First data of natural recovery of any Orinoco crocodile *Crocodylus intermedius* population: Evidence from nesting.

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ABSTRACT - Since the end of commercial hunting in the 1960's, there were no signs of recovery of the Orinoco crocodile (*Crocodylus intermedius*) populations throughout its range. In this study, nest counts have been used to establish population trends in the Arauca Department, Colombia. From December 2014 to April 2015, we surveyed 166.7 km of rivers for nests. Twenty-four nests were located, 2.2 times more than recorded 13 years previously. Our results indicate that *C. intermedius* populations in the area are increasing. The awareness of local people, a reduction in fishing activities and use of the river for transport may explain the recovery.

INTRODUCTION

The original populations of the Orinoco crocodile (*Crocodylus intermedius*) were depleted over its entire distribution area (Colombia and Venezuela) due to an intensive period of commercial hunting during the second third of the last century (Medem, 1981; Godshalk 1982). Since the end of commercial hunting 50 years ago, there has been no evidence of recovery in any of the remaining populations, either in Colombia or Venezuela. However, in Venezuela all the populations have been strengthened through the reintroduction of hundreds of captive-reared crocodiles but the two most important populations (Cojedes and Capanaparo Rivers) remain in decline (Mena et al., 2010; Moreno 2012). Antelo (2008). Antelo et al. (2010) describe the establishment of a new *C. intermedius* population in Venezuela, but in this case all the crocodiles were reintroduced. The reasons given for non-recovery are related to the human factors: contamination, habitat destruction, poaching, egg-robbing and the sale of hatchlings (Thorbjarnarson & Hernández, 1992; Seijas et al., 2010). Competition with the sympatric *Caiman crocodilus* has been also suggested (Thorbjarnarson & Hernández, 1992; Seijas et al., 2010).

The first census conducted in Colombia, from 1974 to 1975, showed that the most important *C. intermedius* population was in Arauca, with 180 individuals observed with the total estimated number in Colombia at 780 (Medem, 1981). Despite the ending of commercial hunting, 20 years later Lugo (1996) estimated the *C. intermedius* Colombian population at 123 crocodiles, 50 of them in Arauca. Six years later, Ardila et al., (2002), concluded that this population remained stable.

This study presents new information about *C. intermedius* population numbers by surveying for nest sites. Previously, Bonilla & Barahona (1999), Ardila et al. (2002) and Castro et al., (2012) presented some data concerning the population status and reproduction of *C. intermedius* in Arauca. We add to this knowledge with new observations on reproductive biology including the results of the first ranching in Colombia with this species. Ranching is the main action proposed in *The National Program for the Orinoco Crocodile Conservation* (Ministerio del Medio Ambiente, 1998). The results presented are of great importance for the *C. intermedius* conservation in Colombia. Our results are based on nest counts, which we believe is a valid method to establish the population trends of *C. intermedius*. The method avoids the high variability of counts produced by traditional spotlight methods (e.g. Chabreck 1966; Woodward & Marion 1978; Hutton & Woolhouse 1989) due to the risks involved in night work at this area as a result of armed conflict.

MATERIALS AND METHODS

The field study was conducted by one of us (L.F.A.) in three sections of the rivers Lipa, Ele, and Cravo Norte (Arauca Department). Five surveys were conducted: 1) from 19 December to 23 December 2014; 2) from 8 January to 11 January 2015; 3) from 16 January to 19 January 2015; 4) from 12 April 2015 to 17 April 2015 and 5) from 22 April 2015 to 24 April 2015.

A total of 166.7 km of the following rivers were surveyed for and the monitoring of *C. intermedius* nests: Lipa River (34 km, from 6°43'16.94"N; 70°53'54.42"W to 6°35'11.65"N; 70°43'23.68"W); Ele River (35.7 km, from 6°34'54.19"N; 70°47'1.26"W to 6°35'11.65"N; 70°43'23.68"W) and Cravo Norte River (97 km, from 6°30'53.00"N; 70°47'50.08"W to 6°23'24.00"N; 70°25'58.80"W). This territory is not under any form of protection, but there has been armed conflict between local guerrillas and the National Army of Colombia for the previous 50 years.

Surveys were conducted using a wooden boat powered by a 40HP outboard motor. Nests were located using footprints left in the sand by breeding females. A wooden stick was gently introduced into the sand to detect the eggs.

Once located, the nest was geo-referenced with a GPS and distance to water and vegetation was measured. Due to the lack of permission, the nests were not opened. Nests were monitored until they were harvested by local people or lost due to egg predation.

Simultaneously, in collaboration with Corporinoquia, the regional environmental authority, 150 eggs from four nests were collected from sites situated on the Ele River and transported to Wisirare Park (Orocué, Casanare) for controlled incubation. Transport and egg incubation is as explained in Antelo et al. (2010) and was carried out by local people on 30 January 2015. Eggs were transported 536 km on roads and paths after being issued with certificate of biodiversity No. 0560531, from the Corporinoquia.

RESULTS

Twenty-four nests were found along the banks of the 166.7 km surveyed (0.14 nests/km): one at the Lipa River (0.03 nests/km), 10 at the Ele River (0.28 nests/km) and, 13 at the Cravo Norte River (0.13 nests/km). Nesting occurs during the early dry season, in January. We were able to determine the date of 20 nesting events (Table 1). The earliest clutch was laid 4 January and the latest on 24 January 2015. Nesting peaked in the third week of January (12 nests), followed by the second week (5 nests). Wild clutches hatched between 3 April and 23 April 2015. The mean incubation time for seven wild clutches was 89.8 days, ranging from 88 to 97 days. In captivity, hatchling took place between 4 April and 19 April. Natural and artificial incubation lasted between 79 and 85 days.

Twelve of the nests (50%) hatched normally, five (20.8%) were harvested by local people, four (16%) were collected for artificial incubation, two (8.3%) were flooded due to rising river levels and one (4.2%) was partially predated by feral pigs although some of the eggs hatched (Table 1). Average distance from nests to the water and gallery forest was 12.5 m (maximum 41m; minimum 3m; SD=9.1m) and 21.5m (maximum 86 m; minimum 3 m; SD= 20m) respectively. Median height above water level was 112.7 cm (maximum 220 cm; minimum 57 cm; SD = 38.8m). In nest number 5 (Table 1), six crocodiles had emerged from the nest and were found in the water without any signs of nest opening. Later we placed two camera-traps close to the nest to film nest opening by the female but after 5 days we achieved no results and we removed the cameras. However, later it was found the female had subsequently opened the nest.

Nest attendance was observed at 21 nests (87.5%). An adult crocodile (presumably the mother) was recorded

Table 1. Nests location and incubation result. "Hatchlings" indicates the maximum number of *C. intermedius* counted in the vicinities of the nest. NF= Not found; --- No data.

Nº	Latitude	Longitude	River	Result	Hatchlings
1	6°37'45.57"N	70°45'04.85"W	Lipa	Hatched	41
2	6°33'30.65"N	70°42'01.09"W	Ele	Hatched	59
3	6°33'25.46"N	70°41´53.40"W	Ele	Harvested	---
4	6°33'37.45"N	70°41'44.45"W	Ele	Hatched	NF
5	6°32'18.76"N	70°41'04.05"W	Ele	Hatched	23
6	6°32'06.73"N	70°41'05.31"W	Ele	Collected	8
7	6°32'05.04"N	70°41'07.37"W	Ele	Collected	34
8	6º32'03.82"N	70º41'08.02"W	Ele	Collected	22
9	6º31'57.20"N	70º40'27.92"W	Ele	Collected	19
10	6º32'27.22"N	70º40'58.08"W	Ele	Flooded	---
11	6°31'44.91"N	70°40'05.49"W	Ele	Harvested	---
12	6°31'40.99"N	70°48'30.98"W	Cravo Norte	Harvested	---
13	6°30'15.66"N	70°44'22.28"W	Cravo Norte	Hatched	42
14	6°29'15.28"N	70°40'26.48"W	Cravo Norte	Predated	4
15	6°28´50.17"N	70°39´30.30"W	Cravo Norte	Hatched	28
16	6°28´14.58"N	70°38´07.05"W	Cravo Norte	Hatched	59
17	6°27'50.22"N	70°38'51.33"W	Cravo Norte	Hatched	13
18	6°27´57.37"N	70°36´28.34"W	Cravo Norte	Hatched	42
19	6°28'00.66"N	70°37'21.07"W	Cravo Norte	Flooded	----
20	6°27'31.61"N	70°35'56.08"W	Cravo Norte	Hatched	39
21	6°26'43.40"N	70°31'15.83"W	Cravo Norte	Hatched	37
22	6°27'03.38"N	70°31'17.26"W	Cravo Norte	Harvested	----
23	6°26'03.48"N	70°28'29.19"W	Cravo Norte	Harvested	----
24	6°23'25.62"N	70°25'55.96"W	Cravo Norte	Hatched	40

Figure 1. Female *C. intermedius* (bottom right of picture) guarding her hatchlings at Ele River. Picture taken by camera trap at 10.35 am.

in the vicinity of the nest, but her behaviour was not aggressive towards the investigator. Based on the presence of sand tracks, seven females had continued to visit their nest even after they had been predated or collected. In 12 of 13 cases where the eggs hatched parental care was also observed; in the remaining nest no hatchlings were found. Hatchlings and females were located downstream on the same shore as the nests in 3 cases; downstream in the opposite shore of the nest in 8 cases and in 1 instance were found upstream in the opposite shore of the nest. Only two groups of hatchlings were protected by aquatic vegetation, the rest were found on bare banks. Size of the hatchlings groups observed ranged from 4 (in the partially predated nest) to 59 (Table 1).

Median clutch size of the 4 collected nests was 40, ranging from 37 to 44 eggs/nest. Ten eggs of each of the 4 nests were measured and weighed. Median length, width and weight was respectively, 7.8 cm, 4.9 cm and 90.2g (n = 40). From the incubation of 150 eggs at Wisirare Park, 84 crocodiles hatched (56%), which will be reared in captivity until they reach at least 80 cm total length prior to release back to the wild.

DISCUSSION

Previous works reported seven (Bonilla & Barahona 1999), 11 (Ardila et al., 2002), and 9 (Castro et al., 2012) nests. Bonilla & Barahona (1999) surveyed 168 km of Lipa, Ele and Cravo Norte Rivers from January to April 1995. Ardila et al. (2002) surveyed 100.2 km of Lipa, Ele and Cravo Norte Rivers for four months (November-December 2000 and March-April 2001). Castro et al. (2012) surveyed 185 km of Cravo Norte, Ele and Lipa Rivers in April 2012. Study areas of these works do not match exactly with ours, but are almost the same. In this study twenty four nests were observed, and consequently we report the highest nest density in the study area. In the Venezuelan populations, Antelo (2008) reported 31 breeding females for the El Frío Biological Station (3.8 nest/km) and Caño Guaritico Wildlife Refuge; Hernández et al., (2014) founded 25 nests at the Capanaparo River (0.25 nest/km) and 27 nests were estimated by Espinosa & Seijas (2010) at the Cojedes River System (1.3 nests/km).

Reproductive chronology, nest, clutch, and egg characteristics are similar to those described for this region previously and for other wild and captive populations of *C. intermedius* (Thorbjarnarson & Hernández, 1993; Ramo et al., 1992; Seijas, 1994; Lugo, 1995; Colvée, 1999 and Antelo, 2008). In our sample, egg mass is lower than found in these other studies, perhaps a consequence of differences in sample sizes. Bonilla & Barahona (1999) observed nesting from December to January and Ardila et al., (2002) from January to February. In our study nesting was restricted to January.

Nest predation observed in our study (4.2%), is significantly lower than reported for the Cojedes River (11%) or the Biological Station El Frío (60%) (González-Fernández 1995; Antelo, 2008). Thorbjarnarson & Hernández (1993) noted that human predation was the only cause of nest loss at the Capanaparo River. In the same river, Hernández et al. (2014) observed that 4.5% and 53.8% of the Orinoco crocodile nests were predated and harvested respectively. Egg harvesting was previously noted in Arauca (Bonilla & Barahona 1999; Ardila et al., 2002; Castro et al., 2012), and seems to be a traditional issue in the area.

Antelo (2008) stated that Orinoco crocodiles were not able to leave the nest without the help of the mother, but in this study it was observed that at least the hatchlings placed in the upper side of the nest can emerge from the nest on unaided. Nest attendance (Fig. 1) observed (87.5%) is higher than reported for the Biological Station at El Frío (59%; Antelo 2008) and for the Cojedes River System (47.7%; Seijas & Chavez, 2000). Antelo (2008) described aquatic vegetation being employed as cover by hatchlings, but in our studies most of the hatchling groups were located in open areas, so risk of predation could be higher. Hatching success (56%) of collected eggs is low compared with other studies (Joanen & McNease 1987; Piña et al., 2005; Piña et al., 2007; Moreno et al., 2011 in Hernández et al., 2014), but in good agreement with certain other crocodilian studies (Webb et al., 1983; Whitaker 1987; Piña et al., 2003). Lack of experience of local people collecting the eggs and the long distance from the beaches to the incubator could explain these results.

CONCLUSIONS

Our data suggest that the *C. intermedius* population in Ele, Lipa, and Cravo Norte Rivers has recovered in recent years without any kind of management. Another explanation is that the field effort made in this study is slightly greater than in previous studies. Nevertheless, increases in the number of adult crocodiles (> 2.5 m), estimated at 152 (Anzola, unpublished data), support the assertion that the population is indeed increasing. These results also demonstrate that the Arauca population is the most important in Colombia and one of the most important in entire range of *C. intermedius*. There are no records of any other instances of natural recovery of this species.

There could be several possible reasons this population

has recovered naturally. They include a) the awareness of the local people towards crocodile conservation; many, for example, do not consider the crocodile as a threat; b) a reduction in commercial fishing, which is no longer economically viable due to decreasing fish numbers and c) river navigation has decreased due to increased road building by oil companies, local and national governments. The number of nests located indicates that an adequate ranching program could substantially increase the number of available crocodiles for reintroduction in Colombia. Ranching of hatchlings should be a more effective strategy than egg ranching. Ranching should be done with the collaboration of local people, due to their deep knowledge about *C. intermedius* nesting behaviour in the area. The challenge is to change their harvesting tradition into a conservation activity. Between 10 to 20% of the crocodiles bred in captivity should be returned to the Arauca Rivers, with the remaining individuals used to establish new wild populations or strengthen existing ones.

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