# Artificial incubation of wild-collected eggs of American and Orinoco crocodiles (*Crocodylus acutus* and *C. intermedius*), Guárico and Zulia, Venezuela

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**SUMMARY**

During 2009, wild eggs of two Venezuelan crocodilians (Orinoco crocodile *Crocodylus intermedius* and American crocodile *C. acutus*) were collected and artificially incubated using low-technology methods under basic conditions. Hatch success was 53.7% for *C. intermedius* eggs, and 65.6% for *C. acutus* eggs. Overall, 316 hatchlings were obtained from a total of 521 eggs (60.7% hatch success). These results compare favourably with similar artificial incubation trials, but incubation time for *C. acutus* eggs (87 to 102 days) was rather longer than the typical incubation period for the species (around 82 to 83 days). This may be indicative of a low incubation temperature; if so, most of the hatchlings may have been females. Only as these young mature will their sex be determinable. Hatchlings were taken to captive-rearing facilities where they will be maintained until they reach a suitable size for release into the wild. Participation of local people in this project was considered a very important factor in its success, and had additional conservation benefits including raising public awareness of the plight of crocodile populations and problems of over-exploitation in the study areas.

## BACKGROUND

Collection of eggs from natural nests for artificial incubation has been widely performed for crocodilians of several species, both for commercial and conservation purposes (Webb *et al*. 1987). Once collected, eggs are incubated in artificial nests and hatchlings are raised in captivity. Where conservation is the objective, juveniles are often released when they have attained a size where they are less susceptible to predation (known as 'head-starting'), the long-term aim being to restore or strengthen wild populations and accelerate species recovery.

In Venezuela, American crocodiles *Crocodylus acutus* and Orinoco crocodiles *C. intermedius* are now confined to small and disjunct populations in isolated areas within their original distribution range (Seijas 2007, Seijas *et al*. 2008). One of the many factors that hinder the recovery of crocodile populations in the region is the collection of eggs by local people for consumption (Thorbjarnarson 1993, Jimenez-Oraá *et al*. 2007). From a conservation perspective therefore, objectives of egg collection and artificial incubation are both to prevent egg losses due to human exploitation and to reduce losses due to natural factors (e.g. nest predation or flooding), with subsequent captive-rearing. During 2009, wild eggs of these two crocodiles were collected and artificially incubated using low-technology methods under

basic conditions at two sites in Venezuela. The methods used and outcomes are reported here.

## ACTION

**Study areas:** Collection of crocodile eggs was undertaken in two river basins: *C. intermedius* in the Manapire River (State of Guárico; 8°22'24"N, 66°14'53" W), and *C. acutus* in the Santa Rosa and Negro rivers (State of Zulia, 9°34'51"N, 72°12'43"W) both tributaries of Santa Ana River.

Along the Manapire River, the population of Orinoco crocodiles is much depleted. The river is divided into numerous branches that lose their connectivity during dry season as water levels drop, forming long pools. Nine of these pools (0.5 to 2.4 km in length) were surveyed from 2000-2009. Annually from zero to 12 non-hatchling crocodiles have been observed within them, with a combined maximum of 44 individuals (M. Jiménez-Oraá, unpublished data). Although the region has a low human population density, those people inhabiting the area can easily access such pools (simply by walking); the pools are constantly visited during the dry season and actively searched, primarily, for yellow-headed sideneck turtle *Podocnemis unifilis* eggs. The few crocodile nests in the area are also often found and likewise collected for food.

In the Santa Rosa and Negro rivers, the population size of American crocodiles has never been evaluated. The area is inhabited by settlers devoted to farming and livestock breeding, and by natives of the Bari ethnic group. The latter have traditionally used the resources of the river, including collection of crocodile eggs for their own consumption but recently also for commercial sale. According to some Bari, around 60 *C. acutus* nest each year along about a 45 km length of the Santa Rosa.

**Nest searches:** During 2009 crocodile nests were searched for along potentially suitable stretches of the Santa Rosa and Negro rivers, and along accessible pools in the Manapire River basin. Once located, the nests were carefully excavated by hand and eggs were collected following standard handling recommendations (Hutton & Webb 1992). At sites along the Santa Rosa and Negro, each clutch of eggs was initially transferred to a cylindrical plastic bucket (20 l capacity). The original nest substratum (mostly sand plus some decomposing vegetation) was excavated and used to bed the eggs down and then to cover all eggs within a bucket. Then, the eggs were transported by foot and by car (along unpaved roads) to the incubating room. Transport took from one to five hours, depending on the distances from the collecting site. In Manapire River, nest search and egg collection followed a similar procedure, but eggs were transferred directly to insulated polystyrene boxes (60 l internal volume) in which they were subsequently incubated. Transport to the incubating room was from 0.5 to 2 hours. Along the Manapire River, farmers and other members of local communities participated in nest searches and in the care provided during the incubation process. At the Santa Rosa and Negro rivers, nest search and care activities were performed with the assistance of members the Bari ethnic group, whom received a basic salary for their work.

**Artificial incubation:** The incubation room (25 $m^2$) at the Santa Rosa and Negro site had brick walls, a zinc roof and a terracotta floor. Upon arrival, the collected American crocodile eggs were transferred to sand-filled insulated polystyrene boxes (60 l internal volume). These were left on floor over the course of the incubation period. The room had a single window which was kept closed to keep out any potential egg predators. Five light bulbs, positioned above the incubation boxes, were used as required to produce heat to maintain the room temperature at around 32°C (particularly so during the night). A similar procedure was applied in Manapire (the incubation room being of similar construction but of smaller size, 5 $m^2$) but an artificial heat source was not used to maintain temperature.

Local people caring for the eggs during incubation were taught basic husbandry techniques: they were asked to remove periodically the ventilated box lids (at least once a week) and to add around 250 ml of water to maintain the moisture of the substratum, but taking care never to reach saturation point; and instructed on how to manipulate hatchlings and to transfer them to temporary holding containers prior to transport to the breeding facility. The researchers were notified when hatching took place. At both study sites therefore, a low-technology approach was taken regards the incubation procedure. Whilst this has potential

shortcomings, it has obvious advantages in that it can be undertaken near collection locations as little specialized equipment is required and costs are kept low.

## CONSEQUENCES

**Egg collection and incubation success:** In 2009, a total of 521 eggs (216 *C. intermedius*; 305 *C. acutus*) from 14 nests (four of *C. intermedius*; 10 of *C. acutus*) were collected and artificially incubated (Table 1). An overall hatch success of 60.7% was achieved. For the American crocodile eggs, hatching occurred from 87 to 102 days after collection. No precise figure is available regards the incubation period of the Orinoco crocodile eggs in Manapire, but given that eggs were collected on February 20, and local people notified that hatching took place at the beginning of June, then incubation was around 100 days. In both cases the incubation period is likely to have been underestimated, as some eggs were considered to have been laid several days before the collection date.

**Discussion:** Overall hatching success was a little lower than the values reported by Jimenez-Oraa *et al.* (2007) and Mercario *et al.* (2008) in previous works (61.9% and 71.7%, respectively) conducted in the same locations and under similar incubation conditions. Hatching success above 80% has been obtained for Orinoco crocodile eggs (using more advanced techniques) incubated at a temperature maintained around 32°C and at high humidity (99%) (Seijas & González 1994, Antelo 2008). Of concern is that the incubation period for American crocodile eggs is typically around 82-83 days (Fonseca & Benavides 2000, Casas-Andreu 2003), and that of Orinoco crocodile 86-90 days (Seijas & González 1994, Antelo 2008). The long duration of the incubation period observed in this study (up to 102 days for *C. acutus* in the unheated room at Manapire) may be indicative of too low an incubation temperature. If that was the case, most of the hatchlings emerging may have been females, as incubation temperature governs the sex of offspring, as has been reported for other crocodilian species (Hutton & Webb 1992).

Although a hatch success of only 53.7% was achieved for Orinoco crocodile eggs (collected from localities in the Manapire basin) in this study, it is considered that the eggs if left *in situ*, would probably have been taken by people for consumption. Likewise, human collection pressure in the Santa Ana basin, combined with natural losses due to predation or unsatisfactory incubation conditions, as reported for several crocodile species (Pooley & Ross 1989), would almost certainly have resulted in high nest failure. Therefore, collection of eggs for incubation is very likely to have greatly increased the number of hatchings than otherwise would have been produced at both localities.

The 316 hatchlings have been taken to captive-rearing facilities to be raised for a year or more, the aim being to release them back into suitable natural habitat. This procedure has been previously carried out in Venezuela; 434 Orinoco crocodile juveniles derived from eggs collected in the Manapire River have been released in several areas of the country (Jimenez-Oraa *et al*. 2007). Also, during 1992 and 1993, 576 Orinoco crocodiles were released in the Capanaparo River, where originally collected as eggs in previous years (Thorbjarnarson & Arteaga 1995). Additionally, captive reared American and Orinoco crocodiles, coming from captive-breeding facilities, have been release in several Venezuelan localities (Barros *et al*. 2005, Hernández 2007). Although monitoring of these releases has been very limited, some success has been demonstrated (Muñoz & Thorbjarnarson 2000, Antelo *et al.* 2010).

**Table 1.** Number of crocodile nests located, eggs incubated and hatch success, Manapire and Santa Ana River basins, 2009.

| Species (collection location) | Number of nests collected | Number of eggs incubated | Hatchlings obtained | Hatch success (%) |
|---|---|---|---|---|
| *Crocodylus intermedius* (Manapire basin) | 4 | 216 | 116 | 53.7 |
| *Crocodylus acutus* (Santa Ana basin) | 10 | 305 | 200 | 65.6 |
| Total | 14 | 521 | 316 | 60.7 |

A very important component of this egg collection and incubation programme was the participation of local people. Involvement of local communities is an integral component of this type of conservation initiative if we hope to successfully conserve these crocodiles in the long term. Participation of local people, as well as providing them with a source of income, had conservation benefits including raising public awareness of the plight of crocodiles and problems of over-exploitation in the study areas. A further beneficial outcome was the increase of knowledge regarding the population status of the two crocodile species and the pressure that humans exert. In Santa Ana basin, for example, the Bari ethnic group indicated that it is possible to collect at least 30 nests in the Santa Rosa and Negro Rivers during a reproductive season, which represent around half the number of nests that they estimate, are laid in each year.

During 2009, other populations of these two crocodiles were evaluated. It was determined that there were other areas in Zulia State with great potential for implementing similar egg collection and incubation programmes. Prime locations were in the vicinity of the Pueblo Viejo Water Reservoir and the Chama River, where two and three nesting areas were identified, respectively.

**Conclusions:** The loss of crocodile nests that would have occurred due to human exploitation (and additional natural factors) was considered sufficient to justify the collection of crocodile eggs in the two study areas and to attempt artificial incubation, albeit taking a low-technology approach (with its acknowledged limitations). This was however, the only practical option given funding constraints. If basic incubation techniques are improved, it is likely that the percentage of eggs successfully hatching can be increased, and potential problems revolving around excessive incubation periods rectified. Information on the population status of the crocodiles obtained during the programme is very useful, giving a starting point to evaluate population trends in the longer term. Participation of local people (given their prior knowledge of the study areas) was of great value. Their involvement also served to raise awareness of the plight of crocodile populations and problems of over-exploitation in the study areas.

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