Spatial ecology of crocodylia in Natural Tayrona National Park, Colombian Caribbean.

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ABSTRACT

Spatial ecology allows us to understand the life areas and dispersal patterns of organisms; however, it is a topic that has been little evaluated at the international and national level in crocodylids. We evaluated the home range and movement of crocodylians inhabiting the eastern sector of Tayrona National Natural Park (PNNT) between July 2021 and January 2022 using VHF radio telemetry. A total of 365 records were obtained with an error of 12.56 % from 6 individuals (five *Caiman crocodilus* and one *Crocodylus acutus*). Minimum convex polygon (MPC), local convex hull (LoCoH) and kernel density with isopleths at 50%, 95% and 100% were used to determine the home range per individual for *C. crocodilus*, and MPC for *C. acutus* due to the low number of points obtained in the surveys. Mean (DMR) and maximum distances traveled (DRM) were estimated. It was observed that C. crocodilus females moved less than males. On the other hand, a generalized linear model was used to analyze the effect of environmental variables (precipitation, radiation, humidity, average, minimum and maximum temperature), sex, individual and week on the movement of the species, and it was found that the only significant variable that influences the average weekly movements is the individual. The present research is the first to deepen the spatial ecology for both species at the national level, and the results are fundamental in decision making with interest in the conservation and protection of crocodylians in coexistence with human communities and related ecosystems within the Protected Area.

INTRODUCTION

Ecological studies that address the spatial ecology of organisms allow understanding the life areas and dispersal and occupancy patterns, information necessary for the generation of strategies for the management, control and protection of wildlife, which are fundamental for the conservation of species and ecosystems (Fletcher & Fortin, 2019). For *C. crocodilus* and *C. acutus*, their spatial ecology at the

national and regional levels is largely unknown, limiting decision-making for their conservation. In addition, in recent years, sightings of crocodylids have increased in the PNNT in areas of high tourist occurrence (Balaguera-Reina et al., 2012), evidencing a high level of ignorance and fear on the part of people towards these species (Balaguera-Reina et al., 2019). In turn, the presence of *C. acutus* in the PNNT can play an important role in the conservation and recovery of its threatened populations. Therefore, we analyzed the home range and movement patterns for these two species within the PNNT during 2021-B.

METHODOLOGY

Study area: Tayrona National Natural Park (PNNT) is located in the north of the department of Magdalena (11°16' N, -74°12' E; 11°21' N, -73°53' E). It has an area of approximately 12972 ha of terrestrial ecosystems, which are mainly composed of scrubland, dry forest, rainforest, cloud forest, beaches, lagoons and old mothers, as well as a marine area of 6574 hectares. Its altitudinal range goes from 0 to 900 m above sea level, with an average temperature of 27°C and an average rainfall of 570 m. It is part of the Sierra Nevada de Santa Marta ecoregion (Parques nacionales naturales de Colombia dirección Territorial Caribe, 2020). It is characterized by low precipitation between December-April and July-August due to the northeast trade winds, which are the driest seasons (Parque Nacional Natural Tayona, 2006).

Captures and monitoring: This work is the second phase of the project "SPATIAL ECOLOGY OF THE NEEDLE CAYMAN IN THE TAYRONA NATURAL NATIONAL PARK". At the beginning 4 individuals were being monitored (C. acutus n=1 [ID 11] and C. crocodilus n=3 [ID 7, 10 and 11]). Crocodilids were mainly captured at night, skirting the water bodies on foot (Rueda-Almonacid et al., 2007). The captured individuals were weighed, sexed and different morphometric measurements were taken (Sánchez Herrera et al., 2011).

Three models of Telenax transmitters (TXE-311BR, TXF-315BR and TXF-317BR) were used. The transmitters were installed according to the method performed by Balaguera-Reina et al. (2016). All captured individuals were marked by removing caudal scales (De La Ossa, 2001). Individuals were released at the same capture sites. The monitoring of the individuals with transmitters was carried out on the following release day, monitoring three times a day, during each day from July 20, 2021 to January 25, 2022, where the location of the individuals was determined by triangulation of the frequencies recorded with an error of no more than 7 meters, from at least three different stations.

Then, the home range or area (Minimum Convex Polygon [MPC], Kernel density, Local Convex Hull [LoCoH]) was estimated with 100%, 95% and 50% isopleths, together with the trajectories, velocities (maximum and average) and average movement distance (AMD) of the individuals, using the ArcMET extension (Wall J., 2014) for ESRI® ArcGIS 10.6.

Statistical analysis: Using R software, the non-parametric Kruskal Wallis test was used to compare the medians between individuals' movements. A Mann-Whitney-Wilcoxon Mann-Whitney test was performed to find significant differences between sexes with respect to displacements. Finally, a climatic database provided by PNNT was used to analyze its influence on the movement of individuals. A generalized linear model (GML) with negative binomial distribution was run with these abiotic covariates as well as the sex, individual and week variables.

RESULTS AND DISCUSSION

Six individuals were monitored, obtaining a total of 364 records with a triangulation error of 12.56%. Four individuals were being monitored at the beginning of the present work, three of *C. crocodilus* (Hugo "10", Lulo "7", Rosa "11") and one of *C. acutus* (Joselito "11"), and together with them, two individuals of *C. crocodilus* captured during the course of the project (Helena "18" and Gorda "20") were monitored. The crocodylid with the most geopositions obtained was Helena with 158 records (43.40%), followed by Rosa with 84 (23.07%). The rest of the monitored individuals obtained between 70 and 4 geopositions.

The home range of the individuals of both species monitored covered a total of 31.3 ha (MPC 100%), including tourist areas, which do not have the necessary warning signs to inform people of the presence of crocodylids in the area. The total home range for *C. crocodilus* was 30.7 ha for the minimum convex polygon, which is greater than the estimate for the local convex hull of 9.3 ha and KD of 5.6 ha (Figure 1). In the case of C. acutus, only MPC was estimated due to the limited number of records obtained in the field.

Using MPC at 95%, *C. crocodilus* presented a greater home range than that reported for C. yacaré (De la Quintana et al., 2020). The opposite was true when compared to what was observed in *C. latirostris* (Marques et al., 2020). In the case of the range occupied by females, it was less than that reported for the same sex of C. crocodilus by Ouboter & Nanhoe (1988). The Convex local hull (LoCoH) method performed better compared to the other two methods to determine the home range, because it did not overestimate areas not occupied by individuals (Minimum convex polygon [MPC]) nor underestimate areas of activity (Kernel Density), agreeing with what was observed by Bonke et al., (2014).

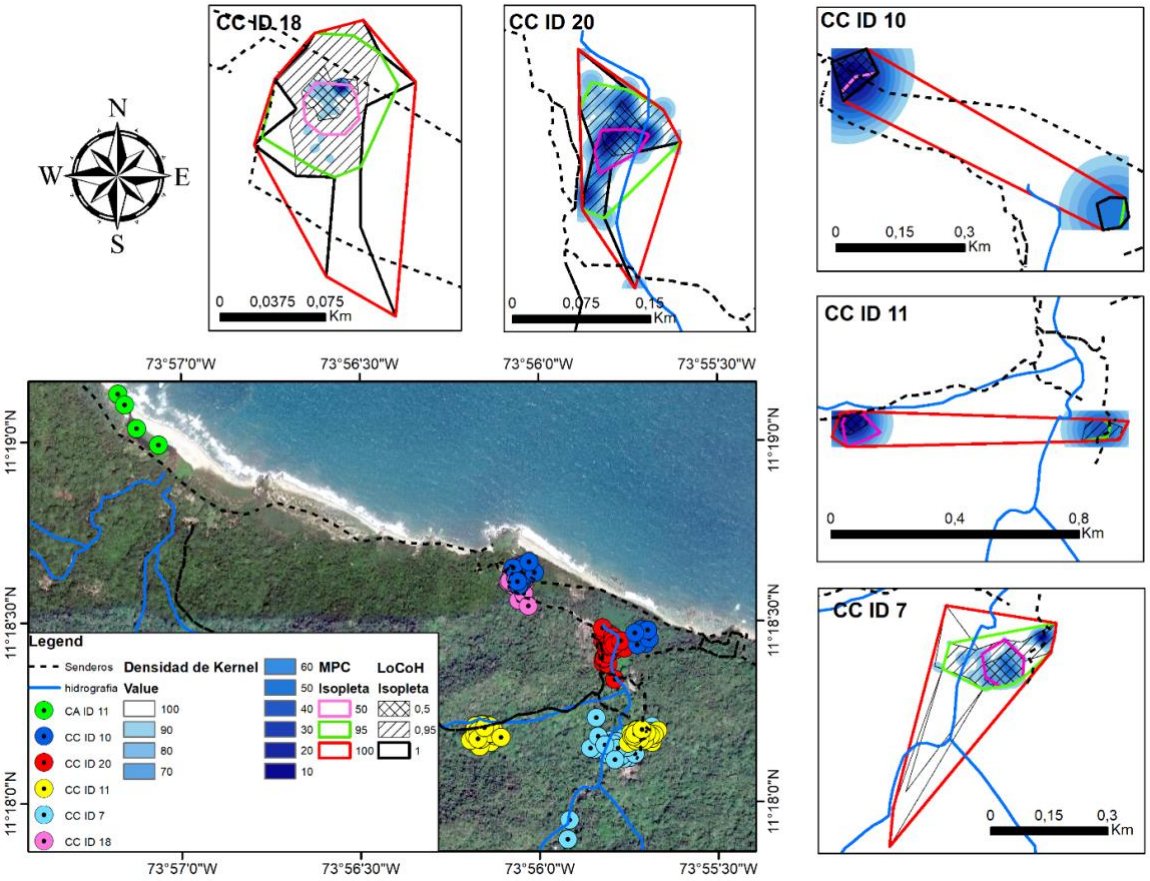


Figure 1. Home range of monitored individuals, using minimum convex polygon (MPC), local convex hull (LoCoH) and Kernel density. Where, CC: Caiman crocodilus; CA: Crocodylus acutus.

In the case of *C. acutus*, the area of activity was smaller than that reported for juveniles of the same species (Balaguera-Reina et al., 2016). However, the low number of records obtained for that species must be taken into account (Table 2). Nevertheless, individual 11 ("Joselito") was found to be associated with coastal areas, coinciding with what is reported for juveniles in the literature (Brandon-pliego, 2007).

The maximum values of displacements and velocities were recorded in individual 7 ("Lulo"), which showed changes in the area it occupied as rainfall increased and floods were generated. The maximum average weekly displacements correspond to the weeks of higher rainfall (Figure 2), where the individual moved to higher ground. The same happened with individual 11 ("Rosa"). Individuals 18 and 20 ("Helena" and "Gorda") moved during the October rains to areas where it was not possible to track them.

However, they returned to the usual monitoring areas when rainfall decreased, corroborating the observations of Ouboter & Nanhoe (1988).

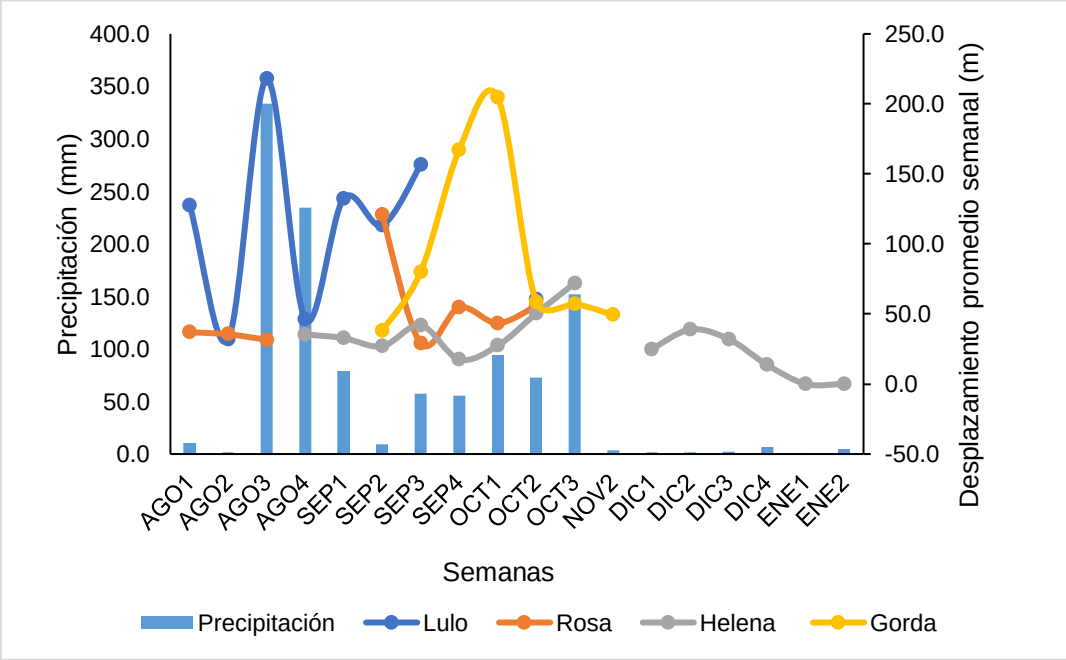


Figure 2. Average weekly movements of C. crocodilus individuals along with precipitation.

The maximum distances traveled were shorter than those reported for the same species (Ouboter & Nanhoe, 1988) and for *C. yacare* (Campos et al., 2006). However, they are similar to those recorded for *C. latirostris* (Marques et al., 2020). Babillas tend to move in search of territory, food, reproduction and/or competition, and these movements can be strongly associated with sex (Morales-Betancourt et al., 2013). Significant differences were observed in movements grouped by sex, being greater in male individuals, these results are similar to those obtained by Marques et al., (2020).

Some authors suggest that climatic variables such as rainfall may have an impact on the movement patterns and area of activity of baboons (Ouboter & Nanhoe, 1988). Likewise, natural processes such as river intrusion into a lake (De la Quintana et al., 2020). However, the GML showed that the only significant variable influencing average weekly movements was the individual variable (p-value of 0.0159; AIC 365.75). Of course, the data collection could not be done with the same effectiveness, due to the rains that flooded several monitoring areas, making it impossible to detect the animal with the same effectiveness, which generated some information gaps for some weeks, assuming that they have an impact on the result of this analysis.

The dissimilarities found compared to those reported by Ouboter & Nanhoe (1988) show that there is a lack of information on the spatial ecology of *C. crocodilus*. This demonstrates the need to join efforts to generate more studies focused on the spatial ecology of this species that allow comparison with other populations, preferably belonging to the same subspecies.

CONCLUSIONS

- It was possible to determine the spatial ecology during July 2021 and January 2022 for *C. crocodilus* within the protected area; in the case of *C. acutus*, the results were limited. However, given the number of records and individuals monitored, it is not possible to accept the hypotheses proposed, since it would be biased in the assertion of the hypotheses.
- There are differences in home ranges and movement patterns in relation to *C. crocodilus* individuals and their sex for the time period studied.
- The ecological data obtained contribute significantly to the lack of knowledge about home range and movement patterns for C. crocodilus.

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