SRAS Final Report: Monitoring reintroduction success of *Crocodylus intermedius* in Colombia: a hope for recovering the Species

Ana María Saldarriaga
Fordham University, Rose Hill Campus 2691 Southern Boulevard, Bronx, NY 10458.

Abstract

The Orinoco crocodile (*Crocodylus intermedius*) is the most endangered and least studied crocodilian in the Americas, with historical overhunting driving the species to the brink of extinction. In 2015, four adult individuals bred in captivity were released into the Guayabero and Losada Rivers in La Macarena, Meta department in Colombia, fitted with satellite telemetry tags. While initial tracking was conducted, no subsequent field monitoring occurred. This study aimed to assess the current presence of *C. intermedius* in the area and evaluate potential reproduction a decade after the release. Between July 16–30, 2025, we carried out nocturnal transect surveys (14 km upstream and 14 km downstream from La Macarena) and targeted capture expeditions. Surveys recorded four *C. intermedius* individuals—two males (3.5 meters and 2.1 m) and two females (2.4 m and 1.2 m)—all captured, measured, uniquely marked via dorsal caudal scute clipping, and sampled for genetic analyses. Additional samples were collected from *Caiman crocodilus* and *Paleosuchus* spp. No hatchlings or juveniles were observed, suggesting a lack of recent recruitment despite the presence of reproductive-sized females. Interviews with local residents corroborated the survival of some released individuals but confirmed that two were killed within the past decade. The findings highlight the persistence of *C. intermedius* in the region but raise concerns over reproductive success and long-term viability. Follow-up efforts will include genetic parentage analysis, *Paleosuchus* species identification, habitat assessment, and expanded dry-season surveys to identify nesting areas. These results provide critical data for guiding future releases and conservation strategies in one of the most crocodilian-diverse regions globally.

Introduction

Crocodylus intermedius commonly known as the Orinoco crocodile is considered the most endangered and least studied of the New World crocodylians (Moreno-Arias & Ardila-Robayo, 2020; Parra-Torres et al., 2020; Saldarriaga-Gómez et al., 2023). During the 20th century, intense commercial hunting driven by the high demand for its skin brought the species to the brink of extinction. As a result, it is currently listed as Critically Endangered (CR) on the IUCN Red List (IUCN, 2020). Today, the population status of *C. intermedius* remains uncertain, with the most recent surveys, conducted more than 15 years ago, reporting either stagnation or continued decline in population numbers (Medem, 1981; Lugo, 1996; Seijas et al., 2010; Parra-Torres et al., 2020; Saldarriaga-Gómez et al., 2023, Castillo-Rodríguez et al., 2024a).

A captive breeding program was established in 1971 at the Roberto Franco Tropical Biological Station (EBTRF by its acronym in Spanish) of the National University of Colombia (UNAL) located in Villavicencio, Meta department. On 2015 the EBTRF, Government Environmental Agencies, and the Colombian Air Force supported the reintroduction of 4 adult crocodiles into their natural habitat in the Guayabero and Losada Rivers in La Macarena municipality, Meta department, Colombia. Reintroducing adult crocodiles saves time, as they are reproductively active, and helps restore populations by reducing the risk of predation, which limits recruitment rates (Vargas-Ramírez et al., 2023). The released crocodiles were fitted with satellite telemetry tags, which led to the publication by Moreno-Arias & Ardila Robayo (2020)—the first study in Colombia to use GPS data for crocodile spatial ecology research. However, aside from this satellite tracking, no direct monitoring of the released crocodiles was conducted in the area. Monitoring the released crocodiles is just as important as the initial release event and is a requirement of the country's National Program for the Conservation of the Orinoco Caiman (PROCAIMAN; MAM, 2002). Although this is not a guarantee of the survival of individuals, it

is a first step in determining the success and short-term impact of the release of adult crocodiles. This information is solid support for continuing more releases, which are the only solution for the crocodile's conservation in places where the species is in the brink of extinction.

The primary aim of this project is to assess the presence of the Orinoco crocodile in La Macarena municipality, Meta department, Colombia, and to evaluate any potential reproduction events that may have occurred a decade after four adult crocodiles were released into the Guayabero and Losada Rivers. Considering that the midterm goal of this reintroduction is to restore the species by increasing its abundance in areas where it was historically present, this project seeks to evaluate whether the released individuals have survived, and to better understand the status of crocodiles in the area. Specific objectives include assessing the presence or absence of individuals of different size classes—juveniles, subadults, and adults—through nocturnal survey, as well as collecting genetic material samples from these individuals. Additionally, interviews with local communities will help gather valuable anecdotal information regarding sightings, nesting events, and human-wildlife interactions. These objectives will help assess the effectiveness of this reintroduction effort, which is critical for the species' conservation and long-term survival.

Methods

Between July 16 and 30, 2025, a field expedition was conducted in La Macarena, Meta. Data collection was carried out through both nocturnal and diurnal surveys in the Guayabero River. Nocturnal transect monitoring was conducted on July 18, 20, 21, and 22, 2025 (Figure 1) followed by night expeditions on July 23, 24, 25, and 26, 2025, dedicated exclusively to capturing Orinoco crocodiles previously detected during the transects. The remaining days were devoted to coordinating logistics in the area and conducting interviews.

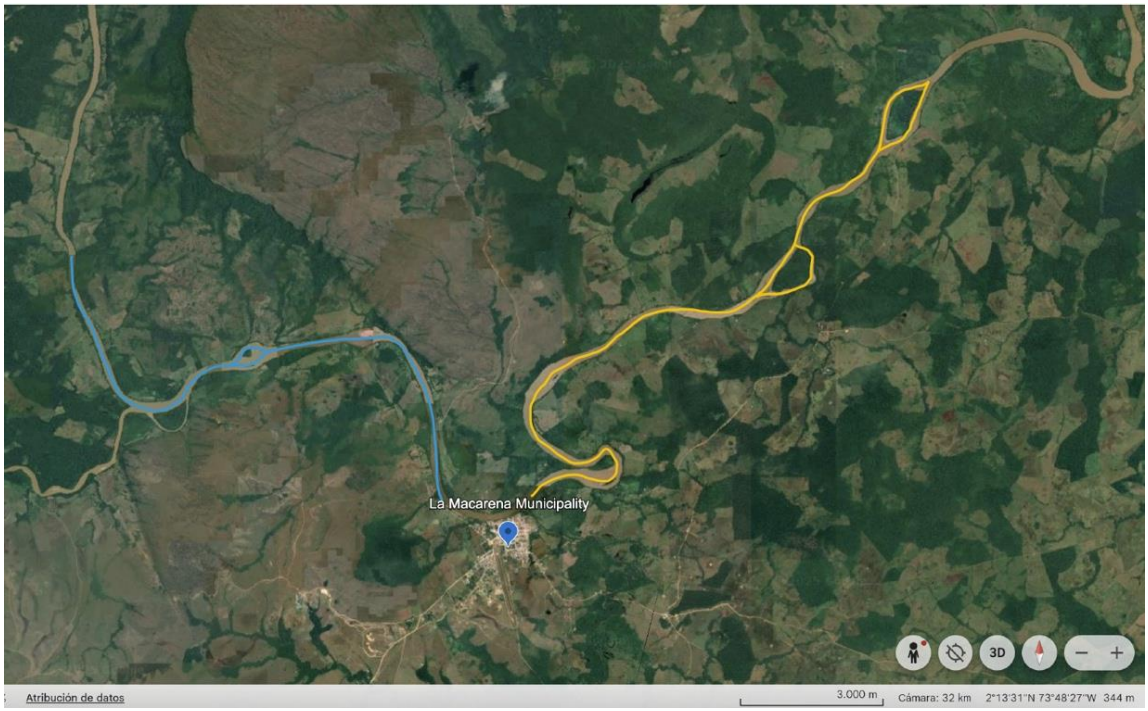


Figure 1. Transects conducted on July 18 and 22 (in yellow) downstream from La Macarena Municipality, and on July 20 and 21 (in blue) upstream from La Macarena Municipality in the Guayabero River. Each transect covered approximately 14 km of river.

For the monitoring transects, we covered 14 km upstream and downstream from La Macarena, in a 15-meter-long fiberglass boat equipped with a four-stroke engine (Figure 2a). This distance was determined in consultation with Julio, the local boat operator who accompanied us during the surveys and corresponds to the area where the local authorities and guerrillas permits monitoring activities. To secure this, on July 16 and 17 we coordinated logistics to obtain permission. For the nocturnal transects, the three researchers and the boat operator navigated along the Guayabero River, departing at 6:30 p.m. and returning at 11:00 p.m. These timeframes were also determined according to the time restrictions set in the area. During the surveys, one person stood at the bow of the boat, scanning the riverbanks and adjacent vegetation with a flashlight to detect individuals, identified by the characteristic eye-shine visible when illuminated. In the area, this reflection can correspond to *Caiman crocodilus* (Spectacled caiman), *Crocodylus intermedius* (Orinoco crocodile), *Paleosuchus trigonatus (*Smooth-fronted caiman), or *Paleosuchus palpebrosus (*Cuvier's dwarf caiman). Species identification was based on morphological traits. The presence of an interorbital ridge is associated with *Caiman crocodilus*. An exposed fourth mandibular tooth, a more elongated snout, and a flatter rostrum are characteristic of *Crocodylus intermedius*. *Paleosuchus* species are significantly smaller in size, have a shorter snout that is broader at the base with a U-shaped or blunt profile, and possess thicker, rougher dorsal and caudal scutes with pronounced keels. Identification of *Paleosuchus* to the species level (*P. trigonatus* or *P. palpebrosus*) is being carried out through examination of photographs by experts. Once eye-shine was spotted, the boat operator would approach as closely as possible, and with the aid of binoculars the researchers attempted to identify the species and estimate size. For each sighting, we recorded the species (or "eyes" if unidentified), estimated size, coordinates and time of observation. Transect tracking and data collection were carried out using the AllTrails application, available on the App Store. These transects were dedicated exclusively to counting and identifying individuals.

Between July 23 and 26, we conducted night expeditions to capture *C. intermedius* individuals previously detected during the transects, considering the high site fidelity of crocodiles. For capturing individuals, searches are carried out using flashlights, and then, with the aid of poles fitted with metal cable snares (Figure 2b), the animals are secured by the neck. Once captured, they are handled with the help of ropes, either by bringing them onto the boat or managing them directly from the water. Captured individuals were measured and marked with a small-scale cut on the tail to prevent resampling upon recapture. This marking also served as a genetic sample, preserved in 96% ethanol, and deposited in the Colombian Biodiversity DNA and Tissue Bank at the Genetics Institute of the National University of Colombia (BTBC-UNAL). Samples were processed in accordance with the "Permiso Marco de Recolección de especímenes de especies silvestres de la Diversidad Biológica con fines de investigación científica no comercial" (Resolution 0255-2014) granted by the National Environmental Licensing Authority (ANLA) to the National University of Colombia, under the Biodiversity and Conservation Genetics Group. Additionally, this work was conducted under an IACUC permit (EH-24-02) granted by Fordham University, in the United States.

Initially, the plan included searching for crocodile tracks on sandbanks during the day; however, due to extremely high river levels, no beaches were present, and spotting individuals in the water during daylight was not feasible. Therefore, daytime activities focused on interviews with residents to gather information on sightings, nesting behavior, juvenile presence, and general perceptions of crocodiles in the area.



Figure 2. A) Boat used for monitoring and B) preparation of the equipment used for capturing individuals.

Results

During the nocturnal transects, we collected the following information: Transect 1 (downstream, July 18, 2025) recorded 2 *Crocodylus intermedius*, 16 *Caiman crocodilus*, 5 *Paleosuchus* spp., and 6 unidentified eye-shines; Transect 2 (upstream, July 20, 2025) recorded 4 eye-shines, 6 *C. crocodilus*, 1 *C. intermedius*, and 2 *Paleosuchus* spp.; Transect 3 (upstream, July 21, 2025) recorded 10 eye-shines, 8 *C. crocodilus*, 1 *C. intermedius*, and 3 *Paleosuchus* spp.; and Transect 4 (downstream, July 22, 2025) recorded 9 eye-shines, 18 *C. crocodilus*, 2 *C. intermedius*, and 2 *Paleosuchus* spp. Based on these observations, we identified four Orinoco crocodiles (*C. intermedius*) in the area (Figure 3).

Subsequently, during the nocturnal capture expeditions, we successfully captured all four *C. intermedius* individuals observed during the transects (Figure 4). These individuals were measured and marked: a 2.1 m male marked with scale cut 1S (corresponding to the first single dorsal caudal scute; genetic sample catalog number BTBC13761; Figure 5), a 3.5 m male with scale cut 2S (BTBC13764), a 2.4 m female with scale cut 7S (BTBC13768), and a 1.2 m female with scale cut 10S (BTBC13769). Additionally, during these capture efforts, we collected genetic samples from other crocodilian species for future research: four *Paleosuchus* spp. (BTBC13754, BTBC13757, BTBC13761, and BTBC13766; Figure 6) and seven *C. crocodilus* (BTBC13756, BTBC13758, BTBC13759, BTBC13760, BTBC13763, BTBC13765, and BTBC13767).

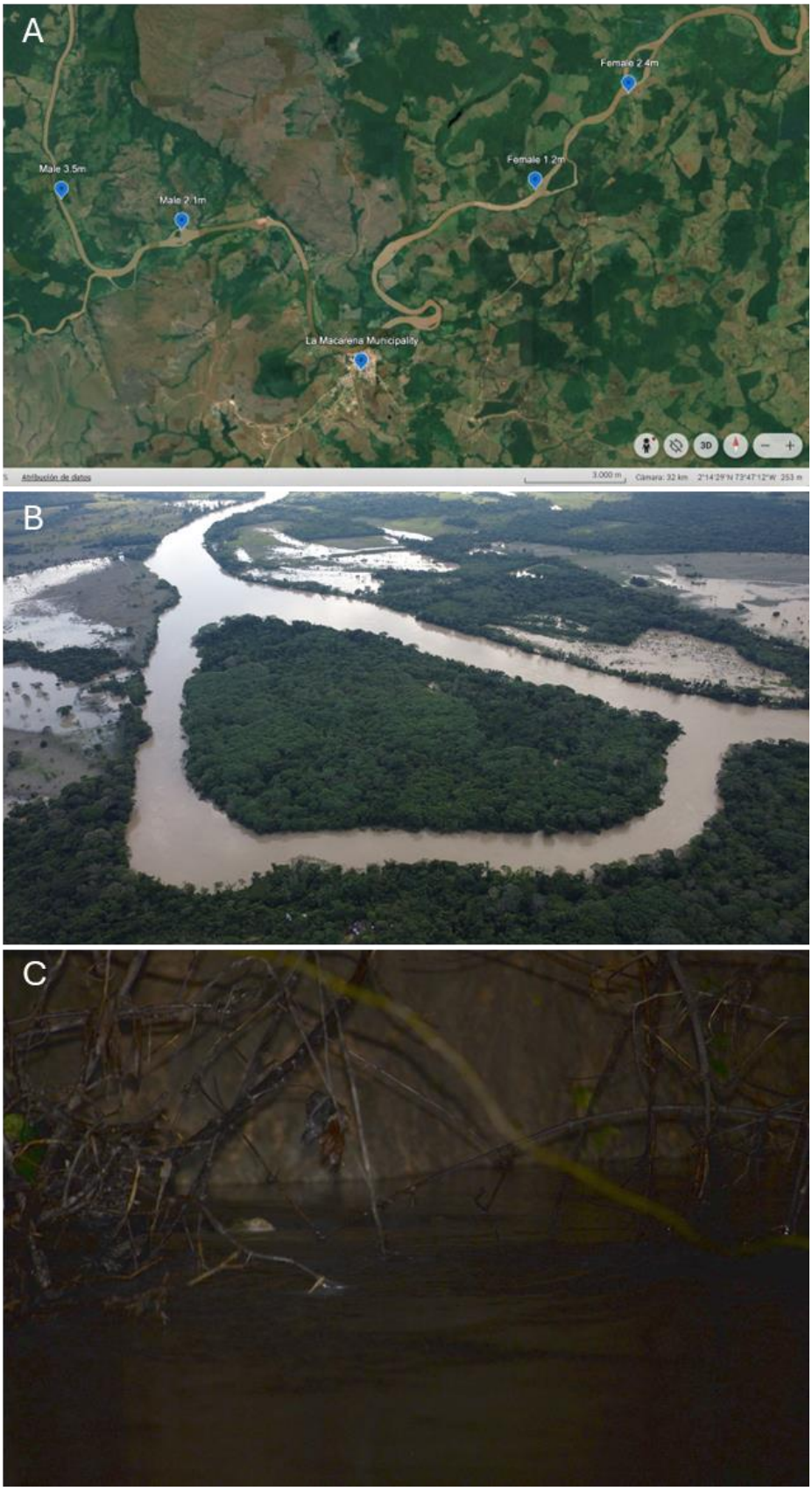


Figure 3. A) Map showing the locations of the four Orinoco crocodile individuals identified during the transects; B) diurnal aerial photograph of the island where the 1.2 m female was found showing the flooding caused by the Guayabero River and C) photograph of the eye of the 2.4 m female Orinoco crocodile identified during the monitoring transects.

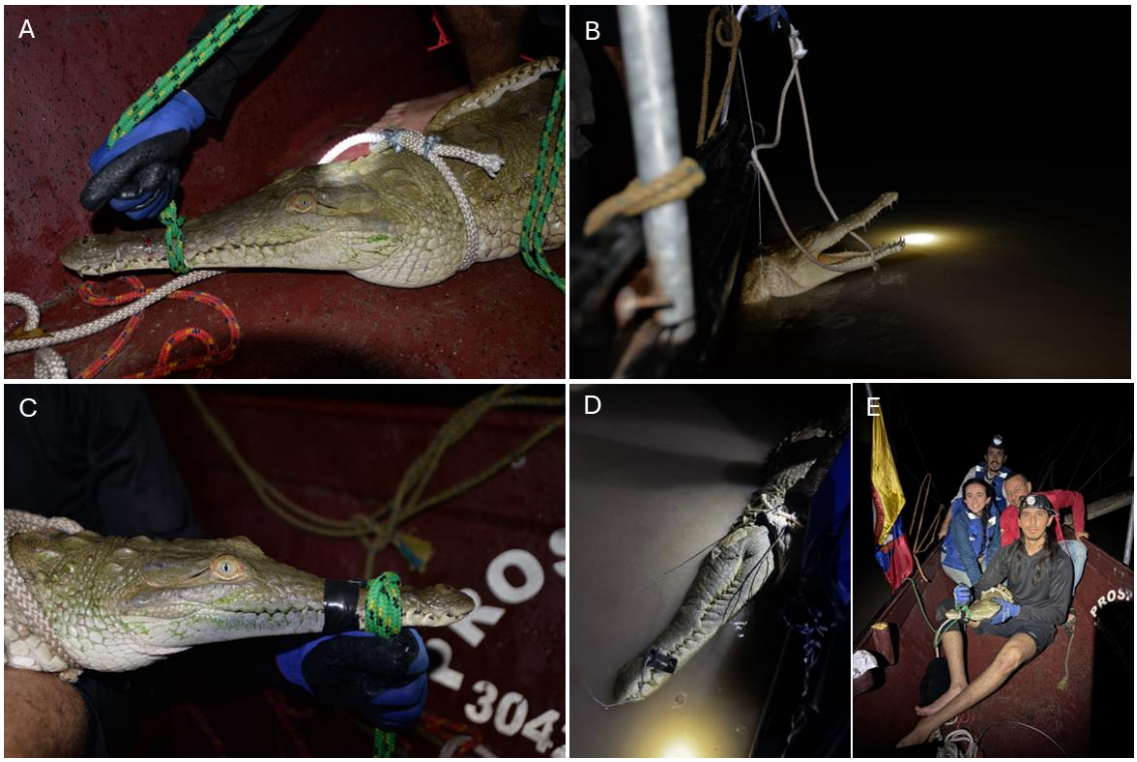


Figure 4. Photographs of the four *Crocodylus intermedius* individuals captured. A) 2.1m male, B) 2.4m female, C) 1.2m female, and D) 3.5m male as well as E) the team with the 2.1 male.



Figure 5. Clipped scute from an Orinoco crocodile, serving both as a genetic sample and as a unique identification mark for the individual.



Figure 6. Photographs of three of the four captured *Paleosuchus* individuals.

Local residents remember the release event that took place 10 years ago, and multiple sources reported that one of the crocodiles is still alive and resides in a site known as "El Raudal," located upstream on the Guayabero River. People recognize it because it still carries the satellite telemetry tag. Another of the released individuals was reported to have been seen roaming near the town for several days before moving away, about two years ago. Two of the four released crocodiles were killed, the last one approximately 6–7 years ago. We also spoke with a local guide who reported monitoring 27 juveniles and 3 adults (over 3 m in length) between La Macarena and El Raudal (upstream) (Figure 7), and that between La Macarena and the downstream endpoint of our survey, there are three large individuals.



Figure 7. Photograph of a young adult Orinoco crocodile inhabiting the area between La Macarena and El Raudal. Source: Hermel Polanco, local boat operator.

Locals reported no sightings of hatchlings, eggs, or nests; all crocodiles known in the area are juveniles or adults. Julio told us that people do not kill them—first, because they attract tourism, as visitors are excited to see large crocodiles, and second, because the guerrilla also prohibits their

killing. Julio is highly familiar with crocodiles, can distinguish them from spectacled caimans, and knew the locations where we eventually found them. However, as is common, fishermen sometimes mistake large caimans for crocodiles.

Discussion

This work contributes to multidisciplinary long-term efforts to evaluate the success of reintroduction programs, moving beyond the act of releasing individuals to understanding their survival and integration into the ecosystem. By compiling data on the present status of these crocodiles, this work is a foundation for future monitoring, recognizing that establishing a viable wild population is a long-term goal that requires sustained effort. This research not only produce valuable data for conservation but also provide critical professional development for me as a student, including fieldwork coordination, data analysis, community engagement, and in the future, the dissemination of findings from local to academic communities.

The field expedition was planned for the last two weeks of July, a period that typically coincides with a short dry spell ("veranillo") within the rainy season, which lasts from May to November. However, we arrived in the area to find the river at its highest level in the past five years due to heavy rains. According to local residents, the expected dry spell had not occurred, likely as a result of climate change, which has either eliminated this period altogether or shifted it to unpredictable dates. When we arrived in La Macarena on July 16, the river was extremely swollen, carrying large amounts of driftwood and debris. The riparian zones were heavily flooded (Figure 3b), significantly affecting the survey, as animals moved into these inundated areas where they were very difficult to spot, even by detecting their eye-shine. Fortunately, from that day onward the river began to recede, and during most of our nocturnal transects there was no rainfall—a favorable condition, as both visibility and crocodile activity are affected, making data less comparable under heavy precipitation. In our case, only during Transect 3 we experienced intermittent rainfall, which likely explains the higher number of "eyes" recorded that night, as species identification was hindered by the environmental conditions.
In our case, we were able to observe and capture four wild Orinoco crocodile individuals in the area. However, based on information gathered from interviews, we know there are additional wild crocodiles nearby. In fact, Julio told us that between the starting point of our upstream transect and "El Raudal," he has seen three other adult crocodiles, noting that they are always found in deep river sections known locally as *charcones*. This behavior has also been reported by other fishermen living in areas inhabited by crocodiles, such as along the Manacacías River. Moreover, during Transect 4 (downstream), as we were returning—and thus the following information is not included in our official count—we passed a location where Julio stated a crocodile is frequently present, at coordinates 2.21088, -73.77662. Given Julio's extensive experience with the river, it will be necessary to return and search for this crocodile, which is located not far from the urban center of La Macarena.

Based on both transect observations and local accounts, there is no evidence of reproduction for the species in the area. In our case, the smallest individual we observed measured 1.2 m in length—already around five years old—while the other three were adults over 10 years old. Considering that hatching for this species occurs at the end of April, coinciding with the onset of the rainy season, and that newborn individuals remain together with the mother for about three months after birth, during the period of our visit we would have expected to find females accompanied by young crocodiles, as well as groups of newborns. However, none were observed, despite the presence of at least one female of reproductive size. This warrants further investigation. In particular, the known reproductive-sized female should be monitored during the egg-laying season (January–February) to determine whether she exhibits nest-guarding behavior between that time and April, which would help identify nesting beaches that could serve as critical sites for reproduction and should be prioritized for conservation. In line with this, it is also

necessary to return and survey the stretch of river between the community and El Raudal to assess age-class composition and identify other potential reproductive females for similar monitoring.

In the area, Moreno et al. (2018) conducted a study in 2016 to assess human–crocodile interactions in La Macarena, which also included a habitat characterization. They describe La Macarena as a site that was once protected by armed groups, but where anthropogenic activities have increased following the peace agreements and the arrival of settlers. Their report notes the presence of three crocodilian species (excluding *Paleosuchus trigonatus*, which we are not entirely certain we observed—although we believe we did and are currently verifying this), and a habitat in generally good conservation status. Although they did not identify direct interactions between humans and crocodilians, Moreno et al. 2018 found factors that could trigger negative encounters, such as the presence of domestic animals along riverbanks, poor management of fishing waste, and lack of access to potable water. Their study discusses fishing as one of the main issues, citing the use of gillnets ("transmayo") and commercial fishing for transport to other regions of the country. However, during our visit, fishing was entirely banned by the guerrilla, even for local consumption. This appears to have changed over the last 10 years. While this ban is detrimental for local residents, it is beneficial for the ecosystem, creating a contradictory situation. For this reason, and somewhat paradoxically, one concern for wildlife conservation is that if these armed groups leave the area, people might begin killing crocodiles out of fear or that crocodiles might become entangled in fishing nets if large-scale fishing is once again permitted in the area.

Moreno et al. 2018 found that the species with the highest relative abundance (number of individuals observed per kilometer traveled) was *Caiman crocodilus* with 2.06 individuals/km, followed by *Paleosuchus* spp. with 0.51 individuals/km, and finally *C. intermedius* with 0.20 individuals/km. In total, they recorded four individuals in the upper Guayabero River (upstream from La Macarena) and three in the lower section (downstream). These abundance values are similar to what we recorded in our surveys, although they covered a much greater distance than we did. For 2016, the authors did not report any direct negative interactions, and according to our interviews, the community also claims that such incidents do not occur. However, we know that two of the released crocodiles were killed, and in 2023 a wild individual was killed near El Raudal following an incident involving a fisherman. It is unclear whether the lack of reported incidents is due to unawareness.

Colombia is the richest country in the world in terms of crocodilian diversity, with six of the 23 extant species, and La Macarena region is one of the few places globally where such a high number of crocodilian species coexist, with four species. This offers a unique opportunity to study interspecific interactions within the same habitat and raises many future research questions. As a follow-up to this study, our first goal is to identify the *Paleosuchus* species we encountered, to determine whether both species occur in the area or only one. To address this, we are working with photographs, consulting experts, and analyzing genetic samples collected in this expedition. A follow up of this expedition is to assess riparian cover using publicly available landscape layers and to replicate the correlation analyses performed by Moreno et al. (2018). La Macarena is one of the regions with the highest deforestation rates in the country—we could see numerous patches of recently burned forest from the airplane—so we expect to detect a reduction in vegetative cover.

In addition, by genetically analyzing the tissue sample collected from the 1.2 m crocodile, we can determine whether this individual is the offspring of one of the released crocodiles, as we have tissue samples from those individuals, previously genotyped with microsatellites (Saldarriaga-Gómez et al., 2023). We also aim to analyze the genetic samples from all crocodilian species detected in the area to place their genetic diversity within the national context, using the markers and datasets previously published for each taxon.

Finally, we are considering returning during the dry season next year or in two years to search for nests and crocodile tracks along the same route we surveyed, given the confirmed presence of at least one reproductive-sized female. We also intend to collect habitat characterization data along our transects and to explore the possibility of expanding the survey area to match, and even exceed, the coverage of Moreno et al. (2018). This would include the Duda River, where the strong presence of guerrilla groups has so far prevented agricultural encroachment, providing a unique form of protection that we believe has allowed crocodiles to persist with cohesive populations, reproductive activity, and individuals across a range of age classes. To achieve this, we are actively seeking funding sources.

Acknowledgements

I would like to thank the organizations that funded this expedition: the IUCN SSC Crocodile Specialist Group Student Research Assistance Scheme, the Lewis and Clark Fund Grant from the American Philosophical Society, and the Exploration Fund Grant from The Explorers Club. I am also grateful to my PhD advisor, Dr. Evon Hekkala from Fordham University; to the Genetics Institute at the National University of Colombia for their support with national permits and sample transport; to the Permian Global Guayabero Crocodile Reserve for allowing us to conduct sampling within their territory; to the Civil Defense, Cormacarena, and the La Macarena municipal government for logistical support; to Julio, our boat operator in La Macarena (Figure 6); and to all the residents of La Macarena who generously shared information with us.

Literature Cited

Castillo-Rodríguez, N., Saldarriaga-Gómez, A. M., Antelo, R., & Vargas-Ramírez, M. (2024). Population genetic structure in the critically endangered *Crocodylus intermedius* (Crocodilia: Crocodylidae): A shift in perspective for conservation actions in Colombia. *Biological Journal of the Linnean Society, 143*(3), blad174. https://doi.org/10.1093/biolinnean/blad174

IUCN. (2020). *The IUCN Red List of Threatened Species* (Version 2020-3). International Union for Conservation of Nature. https://www.iucnredlist.org

Lugo, L. M. (1996). Advances in the studies of the status of the Orinoco crocodile in Colombia. *Newsletter Crocodile Specialist Group*, *15*, 21–22.

Ministerio del Medio Ambiente (MAM). (2002). *Programa Nacional para la Conservación del Caimán Llanero (PROCAIMÁN)*. Dirección General de Ecosistemas, Subdirección de Fauna, Santafé de Bogotá, Colombia.

Medem, F. (1981). *Los Crocodylia de Sur América. Los Crocodylia de Colombia* (Vol. I). Ministerio de Educación Nacional, Colciencias. Bogotá, 354 pp.

Moreno-Arias, R. A., & Ardila-Robayo, M. C. (2020). Journeying to freedom: The spatial ecology of a reintroduced population of Orinoco crocodiles (*Crocodylus intermedius*) in Colombia. *Animal Biotelemetry, 8*(1), 15. https://doi.org/10.1186/s40317-020-00202-2

Parra-Torres, F., Moreno-Arias, R., & Montenegro, O. (2020). Evaluation of crocodilian populations along the Bita River (Vichada, Colombia). *Herpetological Conservation and Biology, 15*(2), 416–426.

Saldarriaga-Gómez, A. M., Ardila-Robayo, M. C., Medem, F., & Vargas-Ramírez, M. (2023). Hope is the last thing lost: Colombian captive-bred population of the critically endangered Orinoco crocodile (*Crocodylus intermedius*) is a genetic reservoir that could help to save the species from extinction. *Nature Conservation, 53*, 85–103. https://doi.org/10.3897/natureconservation.53.104000

Seijas, A. E., Antelo, R., Thorbjarnarson, J. B., & Ardila Robayo, M. C. (2010). Orinoco crocodile *Crocodylus intermedius*. In S. C. Manolis & C. Stevenson (Eds.), *Crocodiles. Status Survey and Conservation Action Plan* (3rd ed., pp. 59–65). Crocodile Specialist Group.

Vargas-Ramírez, M., Forero-Medina, G., Moreno Torres, C., & Balaguera-Reina, S. A. (2023). Reintroduction of adult Orinoco crocodiles: a crucial step towards the species recovery. *Oryx, 57*(5), 557–558. https://doi.org/10.1017/S0030605323000613