

RECENT INVESTIGATIONS INTO THE STATUS OF ORINOCO
CROCODILES IN VENEZUELA

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I. Project Background

The Orinoco crocodile (Crocodylus intermedius) is a large riverine crocodile found in the middle and lower sections of the Orinoco river drainage in Colombia and Venezuela. Accounts written by early explorers and naturalists reveal that the Orinoco crocodile was at one time very abundant throughout this region, particularly in the low-lying llanos savanna habitat where crocodiles were one of the most characteristic faunal elements (Appun 1871, Gumilla 1741, Humboldt 1860, Paez 1868). Crocodiles were greatly feared for their size, carnivorous habits and, at times, aggressive nature and consequently were killed whenever possible. Nevertheless, crocodiles remained abundant in the Orinoco basin through the first two decades of the twentieth century.

Beginning in the late 1920's, widespread hunting of Orinoco crocodiles started in the llanos. Fueled by the European demand for crocodile hides a well organized, large scale commercial harvest quickly decimated crocodile populations throughout Colombia and Venezuela. The total number of crocodiles killed will never be known accurately, but prior to 1950, an estimated 2-4 million crocodile skins were exported from the two countries (Thorbjarnarson 1987). Commercial trade in Orinoco crocodile hides began to decline in the 1940's as crocodiles became increasingly scarce, and hunters were forced to search in more remote areas. The organized hide industry eventually disappeared in the 1950's due to the scarcity of crocodiles, but opportunistic poaching of crocodiles continues to this day.

Despite the cessation of commercial hunting some 30 odd years ago, little or no significant crocodile population recovery has occurred. Rather, populations continue to decline in most regions

due to direct human-related mortality or indirectly via habitat destruction. Crocodiles are still viewed with great trepidation by most campesinos and are killed when they are seen as a threat to local people or their livestock. Additionally, crocodiles drown in illegally set seine or gill nets, or are shot simply for "sport," or to sell their hides. In many parts of the llanos, agro-industrial expansion is leading to significant habitat deterioration. Complete habitat loss, via draining or river channelization is also a severe problem for at least one major crocodile population (Rio Cojedes/Sarare; J. Ayarzagüena, pers. comm.).

Although Orinoco crocodile populations were for some time known to be severely depleted, few data were available to assess population status or trends. The first large-scale attempts to evaluate population levels began in the 1970's. Surveys in both Colombia (Medem 1981) and Venezuela (Godshalk 1978, 1982) found crocodiles to be extremely rare or completely absent from large parts of their former range. In 1984, the Orinoco crocodile was placed on the list of the world's 12 most endangered species of animals by the International Union for Conservation of Nature and Natural Resources (IUCN). This paper will summarize the current known status of Orinoco crocodiles in Venezuela, and outline some of the conservation work currently in progress. Information presented here is based largely on published accounts and our own survey work in the Venezuelan states of Guarico, Aragua, Apure, Bolivar and Portuguesa during the period 1985-8.

II. Historical Distribution in Venezuela

The former distribution of the Orinoco crocodile in Venezuela included the Orinoco river and virtually all its major tributaries in the llanos. Crocodiles also extended far up many llanos rivers and into surrounding piedmont areas in the foothills of the Andes (e.g. Rio Tucupido, Portuguesa state) or the Venezuelan coastal range (e.g. Rio Guarico). Crocodiles also inhabited the Orinoco floodplain regions of most of the southern Orinoco tributaries and in some cases extended into the heavily forested Guyanan shield region of southern Venezuela (e.g. the Rio Caura).

The upstream and downstream limits of distribution of crocodiles in the Rio Orinoco remain somewhat problematical. Crocodiles are known from as far upstream as the Rio Ventuari and some reports indicate that scattered individuals may occur farther upstream. Crocodiles never extended into the upstream sections of the Orinoco or the Casiquiare (and then into the Rio Negro-Amazon) drainage is unknown and has been a source of speculation ever since the days of Humboldt (1860).

Although one of the common names of C. intermedius is the Orinoco Delta (or Venezuelan Delta) crocodile, very little information exists concerning its presence in the Orinoco delta region. Large crocodilians have been seen in the delta, but their specific identity could be either C. acutus, C. intermedius, or even Melanosuchus niger (S. Gorzula, pers. comm.). Four C. intermedius (male/2 female) were collected from the upstream delta region in 1959.

(Ramirez et al. 1977). Also unconfirmed reports indicate that crocodiles held in private homes in Tucupita (in the upper Delta) are all C. intermedius (E. Cartaya, pers. comm.).

III. Present Status and Distribution

Beginning in 1985 investigations sponsored by FUDENA (Fundacion para la Defensa de la Naturaleza) were initiated to determine the present status and ecology of remaining Orinoco crocodile population in Venezuela. The objectives of the the study were threefold: 1) determine the present status of Orinoco crocodiles in Venezuela, 2) investigate conservation-related aspects of the ecology of the species in the wild and under captive conditions, and 3) develop recommendations for a national conservation program. This work has been done in conjunction with Dr. Jose Ayarzagueno of the Fundacion La Salle de Ciencias Naturales who has surveyed the Rio Cojedes crocodile population as well as other rivers in the states of Potuguesa and Cojedes. Dr. Ayarzagueno's investigations are still in progress and will be reported on elsewhere. Financial support for our work has been generously provided by FUDENA, World Wildlife Fund, the World Wide Fund for Nature, the New York Zoological Society, and Tomas Blohm.

Methods

Several methods were used to compile information on crocodile status and distribution. Due to limitations of time, and the large area involved, detailed site-specific censusing was only feasible in a few areas. Information was principally obtained via: 1) interviews with llanos residents familiar with the llanos fauna, 2) on-site visits to areas and interviews with campesinos, 3) daytime boat or foot surveys of habitat, 4) nocturnal spotlight censuses from a boat, and 5) aerial surveys from fixed-wing aircraft.

During nocturnal surveys data on the sympatric Caiman crocodilus were also collected. The presence of numerous Caiman made censusing more difficult and necessitated a close approach (generally <5 m) in order to distinguish the two species. Large-scale censusing of rivers and reservoirs was done from a small fixed-wing aircraft. Aerial surveys were flown during the dry season of 1986 (18-22 April, total 42 hours flying time), 1987 (13,31 March, 1, 14-17 April, total 47 hours flying time), and 1988 (1-5 March, total 25 hours flying time) over areas known to, or suspected to have crocodile populations. The 1986 surveys were flown in a Cessna 170-B, in 1987 using a Cessna 172 or 206, and in 1986 with a Cessna 180. Flight speeds were 150-170 km/hr, and surveys were flown at an altitude of 75-150 m. Crocodiles were usually spotted basking on shore although some were seen in shallow water, or swimming or floating in open water. Surveys were timed for the peak basking periods of the crocodiles (0800-1000 h, 1500-1700 h), although in some cases censuses were extended until 1100 h, or began at 1315 h. Two spotters were present during all surveys. The locations of all crocodiles was noted along with an estimate of total length, notes on habitat, as well as other species of importance (Caiman, dolphins and

otters). The majority of areas surveyed by airplane were chosen based on the likelihood of having crocodiles, and so represent some of the best areas remaining in Venezuela.

Results

Rio Orinoco

The river from which *C. intermedius* gets its common name is at present essentially devoid of crocodiles. The Orinoco was one of the first areas hunted out by the caimaneros during the 1930's, and little or no population recovery has taken place. The river is heavily utilized as a transportation route, and most of the riverbanks and major mid-channel islands are settled or used for agriculture. Continued hunting or incidental mortality has effectively kept crocodile populations low. During aerial surveys for crocodiles in 1986 (560 km of river), and 1987 (45 km) no crocodiles were seen (Thorbjarnarson et al. in press; Table 1). However, crocodiles were sighted basking in two separate locations during aerial surveys for manatees in March 1986: near La Sardinia (Edo. Anzoategui, 7 adult crocodiles on two adjacent mid-channel islands), and just west of Borbon (Edo. Bolivar, two crocodiles on south river bank; O'Shea et al. 1986).

Comments received during interviews also suggest the virtual disappearance of crocodiles from the Orinoco. Nevertheless, certain sections of the river were said to still have small populations. Among these were the region between the mouths of the Rio Apure and the Rio Arauca, especially near Isla Cabure, and in the vicinity of Las Bonitas (Edo. Bolivar). Crocodiles are also still seen occasionally in the Orinoco near Puerto Ayacucho (Amazonas Terr.). Two captive crocodiles in Puerto Ayacucho (FONAIP station) and one San Fernando de Apure are reportedly from the Puerto Ayacucho region. Additionally, a 4 meter crocodile was captured alive in a fishing net (and later sold) in the Orinoco near the mouth of the Rio Parguaza in June 1986 (pers. obs.). These data suggest that crocodiles may still be found at very low densities in parts of the Orinoco.

Apure State

Apure state (76,500 sq. km) is centrally located in the low-lying western llanos region, and is bounded by the Rio Apure, the Orinoco, and the Rio Meta. Most of the state is still sparsely inhabited (mean density 2.2/sq. km), with the majority of the population located along the Rio Apure. Crocodiles were seen, or reported from a number of rivers in this state, usually in very low numbers. However, by far the most important crocodile population remaining in Apure, and one of the largest remaining anywhere, is the Rio Capanaparo, a moderate sized river that runs over the nutrient poor aeolian llanos region south of the Rio Arauca. A thin strip of gallery forest borders the river and its many associated oxbow lakes. Aerial surveys in 1986, 1987 and 1988 revealed a relatively healthy crocodile population upstream of Macanilla, and downstream of the Rio Riecito (188 km). The Capanaparo provided nearly ideal conditions for performing aerial surveys. The river

broad enough to allow one observer on each side to cover virtually all potential basking beaches. The river did not have extremely sharp meanders, nor heavy overhanging forest cover, and perhaps most importantly, the virtual absence of boat traffic meant that a sizeable portion of the crocodile population could be expected to be out basking during the mid-morning hours 0800-1000 h. Small crocodilians were difficult to spot from the airplane, and no crocodiles less than 1.0 m total length were observed.

Differences in mean density values of crocodiles spotted (Table 1) result from surveying different sections of the river, and to a lesser extent during different times of the day. The initial 1986 survey covered the majority of the Capanaparo in Venezuelan territory (445 km), and was done partially during afternoon hours when a smaller fraction of the population is basking. The 1987 and 1988 surveys were conducted only during the morning basking peak and concentrated principally on the middle river sections where the highest crocodile density was found. Crocodile densities varied greatly between river sections with the greatest concentration being found in a 25 km stretch between Cano Amarillo and San Luis (section 3; Table 2). Nocturnal spotlight counts conducted along this same stretch of river were made during February and April 1987, and again in January and May 1988. The highest observed non-hatchling crocodile density (1987) was 1.64/km with the maximum number of non-hatchlings counted on any one survey being 41 (Table 3).

Based on data from the aerial and nocturnal spotlight counts the total non-hatchling crocodile population in the Rio Capanaparo, its major tributaries and oxbow lakes was estimated to be approximately 500 (Thorbjarnarson 1987).

A low density of crocodiles was also found in the neighboring Rio Cinaruco during aerial surveys in 1986 and 1988 (Table 1), however nocturnal counts along the lower and middle stretches of the river revealed only Caiman (non-hatchling densities: river 3.25/km; oxbow 8.36/km plus one Plaeosuchus palpebrosus). Based on interviews with local residents the Rio Claro, a small river located to the north of the Capanaparo, also has a remnant crocodile population. Aerial surveys of this river failed to locate any crocodiles. However most of the crocodiles in this river were reported to aestivate during the dry season.

Portuguesa State

One river in Portuguesa state was surveyed, the Rio Tucupido. The Tucupido crocodile population was unknown to science until 1980, when crocodiles were discovered there accidentally by ichthyologists. The Tucupido is poor crocodile habitat in the classical sense, being a small piedmont river draining the foothills of the Andes just to the northwest of Guanare, the capital of Portuguesa state. However, a small but locally dense crocodile population (Ramo and Busto 1986) has managed to survive, principally because the region has remained very isolated until recently. The river has recently (September 1988) been dammed to form a reservoir.

Two aerial surveys were flown over the Tucupido, prior to closure of the dam, on consecutive days in 1986 (Table 1). The maximum number of crocodiles spotted was 19, which over a survey

length of 31 kilometers represents a density of 0.613 crocodiles/km, the highest aerial survey density found during this study. Eight days after the aerial survey, a nocturnal census of 7.2 km of river revealed a density of 1.34 juvenile crocodiles per km. The total non-hatchling crocodile population in the river above the site of dam construction is estimated to be approximately 100. Extensive sandy beaches are present and provide good nesting habitat. One recently hatched nest was found, and a total of 14 hatchlings counted in the river next to an attending adult.

A number of crocodiles have been killed in the Tucupido during the last several years. Because the river level drops sharply during the dry season, crocodiles in the Tucupido dig burrows into the river bank and become vulnerable to hunters who pull them out of the dens. This type of poaching will no longer be a problem with the flooding of the reservoir. However, the change from a riverine to a lentic habitat may create a habitat better suited for Caiman than for crocodiles (see below).

The Rio Cojedes/Sarare system found in neighboring Cojedes state and partially in Portuguesa contains one of the largest remaining Orinoco crocodile populations in existence. Although it is located in an area being developed for agriculture, and in a very polluted river, this population has managed to survive. Crocodiles were first reported from this region by Godshalk (1978, 1982), and the population is currently under investigation by Dr. Jose Ayarzagüena of the Fundación La Salle de Ciencias Naturales.

Guarico and Arauca States

The Rio Guarico is a medium sized turbid water river draining a section of the north-central llanos region and adjacent southern slopes of the coastal mountain range. Water level now varies some 3-4 meters on an annual basis, and an extensive deciduous-mesofil forest fringes the river for much of its course. Initial information suggested that crocodiles were found in at least three parts of the Rio Guarico, two of which were reservoirs (Embalse de Camatagua, Arauca state; Embalse de Guarico, Guarico state). The other "population" is located in the Caño Rabanal/Caño El Caballo, through which the Rio Guarico now runs because of a change in river course approximately 30 years ago.

The Camatagua reservoir was formed in 1969 by damming the Rio Guarico near Camatagua. The river flooded back into a hilly, piedmont area forming a reservoir bordered by steep hillsides, with occasional lower, swampy regions near the entrances of tributary streams. An extensive fringe of semi-floating vegetation (mostly Chara) is found around the lake.

Crocodiles were seen in the Embalse de Camatagua during surveys in 1986 (13 seen) and 1987 (6 seen). Most crocodiles were observed "basking" atop the fringe of floating vegetation, where sunlight would rapidly heat the water. Two nocturnal spotlight counts (10 June, 3 December 1986) along 19 km of shoreline revealed a very high Caiman density (16.1/km; 12.6/km) but very few crocodiles (0.05/km, and 0.00/km). One nest site was located, in a steep talus/soil slope, and 25 hatchlings and one adult crocodile were seen nearby (the only non-hatchling crocodile seen during nocturnal surveys).

Additional nesting activity in the Camatagua reservoir was reported by Blohm (1982). Although more survey work needs to be done to better estimate population size, the number of non-hatchling crocodiles in the Camatagua reservoir in all likelihood numbers more than 50. Other than sport fishing and a few picnicing areas the reservoir is not heavily used by people. Nevertheless, over the last 10 years several crocodiles have been killed both in the reservoir, and in the Rio Guarico just below the dam.

Crocodiles have also been reported from the large, shallow Guarico reservoir near the town of Calabozo and from downstream sections of the Rio Guarico, most notably in the Cano Rabanal. No crocodiles were observed during aerial surveys for crocodiles in the Guarico reservoir, but aerial and nocturnal surveys have confirmed the presence of a small crocodile population in the Caño Rabanal area. Recent reports have also suggested that crocodiles are now being seen at irregular intervals in the river section between the Rabanal and the Guarico reservoir.

The Rio Orituco is a small tributary of the Rio Guarico that feeds into the latter river just southeast of Calabozo. Recent reports indicated that despite the close proximity to a major town, crocodiles were still found in parts of the Orituco. Like many smaller rivers, the Orituco dries up into a series of interconnected, or isolated pools (charcos) during the dry season (December-April). One charco was surveyed at night on 14 May 1987. Over a total length of 2.3 km, 2 small adult or subadult crocodiles (2-2.5 m TL) were observed. Only three weeks previous to the survey, another crocodile (2.6 m TL, female) had been captured alive and taken from this area. Local residents also say a large crocodile (4-5 m TL) is seen in the same area.

A small population of crocodiles has also been reported from the Rio Chirgua, a small-medium sized, turbid water river that runs through a heavily forested region along the border between Guarico and Cojedes states. The area has been relatively isolated until recently, and wildlife is still fairly abundant in many places. Crocodiles were reported in this river both by personnel from Hato Pinero in Cojedes, and Hato El Tigrillo in Guarico state. Several large crocodiles were reportedly seen in the river in 1982 by the owner of Hato Tigrillo and one large male (5 meters) was shot and the skin and skull preserved. The river has densely forested banks and so aerial surveys were impractical. Many sections of the river are impassable by boat due to blocking emergent vegetation and tree trunks. However, a number of river sections are navigable for short sections and one such section (3.5 km long) was surveyed in 1985 and 1986. Although local residents say that crocodiles are seen in this stretch of river, none were observed during the night census. The surveys did reveal a very high Caiman density (52.3/km).

Bolivar State

Bolivar state covers a large (238,000 sq. km), sparsely inhabited (1.7 inhab./sq. km) region south of the Orinoco river. Habitats range from open savannas along the Orinoco, to dense tropical rain forest. The region of the state outside the floodplain

of the Orinoco river was never considered good crocodile habitat. Nevertheless, small crocodile populations have been noted from some rivers most notably in the Rio Caura, a large blackwater river that drains the western Guyanan shield region of Bolivar state. The presence of crocodiles in the Rio Caura remained unknown to science until the early 1980's (Franz et al. 1985). Crocodiles were not thought to inhabit blackwater, nor swift flowing rocky rivers, both of which well characterize the middle section of the Caura where the crocodiles have been seen. The Caura was surveyed twice by airplane in 1986, once each during crocodile and manatee surveys. Both surveys observed only 4 crocodiles (0.016/km), all located upstream from the town of Las Trincheras. These results appear to indicate a decline from the 1982 aerial surveys conducted by Franz et al. (1985). A survey of the river was also made by dugout canoe between 23-27 March 1987. Due to the rocky nature of the river and the presence of numerous rapids, night surveying was difficult. During two nocturnal boat surveys, covering a total of 6 km of river, only one crocodile was spotted (0.17/km), a 1-1.5 m TL juvenile seen near the base of the Salto Para. These falls form the upstream limit to crocodile distribution on the Caura. A low density Paleosuchus trigonatus population is also found in the main Caura, but interestingly only adult males were seen. An additional 7 km of the Rio Nichare, a clearwater tributary were surveyed at night, but only Caiman and Paleosuchus were observed.

The Cuchivero is the next major Orinoco River tributary to the west of the Caura. It is a smaller, clearwater river that courses through some 150 km of lowland savanna before entering the Orinoco. Aerial surveys of the lower 140 km of the Cuchivero failed to reveal any crocodiles. The possible presence of crocodiles in this river, and the Rio Guaniamo (a major Cuchivero tributary) was suggested by Sr. Nouble Seguias of Caicara. Sr. Seguias had one 2.2 m TL female crocodile in captivity that reportedly came from the Cuchivero. The upper regions of the Guaniamo are being extensively mined, and the waste from these operations has severely polluted the Guaniamo as well as the downstream section of the Cuchivero.

Amazonas Territory.

Amazonas territory is a vast (175,750 sq. km), virtually unpopulated (0.1 inhab./sq.km) region in southernmost Venezuela, bordering Brazil and Colombia. The territory contains the headwaters of both the Rio Orinoco and the Rio Negro, a major blackwater Amazon tributary. The two drainages are interconnected by the Brazo Casiquiare. No survey work was done specifically in Amazonas territory. However, in 1986 2 crocodiles were spotted in the Rio Ventuari during aerial surveys for manatees (O'Shea et al. 1986). Informants in Puerto Ayacucho stated that crocodiles are still seen in the Rio Orinoco near Pto Ayacucho, and also in the Rio Ventuari.

Delta Amacuro

The only survey work of the Orinoco delta region was 18 hours of aerial surveys flown looking for manatees in 1986. During these surveys, observers were also looking for crocodiles. Most of the

major caños within the delta were covered, but no crocodiles were spotted (O'Shea et al. 1986).

IV. Factors Limiting Crocodile Population Recovery

A combination of factors is probably responsible for the failure of Orinoco crocodile populations in Venezuela to recover, despite the cessation of extensive commercial exploitation some 30 years ago. A clear understanding of these processes is of the utmost importance for planning a recovery program. Below is a discussion of what we view as the most important of these factors, segregated into those that can and cannot be directly related to human influence.

A. Human-Related Factors

Intentional Killing

Despite the collapse of the commercial hide industry in the late 1940's and 1950's, a limited amount of commercial hunting still occurs, mostly on an opportunistic basis. Local people who live along river courses are usually very familiar with the crocodiles and where they may be found. Most are cognizant that a market still exists for skins, and if the opportunity presents itself, they will try to kill crocodiles to obtain their hides. Illegal Caiman hunters of Colombian origin would also take crocodiles opportunistically (Godshalk 1982). The biggest market for hides is apparently through the Colombian town of Puerto Carreno, although some skins are reportedly still purchased in Venezuela in San Fernando de Apure. Apparently, most of the current commercial trade is from the Rio Meta, and to a lesser extent the Cinaruco.

Crocodiles (particularly adults) are often killed for a variety of other reasons: for "sport," because they represent a real or imagined threat to people or livestock, or simply for the sake of killing them. Certain crocodile by-products are occasionally utilized (e.g. teeth which are considered to have magical properties). The subsistence use of crocodile meat is not widespread in Venezuela. Among certain Indian groups, Caiman or Paleosuchus meat is readily eaten, but crocodile meat is not. Although there are exceptions, campesinos do not eat crocodile meat either. However, in many areas crocodile eggs are considered a delicacy. During the early dry season, beaches are frequently checked for turtle eggs (Podocnemis expansa, P. unifilis), and when encountered, crocodile eggs will also be taken. Nest robbing is a major problem in the two largest crocodile populations, the Rio Capanaparo (pers. obs.), and the Rio Cojedes (Godshalk 1978, J. Ayarzagüena pers. comm.), and may be widespread throughout the llanos and other areas where reproductive crocodile populations are found.

Recently there has been an increase in the capture of crocodiles for sale to tourists or local ranchers. In certain areas such as the Rio Capanaparo, hatchling crocodiles are actively sought (mostly by Indians) for sale to tourists from San Fernando, or from the larger northern cities. This illegal commerce has been ongoing for at least a decade, but apparently has intensified in recent years.

Likewise, captured juvenile or adult crocodiles are now also being offered for sale, frequently at exorbitant prices. Adult crocodiles reportedly have been purchased by ranchers in Apure state to keep in captivity on their property.

Accidental Killing

Accidental killing principally occurs by drowning crocodiles in fishing nets. Crocodiles are attracted to fish caught in gill net and will frequently become entangled themselves and drown. Illegal gill or seine nets are frequently used throughout the llanos in the dry season and may take a considerable toll of animals from the few remaining crocodile populations. Crocodiles accidentally caught in seines are usually killed, although recently some crocodiles have been removed alive and offered for sale. In some instances crocodiles that have been accidentally drowned are skinned and the hides sold. This has been reported from the Rio Caura and the Capanaparo.

Deterioration and Destruction of Habitat

The expansion of the human population and agricultural industry in the llanos has led to widespread habitat deterioration and some instances of almost complete habitat destruction. Water pollution caused by town effluent or pesticides are a major problem in several river drainages, most notably in the Rio Portuguesa and the Rio Guarico. The Rio Cuchivero is also contaminated with runoff from several mining operations on the Rio Guaniamo, its principal tributary.

Outright destruction of crocodile habitat represents a grave threat to the Rio Cojedes/Sarare crocodile population. River channelization and the construction of irrigation canals will all eliminate most of the riverine habitat in this area. Furthermore, this river is highly contaminated with sewage from the city of Barquisimeto, and pesticide runoff from the nearby Turen agro-industrial center (J. Ayarzagüena, pers. comm.).

Another form of human-related environmental alteration is the construction of reservoirs. The overall effect of creating reservoirs on crocodile ecology is unclear, but large static bodies of water appear to favor Caiman populations over crocodiles. Reservoirs usually lack sandy nesting beaches and do not have extensive shallow water habitats that the crocodiles prefer. However, reservoirs usually receive less intensive human use and do not expose aestivating crocodiles to human predation as occurs in many small to medium sized llanos rivers during the dry season.

B. Biological Factors

Ecological Replacement by Caiman

At present the spectacled caiman (Caiman crocodilus) is by far the most widespread and abundant crocodylian in Venezuela. However, based on historical accounts of llanos natural history, and

interviews with old crocodile hunters, caiman were much less abundant in the llanos prior to the commercial exploitation of the Orinoco crocodile. Crocodiles were found principally in the rivers and larger streams (caños) and Caiman were usually restricted to isolated lagoons or small caños. Two subsequent events have resulted in a tremendous increase in llanos populations of Caiman: 1) the virtual extirpation of crocodiles, and 2) the expansion of the llanos cattle industry and increased road construction with the associated creation of many new permanent water habitats in the form of dammed caños or borrow pits.

Niche expansion of Caiman crocodilus has been reported from other parts of South America as 1) a consequence of the decline of a sympatric, but more commercially valuable, crocodylian species: Melanosuchus niger in Brazil (Magnusson 1982), Caiman latirostris in Argentina (Muniz Saavedra 1983), or 2) by colonization of newly formed aquatic habitats: (Magnusson 1982). The expansion of Caiman populations along the Venezuelan coast has been attributed to both the near extinction of C. acutus and the creation of new aquatic habitats (Seijas 1986). In the Venezuelan llanos the opening of large amounts of new habitat, combined with the high reproductive potential of Caiman, and human tolerance for its presence has resulted in a great increase in Caiman populations over the last 50 years. Caiman now occupy virtually any sizeable body of water in the llanos including the rivers and large caños, the former habitat of the crocodile. In some areas Caiman densities can reach prodigious levels. Dry season densities of non-hatchlings in some bodies of water may exceed $0.5/m^2$ (500/Ha). Likewise in rivers and reservoirs, Caiman density can be extremely high during the dry season. In the Rio Guarico, wet season density has been measured at 1.24/km (30 July 1986). The corresponding density during the dry season (8 March 1987) was 24.9/km, a 20 fold increase. Caiman densities have been noted to be equally high or higher in other llanos rivers during the dry season: Rio Chirgua 52.3/km, Rio Orituco 22.2/km. In areas where reasonably dense crocodile populations are still found, Caiman densities are lower: Rio Capanaparo-7.27/km, Rio Tucupido-12.5/km. These lower densities may reflect a degree of competition between crocodiles and Caiman or may merely be caused by less favorable ecological conditions for Caiman in the river and surrounding area. Likewise, Caiman densities in reservoirs are high, but do not change as much on a seasonal basis: Camatagua reservoir, low water-16.1/km, high water-12.6/km.

The high densities of Caiman in crocodile habitat may have negative effects on crocodile population recovery via two mechanisms: 1) ecological competition for limiting resources (food, preferred habitats), or 2) the predation of hatchling or young crocodiles by larger Caiman. Few data exist indicating what, if any, ecological resources are limiting crocodylian populations and what form interspecific competition may take. Former niche partitioning between crocodiles and Caiman in the llanos was apparently partially along habitat lines. The crocodiles inhabited the rivers and larger caños, while the Caiman were relegated to the smaller, more ephemeral savanna wetlands. Presently, in areas where small numbers of crocodiles still exist in rivers or reservoirs, they live among dense Caiman concentrations during the dry season. Once crocodiles reach

adult size, they are larger and behaviorally dominant over Caiman. However competition for resources may be occurring, especially among the smaller size classes. Perhaps the two most important resources under these circumstances are food and space. However, few specific data exist for the llanos. A recent study by Seijas (1988) for a similar situation with C. acutus and Caiman along the Venezuelan coast concluded that there exists a high potential for competition between the two species. Seijas showed that there is a high degree of overlap in habitat selection and diet, and found evidence of direct predation by Caiman on hatchling crocodiles as well as crocodile cannibalism. From the results of his investigation Seijas concluded that the population recovery of C. acutus could be delayed by the presence of dense Caiman populations.

Cannibalism is known to occur frequently in dense savanna populations of Caiman (Thorbjarnarson, unpublished data). Along tropical rivers hatchling crocodiles emerge from the nests in the late dry season or early wet season, when water levels are at their lowest. Caiman populations are the most concentrated. This combination of factors results in a high probability that in some areas, hatchling crocodiles will fall prey to Caiman.

In situations such as the Rio Capanaparo, and the Rio Tucupid where reasonably dense crocodile populations still exist and a degree of habitat segregation can be seen, Caiman predation may be of secondary importance. However, crocodiles still exist in many parts of their historical range at extremely low population levels. It has been previously assumed that, under these conditions, density levels were so low that animals could not encounter one another for reproduction (Godshalk 1982). However, it may be equally likely that crocodiles are reproducing amidst the dense Caiman populations, but that little or no recruitment is taking place due to severe first year mortality, in part due to Caiman predation. In these situations we would expect to find senile crocodile populations consisting of few adult crocodiles and few or no juveniles. This appears to be the case in some rivers such as the Guarico and the Chirgua, and may be the rule for crocodile populations in reservoirs where an additional problem is the lack of suitable nesting beaches.

Intrinsic Properties of Population Dynamics

Another biological phenomenon that may slow crocodile population recovery has to do with aspects of the crocodiles natural population dynamics. In several cases where other endangered populations of other species have been protected, population recovery has been relatively slow. This has been the case in southern Florida with the American crocodile (C. acutus) (Kushlan and Mazzotti 1982), as well as in northern Australia with the estuarine crocodile (C. porosus) (Messel et al 1981). This is in spite of the fact that most of the human-related mortality had been effectively controlled, and there was no ecological equivalent of Caiman to occupy the empty ecological niche. In both these cases a complex series of factors were probably involved in the slow recovery. But these examples indicate that population recovery in certain large, long-lived crocodilians may naturally be a slow phenomenon, even under the best of circumstances. The elucidation of the mechanisms at work in these situations will

have to await a better understanding of the population dynamics of crocodilians.

V. Conservation and Management Considerations

Recommendations concerning the conservation of Orinoco crocodiles must address the several principal points: 1) the amelioration of human-related crocodile mortality, 2) protection of habitat, and 3) reduction of non-human related mortality, especially in the hatchling and juvenile size-classes. Further points of critical importance are: 1) further research on crocodile ecology, 2) continued status surveys of the remaining crocodile populations, and 3) addressing the public relations problems that will invariably stem from a plan designed to increase populations of large, potentially dangerous predators.

The complete protection of crocodiles throughout Venezuela is presently an impractical consideration. Most crocodiles are found in remote areas where little or no law enforcement capabilities exist. In many of these areas a frontier-type outlook prevails and convincing people not to kill animals, especially ones they view as dangerous, is virtually impossible. The recovery of crocodile populations in many parts of its historical range will be very difficult because of heavy human usage of llanos rivers, and because of the large Caiman population that has filled the riverine crocodilian niche.

Because of the antipathy of man towards crocodiles, as well as the population expansion and associated habitat deterioration in the llanos region, the long term conservation of Orinoco crocodile populations in Venezuela will depend largely on two factors: setting aside representative areas of crocodile habitat as reserves and providing effective protection in these areas, and the development of sound management programs based on limited economic utilization in certain regions outside of protected areas. Because current crocodile populations are so depleted, the commercial exploitation of wild Orinoco crocodile populations at present cannot be considered even on a preliminary basis. However, the potential for future exploitation can be used effectively as a tool to obtain cooperation, both from the Venezuelan government as well as private industry, to establish an effective conservation program. Closed-cycle farming operations based on captive breeding could be established with the understanding that they are to also play a conservation role in the recuperation of wild populations, either through the release of captive bred specimens or by "headstarting" wild produced crocodiles.

Despite recent concern for the status of the crocodile by many parties, crocodile populations have languished for a lack of concrete programs to aid population recovery. With the exception of a few international and Venezuelan conservation organizations and individuals it has been difficult to obtain support for the protection of Orinoco crocodiles. The spectacled caiman, on the other hand, has received abundant attention from the Venezuelan government as well as private groups owing to its economic potential. The Venezuelan caiman management program has quickly become the premier national crocodilian management program in Latin America.

Many of the same individuals and organizations that are involved in the exploitation of caiman in Venezuela should also be concerned with crocodile conservation in terms of the potential for future utilization of the superior hides produced by these species.

Unless crocodile conservation receives considerably more economic and political support than it has in the past, few major changes can be expected and crocodile populations will continue to dwindle. The most expedient means of achieving more conservation momentum for crocodiles will be to tie crocodile conservation, either directly or indirectly, to the developing Venezuelan caiman management program. This could be accomplished in two ways; either through direct governmental support of crocodile conservation programs from tax revenue derived from the caiman harvest, or with support of private groups such as ASOBABA that have recently formed in order to promote the efficient, long-term utilization of caiman populations. The Venezuelan government should be encouraged to develop an overall management program for all Venezuelan crocodiles instead of one specifically designed for the caiman. In any event considerable increase in in-country support for crocodile conservation (both for Orinoco as well as the American crocodile) needs to be forthcoming before any effective conservation programs can be put into action.

At present the most urgently needed conservation measures are habitat protection and restocking/reintroduction programs. At present no crocodile habitat is effectively protected in the Venezuelan llanos. Only one national park exists, and this park (Aguaro-Guaritico) lacks even a rudimentary park infrastructure for wildlife protection. A recent conservation bright spot in the llanos has been the declaration of the Cinaruco-Capanaparo National Park. This park will include most of the downstream and parts of the midstream sections of these two llanos rivers. In terms of crocodile conservation the Capanaparo is especially important as it contains perhaps the last relatively large crocodile population in an intact habitat. The creation of this park by the Venezuela government should be strongly endorsed. Particular attention should be given the protection of the riverine fauna in the Capanaparo, the Cinaruco and their major tributaries. Besides Orinoco crocodiles, both rivers contain populations of endangered or threatened river turtles (Podocnemis expansa, P. unifilis), giant river otters (Pteronura brasiliensis), and river dolphins (Inia goeffrensis). The lower sections of both rivers may also harbor manatees (Trichechus manatus) on a seasonal basis.

Although inclusion of the Capanaparo in the national park will be a tremendous step forward, it will not in and of itself guarantee the continued survival of the crocodile or other riverine fauna. Restrictions must be placed on the excavation of crocodile eggs, and the capture of hatchlings for sale. Together, these two factors are the most responsible for limiting crocodile population growth in the Capanaparo system. Another major source of crocodile mortality is drowning, or capture in fishing nets. Hence, restrictions on gill and seine netting will also need to be better enforced. The future survival of crocodiles, as well as the other riverine wildlife in the park, will depend on the development and rigid enforcement of a

management program designed to protect the remaining wildlife in the region.

As a potential supplement to the official designation of areas as national parks or wildlife refuges, consideration must also be given to the establishment of private reserves on ranches with conservation minded owners. Much of the llanos is divided up among large cattle ranches where effective wildlife protection could be achieved under private sponsorship. Short sections of rivers or large lagoon could be established as crocodile preserves. Through the work of Dr. Jose Ayarzagüena the first such reserve is now well on the way to being established along a section of the Cano Guaritico in Apure state that borders two large ranches. This area will be used as a release site for crocodiles either bred in captivity, or translocated from the severely endangered Rio Cojedes population (J. Ayarzagüena, pers. comm.).

Other areas outside the llanos need to be considered as well. The Rio Caura has great tourist potential because of its natural beauty and wildlife. The establishment of a park along the Caura could be used to promote tourism and wildlife conservation as well as providing much needed employment for the local Makititare indians. Reservoirs that have been formed in the foothills that form the northern and western boundaries of the llanos should also be given serious consideration as crocodile refuges. Several of these reservoirs are known to have crocodile populations (Camatagua, Tucupido). Although the lentic habitat created by damming these rivers apparently forms less than ideal crocodile habitat, the reservoirs frequently receive little human use and are logistically easier to monitor and protect than are rivers.

Because most areas presently have very low crocodile population densities, habitat protection should also be accompanied by a crocodile restocking program. Where feasible, crocodiles released into an area should be stock reared from eggs produced in that area (headstarting). This could be feasible for areas such as the Capanaparo and the Caura, and to a lesser extent in reservoirs such as Camatagua. However, if sufficient stock cannot be obtained from natural nests in the area, crocodiles produced in captive breeding stations could be used. Currently two captive breeding centers in Venezuela (Hato Masaguaral, and the Universidad Nacional Experimental Ezequiel Zamora in Guanare) are producing and rearing Orinoco crocodiles for future release programs.

An education program designed to minimize potentially dangerous interactions between people and crocodiles will be necessary in areas where the reintroduction or restocking of crocodiles is contemplated. In the Capanaparo region a campaign alerting the local residents and tourists about the dangers of swimming in areas where crocodile are present will be essential. Most residents of the region already are cognizant of the danger and rarely swim in areas frequented by crocodiles. Most tourists that visit the region during the dry season bathe in the small, clearwater tributaries where crocodiles are not present or pass the dry season aestivating in burrows. However, clear measures must be taken to avoid the potentially disastrous consequences of human death resulting from crocodile attack.

An important ingredient in the success of these programs will be the support and active involvement of the local people. This has been one of the principal lessons learned by the Indian crocodile release program (Singh 1987). The banks of the Capanaparo are inhabited by people who utilize crocodiles on a subsistence basis (Yaruro Indians), as well as by campesinos who do not see any need to increase the population size of a potentially dangerous animal. Education, as well as providing economic incentives will make the local people more receptive to the conservation program, and greatly increase its chances of success.

The conservation of the Orinoco crocodile will be a long-term project. Status surveys of crocodile populations and continued research on crocodile ecology will be important ingredients for the success of the program. Population surveys will need to concentrate on two major topics: the location, status and population trends of remaining crocodile "populations" (relatively dense crocodile concentrations), and the extent of low-density crocodile distribution and population trends throughout the historical range of the species. In terms of crocodile ecology perhaps the most important topic in terms of conservation in defining the nature of crocodile-Caiman ecological interactions and what effects this has on crocodile population recovery.

VI. Summary

Orinoco Crocodile populations continue to remain extremely depleted throughout Venezuela. Little or no population recovery has taken place in any part of the country. A larger total crocodile population estimate can be made than was previously thought (e.g. Godshalk's estimate of 1,000 wild animals (IUCN 1983)), but this is based primarily on more detailed surveys of known populations, or the discovery of new ones. Based on the results of this study, and the work of Dr. Jose Ayarzaguen, only four populations can be said to have more than 50 non-hatchling crocodiles: the Rio Capanaparo and its tributaries (estimated population 500), the Embalse de Camatagua (>50), and the Rio Tucupido (100), and the Cojedes-Sarare area (>150). Several other crocodile populations may number more than 50, but more survey work needs to be done to confirm this. Among these rivers are: the Rio Cinaruco, the Caura, and the Ventuari. Crocodiles still remain in many other parts of their historical range but at extremely low densities and reproduction or recruitment in many of these areas may be negligible. In many parts of the former range of the species a very diffuse crocodile population still remains. However, because they are found within a very dense population of spectacled caiman, this segment of the Orinoco crocodile population is very hard to quantify.

Human-related and biological factors that may be responsible for impeding crocodile population recovery are analyzed. Potential factors include: intentional killing for hides, killing as vermin, the subsistence use of crocodile eggs or commercial trade of live crocodiles (mainly hatchlings), accidental drowning in nets, habitat deterioration or destruction, natural crocodile population dynamics

or ecological factors related to the greatly expanded Caiman population.

Some or all of these factors may be operating to varying degrees throughout the range of the Orinoco crocodile. The order of importance appears to be different depending on local circumstances. For instance in the Rio Capanaparo, the most important factors appear to be the subsistence use of eggs, and the sale of hatchlings to tourists. The remnant population in the Rio Cojedes/Sarare is most threatened by habitat destruction. However, in areas of extremely low crocodile density, ecological replacement by Caiman may be of overriding importance.

Conservation action needs to concentrate on the protection of crocodile habitat and the initiation of restocking and reintroduction programs. A considerable increase in the amount of in-country support needs to be developed in order to make the program successful. The recent success of the Venezuelan Caiman management program offers hope for more economic and political support for conservation programs dealing with native species of crocodiles.

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Table 1. Summary of aerial survey for Orinoco crocodiles in Venezuelan Rivers: 1986-8.

River	Date	Linear River Distance (km)	# Crocodiles Seen	Density (/km)
Region: <u>Llanos</u>				
Orinoco	17/19 Apr 86	560	0	0.000
Arauca	18 Apr 86	335	0	0.000
	31 Mar 87	9	1	0.111
Capanaparo	18/19 Apr 86	445	39	0.088
	01 Apr 87	78	17	0.218
	14 Apr 87	158	31	0.196
	16 Apr 87	142	12	0.085
	17 Apr 87	247	43	0.174
	01 Mar 88	146	29	0.199
	04 Mar 88	108	21	0.194
	05 Mar 88	158	14	0.089
Riecito	16 Apr 87	84	2	0.023
Cinaruco	19 Apr 86	365	2	0.005
	14 Apr 87	210	0	0.000
	02 Mar 88	315	3	0.010
Claro	16 Apr 87	50	0	0.000
Manapire	21 Apr 86	50	0	0.000
Rio Aguaro	21 Apr 86	40	0	0.000
C. Rabanal	21 Apr 86	45	1	0.022
Region: <u>Bolivar State</u>				
Caura	16 Apr 86	270	4	0.016
Cuchivero	15 Apr 87	210	0	0.000
Region: <u>Piedmont</u>				
Tucupido	19 Apr 86	31	4	0.129
	20 Apr 86	31	19	0.613

Table 2. Aerial Survey Summary for the Rio Capanaparo: April 1987.

River Section	Date	Linear Distance (km)	# Crocodiles Seen	Density (#/km)
1) Rio Riecito- Las Campanas	1 April	47	3	0.064
	14 April	47	3	0.064
	17 April	47	4	0.085
2) Las Campanas- Cano Amarillo	1 April	16	2	0.125
	14 April	16	8	0.500
	17 April	16	3	0.188
3) Cano Amarillo- San Luis	14 April	25	14	0.560
	17 April	25	22	0.880
4) San Luis- El Naure	14 April	20	3	0.150
	17 April	20	4	0.200
5) El Naure- Casanarito	14 April	38	3	0.079
	17 April	38	4	0.105
6) Casanarito- El Betun	14 April	12	0	0.000
	16 April	12	3	0.250
	17 April	12	1	0.083
7) El Betun- San Pablo	16 April	22	3	0.136
	17 April	22	2	0.091
8) San Pablo- Macanilla	16 April	18	2	0.111
	17 April	18	3	0.166
9) Macanilla- La Pica	16 April	53	4	0.075
	17 April	53	0	0.000
10) La Pica- Orinoco	16 April	37	0	0.000

Table 3. Nocturnal spotlight counts of non-hatchling crocodiles (<1.5 meters, >1.5 meters total length, and presumed crocodiles, EO/C) in river section 3 (25 km) and adjacent oxbow lakes, Rio Capanaparo, 1987.

Sublocale	Date	Total Non-hatchlings			Density (/km)	
		<1.5m	>1.5m	EO/C	<1.5m	>1.5m
River	23-28 Feb	7	12	9	0.280	0.084
	29-30 Apr	15	21	5	0.600	1.040
Oxbows	23-28 Feb	0	3	5	0.000	1.636