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Population status of the Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes river system, Venezuela

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Abstract

The Orinoco crocodile is one of the most critically endangered crocodilians. The most important Orinoco crocodile population known is found in the Cojedes River System (CRS), Venezuela, an area currently under heavy anthropogenic pressure. Based on spotlight surveys, a minimum population of 547 non-hatchling crocodiles was estimated for the CRS. Middle sections of the CRS, particularly near the downstream-end of Caño de Agua, showed the highest population indices (PI)(7.3 ind/km). Intermediate PI were observed in Cojedes Norte and Caño de Agua Norte (2.2 and 4.4 ind/km, respectively) river sections relatively close to important human settlements and with comparatively higher levels of habitat alteration and contamination. The lowest PIs (< 1.0 ind/km) were observed in navigable river reaches and far from main urban centers. Crocodile populations in northern sections of the CRS were dominated by juveniles, whereas sub-adults and adults composed an important fraction of the population in river reaches with relatively high crocodile densities.

Resumen

Crocodylus intermedius es una de las especies de cocodrilo más amenazadas. La población conocida más importante de esta especie se encuentra en el sistema del río Cojedes (SRC), Venezuela, un area bajo fuerte presión humana. Con base en conteos nocturnos, la población del cocodrilo del Orinoco en el SRC se estimó en un mínimo de 547 individuos (excluyendo crias). Secciones en el la parte media del SRC, particularmente hacia el final de Caño de Agua, mostraron los indices poblacionales mayores (7.3 ind/km). Indices poblacionales intermedios se observaron en Cojedes Norte y Caño de Agua Norte (2.2 and 4.4 ind/km, respectivamente), secciones del SRC relativamente cercanas a importantes centros urbanos y, comparativamente, altos niveles de alteración de habitats y contaminación. Los menores indices poblacionales (< 1.0 ind/km) se observaron en secciones navegables del SRC alejadas de los grandes centros urbanos. La población de cocodrilos en las secciones del norte del SRC estuvieron dominadas por juveniles, mientras que sub-adultos y adultos representaron una importante fracción de la población en lugares con relativamente altas densidades de cocodrilos.

Keywords: Crocodiles; Endangered species; Conservation; Population structure; Anthropogenic pressure

1. Introduction

Orinoco crocodile (*Crocodylus intermedius)* is one of the most critically endangered crocodilian species of the world (Thorbjarnarson, 1992; Rodriguez and Rojas, 1995). Commercial overexploitation from 1930 through to the 1960s, decimated its populations from most of its distribution area (Medem 1981, 1983). *Crocodylus intermedius* has been legally protected both in Colombia and Venezuela for almost 30 years, and international trade has been prohibited by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since the middle 1970s (King, 1989). However, despite these legal efforts, little recovery of wild crocodile populations has occurred.

Historical accounts indicate that the primary habitat of this species was in the major river systems of the Llanos region of Colombia and Venezuela (Codazzi,

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1940; Humboldt, 1975; Páez, 1980; Medem, 1981, 1983). The species also extended, although probably at low densities, well up many Llanos rivers and into surrounding piedmont areas in the foothills of the Andes (Ramo and Busto, 1986; Thorbjarnarson and Hernández, 1992), and most of the southern bank tributaries of the Orinoco including heavily forested regions (Hitchcock, 1948; Franz et al., 1985).

Currently, the most important, and probably only viable populations of the Orinoco crocodile (Arteaga et al., 1997), are found in two areas of contrasting characteristics in Venezuela: (1) The Capanaparo river in the state of Apure, a prime-quality habitat, impacted relatively little by human activities, in the center of the species' range and where it reached its historically highest densities, and (2) the Cojedes region, in the states of Cojedes and Portuguesa, a system of narrow rivers, near the periphery of the distribution of the Orinoco crocodile and very close to some of the most important agricultural, urban and industrial centers in the country (Godshalk, 1978, 1982; Ayarzaguena, 1987, 1990; Thorbjarnarson and Hernández, 1992, 1993a,b).

In addition to its isolation from urban, agricultural and industrial centers, part of the Capanaparo River is currently protected as the Santos Luzardo National Park. This offers an umbrella of protection to its Orinoco crocodile population, an important, although not sufficient, step toward the conservation of the species (Thorbjarnarson and Hernández, 1992, 1993a,b). No protected area exists in the Cojedes region, and the Orinoco crocodile population in that river system is under strong anthropogenic pressure (Seijas, 1998).

As the site of the largest known population of an endangered species, the CRS should be the focus of a major national conservation program. Careful and reliable monitoring of crocodile populations is an essential requirement for implementation of a management program for its conservation. In this study we update the population status of *C. intermedius* in the CRS and suggest ways to increase the accuracy of population indices by identifying sources of variation that should be controlled when monitoring trends in the future.

2. The Cojedes River System

For the purposes of this study, the Cojedes River System (CRS) is defined as the mid and lower portion of the Turbio–Cojedes river basin. It covers a wide fringe along the Cojedes and Sarare rivers in the states of Cojedes and Portuguesa. The system encompasses the cities of Acarigua and San Carlos to the north and extends southeast to the confluence of the main course of the Cojedes river with Caño Amarillo-La Culebra near the town of El Baúl (Fig. 1). In the northern part of the CRS, agricultural lands dominate the landscape and are interspersed with large-and medium-sized urban centers and cattle ranches. The southern part of the region (south of the Lagunitas-Santa Cruz road) is a matrix of forested savannas and cattle pastures intermixed with forest relicts, scattered agricultural lands, wetlands, and other less extensive land-cover categories. The CRS has zones of relatively high human population densities in the north, where the cities of San Carlos (> 80,000 people) and Acarigua (~200,000 people) are located and the rivers there have been modified by damming, channelization, dredging, contamination, and deforestation. In zones of low human population densities (in the south) no town larger than 6000 people exists and the rivers are more pristine. In 1975, 33% of the state of Cojedes was covered by forest. That percentage decreased to less than 16% in 1988. The annual rate of deforestation in the state of Cojedes (3.81%) is the second highest in the country, surpassed only by the state of Portuguesa, its neighbor, with 4.08% per year (MARNR, 1995). No protected area or conservation reserve of any type exists within the Cojedes River basin.

There are two clearly defined seasons in the CRS, as is typical of the Llanos region in Venezuela. The rainy season extends from May to October, and the dry season from December to March. April and November are transitional months. The annual mean precipitation (1975–1996) is 1323 mm in the middle part of the study area (Fig. 2) and a little higher (1514 mm) toward the south at El Baúl. During the rainy season the river discharge increases (Fig. 2) and frequently overflows its banks and inundates the floodplain, particularly in the southern portion of the study area. The annual range between the absolute minimum and maximum temperatures is 11.6°C (21.7–33.3°C) (MARNR, 1995).

3. Methods

From 1991 to 1997, nocturnal spotlight surveys were carried out from a 3.7 m open boat powered by 10 or 15 hp outboard engine. Most of the sampling was conducted along a section of the Cojedes River called Caño de Agua, which was divided into segments named Caño de Agua Norte (CAN) and Caño de Agua Sur (CAS)(the road between Lagunitas and Santa Cruz was the dividing point). The segment of the river between Merecure and the fork of Caño Amarillo (CAM) was also surveyed repeatedly. Less frequently visited were a short section of the Cojedes north of Apartaderos-San Rafael (Cojedes Norte, CON), the southern segment near Sucre (SUC) and the lower portion of La Culebra (CUL). Sections of the Sarare River, the larger tributary of the Cojedes River to the west, were also studied (SAR). Surveys were started between 1930 and 2000 hr. The direction of the survey was clockwise in Las Majaguas

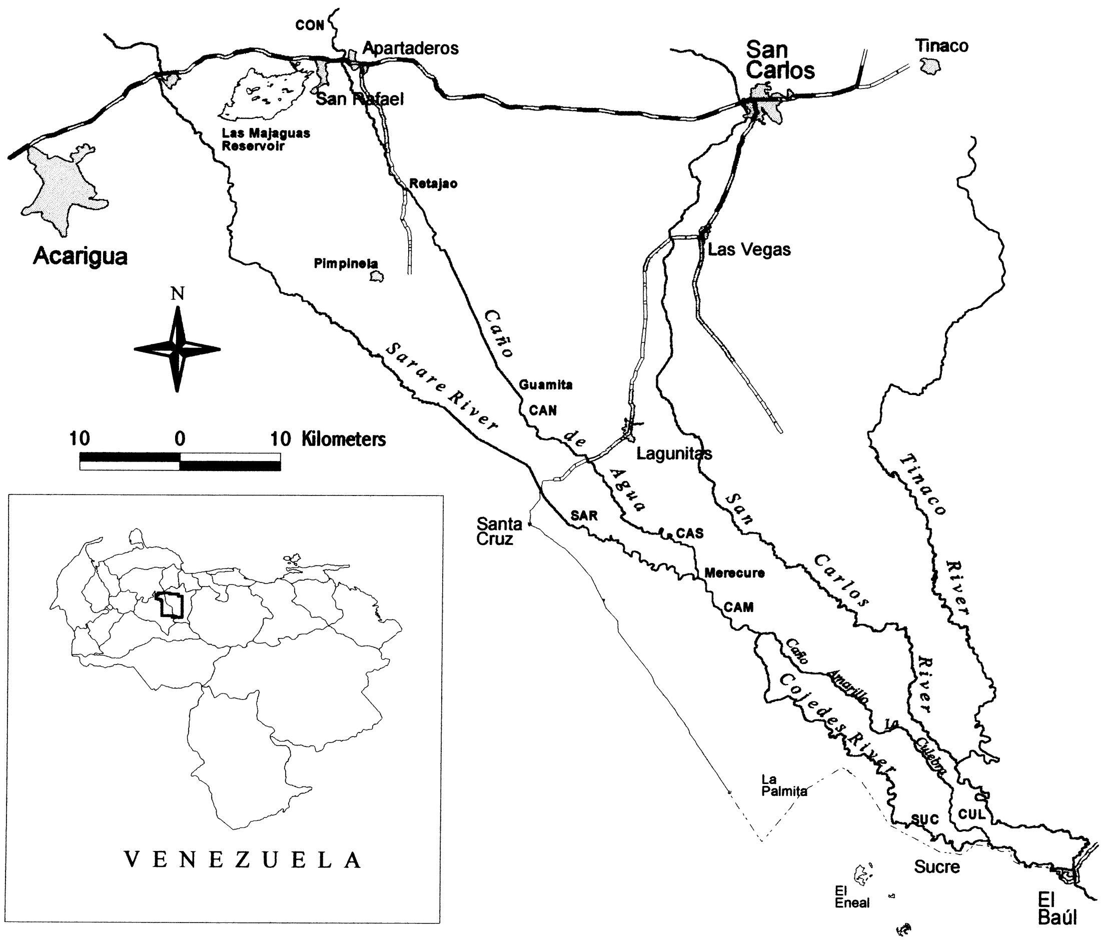

Fig. 1. Cojedes River System, Venezuela. Rivers flow toward the south. The acronyms indicate the location of the river segments surveyed: CON, Cojedes Norte; CAN, Caño de Agua Norte; CAS, Caño de Agua Sur; SAR, Sarare; CAM, Caño Amarillo-Merecure; SUC, Sucre section; CUL, Caño La Culebra.

reservoir and downstream in the rivers, except for the river sections named as CAM and SAR, which were always surveyed upstream. Some locations used as references during the surveys are shown in Fig. 1. (See Seijas, 1998, for more details).

All crocodilians sighted were approached as close as possible to allow positive identification of the species (*C. intermedius* or the sympatric *Caiman crocodilus*) and to estimate body size (total length, TL). In the field, 30 cm size-class intervals were used, but for analyses of size class distribution, the following broad size categories were used: Size 1, TL $<$ 0.6 m; Size 2, TL = 0.6 to $<$ 1.2 m; Size 3, TL = 1.2 to $<$ 1.8 m; Size 4, TL = 1.8 to $<$ 2.4 m; Size 5, TL $\geqslant$ 2.4 m.

Hatchling crocodiles (individuals less than 6 months old) and caimans were counted but not considered in this study. Based on information available in the literature (Brazaitis, 1973; Medem, 1981, 1983) and our experience with captive-reared crocodiles (Seijas, 1995), non-hatchling crocodiles less than 1.8 m in total length were regarded as juveniles; crocodiles in size category 4 were considered sub-adults, and those in category 5 were classified as adults. When an individual could not be identified as crocodile or spectacled caiman, it was placed in a 'Not Identified' (NI) category. These individuals were not used in the analysis.

The length of the river surveyed was measured with the odometer of a Global Positioning System (GPS, models Magellan 4000 and 4000XL). The length of surveys in the Majaguas reservoirs and in other sections of rivers that were only visited before 1996 were estimated using a wheeled map measurer on a 1:25,000 map. Maps of the study area, particularly of the most important river courses, were based on a Landsat TM image taken on January 1990. The index of relative population abundance (PI) of crocodilians was expressed as number of individuals observed per kilometer.

To establish if the fraction of crocodiles sighted changes as the dry season progresses, the PI obtained in every survey was expressed as a percentage of the highest PI calculated during April (taken as 100%) in the same river segment. April is usually the last month of the dry season, a time when the river reaches its lowest level. April was also the only month for which surveys

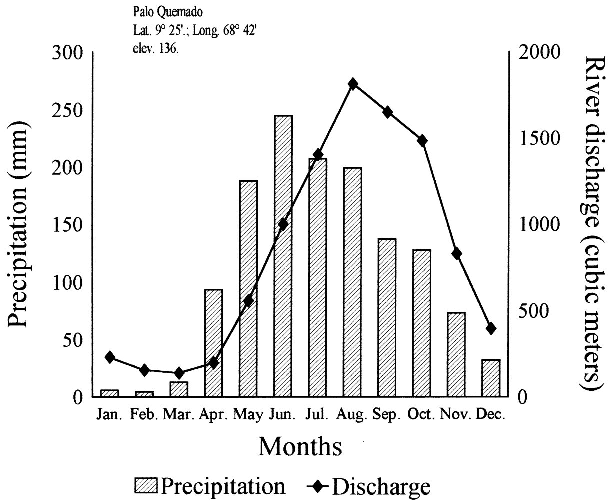

Fig. 2. Annual pattern of precipitation and river discharge in the Cojedes River System, Venezuela. Data of river discharge are from the metereological station at El Baúl. Precipitation data from Palo Quemado lat. 9° 25′; long. 68° 42′ elev. 136).

were conducted in every river section. This method allowed comparison of the results of localities with different PI. A correlation analysis was used to describe the relationship between these percentages and days after 1 January, an indirect measure of water level. Surveys conducted in November and December (early dry season) were assigned day zero. A similar procedure was used to determine whether the probability of seeing a crocodile, as the dry season progressed, was related to its size. For these analysis, only the river sections with the largest number of surveys (CAN, CAS and CAM) were used. Surveyed segments less than 5 km in length were also excluded.

Population indices of crocodiles were compared among river sections by means of analysis of covariance (PROC GLM, SAS Institute Inc., 1987) using days after 1 January as a covariate. This approach removed bias introduced by differences in how far into the dry season the surveys were conducted. To calculate the minimum population size of *C. intermedius* in the entire study area, we estimated the density of crocodiles in unsurveyed reaches of the river as a value intermediate between the PI of its immediate upper and lower reaches for which information was available.

The population structure of crocodiles at localities with two or more surveys per year was calculated using the maximum number of individuals in a particular size category, regardless of the survey in which they were observed. This was assumed to be the best estimate for that particular size class for that year. This method is referred to by Messel et al. (1981) as the maximum–minimum (MM) method. Comparisons of population structure among localities were made using contingency tables.

4. Results

4.1. Population indices

From 1991 to 1997, 56 nocturnal spotlight surveys were conducted in the CRS. Some places were visited only once, but several others were visited between two and 12 times. Surveys occurred during different periods of the year, but most of them (71%) were conducted during the late dry season (February–April). The study area was not surveyed from August to October. During those months the plains surrounding the rivers were flooded and access to many places was difficult.

The fraction of the crocodile population that was seen during the surveys diminished as the dry season advanced (November–April) and continued to decline during the early rainy season (May–July; Fig. 3). A correlation analysis indicated that this negative relationship was statistically significant ($r=-0.639$, $P<0.001$). The described pattern of decline was due to a decrease in the fraction of juvenile crocodiles sighted ($r=-0.58$, $P<0.01$) (Fig. 4a).

Sub-adults and adults crocodiles showed a more complicated pattern. These crocodiles tended to be seen in relatively higher numbers from November to January, the beginning of the dry season, when the water level in the river was still relatively high. They were seen in lower numbers during February and March (late dry

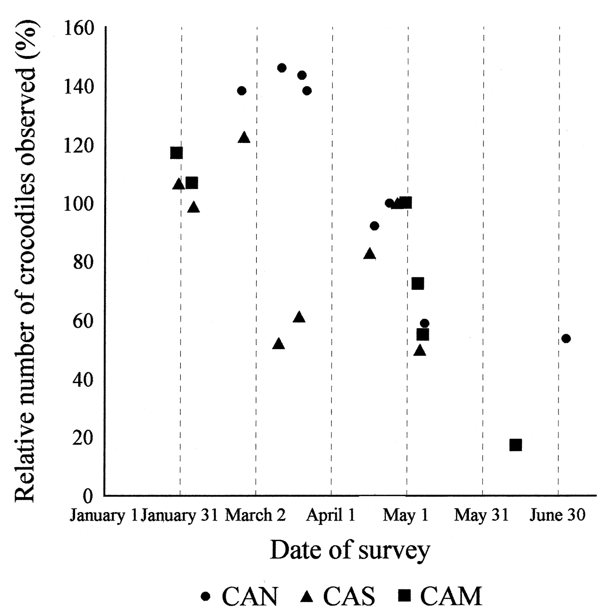

Fig. 3. Decline in the observed fraction of the crocodile population in the Cojedes River System, Venezuela, from January to early July. For every river section, the number of crocodiles observed in a particular survey was expressed as a percentage of the highest number of crocodiles ever seen in April, which was taken as a 100%. Since some river sections were surveyed more than once in April, the percentage for that month is less than 100% in some cases. CAN, Caño de Agua Norte; CAS, Caño de Agua Sur; CAM, Caño Amarillo-Merecure.

season), and reappeared in late April–early May (beginning of the rainy season; Fig. 4b). An analysis of the data grouped by month, indicated that monthly differences in the proportion of crocodiles $\geqslant$1.80 m in TL were significant (Kruskal–Wallis test, $H=12.3$, $P=0.031$). For this analysis, November, December and January (one survey each) were grouped as early dry season months.

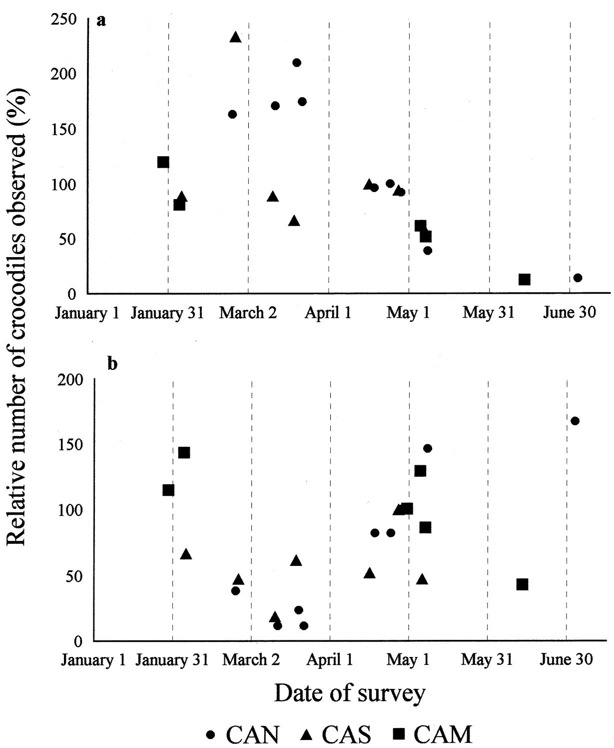

Fig. 4. Changes in the observed fraction of juvenile (a) and sub-adult + adult (b) crocodile population in the Cojedes River System, Venezuela, from January to early July. For every river section, the number of crocodiles of a particular size category observed in each survey was expressed as a percentage of the highest number of crocodiles, of that size category, ever seen in April, which was taken as a 100%. Since some river sections were surveyed more than once in April, the percentage for that month is less than 100% in some cases. CAN, Caño de Agua Norte; CAS, Caño de Agua Sur; CAM, Caño Amarillo-Merecure.

June and July (one survey each) were also pooled. The lowest proportion of large crocodiles was seen in March, in the middle of the incubation period (Seijas, 1998).

With the exception of Las Majaguas Reservoir, crocodiles were seen in all surveyed sections. Ayarzagüena (1987) did not observe crocodiles in Las Majaguas reservoir either, although anecdotal information indicates that a few individuals exist there. Localities where crocodiles were seen but were not included in most analyses were a 2 km stretch of the Sarare river close to Pimpinela (visited once, PI = 4.0 ind./km) and a reach of the lower Sarare, downstream from the bridge near Santa Cruz (visited twice, PI 4.9 and 3.1 ind./km). Six crocodiles were seen on 19 January 1993 near the dam in Toma Cojedes (San Rafael), and in 1996 a female nested close to Retajao.

Caño de Agua Sur was the segment with the highest mean PI (Table 1). The survey with the highest PI also was obtained in this section in February 1997 (12.7 ind./km), although due to the short distance surveyed (3 km) it was not used in the analysis. The lowest PIs were found in the surveyed section of the river closest to the town of Sucre, with a maximum of 0.3 ind./km.

Location (river stretches) explained 71% of the variation of PIs ($F_{5,32}=15.68$, $P<0.001$). The addition of time (days after 1 January) as a covariate (an indirect measurement of water level) explained a higher proportion of that variability ($r^2=0.82$) ($F_{6,31}=22.8$, $P<0.0001$).

The minimum population size of non-hatchling crocodiles in the entire study area was estimated to be 547 individuals (Table 2). This is a conservative estimate because it is based on PI that were below the maximum obtained for all river sections. If the maximum PIs had been used, the estimated population would be 699, a 28% increase.

4.2. Population structure

The population in CON was composed mostly of juveniles (Fig. 5a,b). The differences between 1993 and 1997 were not statistically significant (Fisher's exact

Table 1
Comparisons of populations indices (PIs) for crocodiles in different river stretches in the Cojedes River System

River section	Number of surveys	Densities (ind/km)		Grouping
		Range	LSMEANS[a]	
Caño de Agua Sur (CAS)	8	4.4–10.8	7.3 ± 0.46	A
Caño Amarillo-Merecure (CAM)	6	1.0–6.8	4.9 ± 0.53	B
Caño de Agua Norte (CAN)	12	2.1–5.7	4.4 ± 0.37	B
Cojedes Norte (CON)	4	2.5–3.8	2.0 ± 0.70	C
Caño Culebra	3	0.8–0.9	1.4 ± 0.76	C
Cojedes Sur (Sucre)	5	0.1–0.3	0.6 ± 0.58	C
Sarare[b]	2	3.1–4.9	–	–
Camoruco-La Batea[b]	3	3.4–6.4	–	–

[a] The Least Squares Means (LSMEANS) are estimations of the class marginal means (in this case river stretches) that would be expected had the structure of the data been balanced (SAS Institute, Inc., 1987). LSMEANS with the same letter are not statistically different at the 0.05 alpha level.
[b] Not used in the analyses.

Table 2
Estimated number of non-hatchings Orinoco crocodiles in river reaches in the Cojedes River System, Venezuela

River section	Length (km)	Mean density (ind/km)	Estimated number	Maximum density (ind/km)	Estimated number
Cojedes Norte (CON)	7	2	14	3.8	27
Toma Cojedes-Retajao[a]	14.5	0.6	9	0.3	4
Retajao-La Doncella[b]	16	2.5	40	3	48
Caño de Agua Norte (CAN)	16	4.4	70	5.7	91
El Amparo-Camoruco[c]	13	–	–	–	–
Camoruco-La Batea	6.7	4.8	32	6.4	43
Caño de Agua Sur (CAS)	5.2	7.3	38	10.8	56
Caño Amarillo-Merecure (CAM)	8.4	4.9	41	6.8	57
Caño Amarillo-Sucre[b]	39.5	2.7	107	3.6	142
Sucre (SUC)	11.6	0.6	7	0.3	3
Sucre (SUC)	20.7	3.2	66	3.9	81
Caño Amarillo[b]	12.8	1.4	18	0.9	12
Caño Culebra (CUL)	8.4	4.0	34	4.9	41
Lower Sarare (SAR) Sarare	15.8	4.5	71	5.9	93
Totals	195.6		547		699

[a] Not surveyed. Assigned the lowest density for any surveyed section (sucre 0.6 ind/km).
[b] Not surveyed. Assigned the averaged density of the upper and lower continuous stretch.
[c] This river section is almost all lost due to diversion into smaller branches after a 1996 flood.

test, $P=0.22$). Due to the small sample size only two size categories (TL < 180 cm vs TL ⩾ 180 cm) were used in the analysis for this locality.

The population structure of CAN was estimated for 1996 and 1997 (Fig. 5c and d). The difference between years was not significant ($X^2=3.2$, $P=0.363$, 3 d.f.). As in CON, the population was dominated by small juveniles, but adults represented an important fraction of the population.

Size classes were more evenly distributed at CAS and CAM than at CAN and CON, especially as indicated by the 1996 surveys (Fig. 6). The Camoruco-La Batea section was only surveyed in 1992 (Fig. 6a) and was not compared statistically. The difference between Batea–Merecure for 1996 and 1997 was not statistically significant ($X^2=6.264$, $P=0.099$, 3 d.f.). The crocodile population in CAM 1997 was dominated by individuals less than 1.8 m in total length (Fig. 6d). Comparison of the population structure in this river stretch with the one for La Batea–Merecure obtained the same year, indicated a highly significant difference ($X^2=15.7$, $P=0.001$, 3 d.f.). The population sizes for the SUC and CUL were too small to attempt an analysis of structure. Neither adults nor hatchlings were seen in these river reaches, which suggest that reproduction does not occur there (Seijas, 1998).

5. Discussion

Godshalk (1978, 1982) highlighted the Cojedes River as an area with the most important population of the Orinoco crocodile in Venezuela. This was confirmed by Ayarzagüena (1987, 1990). We found that a minimum

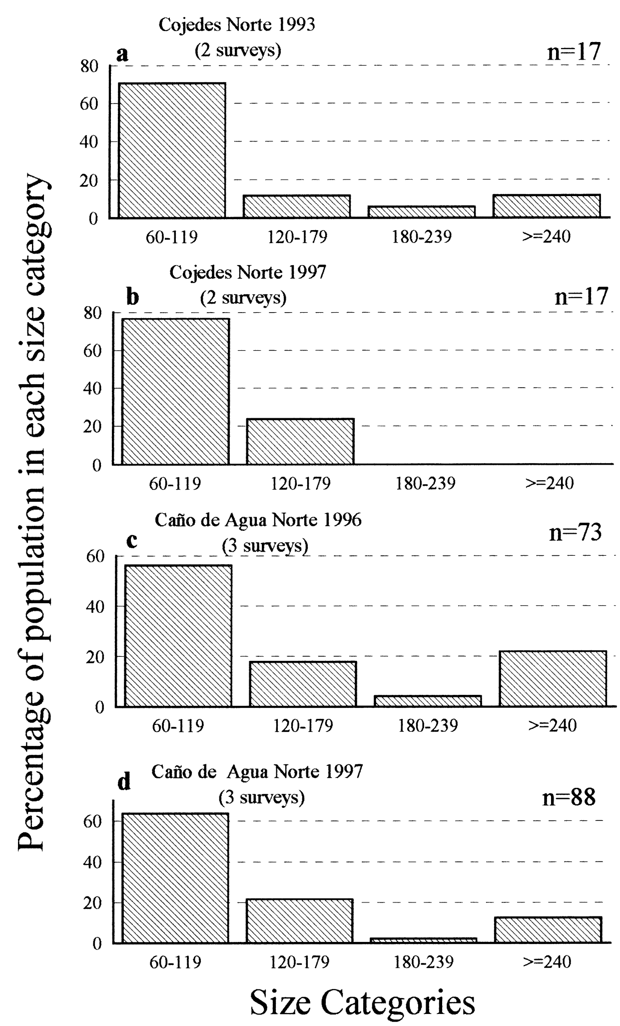

Fig. 5. Population structure of Orinoco crocodiles in river sections of the Cojedes River System, Venezuela. Size categories in cm of total length.

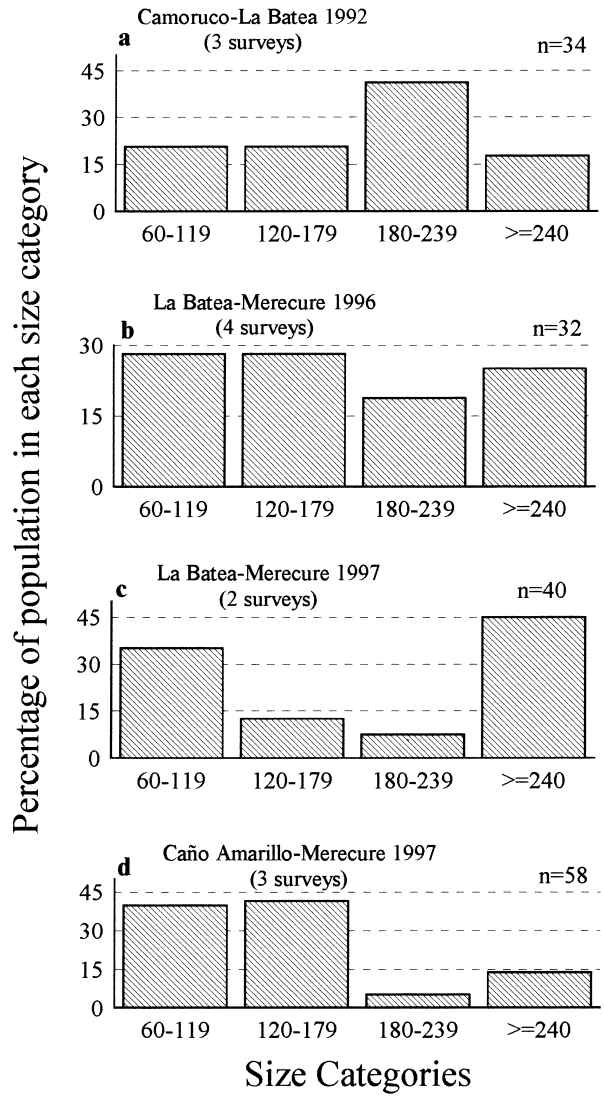

Fig. 6. Population structure of non-hatchling Orinoco crocodiles in three continuous sections of the Cojedes River System, Venezuela. Camoruco-La Batea, and La Batea-Merecure are almost entirely within Caño de Agua Sur. Size categories in cm of total length.

of 547 non-hatchling Orinoco crocodiles may be found in the CRS, a higher figure than the 350 crocodiles more than 1 m in total length reported by Ayarzagüena (1987). However, our results include data from river reaches not previously surveyed and, because we used satellite imagery and GPS, we recorded locations and lengths of river segments more accurately. The differences in methodologies and the imprecision of the boundaries of the river sections surveyed by Ayarzagüena (1987), preclude reliable comparisons. In any case, the population seems to be more widespread than was suggested by Ayarzagüena (1987), who indicated that most crocodiles were concentrated in a 10-km stretch of CAS.

The true population size in the CRS is difficult to determine. The methodology used in this study relies on an assumption that the population was stable from 1991 to 1997. This presumption could not be tested with the current data. Spotlight-counts are subject to problems of interpretation when densities observed at times or habitats with different conditions of visibility are compared (Hutton and Woolhouse, 1989; Da Silveira et al., 1997). Furthermore, indices of relative abundance usually underestimate the true population size (Hutton and Woolhouse, 1989). A fraction of the population usually remains undetected and the relationship between the PI and the true population density is difficult to establish. Studies conducted with marked crocodiles in Zimbabwe, for example, documented that even under the most favorable conditions more than 37% of a population remains undetected, and the proportion of the total population seen during spotlight counts ranges from 0.1 to 0.63. (Hutton and Woolhouse, 1989).

The environmental factor that most affects spotlight counts is water level (Woodward and Marion 1979; Messel et al., 1981; Montague, 1983). But water level is a proximate factor that triggers changes in behavior. The decrease in the number of juvenile crocodiles observed as the dry season advances may indicate that many of these animals seek refuge in burrows along the river bank where they cannot be detected, particularly during late dry season surveys. Most adult crocodiles may also be hidden in burrows during the dry season. They may emerge (particularly adult females), at the beginning of the hatching period in mid-April. When the water level is high (rainy season and early dry season) these burrows might flood, and the crocodiles might abandon them. Mortality could also contribute to the decrease in the number of crocodiles seen. Some crocodiles, particularly the smallest ones, may die during the late dry season, when a higher risk of predation and cannibalism probably occurs.

Other factors may explain part of the variability in PIs among river sections, as has been shown in other crocodilian population studies (Woodward and Marion, 1978; Wood et al., 1985; Hutton and Woolhouse, 1989; Da Silveira et al., 1997). Differences in visibility among localities might introduce some bias in the results. In CAN the river banks are covered by grasses and shrubs which allows many crocodiles to hide and escape detection during the nocturnal surveys. In contrast, CAS and other river sections downstream are generally devoid of that type of vegetation.

Differences in visibility of crocodiles in relation to water levels have important implications for monitoring of population status. The best period to conduct surveys to determine population size is from November to January. Not only is a higher fraction of crocodiles seen during these months, but the number of spectacled caiman (*Caiman crocodilus*) is relatively low (Seijas, 1998), which reduces survey time, therefore, limiting observer fatigue (Thorbjarnarson and Hernández, 1992). During these months, most areas can be accessed by car, and the high water level of rivers facilitates navigation.

The Orinoco crocodile population in the CRS is not uniformly distributed. Differences in size and structure were observed among the several river reaches that were surveyed from 1991 to 1997. The highest densities were found in CAS, a stretch of the CRS that maintains its meandering condition and is still surrounded by forest. This result is in general agreement with data reported by Ayarzagüena (1987) for the same location. Densities of crocodiles decrease upstream in CAN and CON, areas that are affected by deforestation, channelization and contamination (Seijas, 1998).

Our results for SUC and CUL sections represent the first data on the population status of crocodile at these localities. Here, the Orinoco crocodile population is extremely low, particularly near Sucre. These river sections are the only ones of the study area that are navigable year-round. There is commercial and subsistence fishing and, possibly illegal caiman hunting, around Sucre and in La Culebra. Accidental or intentional killing of Orinoco crocodiles by people may prevent the recovery of the species crocodile in these areas, although we did not obtain direct evidence of this.

If data from SUC and CUL are removed, densities of crocodiles in the CRS are very high (from 3.08 to 7.43 ind./km) compared to these reported by Thorbjarnarson and Hernández (1992) for the Tucupido (before it was dammed) and the Capanaparo rivers (1.94 and 1.64 ind/km, respectively). These contrasting figures are paradoxical because, compared to the CRS, the Capanaparo river is relatively isolated from important human settlements and is regarded as good crocodile habitat by Thorbjarnarson and Hernández (1992). However, egg predation and collection of hatchlings by humans, management problems known from the Capanaparo river (Thorbjarnarson and Hernández, 1992), are factors of marginal importance in the CRS (González-Fernández, 1995).

Population structure differed among river sections. CON and CAN were dominated by small crocodiles (less than 1.2 m in TL), which accounted for 56.2% of the crocodiles seen. In contrast, the crocodile population in CAS was composed largely of sub-adults and adults (>1.8 m in TL). CAM showed an intermediate population structure. These dissimilarities may be partially explained by differences in habitat quality among sections. The principal nesting beaches are found in CAS (Seijas, 1998). Differences in mortality may also play a role in structuring these populations. The injury rate of juvenile crocodiles is lower in northern sections than in the southern sections of the CRS, which may indicate a higher risk of predation in southern localities (Seijas, 1998).

An alternative explanation for differences in population structure among localities is that sites composed predominantly of juveniles (CON and CAN) may be recovering from overexploitation (Webb and Messel, 1978; Rebelo and Magnusson, 1983). In the case of CAN it is more plausible to think that the Orinoco crocodile is simply colonizing that river stretch. Most of CAN is an artificial channel which has received the water of the Cojedes river only since the 1960s (Pedrañez 1980; Campo and Rodríguez, 1995).

Finally, population structures may be shaped by human activities. Large crocodiles are more conspicuous and probably more frequently killed by people. Areas surrounding CON and CAN are more developed and encounters betwee human and crocodiles may occur with increased frequency. Fewer adults could remain in the river under these circumstances, and the less conspicuous juveniles may escape detection, although at lower densities than juveniles at CAS. In river sections less accessible to humans, such as CAS, large crocodiles may have greater chances to survive and became established as a reproductive population.

The procedures reported here and the population indices derived from them, represent the first attempt to standardize methodology for the study of the Orinoco crocodile population in the CRS, the most important population of this endangered species. These results serve as a baseline for future investigation of the species in the area.

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