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Population Status and Management Guidelines for the Orinoco Crocodile (*Crocodylus intermedius*) in the Capanaparo River, Venezuela (Progress Report)

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ABSTRACT: In order to define management strategies oriented towards the conservation and recovery of the Orinoco Crocodile (*Crocodylus intermedius*) in the Capanaparo River, the abundance and population structure were determined, including temporal and spatial variations. Night surveys were conducted along 185 km of river between October 2000 and June 2001. Abundance indices between 0.39 and 2.92 individuals/km were recorded, with significant statistical differences between river sections ($P < 0.01$); the overall mean for all sections was 1.43 individuals/km. The population size was estimated as 536 non-hatchling individuals for all the Capanaparo River basin. No differences were recorded on the population structure between river sections, with a general structure mainly composed by juveniles (58.0%), followed by adults (24.1%), and subadults (17.9%). A significant negative correlation (-0.52, P = 0,0002) between crocodiles and caimans (*Caiman crocodilus*) in different river sections was obtained. One of the main problems for the conservation of crocodiles at Capanaparo River is the local practice of harvesting eggs and hatchlings. Considering our results, reducing the actual pressure on the species and accomplishing the recovery of this crocodile, may be possible by incorporating local human communities in the conservation efforts in combination with a crocodile release program.

Keywords: Abundance, conservation, *Crocodylus intermedius*, population structure.

INTRODUCTION

The Orinoco Crocodile (*Crocodylus intermedius*) is one of the most critically endangered species of crocodile in the world (Thorbjarnarson 1992). Commercial overexploitation from 1930 to the end of 50's, decimated its populations in most of its original area of distribution (Medem 1983, Seijas 1998). Even though crocodiles have been legally protected in Colombia and Venezuela for almost 30 years, and the international trade has been prohibited by the Convention of International Trade in Endangered Species (CITES) (King 1989), the species is still threatened by a combination of factors including habitat destruction, egg harvesting, incidental and intentional killing, and collection of animals to be sold as pets (Thorbjarnarson & Hernández 1992). Other factors affecting the recovery of the Orinoco Crocodile are related with the expansion of *Caiman crocodilus* populations, a species which could have some degree of competition with the crocodiles, in particular in those places where *C. intermedius* maintains very low population levels (Thorbjarnarson & Hernández 1992, Llobet 2002).

The Orinoco Crocodile is present just a small fraction of the territory which represented its original area of distribution. The commercial hunting of this species eliminated the populations from the most of rivers originally occupied by crocodiles. This is the only crocodilian species in the world with a distribution restricted to one basin, The Orinoco River Drainage (Medem 1981, 1983, Thorbjarnarson & Hernández 1992). This basin comprises approximately 1100000 Km^2, which represents 70% of Venezuelan and 30% of Colombian territory (Lewis 1988, Hamilton & Lewis 1990). Historical information stated that the primary habitat of this species was in the major rivers of the Llanos region of Colombia and Venezuela (Humboldt 1975, Páez 1980, Wickham & Crevaux 1988), especially the Meta, Arauca and Guayavero-Vichada rivers in Colombia, and Apure, Portuguesa, Arauca and Orinoco rivers in Venezuela (Seijas 1998).

Apparently in Venezuela, the Orinoco crocodile populations extended (in low densities) up stream of many Llanos rivers even into surrounding areas close to the foothills of the Andes, and also in some of the southern tributaries of the Orinoco in heavily forested regions of the Cuchivero and Caura rivers (Ramo & Busto 1986, Thorbjarnarson & Hernández 1992, Arteaga *et al.* 1994). Unconfirmed information exists about the presence of this species in the Casiquiare and Ventuari rivers. Nevertheless, it is probable that these regions contain very low population levels of crocodiles.

In Venezuela, during the last twenty five years, scattered individuals and small populations have been reported. However, the most important and probably the only viable populations are found in two very different areas: the Capanaparo River in the state of Apure, and the Cojedes-Sarare system river in the states of Cojedes and Portuguesa. Prior data suggested that a population of more less 1000 individuals could be found in both rivers (Godshalk 1978, 1982, Thorbjarnarson & Hernández 1992, Seijas & Chávez 2000).

The compicated situation of crocodile populations led to the development of an Action Plan (FUDENA 1993) and a Strategic Plan (PROFAUNA 1994), each with a groups of midterm strategies and goals for the recovery of the Orinoco crocodile populations (Program for the Conservation of the Orinoco Crocodile in Venezuela – PCOCV) (Seijas *et al.* 2001). After eight years of the development of this program (PCOCV), it is considered that the goal of consolidating at least ten viable populations of the species is still to far from being achieved. Except for the Santos Luzardo National Park, and the Aguaro-Guariquito National Park, the situation of the species is not known for certain in the entire Venezuelan system of protected areas. Moreover, there is evidence that small crocodile populations (Tucupido, Anaro, and North Cojedes rivers) are experiencing a serious decrease in size (Seijas *et al.* 2001), while no actions have been taken to protect the major two populations of the species (Capanaparo and Cojedes rivers), which could not assure, by themselves, the conservation of *Crocodylus intermedius* in Venezuela.

The crocodile population of Capanaparo River (within Santos Luzardo National Park) still face several threats by egg collecting and the sale of hatchlings, carried out by local people (Thorbjarnarson 1992, Llobet 2002). The importance of this population was previously mentioned by Godshalk (1978, 1982), and confirmed by later research (Thorbjarnarson 1988, Thorbjarnarson & Hernández 1992). These authors emphasized the good habitat conditions of Capanaparo River for the crocodile population, and reported sections of the river with high population densities. Following these results reintroductions of almost 500 non-hatchling individuals, collected previously from the Capanaparo River and raised in captivity for almost a year, were carried out (Arteaga et al. 1997).

After these management actions were occurred, some conflicts between local people and the office in charged of the national parks administration (INPARQUES) started at Santos Luzardo National Park. These conflicts led to the end of the administration of the Park, and blocked any chance to continue with the ongoing conservation activities. This situation probably had a significant effect on the wildlife, and particularly on the crocodile population. The major threat represented bay collecting the eggs and hatchlings (for local consumption and for sale to tourists), was certainly increased due to the lack of administration of the Park. No control mechanisms or conservation activities could be applied as long as the Capanaparo River was not recovered as an *in situ* conservation area. This situation, continuing for the last ten years, delayed the realization of any effort to accelerate the recovery of the species or to obtain information on the ecology.

Careful and reliable monitoring of crocodile populations is an essential requirement for the implementation of a management program for its conservation. In this study, we attempt to update the population status of *C. intermedius* in the Capanaparo River and recommend some guidelines for future management actions intended to accelerate the recovery of crocodile populations in the area.

STUDY AREA

The Santos Luzardo National Park is located in the southwest Llanos of Venezuela; the northern boundary of the Park is the Capanaparo River. The south border of the Park is the Cinaruco River, the east border is the Orinoco River, and the west border is also the boundary between Achaguas and Pedro Camejo municipalities (Figure 1).

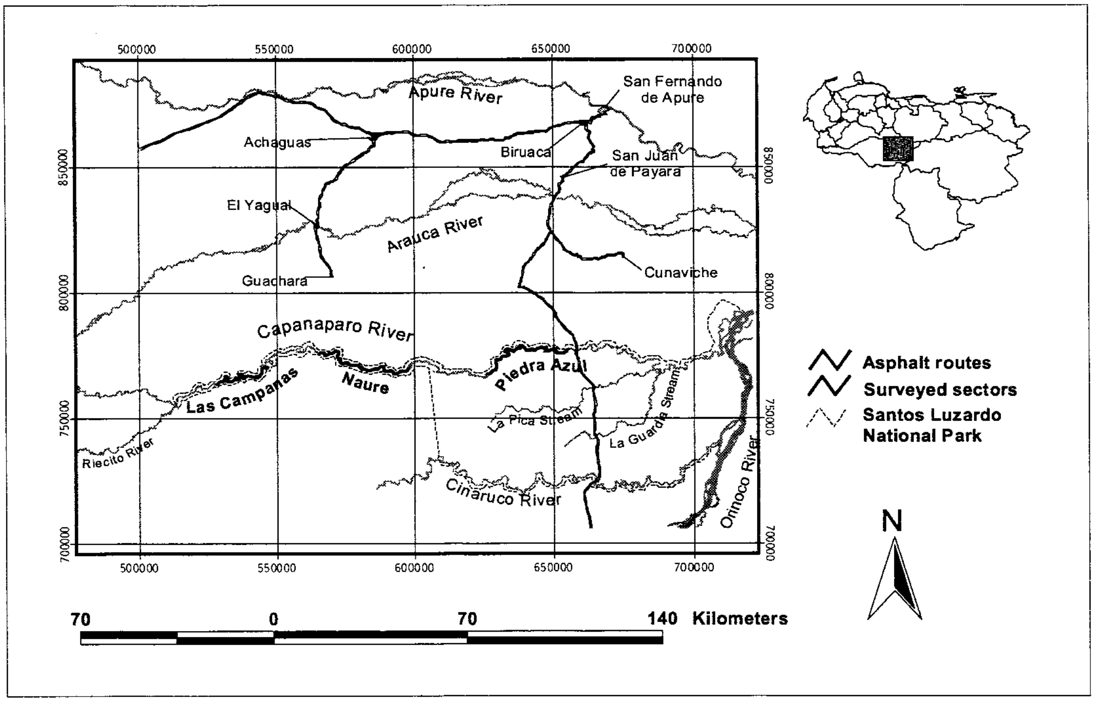

Figure 1. Capanaparo River at Santos Luzardo National Park (state of Apure, Venezuela). Rivers flow toward the east.

The Capanaparo River is an effluent of Orinoco River and it drains the lowlands of South Apure. Its waters contains an important amount of silts and receive many tributaries with black water (and low productivity) whose origin is in the lowlands. This situation makes the Capanaparo River a mixture between clear waters and black waters (Thorbjarnarson 1988, Thorbjarnarson *et al.* 1993). Along the river is a gallery forest, aften associated with oxbow lakes or old meanders of the river. During dry season, long beaches alternate with deep pounds, this situation makes the Capanaparo River a good habitat for crocodiles, it provides a great number of places for basking and nesting. Conductivity varies from 27.1 a 45.3 μS, with an average of 34.5 μS, and the average temperature of water is 29 °C (Muñoz & Thorbjarnarson 2000).

According to data from the Environment Ministry (MARN) of San Fernando de Apure, in the area there is a precipitation range from 1640 to 1644 mm. These data were collected in two stations situated approximately 15 km to the north and 20 km to the south of Capanaparo River respectively, both along the road which connects the cities of San Fernando with Puerto Páez (Fig 1). The dry season occurs from December until March, and the rainy season starts during April producing the higher precipitation level during the month of July. This precipitation regime influences the dynamic of Capanaparo River, which presents the highest water level during August, and the lowest level during April.

From a socioeconomic point of view, the Santos Luzardo National Park has a low human population density, with the presence of some cattle ranches, and communities inhabited by campesinos and indigenous people (most of them belonging to Pume or Yaruro tribe). The livelihoods (beside extensive cattle raising) are basically subsistence activities. The poverty levels of local people (especially indigenous people) are very high.

For the purposes of this study, three sectors of Capanaparo River were selected. The first, called Piedra Azul by the presence of a community with that name, had an approximate length of 45 Km. The second one, called Naure by the presence of that community, also had an approximate length of 45 Km. The third one, called Las Campanas (the community Las Campanas was located in the middle of the sector) had an approximate length of 30 km (Fig. 1).

METHODS

To determine population status of crocodilians at Capanaparo River, night surveys were made from October 2000 to June 2001, using a 12 foot boat powered by a 30 hp outboard engine. Monthly repetitions were made, surveying approximately a section of 15 km of river each night. The distance of the surveys was measured with the odometer of a Global Positioning System (GPS Garmin 12).

As we stated before, the entire study area was divided into three sectors named Piedra Azul, Naure and Las Campanas due to the nearest human communities. Piedra Azul and Naure sectors were subdivided into three sections each (P1, P2 and P3 for Piedra Azul, and N1, N2 and N3 for Naure). Las Campanas sector was divided into two sections (C1 and C2). Every section of the entire study zone had approximately 15 km length. The complete surveyed length of river was approximately 120 km, within a 185 km section of Capanaparo River (Fig. 1). Due to the characteristics of Capanaparo River, surveys were made first for one shore and then for the other one. Because of the low water level during dry season, it sometimes was not possible to survey the entire 15 km section. Only surveys longer than 10 km were considered for later analysis.

During surveys, a 500,000 candles power light connected to a 12 V battery was used to locate the crocodilians by means of reflective eye shine. All crocodilians sighted were approached as close as possible to allow a positive identification of the species (*C. intermedius* or the sympatric *Caiman crocodilus*) and to estimate the body size (total length, TL). In the field, 10 cm size-class intervals were used, but for analyses of size class distribution, 60 cm size-class categories were used (Seijas 1998, Seijas & Chávez 2000):

Class I: TL < 60 cm
Class II: 60 cm < TL < 120 cm
Class III: 120 cm < TL < 180 cm
Class IV: 180 cm < TL < 240 cm
Class V: 240 cm < TL

Hatchling crocodiles (Class I individuals, generally less than 6 months old) and caimans were counted but not considered in this study. Based o previous studies (Seijas 1995, 1998, Seijas & Chávez 2000), non-hatchling crocodiles less than 180 cm in total length were considered as juveniles; crocodiles in Class IV (major than 180 but less than 240 cm in total length) were regarded as sub-adults, and those individuals major than 240 cm in total length were classified as adults. To compare our results with those obtained by Thorbjarnarson & Hernández (1992), a second 50 cm size-class intervals were used. When an individual could not be identified as crocodile (*C. intermedius*) or spectacled caiman (*C. crocodilus*), it was placed in a "Not identified" category (NI). These individuals were not considered for the analysis.

The analyses of abundance and population structure were realized considering the results from surveys undertaken from November 2000 to June 2001. The month of October of 2000 was used to investigate the river and to standardize the survey methodology. The relative population abundance index (PI) of crocodilians was expressed as number of individuals per kilometer of river. To analyze how the fraction of crocodiles sighted changes as the dry season progresses, the PI obtained in every survey (individuals/Km) was expressed as a percentage of the PI obtained during April (taken as 100%) in the same river section. April is usually the last month of the dry season, a time when the river reaches its lowest level. This method allows the comparison of results from localities with different PI values. A correlation analysis was used to describe the relationship between theses percentages and the days after November 21 (first day of surveys considered in the analysis), as an indirect measure of water level (Seijas 1998, Seijas & Chávez 2000).

The spatial variation in abundance was analyzed comparing the obtained PI (ind/Km) between sectors of the river, and also between different sections of each sector. The comparisons were carried out using a Kruskal-Wallis test. The average values of PI of every studied section of the river were used to calculate the minimum size of the crocodile population. We estimated the density of crocodiles in unsurveyed sections of the river as a value intermediate of its immediate upper and lower sections for which information was available.

The population structure of crocodiles for the entire river, and for every sector was calculated using the maximum number of individuals in a particular size category, regardless of the survey in which they were observed, as minimum number of individuals corresponding to that category. This method is referred to by Messel *et al.* (1981) as the maximum-minimum (MM) method. Comparison of the population structure among river sections were made using contingency tables (X^2). On the other hand, monthly data of population structure were used for comparison between three hydrological periods (falling water, low water and rising water levels) according with fluctuations of the Capanaparo River during the study period. This comparison was carried out again using contingency tables (X^2).

RESULTS

Population indices

From October 2000 to June 2001, 44 nocturnal spotlights surveys were conducted in the three defined sectors (eight sections) of the Capanaparo River. Between five to seven repetitions (one per month) were made for every section. Results obtained during October were not considered for further analysis, because survey methodology was standardized during that month. The study area was not surveyed from July until September. During those months the high water period occurs, and the surveys would have been hindered due to the dispersion experienced by crocodilians populations. Additionally, the plains surrounding the river were flooded and the access to many places was difficult.

The lowest index of relative population abundance (PI) of crocodiles were found in Piedra Azul sector, P2 section with a value of 0.37 ind/km in February, and P3 section with a value of 0.39 ind/km in May. In contrast, higher PI values were recorded in Naure sector (N3 section during May) and Las Campanas sector (C1 section during June) with values of 2.92 ind/km and 2.73 ind/km respectively.

Although the fraction of the crocodile population that was seen during surveys showed a slight tendency to increase as the dry season advanced, the PI values were nearly constant during all the fieldwork. A correlation analysis among the fraction of crocodiles sighted and days after November 21 (established as first day of surveys) indicates that this positive relationship was not statistically significant ($r = 0.21$, $P = 0.16$).

Different months of working were grouped in three hydrological periods according with fluctuations on water level: falling waters (from November to February), low waters (March and April) and raising waters (May and June). Kruskal-Wallis test suggested that no one of the three sectors showed statistical differences related to crocodile abundance among these periods.

To analyze the spatial variation on crocodile abundance, a Kruskal-Wallis test was performed comparing the PI of each sector. Highly statistical differences resulted from the comparison of Naure and Las Campanas sectors related to Piedra Azul sector ($H = 29.80$, $P < 0.01$). The same test was performed considering every section of each sector. In this sense, we observed three groups of PI values with highly statistical differences ($H = 38.30$, $P < 0.01$). The first group (low PI values) was composed by the three sections of Piedra Azul Sector (P1, P2 and P3); the second group (intermediate PI values) was integrated by N1 section of Naure sector, and C2 section of Las Campanas sector. Finally, the third group (high PI values) was composed by N2 and N3 sections of Naure sector, and C1 section of Las Campanas sector.

The minimum population size of non-hatchling crocodiles in the entire study area was estimated to be 332 individuals (Table 1). The estimation was made using the medium PI values of every section. This is a conservative calculation because it is based on PI that was below the maximum obtained for all river sections. If the maximum PIs had been used, the estimated population would be 382 non-hatchling individuals, a 13.1% increase.

This estimation includes the portion of Capanaparo River from the confluence of Riecito River to the outlet of Capanaparo in the Orinoco River. Nevertheless, if we consider the same approach used by Thorbjarnarson (1988), to estimate the crocodile population in all the Capanaparo basin it would be necessary to consider: 1) the river portion that flows by Venezuelan territory from the Colombian border to the outlet of Riecito river into the Capanaparo, 2) the Riecito river, 3) the floodplain lagoons of Capanaparo river, and 4) other tributaries of Capanaparo river. If we assign to the high potion of Capanaparo River (from the Colombian border to the confluence of Riecito River) the lowest PI value of all surveys (0.37 ind/km), a total of 70 non-hatchling crocodiles could be estimated in that portion of river (Thorbjarnarson 1988, estimated 76). On the other hand, Thorbjarnarson (1988) estimated 71 individuals in Riecito River, 23 individuals in lagoons (oxbow and old meanders of Capanaparo River), 40 individuals belonging to other tributaries of Capanaparo River (Naure, Casanarito and La Pica streams). If these values are added to the results of our study, we could estimate that the entire non-hatchling crocodile population of the Capanaparo basin has at least 536 individuals.

Table 1. Estimated number of non-hatchling Orinoco crocodiles in different sections of Capanaparo River.

SECTION	Length (km)	Mean density (ind/km)	Estimated number	Maximum density (ind/km)	Estimated number
La Pica – Piedra Azul P1 [a]	54.2	0.19	10	0.19	10
Piedra Azul P1	18.2	0.55	8	0.87	13
Piedra Azul P2	15.2	0.90	14	1.18	18
Piedra Azul P3	15.9	0.56	9	0.82	13
Piedra Azul P3 – Naure N1 [b]	40.6	0.37	15	0.37	15
Naure N1	15.5	1.41	22	1.68	26
Naure N2	14.1	2.18	31	2.54	36
Naure N3	11.9	2.11	25	2.92	35
San Luis – Caño Amarillo [c]	32.6	3.09	101	3.09	101
Las Campanas C1	14.2	2.19	31	2.73	39
Las Campanas C2	47.0	1.40	66	1.61	76
TOTAL	**279.4**		**332**		**382**

[a] Just one 15 km survey was carried out during November of 2000.
[b] Not surveyed. Assigned the minimum density of all surveys
[c] Just one 6.15 km survey was carried out during May of 2001.

Population structure

In Piedra Azul sector the population was composed by a major proportion of Class II individuals (38.24%), followed by Classes V, III and IV (29.41%, 23.53% and 8.82% respectively). In Naure sector we also observed a major proportion of Class II crocodiles (35.8%) followed by Classes III and IV (22.22 % each one) and finally Class V (19.75%). In Las Campanas sector, in contrast, a major proportion of adult crocodiles was observed (30.61% of Class V individuals), followed by Class II (28.57%), III (24.49%) and IV (16.33%) (Figure 2).

The differences between sectors structure were not statistically significant (X^2 = 5.026, P = 0.54). The same comparison was carried out grouping crocodiles in categories (juveniles, sub-adult and adult), however this new frequency distribution used in the analysis, no statistical differences were obtained (X^2 = 4.55, P = 0.33).

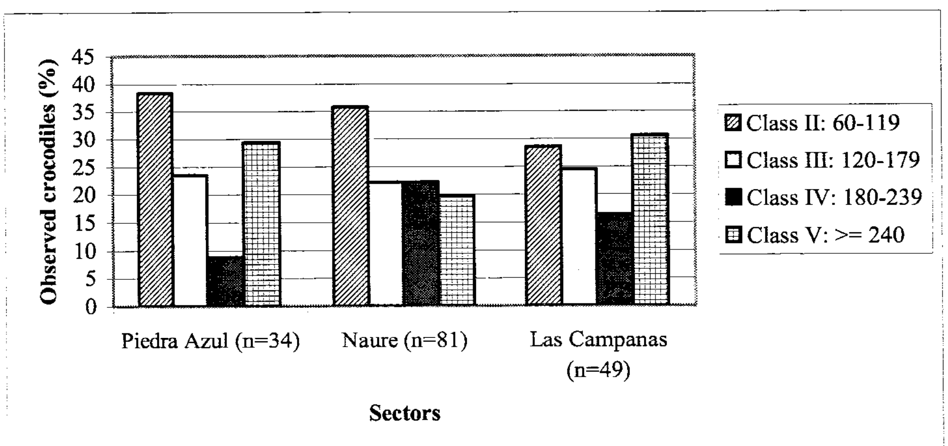

Figure 2. Population structure of Orinoco crocodile population in different sectors of Capanaparo River. Size-Class categories are expressed in cm of total length.

DISCUSSION

Godshalk (1978, 1982) highlighted the Capanaparo River as one of the places were could be found a relatively important population of Crocodylus intermedius in Venezuela. This was confirmed later by the works carried out by Thorbjarnarson (1988), and Thorbjarnarson & Hernández (1992). We found an Orinoco crocodile population with a minimum size of 332 non-hatchling individuals, from the outlet of Riecito river to the confluence of Capanaparo in the Orinoco river. This value is notably higher than the 233 non-hatchling individuals reported by Thorbjarnarson (1988) for the same segment of Capanaparo river. On the other hand, at least 40% of the crocodile population is composed by sub-adult and adult individuals, situation which also overcomes the estimation of 100 individuals longer than 150 cm (TL) made by Thorbjarnarson & Hernández (1992). These differences could principally due to two factors:

1. The survey methodology used. The anterior authors based their results for the major portion of the river in airplane censuses, and made night surveys just in one 25 km section of river (between Caño Amarillo and San Luis community).
2. The fact that between 1991 and 1993, 571 individuals were released in Capanaparo River (Arteaga *et al.* 1997).

Even though is difficult to make an exact comparison between Thorbjarnarson (1988) and Thorbjarnarson & Hernández (1992) and our results, because both studies considered sections with differences in length, we estimate that in Naure sector exist at least 60 more non-hatchling crocodiles in relation to anterior researches. This increase (25.75%) in the crocodile population size, could be due to a several release activities carried out in anterior years (all made in zones near or within Naure sector). This could be a measure of the successful of that release program for the recuperation (slowly yet) of the crocodile population in Capanaparo river.

It is necessary to consider that is very difficult to estimate the real size of a population. Besides, the monitoring of crocodiles presents some problems which have been analyzed by several authors (Woodward & Marion 1978, Messel *et al.* 1981, Magnusson 1982, Larriera *et al.* 1993, Abercrombie & Verdade 1995, Pacheco 1994, Pacheco 1996). It is theoretically possible to control the effect that most of the environmental variables have over night surveys always carrying out them under similar conditions, but it is more difficult to control biological variables as wariness and population density (Pacheco 1994, 1996). In areas where animal hunting with different porpoises has been (or still is) a common practice, crocodiles tend to be more shy, that which can hinder their observation and to produce a bias when calculating the abundance. The tendency to sub-estimate the real population size is present to in populations with very low abundance index or low density, since it diminishes significantly the probability to observe an individual. Finally, the relative abundance indices are going to sub-estimate the real size of that population because a part of this is remains usually undetected, and is too difficult to establish the relationship between abundance index and the real density of the population in the zone (Hutton & Woolhouse 1989).

The environmental factor that could have more effect over night counts of crocodilians is the water level (Woodward & Marion 1978, Messel *et al.* 1981, Llobet & Goitia 1997). However, this variable can be related with behavioral changes which could affect also the results of surveys. Seijas & Chávez (2000) in Cojedes River System reported variations in the number of crocodiles observed as the dry season occurred; on the other hand, this same authors observed an increase of adult crocodiles (most of them females) at the beginning of the reproductive season. In the present study there were no significant variations in the number of crocodiles sighted as the dry season lapsed, probably because the particular conditions of Capanaparo river, where all the crocodiles (widespread in a large area) count with many basking zones from November to June; this situation could reduce the intra-specific competition, so juvenile animals are not forced to seek for refuges.

Other factors that may explain the variability in abundance index (PI) are related with differences in visibility among sectors, which could introduce some bias in the results (Hutton & Woolhouse 1989, Da Silveira *et al.* 1997). The Capanaparo river, besides having extended sand beaches, shows step banks many times covered with riparian vegetation, which could serve to crocodilians as a refuge avoiding them detection during night surveys. Differences in visibility of crocodiles in relation to water level have important implications for monitoring of population status (Seijas & Chávez 2000). According to Seijas (1998), the best period to conduct surveys to determine population size is from November to January, when a major proportion of crocodiles can be sighted, and the number of spectacled caimans (*Caiman crocodilus*) is relatively low, which reduces survey time, therefore, limiting observer fatigue (Thorbjarnarson & Hernández 1992). In Capanaparo River, the monthly variation of the number of crocodiles was no significant, alternatively, the number of spectacled caimans sighted increased from month to month, which had an effect in the survey effort.

The Orinoco crocodile population in the Capanaparo River is not uniformly distributed. Highest densities were observed in N2 and N3 sections of Naure sector, C1 section of Las Campanas sector, and the section between San Luis and Caño Amarillo (surveyed just once during all the study). The access to the river into these sections is more difficult because the "sabana" roads only can be used during dry season. On the other hand, human communities are widespread and are not too much populated. The crocodile density in Piedra Azul sector (were lowest values were registered) could be affected by a bigger human pressure due to the easy access to this part of the river. These results in general agree with those reported by Thorbjarnarson (1988) and Thorbjarnarson & Hernández (1992) who reported major crocodile densities in river sections between Naure and Las Campanas sectors.

Population structure showed no statistical differences among river sectors, even though Piedra Azul and Naure sectors had a major proportion of juvenile crocodiles, and Las Campanas sector showed a population structure dominated by adult crocodiles. Population structures dominated by juvenile size-classes could suggest that the population may be recovering from overexploitation (Webb & Messel 1978, Seijas 1986). However, we also must considerate that this kind of structures could due to actual human pressure exerted over adult crocodiles of the population.

The population structure could be shaped by human activities present in a zone (Seijas & Cháves 2000). Large crocodiles are more conspicuous and probably more frequently killed by people than small crocodiles. This situation, besides bad perception that local people have over crocodiles, could affect the population structure of the Orinoco crocodile in the Capanaparo River. Under these circumstances, few adult crocodile could remain in the river; meanwhile less conspicuous juveniles could escape from detection. If we consider, on the other hand, that there is a relationship between crocodiles wariness and human pressure (Pacheco 1996), we could expect to register larger escape distances in zones with major human pressure. In this sense, large crocodile individuals, and probably more experienced about activities directed to its hunting or capture, will be more shy than juveniles, so a new bias could be introduced over the population structure results. In those sectors with some access troubles (as Las Campanas sector), larger crocodiles could have more chances to survive, and also would behave less shy or cautious in the presence of an observer.

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