts, no Orinoco crocodile was spotted. A local resident interviewed during the ascent affirmed that he was not aware of the presence of crocodiles in the waters of the channel, despite having lived in the area for a few years.

“Caño” Gandul

This is very narrow and meandering in the lower part of its course which flows into the left bank of the Meta River, bordered by narrow gallery forest and many fallen trees or entrained material. It was explored in November of 2010, 7.15 km upstream from its mouth (05° 05’ 18.13 “N; 70° 58’ 17.43” W) at the entrance of Hato La Esperanza. No beaches were located in the area explored. Nocturnal sampling was carried out from the boat without turning the engine on, using only oars and taking advantage of the current. The narrowness of the channel made it possible to approach crocodilians to estimate the size class, whose shining eyes marked their presence. The following were identified: 1 spectacled caiman of Class I, 8 of Class II, 6 of Class III and 1 of Class IV; 4 could not be assigned a size type. The 20 caimans identified made up a density of 2.80 individuals / km.

“Caño” La Hermosa

This is a narrow and meandering course bordered by gallery forest and located in an aeolian influenced floodplain, with plenty of sandy beaches with shrubs. Its mouth is 4 km from the small town of the same name, located almost opposite the port of La Primavera. It was explored from its mouth in the Meta River (05° 31’ 18.88” N, 70° 27’ 53.98” W) to a point 40.2 km upstream (05° 38’ 17.00” N, 70º 38’ 17.80’’ W) in November of 2010. The same distance was explored downstream at night, with the moon in its first-quarter phase, calm winds and an overcast sky. The descent was made with the engine running at an overall average speed of 10.9 km/h. 45 spectacled caimans were spotted of Class I, 56 of Class II, 67 of Class III, 16 of Class IV and 45 were not categorized, making a total of 229 individuals (a density of 5.69

individuals/km). The high density of caimans in certain areas made it impossible to classify a large number of them. During the ascent, a stop was made in the confluence of “caño” Las Guamas where a ranch can be found. People from the ranch said caimans were not seen in the “caño”, but mentioned the presence of a black crocodile that wouldn’t let itself be spotted (there is a popular belief that differentiates the Orinoco crocodile from another supposed darker, and more cautious crocodile with a larger body that doesn’t bask in the sun and hunts only from underwater). Information was received from a house owner of the area who claimed to have seen a couple of Orinoco crocodiles in this channel in Easter of 2008.

“Caño” Guachiría

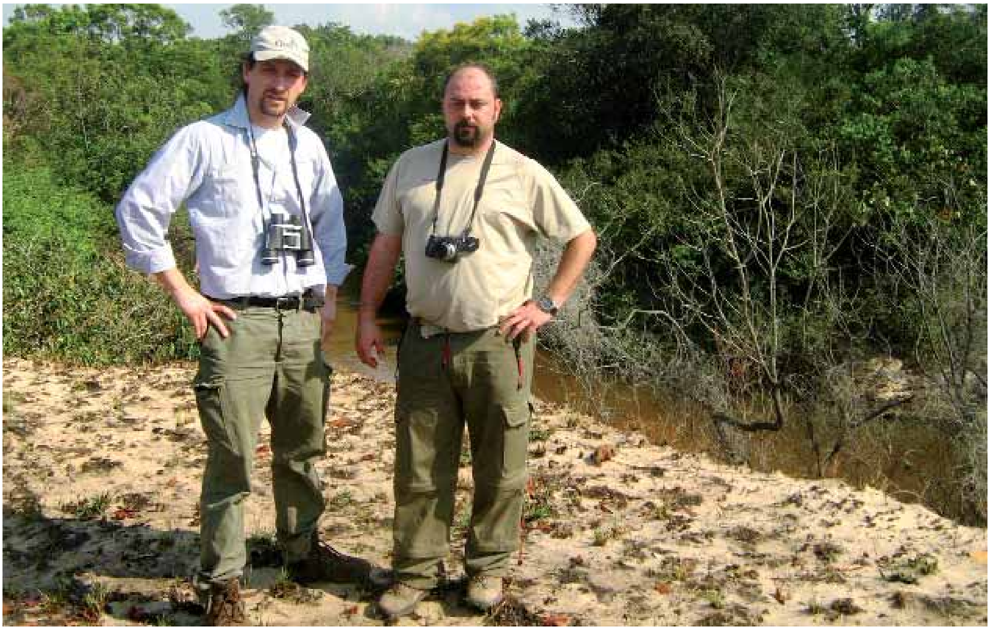
This is a narrow and winding channel, with many sandy beaches suitable for Orinoco crocodile nesting; it has some fairly steep slopes and its banks are lined with gallery forest. Its mouth is located about 17 km upstream from mouth of “caño” La Hermosa, also a floodplain with aeolian influence. Sampling was carried out in morning hours of the month of November, from its mouth (05 ° 26 ‘26.26 “N, 70 ° 35’ 12.76” W) to a point located 18 km upstream (05° 27’ 35.01” N, 70° 37’ 55.55” W). Precipitation in headwater areas that fell during that week resulted in the rise of the water, despite the start of summer or the dry season, so the beaches observed were small. Several “terecay” (*Podocnemis unifilis*) individuals were observed basking on logs on the shore and an “arrau” turtle (*Podocnemis expansa*) individual was located on one of the beaches. The foreman of a nearby ranch on the right bank of the channel was interviewed; he commented he had not seen any Orinoco crocodiles in channel waters in recent years, and pointed out that the influx of fishermen in the summer season seemed to increase each year. A fisherman camped at the mouth of Guachiría said that in the last 10 years he had not seen a crocodile in that area. He mentioned that they could be observed in an area known as “Pata’evacal”, downstream from La Culebra.

Stretch 3: Puerto Borracho (La Primavera) – La Culebra

In December 2010, a stretch of the Meta River between Puerto Borracho (La Primavera) and the town of La Culebra (06° 05’ 36.40” N, 69° 25’ 16.70” W) was sampled during daylight hours on a metal-hulled boat equipped with an outboard

Fieldwork in the savannas near the Dagua River (Vichada). March 2011. © CHELONIA/A. Castro

Matamata turtle (*Chelus fimbriatus*) photographed in a riverine community of the Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez



The biologists Manuel Merchán and Óscar Sanz in the Meta River. January 2010. © CHELONIA/M. A. Cárdenas

Turkey vulture (*Cathartes aura*) photographed in the surrounding area of Orocué (Casanare). August 2010. © CHELONIA/M. Garcés.

Yamaha Enduro 40 hp motor. The distance travelled downstream was 166.30 km. The descending water levels in the river allowed many sandy beaches to be sampled, both on the banks of the river as well as in its central areas.

During the descent, a nocturnal count was carried out with a growing lunar phase and clear skies and calm winds, using a reflector to 1,000,000 candelas (cd) connected to the engine and long-reach flashlights. The width of the channel made it necessary to sail within 50 m of the nearest shore at an approximate speed of 10-15 km/h, approaching individuals to be identified. 14.2 km of shores were explored in 1 hour and 25 minutes, locating and identifying 5 spectacled caimans (*Caiman crocodilus*), 1 of Class III, 2 of Class II and 2 individuals that could not be assigned to any class. The shallowness of the waters in some areas made it impossible to approach some of the individuals detected and hindered the movement of the boat through certain places.

Fourteen beaches along the river were explored during this stretch in search of traces of the target species, but none indicating the presence of the Orinoco crocodile were found. Traces of other animals were detected, such as the capybara (*Hydrochoerus hydrochaeris*), spectacled caiman (*Caiman crocodilus*), Orinoco goose (*Neochen jubata*) or jabiru (*Jabiru mycteria*), among others.

At least twenty-two people were interviewed in populations, communities and camps along the banks. Only six people gave concrete and reliable information regarding the presence of crocodiles in this part of the river, pointing out two specific places. A villager interviewed about 15 km downstream from the town of Aguaverde mentioned the presence of an Orinoco crocodile near his place of residence, around 400 m downstream (05º 55' 46.4'' N, 69º 55' 02.07'' W). Three fishermen in a camp located on the left bank of the river's main channel, in a place known as La Constancia (05º 56' 13.5'' N, 69º 53' 33.1'' W), coincided with the resident interviewed a few miles upstream regarding the presence of an Orinoco crocodile in that part of the river.

Another fisherman interviewed near the mouth of "caño" Picapico (05° 42' 49.65" N, 70° 3' 32.06" W) provided precise information on the location of an Orinoco crocodile that would lie in the sun on a nearby beach (05° 43' 15.87" N, 70° 02' 59.48" W) in periods of low water level (February-March). At the time, the beach, within the area known as La Vorágine, was not yet visible. He commented on the presence of a female that nested annually at a nearby beach. Another fisherman, located in a camp 8 km upstream in the area of La Vorágine (05º 39’ 57.20’’ N, 70º 05’ 50.90’’ W) also confirmed the presence of the species in the area, recalling having seen two adults basking the previous year on a beach that emerges in front of the camp in periods when the water level is low. The two areas mentioned by the interviewees were fully explored along the entire stretch, both up and downstream, prospecting beaches for traces or indications of the presence of the species, to no avail. In Aguaverde, information was collected on crocodiles sighted in the Gavilán River (Vichada Department), a waterway that flows into the Tomo River. During the first few day of March 2011, this stretch was sampled again, specifically from Puerto Borracho (La Primavera) to La Constancia with special attention paid to the area known as La Vorágine, a place mentioned by different people from the region as the area that was inhabited by an undefined though likely small number of Orinoco crocodiles.

The “pool” of La Vorágine seems to be approximately located between the island near the mouth of “caño” La Perra (05° 37’ 57.60” N, 70° 06’ 45.63” W) and the central island situated in the proximities of the mouth of “caño” Picapico (05º 43’ 30.58’’; 70º 02’ 31.08’’), covering a stretch of about 10 km of river. This area has wide sandy beaches on the margins and also on the islands, with varying degrees of inclination and usually has no vegetation. Riparian vegetation is quite far from the water in beach areas, though there are banks on which trees and shrub vegetation can be found, with dry logs and sticks that usually stick out above the surface of the water that turtles (*Podocnemis unifilis*) use to bask in the sun. In one part of the right bank of this stretch of river there was a rocky formation about 100 m long. A villager assured that an individual basked on it. This formation and the beaches close to both shores of the river were explored on foot in search of traces that might indicate the presence of the species in the area.

The area was explored six times in an aluminum hull boat with a 25 hp outboard motor, both during the day and at night to observe and survey the different beaches on foot in search of traces revealing the presence of any individual of the target species, though none were located. On the evening of March 2nd, 14 km were covered on both shores of the area between 19:20 and 21:15, and no crocodiles were seen. Fifteen spectacled caimans were observed: 3 of Class III, 4 of Class II, 2 of Class I and 6 could not be assigned a size as it was impossible to approach the individuals.

Juvenile yellow-headed Caracara (*Milvago chimachima*) in the surrounding area of the Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

The engineer Miguel Cárdenas during field-work in the Cravo Sur area (Casanare). © CHELONIA/M. Merchán

Port of La Primavera (Vichada). © CHELONIA/A. Castro

Adult spectacled caiman (*C. crocodilus*) basking on a trunk on the right margin of the Meta River. March 2011. © CHELONIA/F. Gómez

During a stop in Aguaverde on the morning of March 3rd, two people once again provided information on the presence of the species in the river or “caño” Gavilán, a tributary of the Tomo River, referring to “the pool of Las Mercedes” and “the pool of La Bota” as the sighting places, near Finca Las Mercedes, La Jaula and La Unión.

That night, two nocturnal samplings were carried out in the La Vorágine area: one between 22:51 and 01:00 and the other between 04:41 and 06:37. The first one covered 12 km of shoreline, and 21 spectacles caimans were identified; 6 of Class I, 4 of Class II, 2 of Class III and 1 of Class IV. 8 individuals were not classified to a size type. The second covered 15 km of shoreline and located 15 spectacled caimans which were not assigned a size type. On the way up, a stop was made in a camp on the right bank, about 5 km upstream from the island at the mouth of “caño” La Perra, where the family residing there also confirmed the presence of the species in the area, stating that a few days before they had heard an individual “snoring”. They also mentioned that their acquaintances had seen two individuals basking in the sun on a nearby beach.

In the approximately 235 km explored during that visit, not a single trace of an Orinoco crocodile was detected, nor seen. The fisherman who had informed us about the annual nesting of a female on a beach of the area confirmed that this year she had not appeared.

Sub-basin	River or Channel	Total km covered	Stretch covered (km)	Km nocturnal counting	Nº visits	Date
Meta	Cravo Sur	116.4	31.4	7.3	3	Aug10/Sep10/Nov10
	Güira	7.5	7.5	0	2	Sep10/Nov10
	Caimán	4.8	2.4	0	1	Sep10
	Guirripa	Momentary	Momentary	0	1	Sep10
	Canacabare	24	12	12	1	Nov10
	Meta	1,103	322	55	4	Aug10/Nov10/Dec10/Mar11
	Duya	8.7	8.7	0	1	Aug10
	Guanapalo	89.6	44.8	44.8	1	Nov10
	Gandul	14.3	7.2	7.2	1	Nov10
	Yatea	Momentary	Momentary	0	1	Nov10

	Guachiría	36.0	18	0	1	Nov10
	La Hermosa	80.4	40.2	40.2	1	Nov10
	Ariporo	31.6	26.8	0	2	Oct10/Feb11
	Chire Nuevo	Momentary	Momentary	0	2	Oct10/Feb11
	El Toro	7.0	3.5	0	1	Oct10
	El Indio	4.0	2.0	0	1	Oct10
Vichada	Vichada	1,234	402	52	2	Dec10/Feb11
Orinoco	Orinoco	57.7	30.5	0	1	Mar11
Dagua-Mesetas	Dagua	Momentary	Momentary	0	1	Mar11
Dagua-Mesetas	Mesetas	Momentary	Momentary	0	1	Mar11

Table 18. Bodies of water visited, kilometers covered, number of visits and time of year of the visits. Total km covered: number of kilometers covered on boat. Stretch covered (km): stretch of the water course sampled, some may have been explored on various occasions. Momentary: reconnaissance of various places or short stretches of waterways on foot, horse or vehicle 4x4.

Natural Reserves in the Casanare Department

A) Palmarito-Casanare, San Pablo and El Boral Reserves

It was visited on three occasions. Flights were made over all the properties to obtain a view of the distribution and presence of different ecosystems, and to try to identify and locate samples of the target species.

On flights made during the months of August, September and November, the waterways crossing, bordering, or close to reserves were explored. Flights were conducted at low altitudes and reduced speeds to enable the observation of shorelines and beaches in search of crocodile samples. In addition, photographs and video footage were taken for the characterization of the ecosystems. The waterways flown over were the Cravo Sur River (between its confluence in the Meta River and "caño" Canacabare), "caño" Güira, "caño" Caimán and "caño" Guirripa, as well as the Meta River from the town of Orocué to the mouth of Cravo Sur.

Adult male of *C. intermedius* photographed in December 2010 in Pozo Caimán, Vichada River (Vichada). Observe the arched tail position, typical of territorial behavior. © CHELONIA/F. Gómez

Adult male of *C. intermedius* photographed in December 2010 in Pozo Caimán, Vichada River (Vichada). © CHELONIA/F. Gómez

Adult of *C. intermedius* photographed in Pozo Caimán, Vichada River (Vichada) in February 2011. © CHELONIA/F. Gómez

The biologist Rafael Antelo taking a picture of the shell of a yellow-spotted river turtle (*Podocnemis unifilis*) on a beach on the left margin of the Meta River (Casanare). November 2010. © CHELONIA/A. Castro

Aerial Sampling

In the month of November of 2010, a wide stretch of the Meta River, as well as some sections of the channels that flow into it from the northwest (Casanare), was flown over. In total, 300 km were covered in morning hours on an "Air Cam". The Meta River was flown over from its mouth to Cravo Sur, following its course downstream and covering areas of the course of "caño" Duya, "caño" Guanapalo and the Pauto River. The upstream return was made through the course of the Meta River to the mouth of Cravo Sur, which was also flown over to the Palmarito-Casanare Reserve. Shores, beaches and water surfaces were observed and not one individual of the target species spotted. The choice of tributaries or gorges to explore was based on the information gathered from local residents who reported possible sightings of individuals of the species.

The Palmarito-Casanare and San Pablo Reserves were also partially covered on horseback in September and November to assess the composition of the ecosystems, diversity, and abundance of wildlife and vegetation, and also to reach the bodies of water that cross them. A canoe type fiberglass kayak was used to navigate through the streams that pass through these properties. The navigation assessed the adequacy of the characteristics of these courses to the ecological requirements of the Orinoco crocodile, also looking for clues or traces of their presence. "Caños" Güira –explored on two occasions and in different sections- Caimán and Guirripa were navigated in September.

A.a) "Caño" Güira:

"Caño" Güira was explored from a stream area (4° 48' 21.56" N; 71° 36' 39.90" W), going back 5 km through a flooded floodplain area to a tree-lined area within the Palmarito Reserve (4° 50' 0.81" N, 71° 37' 8.04" W). It was also explored in another area bordered by gallery forest (4° 50' 32.49" N, 71° 37' 21.51" W) for a stretch of about 2.5 km upstream, until the thick branches and logs floating and submerged impeded the boat from passing through.

A.b) "Caño" Caimán:

"Caño" Caimán was explored from the confluence with the path leading to the northeast corner of the Palmarito Reserve (04° 51' 37.00" N, 71° 37' 00.80" W) to the northwestern boundary of the property, for a stretch of 2.4 km surrounded by gallery forest.

A.c) "Caño" Guirripa:

A short distance of "caño" Guirripa was navigated, both up and downstream, as the thickness of the branches and trunks on the water made navigation impossible beyond a few hundred meters.

B) La Aurora Natural Reserve

This reserve (06° 00' 48.50" N; 71° 17' 55.50" W), located in the northern part of the Casanare Department in the sub-basin of the Ariporo River, was visited in October 2010 and February 2011. The Ariporo River, a meandering and narrow course compared to the main rivers in the plains, crosses it and it is where there are historical records of the presence of the Orinoco crocodile.

B.a) Ariporo River:

It is a narrow river born in the Andean Range. It flows into the Casanare River, near its mouth in the Meta River. The prospected area has a winding course and is bordered by gallery forest with an abundance of royal palm, with nearly perpendicular cliffs from 3 to 5 m high. In the dry season the water level prevents outboard navigation, therefore it can be crossed on foot or horseback.

It was prospected during the morning hours in October 2010 on a wooden canoe with an outboard motor in an area near the port of the Reserve, and in the afternoon through a stretch of 22.0 km (06° 00' 48.50" N; 71° 17' 55.50" W) to the place known as San Pedro (05° 56' 35.20" N; 71° 22' 07.40" W). The high water level during this month left few beaches uncovered. Because this river is the main form of transport for communities that live along its banks during winter, boats pass frequently.

B.b) "Caño" El Toro:

It is a stream of calm waters. It was explored in the morning hours in October 2010 on a wooden rowing canoe, from its mouth in the Ariporo River (06° 00' 23.70" N; 71° 18' 15.60" W) along a stretch of 3.5 km until the presence of vegetation prevented further navigation upstream. Very few beaches were observed and no traces of the species were found, though six individuals of the spectacled caimans (*Caiman crocodilus)* were detected on its shores. It has steep cliffs in its lower course that diminish as one travels upstream.

B.c) "Caño" El Indio:

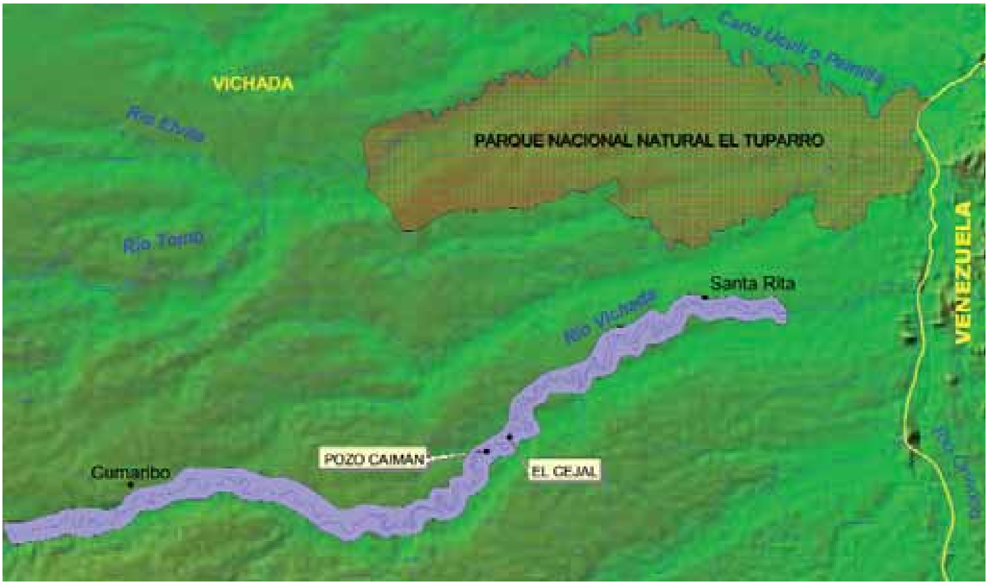
It was explored in the morning hours in October 2010 in a wooden rowing canoe from its mouth in the Ariporo River (06° 01' 57.30" N; 71° 17' 10.14" W). Only 2 km were covered; the presence of vegetation prevented the passage of the boat. No beach was observed on this stretch which presented almost vertical cliffs between 3 to 5 m high.

B.d) Chire Nuevo River:

It is a narrow river that descends in an easterly-northeasterly direction, flowing southeast into the Ariporo River. It forms part of the reserve's northern boundary and an area of marshes cuts through the area visited in October 2010. Only a short stretch of the right bank could be covered on horseback, as the waters exceeded the level of its banks, extending over the surrounding marshlands. Two workers of the reserve who were interviewed mentioned the possible presence of two crocodiles in the river. The owners of the reserve reported having kept an Orinoco crocodile years back, in a body of artificial water near the houses in the northeastern part of the reserve. They said that when it reached a size of about 3 m it was transferred to the Chire Nuevo River where it was released. Weeks later they received word that it had died several miles downstream.

In late February 2011, the Chire Nuevo River was sampled again, this time on foot. During this season, the level of the river was very low, showing its dry riverbed in parts of its lateral tributaries, with few accumulations of water. In the main course of the river, a couple of wells or deeper and wider areas of the river were visited, pursuant to information provided by owners and staff of the reserve. These were located in a wooded area that expands and surrounds the riverbed with a width of more than 1 km on either side of it. In one of the visited wells (06° 04' 53.93" N; 71° 20' 59.50" W), a large number of spectacled caimans were observed and in another one nearby (06° 04' 55.27" N; 71° 20' 55.73" W) a group of five giant otters or adult otters (*Pteronura brasiliensis*) were observed, appearing rather confident in the presence of visitors. No reliable evidence was obtained regarding the presence of Orinoco crocodiles.

7.4.- Sampling Results: Vichada River Basin



Area surveyed of the Vichada River by the Asociación Chelonia

The Vichada River basin covers an area of 26,013.52 km^2, equivalent to 7.49% of the Orinoquia (Correa *et al.*, 2006). The Vichada River has clear waters and begins in the savanna plains from the confluence of the Planas and Tillavá rivers, and further on receives waters from the Guarrojo and Muco rivers with an approximate length of 680 km to its mouth in the Orinoco River (IGAC, 1999). Its course is narrower than that of the great rivers of the plains and it is quite meandering. It has plenty of sandy beaches and is surrounded by gallery forest, which joins up with the Matavén Jungle in some parts on its right bank. Its course, which runs east, is the boundary between the plains themselves and the Matavén Jungle, an area of transition with the Amazon region located further south.

In the second week of December, an expedition was carried out through the Vichada River, using the municipal seat of Cumaribo, the largest municipality in Colombia with a surface area of 65,193 km^2 (Municipal Development Plan 2008-2011), as its operations camp. This small town in the Llanos, with just 4,486 inhabitants (DANE, 2005), is usually accessed by air as the roads that connect it to larger populations are not recommended for all vehicles, and furthermore are only passable during the summer season (December to March).

The Vichada River was explored from Puerto Güipane (04° 25' 59" N; 69° 46' 42" W), located along the shores of a former riverbed 3 km from the center of Cumaribo, downstream to the town of Santa Rita (04° 51' 52" N; 68° 21' 53" W). In this river, one of the population relicts of *Crocodylus intermedius* was located during research carried out in the mid-90's under the auspices of Colciencias, Wildlife Conservation Society (WCS) and the National University of Colombia, estimating the presence of no more than 15 adult individuals in this course of water (Lugo and Ardila, 1998).

Interviews with residents of Cumaribo and surrounding communities confirmed the current presence of individuals of the species in some meanders, known as wells or pools for being areas of deeper waters. The level of the water of the Vichada River was still high, despite it already being the "summer" season. From the marks observed in the riparian vegetation, the water level had dropped about 30 cm from the peak reached during 2010, meaning that many of the coastal beaches had been at least partially submerged. The coordinate points of the places where interviewees indicated the likely presence of crocodiles were registered. These areas were inspected more closely and their beaches were explored on foot in search of traces of the species. 382 km of the river were explored downstream, including access to tributaries that connect with the main channel, from Puerto Güipane to Santa Rita, for example the "caño" Dume (04° 23' 57.58" N; 69° 18' 39.34" W). A visit was also carried out at a former riverbed (04° 53' 01.86" N; 68° 14' 57.60" W) located about 20 km downstream from Santa Rita.

Orinoco Crocodile Sighting in Pozo Caimán

Pozo Caimán (04° 31' 43.5"N; 68° 53' 19.1" W) is a meander of the Vichada River, where both the expedition guide and the settlers consulted emphasized the presence of crocodiles. This meander constitutes a sharp bend of the main river, whose median line from shore to shore is oriented in a northwest-southeast direction, with an area of greater depth on the left bank (northwest). It has a more shallow area with a white sanded beach, which at the time remained covered by water except for a small strip on the right bank (southeast) about 13 m wide and 30 m long. During the exhaustive samplings carried out in the area, the presence of the species was confirmed.

On December 9, 2010 at exactly 13:30 an adult Orinoco crocodile with an estimated length of 300 to 350 cm was located on the inner side of the meander near the edge of the right bank covered by vegetation, in an area protected from the stream. It initially showed only its head, making its nostrils, eyes and skull roof visible for about a minute before submerging again in a position perpendicular to the shore, pointing its head towards the center of the watercourse. The crocodile responded to the noise made from the boat by re-emerging and submerging up to three times. The last time it emerged, it maintained its head, dorsal body surface and tail out of water. At that moment, the individual approached just a couple of meters into the area of the vessel, its snout pointing towards the center of the river and the body more or less perpendicular to the shore, placing observers at an angle of approximately 30° from its longitudinal axis. It again showed the entire dorsal surface of its head, body, and tail, and simultaneously raised its head and tail in an arched position above the water while maintaining the central part of the body submerged, followed by a lateral movement of the tail (tail wag). The head tilt became more pronounced, with an open mouth that later closed violently on two occasions, producing two perfectly audible snaps (jawclap). A short grunt followed, just before slapping its jaw against the surface of the water (headslap). An expulsion of air through the mouth followed, producing a bubbling effect after which the animal submerged back into the water.

The behavior displayed by the individual observed was similar to the description by Medem (1981), Thorbjarnarson and Hernández (1993b), Colvée (1999) and Antelo (2008) of territoriality/courtship behavior of the male *Crocodylus intermedius* in captivity in Colombia and Venezuela, but with slight variations. The individual performed the sequence of actions previously described with the snout directed toward the center of the river. In the absence of another individual of the species, it was concluded that territoriality was being demonstrated due to the presence of the boat.

Medem (1981) described the behavior of several individuals mating in captivity in the Roberto Franco Station (Meta Department), which began with the raising of the head and the tail in an arched position and the emission of 1 to 4 grunts (the first one louder than the others), followed by banging of the jaw against the surface of the water on one or two occasions. They then swam rapidly in circles and eventually adopted a lateral position. Thorbjarnarson and Hernández (1993b) described the same patterns in individuals in captivity in Hato Masaguaral (Venezuela), except for one difference: there was no snapping of the jaw and the growl is emitted after the banging of the head against the water surface through an elevation of the head. Sometimes this occurred more than

The investigator Fernando Gómez examining a fresh trail of a spectacled caiman (*C. crocodilus*) on the shore of the Meta River. December 2010. © CHELONIA/A. Castro

Adult male of *C. intermedius* in the Ecoparque Wisirare, Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

Fieldwork by the Asociación Chelonia team in Pozo Caimán, Vichada River (Vichada). December 2010. © CHELONIA/A. Castro

Giant otters (*Pteronura brasiliensis*). Vichada expedition. February 2011. © CHELONIA/M. Garcés once, and the individual later exhaled through the mouth, producing bubbles. Occasionally, the pattern was completed with a strong lateral movement of the tail. These authors reported that individuals generally displayed this behavior with the body positioned perpendicular to the shore and the head between 0.5 and 1 m away from it. This is contrary to our case, which was conducted with the head facing the center of the course of the water.

Colvée (1999) also described the same behavior as Thorbjarnarson and Hernández (1993b) for a group of individuals maintained in captivity in Agropecuaria Puerto Miranda (Venezuela), but points out that the number of grunts following the headslap against the surface of the water is between 3 and 8, gradually decreasing in intensity. He points out that the grunt can also be one of the actions prior to slapping the head against the water, and not just in the presence of other males. The snaps (jawclap) are described by Colvée as blows of the jaw on the surface of the water, as if it were "biting the water", conducted independently of the other actions described. Antelo (2008) indicates that a typical pattern of territoriality and courtship includes the arched tail, lateral movements, snoring and previous or simultaneous sub-audible vibrations, 1 to 3 headslaps over the water, and bubbling. The jaw snapping action is also described as a threat that can be performed in water or on land, normally not included in the usual pattern of territoriality and courtship.

Both Medem and Antelo point out that roars or grunts occur before the banging of the head on the water. Other authors consider it an action that takes place after the banging of the head. In the case presented here, the observers did not record vibrations in the water produced by the emission of sub-audible sounds, though the distance at which the individual was located and the light waves did not permit a clear observation of this action.

That same day, downstream from the Pozo Caimán in a place called El Cejal (04º 32' 31.7'' N; 68º 50' 13.9'' W), a beach in a small type of lake connected to the river was inspected, in which the trace of a crocodile was detected uphill. It was unmistakable by the type and size of the footprints and the dimensions of the drag zone. The reading of the trail, printed recently, indicated that the crocodile did not quite reach the beach, leaving the tail in the shallow water and causing a wavy mark on the sand under the water. The consistency of the sand and the slope -not very pronounced-, together with the weight of the animal, left deep foot marks, especially the hind ones. The animal was laid out with his body on the sand positioned perpendicular to the shore, with the tail

Juvenile spectacled caiman (*C. crocodilus*) photographed during a nocturnal survey in the Meta River in March 2011. © CHELONIA/F. Gómez

Fresh trails of spectacled caiman. Branch of the Meta River. January 2010. © CHELONIA/M. A. Cárdenas in the water and turned towards his right to go back to the water. The size of the track leads to the conclusion that the animal had a total length of over 250 cm. The final part of the tail that would have been inside the water could not be determined from the track.

On the way back upstream to Cumaribo, the beach in El Cejal was visited once again and two new crocodile tracks were located. This time they were found in the innermost part of the lagoon just outside the main channel.

On the return trip, Pozo Caimán was inspected once again. On the beach, no traces were found indicating that the male crocodile observed the previous day could have accessed it. The boat stayed in place on the shore of the beach and after making sounds during a couple of minutes, the crocodile was spotted again at 16:30 in practically the same place it was observed the previous day, showing only its head above the water, about 70 m from the observers. After about a minute in this position, it went back under the water. An attempt was made to make noise by beating a wooden board against the surface of the water, in an attempt to simulate the sound of the banging of the head against the water which another individual of the species could make. The crocodile resurfaced, showing just the head. At the sound of the board against water, it reacted by lifting its head slightly a few times while slowly opening and closing its mouth, not violently, before going back into the water. About two minutes later it resurfaced about 4 m downstream from its previous position, a little closer to the shore. Darkness crept over this part of the river marked by the shadow of riparian vegetation, so observing conditions became complicated. Once it got dark, a reflector of 1,000,000 cd was used but the individual was never again located.

A nocturnal sampling was conducted from Pozo Caimán, illuminating both sides with a reflector. Only one individual of spectacled caiman *(Caiman crocodilus)* was identified. It is worth pointing out that while covering the Vichada River, this was the only spectacled caiman observed in over 760 km of explored river courses (downstream and upstream). The scarcity of this species, which is usually quite abundant in bodies of water of the Llanos, in the main course of the Vichada River may be due to the high water level at the time, making it possible to find individuals in bodies of shallower and quieter water where they can find food with less difficulty and effort, though factors such as human pressure on the species for consumption could also be considered. No spectacled caimans were detected either in short stretches of streams and lagoons connected with the river routes.

Towards the end of February 2011, another prospection was carried out in the stretch between Puerto Güipane and the place known as El Cejal, including a three-day stay in Pozo Caimán. During this month, the water level was much lower than that registered in December, revealing a much greater extent of sandy beaches and showing some signs of complications when sailing through certain areas of shallow water. On February 21, 2011 at 17:40, again in Pozo Caimán, an adult Orinoco crocodile was detected with a total estimated length of 230-240 cm. When the specimen was located, it first showed its head while moving upstream along the left bank of the river, and occasionally revealed its tail. At one point, it continued moving revealing its entire back from head to tail. The animal's movements were smooth and it continued observing the investigators, watching constantly. When the individual submerged, its trail under the water could be detected by bubbles showing on the surface. It emerged again a few meters downstream.

On the nearby beach located in that meander of the river, an excavation was found that showed that inhabitants of the region opened an Orinoco crocodile nest. The nest was found near the start of the beach's steepest slope (approximately 40°), at a horizontal distance of about 2.5 m away from the edge of the beach and at a height of approximately 2-3 m above the water. It was located on the right bank of the channel about 200 m from the nearest vegetation. On the lower shore of the beach where the nest was located, a full trace of the individual's body was detected in a muddy substrate, lying parallel to the shore a few centimeters away from the water.

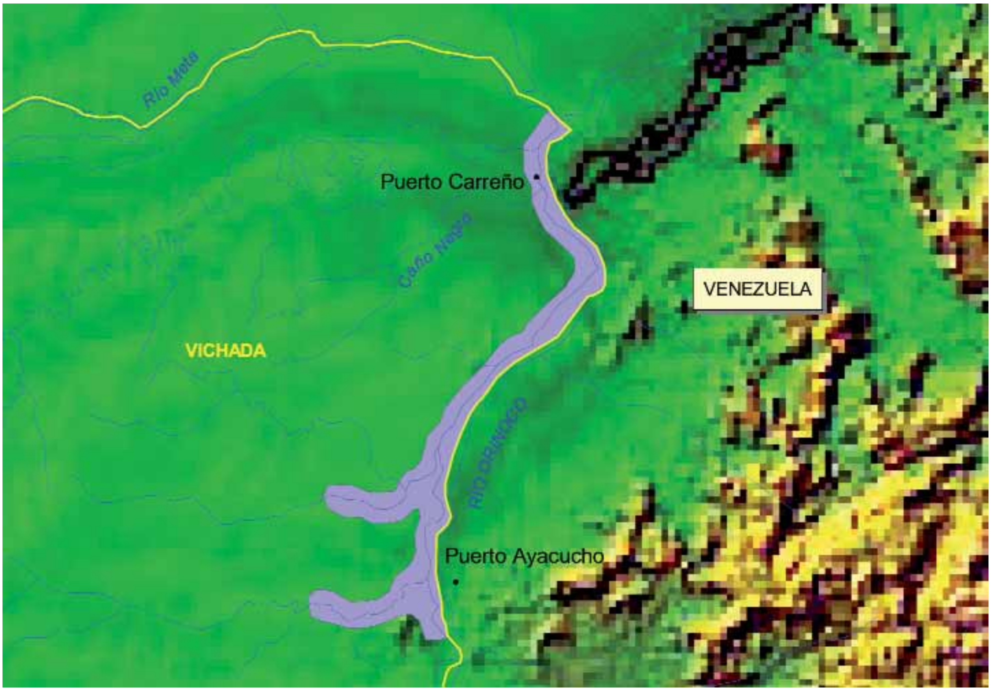
At 00:15 on February 22nd, the same specimen appeared in the same place. It seemed to respond to guttural sounds. It emerged and showed part of the skull roof, eyes, and nostrils above the water surface, allowing it to be seen and located through the use of a 500 lumens (lux) flashlight which exposed the greenish yellow reflection of its eyes. The individual was blinded by the light, allowing researchers to approach at a distance of about 150 cm to confirm the total length deduced from the length of its head. The individual was once again detected at 8:06 on the morning of the 22nd, reaching the left bank of the river, and down through the same place at 8:20.

In the afternoon of the 24th, the stretch of the Vichada River between Puerto Güipane and a place known as El Retorno (04° 22' 44.78" N; 69° 49' 12.30" W), located about 20 km upstream, was surveyed. The sampling was extended towards Emanae Lagoon, adjacent to El Retorno; no evidence was found of the presence of individuals of the target species.

During the researchers´ stay in Cumaribo, information was obtained regarding the sighting of a crocodile close to one of the beaches that is used for the celebration of games during this season. As a result, the scheduled games were suspended, although later no evidence revealing the presence of the species was detected.

7.5.- Sampling Results: Orinoco River Basin

The Orinoco River originates in the Parima Range (Venezuela) and with a length of 2,150 km it is the natural border between Colombia and Venezuela over a stretch of approximately 281 km from its confluence with the Atabapo and Guaviare rivers to its confluence with the Meta River. The Orinoco River basin, a part of both countries, occupies an area of 981,446 km^2 (Bernhard, 2008; Rosales *et al.*, 2010).



Area surveyed of the Orinoco River by the Asociación Chelonia

The stretch between Puerto Carreño and Albarical (05º 57’ 23.89’’ N; 67º 27’ 33.93’’ W) was sampled on its Venezuelan bank in early March 2011, with interviews of fishermen that were on the shores to obtain information on the possible presence of Orinoco crocodile in the area. Most of the people interviewed declared that crocodiles had not been seen in the area for years. Residents and settlers of the town of Casuarito were also interviewed and no reliable information was obtained regarding recent sightings of any individuals. Several people referred to sightings of Orinoco crocodiles in the Meta River, in places known as Aceitico, Yaruro and Parure, an area located between La Venturosa and Puerto Carreño. This information could not be confirmed on the field.

7.6.- Sampling Results: Dagua and Mesetas River Basins

The Dagua and Mesetas rivers are direct tributaries of the Orinoco, forming two small basins that together cover an area of 3,632.83 km^2 (Correa *et al.*, 2006) north of the Tomo River. They are small channels of clear water which originate in high plains. They are moderately meandering and bordered by gallery forest of variable densities with many sandy beaches which are more common and extensive in its lower course.

Based on information received from third parties, several interviewees commented that in both the Dagua and Mesetas rivers, individuals were sighted in wells during the rainy season when the water level of the rivers was higher. This statement would correspond to the migration described by Medem (1981) and the Meta’s riverine inhabitants, in which crocodiles search for the main channels of large rivers in summer (dry season), coinciding with low water levels, larger beaches, and the breeding and reproductive season. With the onset of the rain, and the consequential increase in water levels and the intensity of currents, the crocodiles seek calmer waters of smaller streams and rivers, as well as lagoons connected to the main channel. They remain in them during the winter (May to November).

A lagoon (05° 35’ 43.58” N; 67° 41’ 59.01” W) adjacent to the main channel of the Mesetas River was visited, in the property known as Macaurel. The lagoon has greenish waters and is connected to the river. It appeared to have been an old meander of it and presented a body of water interrupted in various points by vegetation and towering groups of “moriche” palm (*Mauritia flexuosa)*. The perimeter of the lagoon was explored on foot during the afternoon hours, without warning of the presence of any crocodile or caiman. The information obtained from workers of this estate did not permit a confirmation of the presence of the Orinoco crocodile within it or in the nearby stretch of river.

In addition, a 3.5 km stretch of the Dagua River (05° 46’ 34.35” N; 67° 42’ 58.54” W) was sampled using a 4x4 vehicle and stops were made in different areas where the thickness of the gallery forest permitted access to the shore to observe the beaches and waters surfaces. Two small lagoons connected to the main course of water were also prospected. No presence of the target species was detected through direct or track observations. The information from the area’s inhabitants was too vague, with no specific details to corroborate the current presence of any individual of the species within the area.

7.7.- Conclusions of the 2010-2011 Chelonia Expeditions

<u>Meta River</u>

Of the 1,103 km explored along the Meta River, along a stretch of 322 km between the mouth of the Cravo Sur River and the village of La Culebra, no Orinoco crocodile specimen was observed, and no trace or physical evidence of its presence found. In approximately 426 km explored in other waterways that are part of the Meta River sub-basin, all of them within the department of Casanare, no individual or trace of the target species were located.

The presence of the species in the section of the Meta River between La Primavera and La Culebra seems to be confirmed by information from the area’s residents, though in the samplings carried out no specimens or traces of it were observed or found. In the sampling of this section of the river conducted by the National University of Colombia in December 1995 and January 1996, the presence of 15 adult individuals was estimated. According to interviews and visits, it seems that within this stretch of the river one would most likely find samples of the Orinoco crocodile in the place known as La Vorágine (05º 39’ 57.20’’ N; 70º 05’ 50.90’’ W), which covers a stretch of 10 km and includes the area near the mouth of “caño” Picapico (05° 42’ 49.65” N; 70° 3’ 32.06” W).

There is information which seems to be reliable of at least one annual reproductive event in this stretch in previous years, although, according to the same source, no nesting took place in 2010; this may lead one to assume that the female has either altered its location or perished. All the same, like many eggs of the "arrau" turtle (*Podocnemis expansa*) and the "terecay" turtle (*Podocnemis unifilis*), the eggs appear to have been collected for human consumption. All interviewees who provided reliable information on the presence of the species mentioned how elusive and wary the individuals in this area of the river are.

The regular movement of boats in this part of the Meta River and the frequent presence of fishermen, as well as the possibility of the existence of accidental or premeditated hunting due to the fear it provokes, may be an important cause of the specimens´ caution and distrust. At the same time, the pressure from egg collection from the few nests that may be found on the beaches (even though no presence was confirmed during this season) seems to hinder the recovery of the species.

It is possible that "natural" basking behavioral patterns of the individuals in the Meta and Vichada rivers have been altered due to the activity and presence of human beings, as Barahona and Bonilla (1999) also suggest regarding the population in the Arauca Department, north of our study area.

It is necessary to continue sampling and monitoring this stretch of the Meta River to obtain more information that would make it possible to objectively establish or estimate the number of individuals present, while simultaneously further analyzing and quantifying the threats to the species and the factors that prevent the recovery of its populations. Also, it is advisable to extend the area of sampling and exploration of the Meta River towards the mouth of the Orinoco, as there is unconfirmed information on the presence of the species in the areas of Aceitico, Yaruro and Parure.

A large part of the human population in the areas sampled has knowledge of the Orinoco crocodile through word of mouth, though there is great confusion when differentiating the Orinoco crocodile (*Crocodylus intermedius*), the spectacled caiman (*Caiman crocodilus*) and the dwarf caimans (*Paleosuchus palpebrosus* and *P. trigonatus*). All the same, it is known that the species is threatened, although people do not seem to perceive that the actual risk of extinction is real.

Thus, it is necessary to continue awareness-raising and dissemination activities on populations in the distribution area of the Orinoco crocodile, so that people receive more information on the species and its critical conservation status; it is also necessary to achieve greater ownership by residents as a resource and component of the natural and cultural heritage of the Llanos.

Basking sub-adult spectacled caiman. Meta River. March 2011. © CHELONIA/F. Gómez

Sand banks emerged from the Vichada River (Vichada). February 2011. © CHELONIA/F. Gómez

Flooded savanna in the area surrounding Orocué (Casanare). August 2010. © CHELONIA/M. Garcés

Mouth of the Cravo Sur River flowing into the Meta River. Orocué (Casanare). August 2010. © CHELONIA/M. A. Cárdenas

Vichada River

Of the approximately 1,234 km explored of the Vichada River along a stretch of 402 km, between El Retorno and 20 km downstream from Santa Rita, only two specimens of the Orinoco crocodile could be observed, about 205 km from the town of Cumaribo. The two specimens were found through direct observation in the place known as Pozo Caimán. The first one, a male with an estimated total length of 300 to 350 cm, was observed in December 2010. The second one, thought to be female due to its size, behavior, and confirmation of the presence of a nest in the same area where it was observed, was located in February 2011 with an estimated total length of 240-250 cm.

Reproductive events were confirmed by information gathered from villagers and by finding a nest in February 2011 whose eggs had been removed. The nest was located on the beach of the same meander where both specimens had been detected. Locating a recently made trace on the beach of El Cejal, about 10 km downstream from Pozo Caimán in December 2010, a few minutes after having located the first sample, led us to suppose that there are more individuals in this stretch of river.

The information obtained through interviews with local people and fishermen seems to indicate that this is the only known place on a stretch of over 380 km, from El Retorno to Santa Rita, in which annual nesting of the species takes place. This also leads to the removal of the eggs each year and explains why no hatchlings or juveniles were seen in the wild during the last few years, despite the high degree of isolation and low boat traffic in the area. The data obtained from the samples taken and the information obtained allow us to conclude that its population in the Vichada River is in a critical situation, with a lower number now than that estimated in studies carried out in the mid 90s, which reflected a population of about 15 dispersed adult individuals, with the presence of reproductive events and hatchlings (Lugo and Ardila, 1998). Although no hunting pressure on the species seems to exist, the odds of them drowning in fishing nets seems to be low, and the destruction of habitat is minimal due to the isolation of the region, no recovery can be appreciated; instead there is an apparent reduction in the number of individuals of the species.

Bibliography

Alberico M., Cadena, A., Hernández-Camacho, J. H. and Y. Muñoz-Saba. 2000. Mamíferos (Synapsida: Theria) de Colombia. *Biota Colombiana*, 1: 43-75.

Alcaldía de Cumaribo. 2008. *Municipio de Cumaribo. Vichada. Plan de desarrollo municipal 2008-2011. "Visión con futuro y prosperidad para todos"*. Cumaribo Town Hall. Vichada (Colombia). 185 p.

Antelo, R. 2008. *Biología del caimán llanero o cocodrilo del Orinoco (*Crocodylus intermedius*) en la Estación Biológica El Frío, Estado Apure, Venezuela*. Doctoral thesis. Department of Ecology. Universidad Autónoma de Madrid. 286 p.

Antelo, R., Ayarzagüena, J. and J. Castroviejo. 2010. Reproductive ecology of Orinoco crocodiles (*Crocodylus intermedius*) in a newly established population at El Frío Biological Station, Venezuela. *Herpetological Journal* 20: 51–58

Ardila, M. C., Barahona, S. L., Bonilla, O. P. and J. Clavijo. 2002. Actualización del status poblacional del Caimán Llanero (*Crocodylus intermedius*) en el Departamento de Arauca (Colombia): 57-67. In: Velasco, A., Colomine, G., Villarroel, G. and M. Quero (eds.). *Memorias del taller para la Conservación del Caimán del Orinoco (Crocodylus intermedius) en Colombia y Venezuela*.

Ardila, M. C., Barahona, S. L., Bonilla, O. P. and D. R. Cárdenas. 1999a. Aportes al conocimiento de la reproducción, embriología y manejo de *Crocodylus intermedius* en la Estación de Biología Tropical "Roberto Franco" de Villavicencio. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales.* Vol. XXIII: 417-424.

Ardila, M. C., Barahona, S. L., Bonilla, O. P. and D. R. Cárdenas. 1999b. Evaluación del crecimiento de *Crocodylus intermedius* nacidos en la Estación de Biología Tropical "Roberto Franco" de Villavicencio. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales.* Vol. XXIII: 425-435.

Arteaga, A. and G. Hernández. 1996. Evaluation of the reintroduction of *Crocodylus intermedius* in the Caño Guaritico Wildlife Refuge (Apure State, Venezuela). *Ponencia en el 13º Encuentro del CSG.* Santa Fe. Argentina: 207-222.

Arteaga, A., Cañizales, I., Hernández, G., Lamas, M. C., De Luca, A., Muñoz, M., Ochoa, A., Seijas, A. E., Thorbjarnarson, J., Velasco, A., Ellis, S. and U. S. Seal (eds.). 1997. *Taller de análisis de la viabilidad poblacional y del hábitat (PHVA) del Caimán del Orinoco (*Crocodylus intermedius*).* IUCN – SSC Conservation Breeding Specialist Group. Aple Valley. MN. (USA). 52 p.

Ávila-Manjón, P. M. 2008. *Estado poblacional del caimán del Orinoco (*Crocodylus intermedius*) en el río Cojedes, Venezuela*. Tesis de Grado. UNELLEZ. Guanare (Venezuela). 166 p.

Ayarzagüena, J. 1983. Ecología del caimán de anteojos o baba (*Caiman crocodilus* L.) en los Llanos de Apure (Venezuela). *Doñana Acta Vertebrata. Vol.* 10-3. 136 p.

Ayarzagüena, J. 1984. Primeros datos de crecimiento del *Crocodylus intermedius* en semilibertad. *Memoria Soc. Cien. Nat. La Salle*, 122: 149-150.

Ayarzagüena, J. 1987. *Conservación del caimán del Orinoco (*Crocodylus intermedius*) en Venezuela. Parte I. Río Cojedes*. FUDENA, WWF-US, Proyecto 6078.

Ayarzagüena, J. 1988. *Programa para la conservación del Caimán del Orinoco en Venezuela. Estado Actual y proyección.* Instituto de Cooperación Iberoamericano de España. Non-Published Report. 9 p.

Ayarzagüena, J. 1990. An Update for the Recovery Program for the Orinoco Crocodile. *CSG Newsletter*, 9 (3): 16-18.

Ayarzagüena, J. and J. Castroviejo. 2008. La baba (*Caiman crocodilus* L.) en la Estación Biológica El Frío (Estado de Apure). Llanos del Orinoco, Venezuela. 181-294. In: Castroviejo, J., J. Ayarzagüena y A. Velasco (eds.). *Contribución al conocimiento de los caimanes del género* Caiman *de Suramérica*. Publ. Asoc. Amigos de Doñana, 18: 1-294.

Ayarzagüena, J., Velasco, A. and R. Antelo. 2007. A New Population of Orinoco Crocodile. Species. IUCN. *Newsletter of the Species Survival Commission*, 47.

Barahona, S. L. and O. P. Bonilla. 1999. Evaluación del status poblacional del caimán llanero (*Crocodylus intermedius* Graves, 1819) en un subareal de distribución en el departamento de Arauca (Colombia). *Rev. Acad. Colomb. Cienc., Vol. XXIII*: 445-451.

Barahona, S. L. and O. P. Bonilla. 1994. Registros de *Crocodylus intermedius. Trianea*, 5: 420.

Blohm, T. 1948. Observaciones sobre los caimanes traídos del río Orinoco en abril de 1946. *Mem. Soc. Cienc. Nat. La Salle,* 8 (22): 129-132.

Blohm, T. 1973. Conveniencia de criar crocodílidos en Venezuela con fines económicos y para prevenir su extinción. *Simposium Internacional sobre Fauna Silvestre y Pesca Fluvial y Lacustre Amazónica*, Manaus. Brazil.

Blohm, T. 1982. Husbandry of Orinoco Crocodiles (*Crocodylus intermedius*) in Venezuela. 267-284. In: *Proceedings of the 5th Working Meeting of the Crocodile Specialist Group/ SSC / IUCN*. Gainesville. Florida (USA).

Boede, E. and E. Sogbe. 2000. Enfermedades en caimanes del Orinoco (*Crocodylus intermedius*) y caimanes de la costa (*Crocodylus acutus*) mantenidos en zoocriaderos venezolanos. *Revista Científica FCV-Luz*., 10 (4): 328-338.

Bonilla, O. P. and S. L. Barahona. 1999. Aspectos ecológicos del Caimán llanero (*Crocodylus intermedius* Graves, 1819) en un sub-área de distribución en el departamento de Arauca (Colombia). *Rev. Acad. Colomb. Cienc. Vol. XXIII* (86): 39-48.

Calzadilla, F. 1940. *Por los llanos de Apure*. Imprenta Universitaria. Santiago de Chile. 430 p.

Cardona, M. 1964. El caimán en el folklore venezolano. 3-25. In: *Temas del folklore venezolano*: Ediciones del Ministerio de Educación. Caracas.

Castroviejo, J., Ayarzagüena, J. and A. Velasco. 2008. Contribución al conocimiento de los caimanes del género *Caiman* en Suramérica. *Publ. Asoc. Amigos Doñana*, 18: 1-294.

Chávez, C. 2000. *Conservación de las poblaciones de caimán del Orinoco (*Crocodylus intermedius*) en Venezuela*. Ministerio del Ambiente y de los Recursos Naturales Dirección General de Fauna. Profauna. República Bolivariana de Venezuela.

Chávez, C. 2002. Seguimiento de las liberaciones de Caimán del Orinoco (*Crocodylus intermedius*) en el Refugio de Fauna Silvestre "Caño Guaritico" y sus alrededores. 30-56. In: Velasco, A., Colomine, G., Villarroel, G. and M. Quero (eds.) *Memorias del Taller para la Conservación del Caimán del Orinoco (*Crocodylus intermedius*) en Colombia y Venezuela*.

Codazzi, A. 1841. *Resumen de la Geografía de Venezuela.* Imprenta de H. Fournier y Cía. Paris. 648 p.

Colvée, S. 1999. *Comportamiento reproductivo del caimán del Orinoco (*Crocodylus intermedius*) en cautiverio*. Doctoral thesis. Universidad Simón Bolívar. Sartenejas, Edo. Miranda (Venezuela). 321 p.

Congreso de la República de Colombia (Congress of the Republic of Colombia). 1981. Law 017 of 1981, which approved the “Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres”, signed in Washington, D.C. on March 3, 1973, Bogotá D.C.

Congreso de la República de Colombia (Congress of the Republic of Colombia). 1994. Law 165 of 1994, which approved the “Convenio sobre la Diversidad Biológica”, celebrated in Rio de Janeiro on June 5, 1992, Santafé de Bogotá D.C.

Corporación Autónoma Regional de la Orinoquia. 2001. Plan de Gestión Ambiental Regional, Yopal, Casanare, 254 p.

Correa, H. D, Ruiz, S. L. and L. M. Arévalo (eds.). 2006. *Plan de acción en biodiversidad de la cuenca del Orinoco: Colombia 2005-2015*. Corporinoquia, Cormacarena, IAvH, Unitrópico, Fundación Omacha, Fundación Horizonte Verde, Universidad Javeriana, Unillanos, WWF, GTZ. Bogotá, D.C. 330 p.

Cott, H. B. 1961. Scientific results of an inquiry into de ecology and economic status of the Nile crocodile (*Crocodylus niloticus)* in Uganda and Northern Rhodesia. *Trans. Zool. Soc. London*, 29: 211-356.

DANE. 2005. *Censo General*. Departamento Administrativo Nacional de Estadística. Bogotá D. C. 498 p.

De Cisneros, J. L. 1764. *Descripción exacta de la provincia de Venezuela*. Edición BBVA Fundación Provincial. Madrid-Caracas. 2001. 144 p.

De La Ossa, J. and A. Sampedro. 2002. Crecimiento de *Crocodylus acutus* (Crocodylia: Crocodylidae) y su relación con la madurez sexual. *Revista Biología*, 16 (1): 14-18.

Defler, T. R. and P. A. Palacios (eds.). 2002. *Zonificación ambiental para el ordenamiento territorial en la Amazonia colombiana.* Instituto Amazónico de Investigaciones Imani e Instituto de Ciencias Naturales. Universidad Nacional de Colombia. Bogotá, D.C.

Domínguez, C. 1998. *La gran cuenca del río Orinoco*. Biblioteca Virtual del Banco de la República. Original de la editorial del FEN. Bogotá. 324 p.

Donoso Barros, R. 1966. Contribución al conocimiento de los cocodrilos de Venezuela. Conclusión. *Physis, tomo XXVI* (72): 263-274.

Espinosa, A. S. 2010. *Colecta de huevos como estrategia de conservación del cocodrilo del Orinoco en el sistema del río Cojedes Venezuela. Universidad Nacional Experimental de los Llanos Occidentales "Ezequiel Zamora"*. Master thesis. Guanare (Venezuela). 111 p.

Franklin, C. E. and F. Seebacher. 2003. The effect of heat transfer mode on heart rate responses and hysteresis during heating and cooling in the estuarine crocodile, *Crocodylus porosus*. *Journal of Experimental Biology,* 206: 1143-1151.

Franz, R., Reid, S. and C. Puckett. 1985. The discovery of a population of Orinoco crocodile, *Crocodylus intermedius*, in Southern Venezuela. *Biological Conservation*, 23: 137-147.

FUDENA, 1993. *Plan de Acción: Supervivencia del caimán del Orinoco en Venezuela 1994-1999*. Grupo de Especialistas en Cocodrilos de Venezuela. Caracas. 24 p.

Gallegos, R. 1928. *Doña Bárbara*. Ed. Espasa Calpe. Buenos Aires. Edición de 1973.

Godshalk, R. E. 1982. Status and conservation of *Crocodylus intermedius* in Venezuela. *Proceedings of the 5th Working Meeting of the Crocodile Specialist Group/ SSC / IUCN*. Gainesville. Florida (USA). IUCN Publication New Series: 39-53.

Godshalk, R. E. and E. Sosa. 1978. *El caimán del Orinoco,* Crocodylus intermedius*, en los llanos occidentales venezolanos con observaciones sobre su distribución en Venezuela y recomendaciones para su conservación*. Non-published Report of FUDENA (WWF). Caracas (Venezuela). 52 p.

González-Fernández, M. 1995. *Reproducción del caimán del Orinoco (*Crocodylus intermedius*) en el río Cojedes. Propuesta para su conservación*. Master thesis. Universidad Nacional Experimental de los Llanos Ezequiel Zamora (UNELLEZ). Guanare (Venezuela). 70 p.

Goosen, D. 1971. *Physiography and Soils of the Llanos Orientales, Colombia*. Publications of the International Institute for Aerial Survey and Earth Sciences (ITC). Enschede, The Netherlands, Series B, nº 64.

Grigg, G. C. and F. Seebacher. 2000. Crocodilian thermal relations. 297-309. En: Grigg, G. C., Seebacher, F. y C. E. Franklin (eds.). *Crocodilian Biology and Evolution*. Surrey Beatty and Sons Pty Ltd.

Grigg, G. C. and J. Alchin. 1976. The role of the cardiovascular system in thermoregulation of *Crocodylus johnstoni. Physiological Zoology*, 49 (1): 24-36.

Grigg, G. C., Seebacher, F., Beard, L. A. and D. Morris. 1998. Thermal relations of large crocodiles, *Crocodylus porosus*, free ranging in a naturalistic situation. *Proceedings Royal Society of London,* 265: 1793-1799.

Gumilla, J. 1741. *El Orinoco Ilustrado y Defendido*. Biblioteca de la Academia Nacional de la Historia. Ed. Arte. Caracas. 1963 Edition. 519 p.

Gumilla, J. 1791. *Historia natural, civil y geográfica de las naciones situadas en las riveras del Río Orinoco*. Tomo II. Imprenta Carlos Gibert y Tutó. Barcelona, España. 352 p.

Hernández, J., Hurtado, A., Ortiz, R. and T. Walschburger. 1992. Unidades biogeográficas de Colombia. 105-153. En: Halffter, G. (ed.). *La Biodiversidad de Iberoamérica I*. CYTED-B. Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo. Instituto de Ecología A. C. Secretaría de Desarrollo Social. Xalapa. México.

Humboldt, A. 1800. *Viaje a las regiones equinocciales del nuevo continente*. Ed. Monte Ávila de 1991. Caracas.

Humboldt, A. and Bonpland. 1826. *Viage á las regiones equinocciales del nuevo continente.* E. Pochard. París.

Instituto Colombiano de Geología y Minería INGEOMINAS. 2007. *Mapa Geológico de Colombia*. Bogotá D. C. 430 p.

Instituto de Hidrología, Meteorología y Estudios Ambientales IDEAM. 2005. *Atlas climatológico de Colombia*. Bogotá D.C. 219 p.

Instituto Geográfico Agustín Codazzi IGAC. 1977. *Zonas de vida o formaciones vegetales de Colombia, memoria explicativa sobre mapa ecológico* Vol. XIII, nº 11. Bogotá. 268 p.

Instituto Geográfico Agustín Codazzi IGAC. 1986. *Estudio general de suelos de la Intendencia de Arauca*. Subdirección Agrológica. Litografía IGAC. Bogotá. 268 p.

Instituto Geográfico Agustín Codazzi IGAC. 1999. *Paisajes fisiográficos de la Orinoquia-Amazonia (ORAM) Colombia.* Bogotá. 373 p.

Instituto Geográfico Agustín Codazzi IGAC. 2008. *Atlas Básico de Colombia*. Vol. I y II, 7ª ed. Bogotá, 703 p.

Jackson, J. F., Campbell, H. W. and K. E. Campbell Jr. 1974. The Feeding Habits of Crocodilians: Validity of the Evidence from Stomach Contents. *Journal of Herpetology*, 8 (4): 378-381.

Jiménez-Oraá, M. 2002. *El caimán del Orinoco (*Crocodylus intermedius*) en los sectores de Laguna Larga y Chigüichigüe del río Manapire, Guárico, Venezuela*. Masters thesis. Universidad Nacional Experimental de los Llanos Occidentales Ezequiel Zamora, Guanare, Portuguesa.

Jiménez-Oraá, M., Seijas, A. E., Jiménez-Oraá, M. and H. J. Heredia-Azuaje. 2007. Colecta de huevos como estrategia de conservación del caimán del Orinoco (*Crocodylus intermedius)* en el río Manapire, Guárico, Venezuela. 36-42. In: Seijas, A. E. (ed.). *Conservación del Caimán del Orinoco. Memorias del III Taller para la Conservación del Caimán del Orinoco*. San Carlos (Cojedes, Venezuela), 17 to 19 of January of 2007. Biollania, Edición Especial nº 8.

Joanen, T. and L. McNease. 1987. Alligator Farming in Louisiana, USA. 329-340. En: Webb, J. W., Manolis, S. C. & P. J. Whitehead (eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty & Sons Pty Limited. Canberra, Australia.

Lance, V. A. 2003. Alligator physiology and life history: the importance of temperature. *Experimental Gerontology*, 135: 217-222.

Lasso, C. A., Usma, J. S., Trujillo, F. and A. Rial (eds.). 2010. *Biodiversidad de la cuenca del Orinoco: bases científicas para la identificación de áreas prioritarias para la conservación y uso sostenible de la biodiversidad*. Instituto de Investigaciones

Biológicas Alexander von Humboldt, WWF Colombia, Fundación Omacha, Fundación La Salle, e Instituto de Estudios de la Orinoquia (Universidad Nacional de Colombia). Bogotá D.C., Colombia. 609 p.

Lessman, H. and J. Eslava. 1985. Las precipitaciones anormales ocurridas en Colombia durante los años 1970 y 1971. *Atmósfera*, 3: 1-28.

Llobet, A. 2002. *Estado poblacional y lineamientos de manejo del caimán del Orinoco (*Crocodylus intermedius*) en el río Capanaparo, Venezuela*. Tesis de Maestría. UNELLEZ. Guanare (Venezuela). 209 p.

Llobet, A. and A. E. Seijas. 2002. Population, Status and Management Guidelines for the Orinoco crocodile (*Crocodylus intermedius)* in the Capanaparo River, Venezuela. En: Crocodiles. *Proceedings of the 16th Working Meeting of the Crocodile Specialist Group, IUCN- The World Conservation Union*, Gland, Switzerland and Cambridge UK: 109-118.

López, D., Hernández, R. M. and M. Brossard. 2005. Historia del uso reciente de las sabanas de América del Sur. Estudios de casos en las sabanas del Orinoco. Interciencia, 30 (10): 623-630.

Loveridge, J. P. 1984. Thermoregulation in the Nile crocodile, *Crocodylus niloticus. Symp. Zool. Soc. Lond*., 52: 443-467.

Lugo, L. M. 1995. Cría del caimán del Orinoco (*Crocodylus intermedius*) en la Estación de Biología Tropical "Roberto Franco", Villavicencio, Meta. *Rev. Acad. Colomb. Cienc.*, 19 (74): 601-606.

Lugo, L. M. and M. C. Ardila. 1998. Programa para la conservación del caimán del Orinoco (*Crocodylus intermedius*) en Colombia. Proyecto 290. Programa Research Fellowship NYZS. The Wildlife Conservation Society. Proyecto 1101-13-205-92 Colciencias. Universidad Nacional de Colombia. Facultad de Ciencias. Estación de Biología Tropical Roberto Franco. Villavicencio. Non-published report.

Malagón, D. 2003a. Ensayo sobre tipología de suelos colombianos - Énfasis en génesis y aspectos ambientales. *Rev. Acad. Colomb. Cienc.*, Vol XXVII, 104: 319-342.

Malagón, D. 2003b. *Los Suelos de Colombia.* Instituto Geográfico Agustín Codazzi, Subdirección de Agrología, Bogotá, 21 p.

Maldonado, R. A. 2005. Análisis del manejo de la población *ex-situ* del caimán llanero o cocodrilo del Orinoco *Crocodylus intermedius* (Graves 1819) en Colombia. 53-69. In: Reunión Regional de América Latina y el Caribe del Grupo de Especialistas en Cocodrilos (CSG/SSC/IUCN). Santa Fe, Argentina.

Marrero, C., Machado, A., González, V. and J. Velásquez. 1997. Ecología y distribución de los peces de los morichales de los llanos orientales de Venezuela. *Acta Biológica Venezolana*, 17(4): 65-79.

Medem, F. 1958. Informe sobre reptiles colombianos III. Investigaciones sobre la anatomía craneal, distribución geográfica y ecología de *Crocodylus intermedius* (Graves) en Colombia. *Caldasia,* 3 (37): 175-215.

Medem, F. 1981. *Los Crocodylia de Sur América*. Vol. I. Ministerio de Educación Nacional. COLCIENCIAS. Bogotá. 354 p.

Medem, F. 1983. *Los Crocodylia de Sur América.* Vol. II. Universidad Nacional de Colombia. COLCIENCIAS. Bogotá. 270 p.

Mena, J., Espinosa, A. and A. E. Seijas. 2010. Análisis de la población del cocodrilo del Orinoco (*Crocodylus intermedius*) en el sistema del río Cojedes, Venezuela. *Rev. Unell. Cienc. Tec.* (Volumen especial): 14-19.

Ministerio del Medio Ambiente, 2002. *Programa Nacional para la Conservación del Caimán Llanero (*Crocodylus intermedius*)*. Dirección General de Ecosistemas, Grupo de Biodiversidad, Instituto de Investigación en Recursos Biológicos Alexander von Humboldt, Universidad Nacional de Colombia, Facultad de Ciencias, Departamento de Biología, Estación de Biología Tropical Roberto Franco. Bogotá D. C., 32 p.

Molano, B. J. 1998. Biogeografía de la Orinoquia colombiana. 96-101. En: Domínguez, C. (ed.). *Colombia Orinoco*. Ed. fondo FEN. Bogotá D. C.

Mondolfi, E. 1965. Nuestra fauna. *El Farol*, 214: 2-13.

Muñoz, M. C. and J. Thorbjarnarson. 2000. Movements of captive-released Orinoco crocodiles (*Crocodylus intermedius*) in the Capanaparo River. Venezuela. *Journal of Herpetology*, 34(3): 397-403.

Ogden, J. C. 1978. Status and nesting biology of the American crocodile, *Crocodylus acutus* (Reptilia, Crocodylidae) in Florida. *Journal of Herpetology,* 12 (2): 183-196.

Páez, R. 1868. *Escenas Rusticas en Sur América o Vida en los Llanos de Venezuela*. Ediciones Centauro, Caracas. 398 p.

Pérez, A. T. and A. Velasco. 2002. Evaluación del crecimiento de *Crocodylus intermedius* con una dieta experimental. *Bol. Centro Invest. Biol.*, 36 (2): 125-135.

Pérez, A. T. and J. C. Rodríguez. 2005. Influencia de la temperatura del aire y del agua en el crecimiento de *Crocodylus intermedius* en dos condiciones de cautiverio. *Boletín del Centro de Investigaciones Biológicas*, 39 (1): 15-26.

Presidencia de la República de Colombia (Colombian Republic Presidency). 1974. Decreto Ley 2811 de 1974, Código de Recursos Naturales y de Protección al Medio Ambiente, Bogotá.

Presidencia de la República de Colombia (Colombian Republic Presidency). 1978. Decreto 1608 de 1978, por el cual se reglamenta el Código Nacional de los Recursos Naturales Renovables y de Protección al Medio Ambiente y la Ley 23 de 1973 en materia de fauna silvestre. Bogotá.

Presidencia de la República de Colombia (Colombian Republic Presidency). 1991. Constitución Política de Colombia, Secretaría Jurídica (Actualización octubre de 2009), Santafé de Bogotá D.C.

Presidencia de la República de Colombia (Colombian Republic Presidency). 1993. Ley 99 de 1993, por la cual se crea el Ministerio del Medio Ambiente, se reordena el sector público encargado de la gestión y conservación del medio ambiente y los recursos naturales renovables, se organiza el Sistema Nacional Ambiental (SINA) y se dictan otras disposiciones. Santafé de Bogotá D.C.

Presidencia de la República de Colombia (Colombian Republic Presidency). 1997. Decreto 1401 del 27 de mayo de 1997, por el cual se designa la Autoridad Administrativa de Colombia ante la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres (CITES), y se determinan sus funciones, Santafé de Bogotá D.C.

PROFAUNA. 1994. *Plan Estratégico: Supervivencia del Caimán del Orinoco en Venezuela*. MARNR, Servicio Autónomo de Fauna, PROFAUNA, Caracas.

Ramírez, J. A. 2000. Caimán llanero o cocodrilo del Orinoco (*Crocodylus intermedius*): Conservación y Conocimiento público en la Orinoquia Colombiana. *Zoodivulgación*, año 2, vol 1.

Ramírez, J. A. and C. Urbano. 2002. *Crocodylus intermedius* (Caimán Llanero) *ex-situ* en la Estación Biológica Tropical "Roberto Franco" (EBTRF), Colombia. 78-132. In: Velasco, A., Colomine, G., Villarroel, G. y M. Quero (eds.). *Memorias del Taller para la Conservación del Caimán del Orinoco (*Crocodylus intermedius*) en Colombia y Venezuela*.

Ramo, C. and B. Busto. 1984. *Censo aéreo de caimanes (*Crocodylus intermedius*) con observaciones sobre su actividad y soleamiento*. VII Reunión del Grupo de Especialistas en Cocodrilos de UICN. Caracas (Venezuela). 9 p.

Ramo, C., Busto, B. and A. Utrera. 1992. Breeding and rearing the Orinoco Crocodile, *Crocodylus intermedius*, in Venezuela. *Biological Conservation*, 60: 101-108.

Rivas, J. A. and R. Y. Owens. 2002. *Crocodylus intermedius* (Orinoco crocodile). Age at First Reproduction. *Herpetological Review,* 33(3): 203.

Rodríguez, M. 2002. Estado y distribución de *Crocodylus intermedius* en Colombia. Resumen de censos 1994-1997. 21-29. In: Velasco, A., Colomine, G., Villarroel, G. y M. Quero (eds.). *Memorias del Taller para la Conservación del Caimán del Orinoco (Crocodylus intermedius) en Colombia y Venezuela*.

Rosales, J., Suárez, C. F. and C. A. Lasso. 2010. Descripción del medio natural de la cuenca del Orinoco. 50-73. In: Lasso, C. A., J. S. Usma, F. Trujillo y A. Rial (eds.). *Biodiversidad de la cuenca del Orinoco: bases científicas para la identificación de áreas prioritarias para la conservación y uso sostenible de la biodiversidad*. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, WWF Colombia, Fundación Omacha, Fundación La Salle e Instituto de Estudios de la Orinoquia (Universidad Nacional de Colombia). Bogotá, D. C. 609 p.

Sarmiento, G. 1983. The savannas of Tropical America. 245-288. En: Bourliere, F. (ed.). *Ecosystems of the World XIII. Tropical Savannas*. Elsevier, Amsterdam.

Seebacher, F. and G. C. Grigg. 1997. Patterns of body temperature in wild freshwaters crocodiles, *Crocodylus johnstoni*: Termoregulation versus termoconformity, seasonal acclimatization, and the effect of social interactions. *Copeia*, 1977: 549-557.

Seebacher, F., Grigg, G. C. and L. Beard. 1999. Crocodiles as dinosaurs: behavioral thermoregulation in very large ectotherms leads to high and stable body temperatures. *Journal of Experimental Biology,* 202: 77–86.

Seijas, A. E. 1994. Incubación artificial de huevos de caimán del Orinoco. *Revista Unellez de Ciencia y Tecnología*, 12 (2): 36-41.

Seijas, A. E. 1995. Captive breeding and rearing as a conservation tool for the Orinoco crocodile. 596-598. In: Bissonette, J. A. y P. R. Krausman (eds.). *Integrating People and wildlife for a sustainable future*. Proceedings of the 1st International Wildlife Management Congress. The Wildlife Society, Bethesda, Md. 697 p.

Seijas, A. E. 1998. *The Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes river system, Venezuela: Population status and Ecological characteristics*. Doctoral thesis. Universidad de Florida. 192 p.

Seijas, A. E. 2000. *El caimán del Orinoco (*Crocodylus intermedius*) en el sistema del río Cojedes, Venezuela: Ecología y Estado Poblacional.* Trabajo de ascenso a la categoría de Profesor Asociado de la UNELLEZ. Vice-rectorado de Producción Agrícola. Guanare, Portuguesa (Venezuela). 101 p.

Seijas, A. E. and C. A. Chávez. 2002. Reproductive Status and Nesting Ecology of the Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes River System, Venezuela. *Vida Silvestre Neotropical,* 11 (1-2): 23-32.

Seijas, A. E. and P. Meza. 1994. El caimán del Orinoco (*Crocodylus intermedius*) en el embalse del río Tucupido, Estado Portuguesa, Venezuela. *Biollania,* 6: 43-51.

Seijas, A.E. and C. Chávez. 2000. Population status of the Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes river system, Venezuela. *Biological Conservation,* 94: 353-361.

Seijas, A.E., Jiménez-Oraá, M., Espinosa, A., Castillo, J. and N. Arcila. 2010. Monitoreo del estado de las poblaciones del caimán del Orinoco (*Crocodylus intermedius*) en Venezuela: 201-206. In Oliveira-Miranda, R., Lessmann, J., Rodríguez-Ferraro, A. and F. Rojas-Suárez (eds.). *Ciencia y conservación de especies amenazadas en Venezuela: Conservación Basada en Evidencias e Intervenciones Estratégicas*. Provita, Caracas, Venezuela, 234 p.

Seijas, A. E., Antelo, R., Thorbjarnarson, J. B. and M. C. Ardila. 2010. Orinoco Crocodile *Crocodylus intermedius.* 59-65. En: Manolis, S. C. & C. Stevenson. *Crocodiles: Status Survey and Conservation Action Plan*. Crocodile Specialist Group. Darwin, Australia.

Spotila, J. R., Terpin, K. M. and P. Dodson. 1977. Mouth gaping as an effective thermoregulatory device in alligators. *Nature,* 265: 235-236.

Thorbjarnarson, J. B. 1987. *Status, ecology and conservation of the Orinoco crocodile. Preliminary Report*. FUDENA-WWF. 74 p.

Thorbjarnarson, J. B. 1996. Reproductive characteristics of the order Crocodylia. *Herpetologica*, 52 (1): 8-24.

Thorbjarnarson, J. B. and G. Hernández. 1990. Recent Investigations into the Status of Orinoco Crocodile in Venezuela. *Proceedings of the 9th Working Meeting of the Crocodile Specialist Group*. 2: 308-328.

Thorbjarnarson, J. B. and G. Hernández. 1992. Recent Investigations into the Status and distribution of the Orinoco Crocodile, *Crocodylus intermedius*, in Venezuela. *Biological Conservation*, 62: 179-188.

Thorbjarnarson, J. B. and G. Hernández. 1993a. Reproductive Ecology of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. I. Nesting Ecology and Egg and Clutch Relationships. *Journal of Herpetology*, 27(4): 363-370.

Thorbjarnarson, J. B. and G. Hernández. 1993b. Reproductive Ecology of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. II. Reproductive and Social Behavior. *Journal of Herpetology*, 27(4): 371-379.

Velasco, A. and J. Ayarzagüena. 1995. Situación actual de las poblaciones de baba (*Caiman crocodilus*) sometidas a aprovechamiento comercial en los Llanos venezolanos. *Publicaciones de la Asociación Amigos de Doñana*, 5: 1-71.

Velasco A., Colomine, G., Villarroel, G. and M. Quero (eds.). 2002. *Memorias del Taller para la Conservación del Caimán del Orinoco (*Crocodylus intermedius*) en Colombia y Venezuela*. 330 p.

Villarreal, H. and J. A. Maldonado. 2007. *Caracterización biológica del Parque Nacional Natural El Tuparro (sector noreste), Vichada, Colombia.* Instituto de Investigaciones Biológicas “Alexander von Humboldt”. Bogotá, 100 p.

Webb, G., Manolis, J. W. and R. Buckworth. 1982. *Crocodylus johnstoni* in the McKinlay river area, N.T. I. Variation in the diet, and a new method of assessing the relative importance of prey. *Aust. J. Zool.*, 30: 877-899.

Woodward, A., White, J. H., and S. B. Linda. 1995. Maximum size of the American alligator (*Alligator mississipiensis*). *Journal of Herpetology*, 29 (4): 507-513.

Glossary

- "**Babilla**" or **spectacled caiman**: American caiman characterized by the prominent scale present over their eyes. Males can reach sizes of up to 275 cm. They inhabit a variety of aquatic environments in the lowlands of Central America, the Pacific basins of Colombia and Ecuador, Caribbean basins, and basins of the Orinoco and the Amazon up to northern Bolivia. Scientific name: *Caiman crocodilus*. Synonyms: "baba", "caimán de anteojos", "lagarto", "yacaré blanco" and "yacaré tinga".

- "**Bagre**": Generic name given to a large number of leather fish (lacking scales) of the Siluriformes Order known as "catfish" that can reach considerable sizes. They are mainly present in South American rivers.

- **Bongo Boat**: A long slender metal boat used in the Colombian Llanos, with a flat bottom that curves laterally, and outboard motor. It is used in river navigation for fishing and transporting goods.

- "**Cachirre**" or **dwarf caiman**: Popular term usually used to refer to two species of small alligators (*Paleosuchus palpebrosus* and *P. trigonatus*) that inhabit streams of forested areas of the Orinoco and Amazon basins. It is also used to refer to the spectacled caiman (*Caiman crocodilus*).

-"**Cafuche**" or **white-lipped peccary**: Dark-furred American wild pig that has a lighter colored spot on its jaw area. Scientific name: *Tayassu peccari*. Synonyms: "Coyámel", "tropero", "báquiro" and "pecarí labiado".

- "**Caimanero**" or **crocodile hunter**: Person engaged in the hunting of crocodiles. The term was applied especially during the period of successful exploitation in the second half of the twentieth century (1930-1960´s) in the Orinoco Llanos.

- "**Cajaro" or red-tailed catfish**: Fish of the Siluriformes (catfish) order that is black on its dorsal side down to its lateral midline. This species can exceed one meter in length. It feeds on fish, crustaceans and bivalves, and is well distributed throughout the water courses of the Orinoco basin. Scientific name: *Phractocephalus hemiliopterus*.

- "**Caño**" or **creek**: Tributary characteristic of the Llanos, whose seasonal flow picks up and canalizes the outflow water from rivers, ponds and other "creeks".

-"**Caricare**" or **northern crested caracara**: Bird of prey of the Falconidae family, that is an opportunistic predator and scavenger, and is widely distributed from southern Florida to southern Argentina. Scientific name: *Caracara cheriway*. Synonyms: “Carcaña”, “carraco” and “carancho”.

- **Crocodilian**: Term used to refer to the species belonging to the Order Crocodylia: alligators, crocodiles, caimans and gavials.

- **Crocodilid**: Term used to denote species belonging to the Crocodylidae family, which encompasses all true crocodiles.

- “**Charapa**” or “**arrau” turtle**: Freshwater turtle that has a carapace length of up to 90 cm. It’s carapace is dark gray-brown and of a flattened shape with expanded posterior margins. It has a dark colored head, with a pair of lemon-yellow spots present in offspring; these spots remain present in adult males. It is found in water bodies of the lower and middle Orinoco and Amazon basins. Scientific name: *Podocnemis expansa*. Synonyms: “Charapa”, “tortuga” and “tartaruga da Amazônia”.

- “**Chigüire**” or **capybara**: Large-sized aquatic American rodent, whose distribution ranges from southern Panama to northern Argentina. Scientific name: *Hydrochoerus hydrochaeris*. Synonyms: “capibara”, “carpincho” and “piro piro”.

-“**Chiriguare**” or **yellow-headed caracara**: Bird of prey belonging to the Falconidae Family, with light-yellow colored plumage on its head, a dark-brown chest, belly, wings and back, and a dark line feature that runs from the back part of its eye to the back of its head. Scientific name: *Milvago chimachima*. Synonyms: “Chimachima” and “caricare bayo”.

-“**Galápaga**” or **savanna side-necked turtle**: Freshwater turtle with a carapace length of up to 23 cm and a brown head that lacks spots at the adult stage. It prefers to inhabit lakes, streams, ponds and gorges of savanna areas. The species is endemic to the Colombian and Venezuelan Llanos. Scientific name: *Podocnemis vogli*. Synonyms: “Sabanera”.

- “**Gallinazo**” or **black vulture**: American vulture covered in black plumage. Its head and neck lack any sort of plumage but are uniformly colored. Of a scavenging nature, its distribution ranges from the United States to southern Argentina. Scientific name: *Coragyps atratus*. Synonyms: “Chulo”, “zopilote”, “cuervo” and “sucha”.

- **“Garza tigre**” or **rufescent tiger heron**: Robust heron with an ochre-colored feathered head, neck and chest, a medial white stripe on its neck and a yellow beak. Its distribution ranges from southern Mexico to the north of Argentina and Uruguay. Scientific name: *Tigrisoma lineatum*. Synonyms: “Pájaro vaco”, “vaco colorado”, “hoko vaka” and “socó-boi”.

- "**Garzón soldado**" or **jabiru**: White bird of the Ciconiidae Family. It has a long, wide sturdy black bill and a red-colored band around its neck. Individuals of the species can be as tall as 1.40 m. Its distribution ranges along lowlands from southern Mexico to Argentina and Uruguay. Scientific name: *Jabiru mycteria*. Synonyms: "Tuyuyú", "tuiuiú", "bato" and "gaván".

- **Guabina river fish**: Carnivorous fish of the Characiformes Order that has a cylindrical robust body and a large mouth. Considered to be very voracious, this fish inhabits water bodies in areas ranging from the southern United States to the Plata basin (Argentina, Uruguay). Scientific name: *Hoplias malabaricus*. Synonym: "Tarehui", "traira", "tarey" and "tararira".

- **Guahibo**: Indigenous people or ethnic group, originally nomadic, also known as "Sikuani", that inhabit the Orinoco Llanos, mainly the areas between the Meta, Guaviare, Orinoco and Manacacías rivers in Colombia. They are less numerous in Venezuela.

- "**Güío**" or **anaconda**: Constrictor snake that can reach 6 m in length. It inhabits the lower regions of the Orinoco and Amazon Basins. Scientific name: *Eunectes murinus*. Synonym: "Culebra de agua".

- "**Madrevieja**" or **oxbow lake**: Bend or curve of a river that has ceased to form part of the main course, but which is still connected to it when water levels are high.

- "**Mato**" or **gold tegu**: American lizard that can reach a total length of up to 1.5 m, it is an important predator of reptile eggs. Its distribution ranges from Venezuela and Colombia to the north of Argentina. Scientific Name: *Tupinambis teguixin*. Synonyms: "Lagarto overo" and "tejú overo".

- **Morichal**: Plant community dominated by the presence of "moriche" palms (*Mauritia flexuosa*), which are found in low, swampy or flooded terrains.

- **Agouti** or "**Ñeque**": Medium-sized rodent (35 cm) (*Myioprocta* sp.). The name "ñeque" may also be applied to the Genus *Dasyprocta* (see also "picure").

- **Odonate**: Predator insect that has a long thin abdomen and four membranous wings.

- "**Oso palmero**" or **giant anteater**: It's the largest species of anteaters with a long snout, no teeth, and a thick bushy tail. It feeds mainly on ants and termites. It is widely distributed across the Central and South American lowlands. Scientific name: *Myrmecophaga tridactyla*. Synonyms: "Jurumi" and "oso bandera".

- “**Payara**” or **saber-toothed tiger fish**: Fish of the Characiformes Order that has a long silver-colored body and large mouth with large, elongated and conical-shaped teeth, including two fangs of the lower jaw. It lives primarily in the Orinoco basin. Scientific name: *Hydrolycus armatus.*

- “**Picure**” or **agouti**: Medium-sized rodent (50 cm) whose Neotropical distribution is that of the Genus *Dasyprocta*.

- “**Poyata**”: Steep sloped fine sand beach which flattens out in its higher elevations. They tend to be located on the banks of ”caños” or creeks.

- “**Pozo**” or **well**: Name given to the deeper area of a river or gorge. It is usually located on the bend or curve of a watercourse.

- **Riparian**: Term referring to riverine vegetation.

- “**Saíno**” or **collared peccary**: Dark-furred American wild pig that has a white collar shaped mark at the base of its neck. Scientific name: *Pecari tajacu*. Synonyms: “Chácharo”.

- “**Soche**” or **grey brocket**: Medium-sized deer of a gray to red color whose distribution ranges from southern Mexico to northern Argentina. Scientific name: *Mazama gouazoupira*. Synonyms: “Urina” and “guazu vira”.

- “**Solapa**”: Cavity excavated by caiman and crocodiles on the extended banks or ravines of rivers and streams. It is usually used as protection from the summer heat.

- “**Terecay**” or **yellow-spotted amazon river turtle**: Freshwater turtle measuring up to 40 cm in carapace length, with a dark colored head with yellow or yellowish-orange spots in young and adult males. It lays its eggs in sandy or clay substrates. It is found in the basins of the Orinoco, the Amazon and Essequibo rivers. Scientific name: *Podocnemis unifilis*.

- “**Valentón**” or **Goliath catfish**: Fish of the Order Siluriformes (catfish) whose back is generally grey-colored. They feed on other fish and are found in the channels of the large rivers of the Orinoco and Amazon Basins. Scientific name: *Brachyplatystoma* sp. Synonym: “Laulau”.

Acknowledgements

Countless people and institutions made this book, as well as the larger conservation project, possible. As such, the authors and all the members of the Asociación Chelonia would like to use this space to thank each one for their selfless help.

To the Corporación Autónoma Regional de la Orinoquia (Corporinoquia), which lent us all of their support and made it possible to carry out the fieldwork with the Orinoco crocodiles in Colombia. We especially thank its Management, as well as Enrique Luna, sub-director of Control and Environmental Quality, Luz Dersi Rodríguez, regional director for the department of Vichada, Lina González, regional director for the department of Arauca, Ricardo Antonio Combariza and Óscar Cuesta, technical staff at the headquarters in Yopal, and Yolima García, technical staff at the Arauca branch.

We thank the Fundación Biodiversidad of the Spanish Ministry of Environment and Rural and Marine Affairs, as the institution which allowed us to initiate the Orinoco crocodile conservation project, and especially its director, Ana Leiva, and project coordinators Elena Sancho and Irene Sicilia.

To the Fonds de Dotation pour la Biodiversité, whose "Save Your Logo" program has provided us with indispensable support from the beginning. A special thanks to Olivier Chiabodo, Antoine Cadi, Bernard Limal, Christian Marguet, Patrice-Loup Rifaux, Claudine Offermans and Elena Bulmer for their help. To the Lacoste company, which contributed significantly to make this conservation project possible, and especially to its president Michel Lacoste, who personally travelled to Colombia to participate in the project planning.

To Jesús Eugenio Henao Sarmiento "Chucho", executive director of the Corporación Áreas Naturales Protegidas (ANP), for his friendship and continuous support of this and other Asociación Chelonia projects in Colombia.

To Sergio Arturo Medrano Bitar, representative in Colombia of the Crocodile Specialist Group of the International Union for Conservation of Nature (IUCN), for supporting the Asociación Chelonia's crocodiles conservation initiatives.

To the Barragán family, for their warm welcome and help in carrying out the tasks in the La Aurora Natural Reserve. To Myriam Lugo Rugeles, for her advice and information on the Orinoco crocodile. To the Fundación Omacha, and especially Fernando Trujillo, Gloria Clemencia Amaya, Federico Álvarez, Valentina Villegas, Patricia Falla and Félix Jacinto Terán. To Alejandro Siblesz for his company and guidance in Puerto Carreño, and to Juan Llano and Emilio Constantinofor their invitation and attention in Mururito.To Mario Garcés, for his enormous contribution to the project and excellent photographs.

To the Ministerio de Ambiente, Vivienda y Desarrollo Territorial, and especially to Claudia Rodríguez, for her efforts carried out within the Programa Nacional de Conservación del Caimán Llanero (National Conservation Program for the Orinoco Crocodile) in Colombia. To María Cristina Ardila, director of the Estación de Biología Tropical "Roberto Franco" (Universidad Nacional de Colombia), and to Willington Martínez-Barreto and Robinson Manuel Suárez-Daza, for their help in the EBT "Roberto Franco" and EstaciónPiscícola La Terraza (Villavicencio). To the Estación Wisirare and the Gobernación of Casanare, for their collaboration with the project. To the Bioparque Los Ocarros of Villavicencio, for the opportunities and support given to us. To Jorge Londoño and Alejandro Olaya, for their attention, support and means provided in the Palmarito-Casanare Natural Reserve. To Ana Diva, Jairo Rincón, Alberto Beltrán and Richard, our companions in Cumaribo and the boat trips along the Vichada River.

Thanks to the members of the Asociación Chelonia Ana Fidalgo, Óscar Sanz, Miguel Aguilar, David Burrueco and Sebastián Bitón, for their help. Likewise, we thank Paloma Troya and José María Galán for their important contributions to the revision of the texts. We are grateful to Rebecca Greenberg for contributing to the revision of the texts in English. We thank J. M. Galán and the rest of the people who contributed photographs to the book: M. Rivas, M. Camacho, P. Mejía and J. M. Arcos. And to the Museo Nacional de Ciencias Naturales in Madrid, for giving us a place to make our official presentation of this project in Spain.

To all those people who helped transport us, gave us information, accompanied us or took us in during our different trips and excursions through the Llanos ecosystems and landscapes. A special thank you to the Cárdenas Torres family; the hospitality of doña Alejandra and don Evangelista for all the members of the project is invaluable. The authors would also like to express their gratitude to the different institutions, communities, fishermen's associations and community-based organizations and to all those who have supported the realization of this project.

The irrational use of natural resources and the loss of biodiversity are global problems, but they are especially relevant to tropical regions.

The extinction of life forms has accelerated dramatically in the last few decades and today many species are severely threatened. The Orinoco crocodile (*Crocodylus intermedius*) is, undoubtedly, one of these species.

Listed as "Critically Endangered" by the International Union for Conservation of Nature (IUCN), the Orinoco crocodile has suffered devastating declines since the 1930s. More concrete measures must be taken to preserve the meagre remaining populations of the species over its wide range of distribution, which spans the Colombian and Venezuelan Llanos within the Orinoco Basin. This book, which was produced under the framework of the conservation project that the Asociación Chelonia has been implementing since 2010, serves as a contribution to the significant efforts by other public and private organizations working towards the conservation of the species.

Fundación Biodiversidad

SAVE YOUR LOGO

CDF Conservación y Desarrollo Forestal

CORPORACION ANP AREAS NATURALES PROTEGIDAS

ISBN: 978-84-615-8223-5 - Depósito Legal: M-15547-2012