ABUNDANCE, DEMOGRAPHIC STRUCTURE AND HABITAT OF THE AMERICAN CROCODILE *Crocodylus Acutus* (Cuvier, 1807) IN COIBA NATIONAL PARK, PANAMA

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INTRODUCTION

Despite its widespread distribution, *C. acutus* populations have declined throughout its distribution due to habitat loss and hunting (Messel et al. 1981). For this reason, in 1981 the American Crocodile was listed in Appendix I of the Convention on International Trade in Endangered Species of wild flora and fauna-CITES (CITES 2012). Currently, this species is catalogued as Vulnerable by the International Union for Conservation of Nature-IUCN (Ponce-Campos et al., 2012). However, the current actions for its conservation are not enough and the knowledge about population ecology of American crocodile is still poor in some countries (Thorbjarnarson 2010). Therefore, it is necessary to conduct studies on *C. acutus* population ecology and habitat requirements as well as to have continuous monitoring of the species (Ponce-Campos et al. 2012).

The current project made part of the macro-project titled *"Ecology of reproduction and dispersal patterns associated with habitat productivity of the American crocodile (Crocodylus acutus) at Coiba National Park: genetics and telemetry"* directed by Dr. Miryam Venegas-Anaya and Dr. Llewellyn Densmore and sponsored by Secretaria Nacional de Ciencia y Tecnologia SENACyT, Autoridad Nacional del Ambiente ANAM, Smithsonian Tropical Research Institute, Texas Tech University and IUCN/SSC/Crocodile Specialist Group.

OBJECTIVES

General: Determine the abundance, population structure, distribution and relationships with the habitat of the American crocodile *Crocodylus acutus* (Cuvier, 1807) in Coiba National Park, Panama.

Specific

- Estimate the relative density, visible fraction and population size based on three methods and compare them.
- Describe the demographic structure.
- Establish the possible relationships between the presence of the species and biotic (environments) and abiotic (salinity and moon phase) factors.
- Define the spatial distribution of the species in the area.

METHODOLOGY

From January to June 2013 we carried out monthly walking spotlight surveys to assess the *C. acutus* population from Boca Grande to Punta Felipa. Four transects were established (χ 2.05 ± 0.31 km) following the coastline with a distance of 300 m between transects to avoid overestimating the number of animals (Figure 1). Sampling effort was one week per month based on tidal fluctuations and lunar phases. This transects encompassed four kinds of landscape unites: mangrove, beach, riparian forest, and rocky coastline. Seven attributes were considered: Total Length (TL), hour, salinity, lunar phase, tidal fluctuations, habitat type, and geo-reference (Thorbjarnarson, 1989). Total length was estimated based on closer observations of the individuals cataloging them in five size classes (I: < 60 cm, II: 61—120 cm, III: 121—180 cm, IV: 181—240 cm, V: >240 cm; See Seijas 1988).

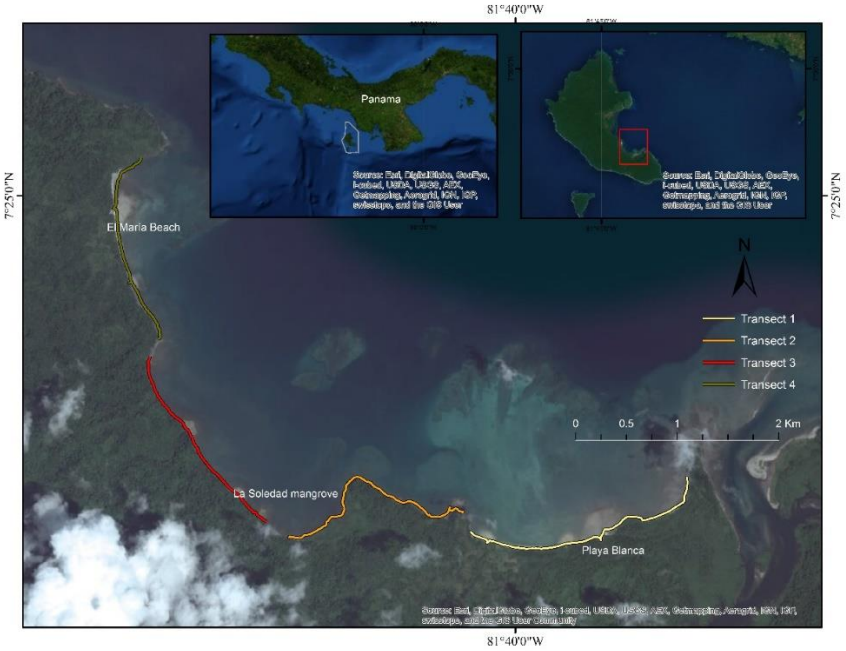


Figure 1. Study area. Transects from Boca Grande to Punta Felipa.

We estimated relative density (number of individuals/sampling unit), visible fraction and population size based on Messel et al. (1981), Messel and King (1981) and Martinez (1999). We also calculated a histogram frequencies using SPSS 19.0 (IBM 2010) to determine the population structure based on size classes. Component Principal Analysis was estimated (SPSS 19.0) in order to determine which variables affected the presence of *C. acutus* in area. Average nearest neighbor analysis was evaluated using ArcGIS 10.1 (ESRI 2012) to determine the distribution model if the *C. acutus* in the area. Transects were described based on landscape units (see Barajas & Borda, 2002) and related to the distribution we found. Contingency tables were calculated focused on testing the independence between the abundance values per transect, size classes, and months and the landscape units (beach, rocky coastline, mangrove, sea, and creeks).

RESULTS AND DISCUSSION

Relative density

We registered a total of 156 sightings of which in 117 of them size class were determined and 39 were registered as "eyes" because its size could not be estimated. Relative density showed a significant average values in transects 1 and 4 (8.4 and 5.4 ind/km, respectively, places where hatchlings were sighted) followed by transects 2 and 3 (4.7 and 1.8 in/km, respectively).

Table 1. Relative densities average and standard deviation across our study.

Months	Transec 1 (ind/ km)	Transect 2 (ind/ km)	transect 3 (ind/ km)	Transect 4 (ind/ km)	Average	stándar deviation
Feb	1,9	5,9	2,7	1,4	2,4	2,0
Mar	2,5	4,1	1,8	1,4	2,0	1,2
Apr	6,9	4,1	0,9	2,4	2,9	2,6
May	21,9	2,7	0,9	10,5	7,2	9,5
Jun	0,6	1,8	0,9	5,7	1,8	2,4
Average	8,4	4,7	1,8	5,4		
Standar deviation	8,8	1,6	0,8	3,9		

Population size

Population size was estimated using the data required for the three methods used: Population Size (PS, see Messel et al. 1981), Maximum Population Value (MPV, see Messel and King 1981) and Population Size with Low number of repetitions (PSL, see Martinez 1994). Using MPV we estimated the visible fraction, the population size and the relative density. On the other hand, using PS we could only calculated visible fraction and population size and with PSL we only population size. PS and PSL showed population size values closer each other and MPV had the lowest value.

Table 2. Visible fraction and population size estimated based on three methods. PS: Population Size, MPV: Maximum Population Value and PSL: Population Size with Low number of repetitions.

Methods	Relative density	Visible fraction (%)	Population size (individuals)
PS (Messel *et al.* 1981)	N/A	42.71	70.1 ± 48.9
MPV (Messel & King 1981)	4.79	25.76	38.8
PSL (Martínez 1994)	N/A	N/A	69.56 ± 19

Demographic structure

The population structure found in Coiba showed a significant numbers of individuals class I. The majority of the sightings were hatchlings and neonates because the hatched period (April) in that area was in our sampling time. Following the parameters proposed by Ulloa-Delgado and Sierra-Diaz (2002) the population of the study area shows an upward tendency due to presents a large number of individuals

of the class I and the presence of animals class IV and V which means more input in the population and more probabilities of recruitment.

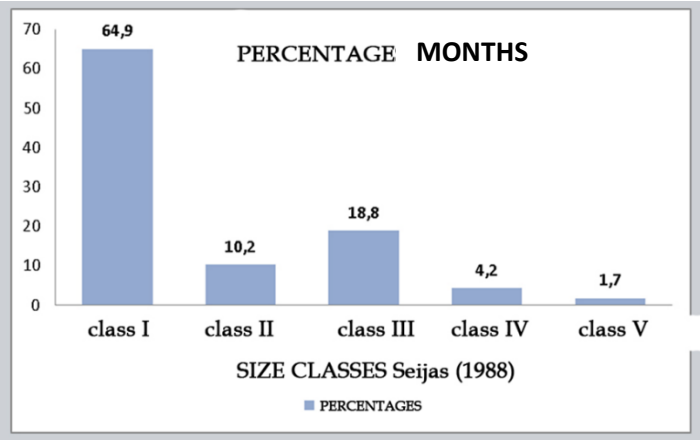


Figure 2. Frequencies histogram based on size classes (Seijas 1988).

Habitat structure

Table 3. Contingency table

Contingency table			
	Chi-square	**p**	**gl**
Months	83.174	0.000	16
Transects	62,018	0.000	16
Class	75.118	0.000	20

Based on the contingency table we found that the species in the area did not show independence between the habitat categories (beach, rocky coastline, mangrove, sea, and creeks) in which we sighted them and the presence of the individuals per months, size class and transects. That means species in the area had a preference based on these habitat categories which likely influence in the distribution of the sightings.

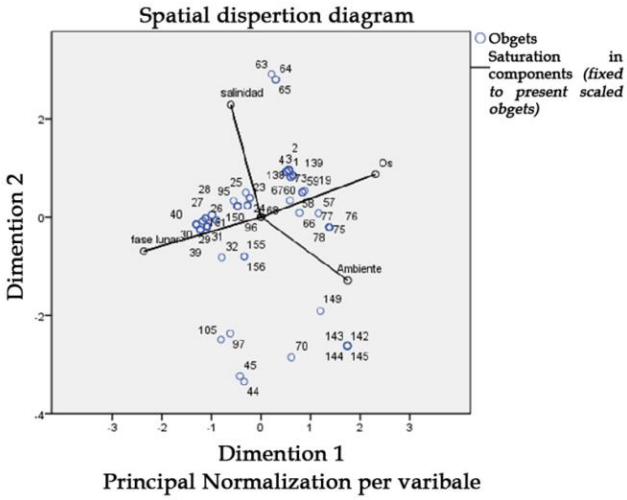


Figure 3. Principal Components Analysis based on Salinity, tidal fluctuation, habitat categories and moon phases.

Tide oscillation was the variable with the most significant effect over the presence of the *C. acutus* in the study area based on the results obtained in the principal components analysis. That behavior is likely due to when the level of the water change affect directly the flooded areas changing the way in which individuals use their space. When the level of the tide is reduce its easier to find a greater number of individuals facilitating their sighting (Vallejo and Santiago, 1994).

Distribution

American crocodile model distribution by transects in Coiba showed a dispersed tendency based on the nearest neighbor analysis. This may be caused by changes in tide, moon phase, nesting or feeding habits of the species in this area (Vallejo and Santiago, 1994). The class I was excluded in this analysis because this class has a clustered distribution due to living in nurseries areas (Cedeño et al, 2006).

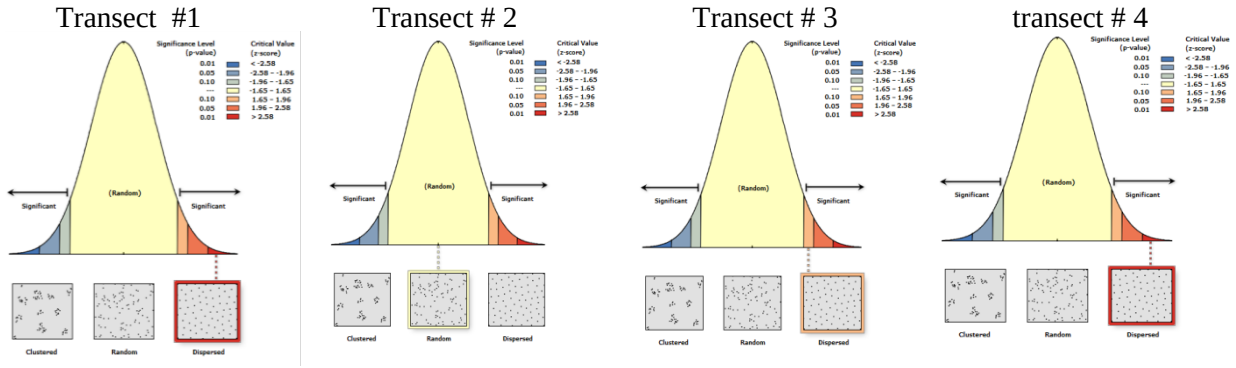


Figure 4. Distribution models estimated per transects based on nearest neighbor analysis

Based on the threatened category of *C. acutus* and the lack of knowledge about population ecology on this species in Panama, our study has a high relevance for the development and implementation of conservation plans. Besides, this study can be a start point and base line to develop research projects around the country in order to determine clearly the current conservation status of the American Crocodile in Panama. We found that the species in Coiba show preferences for microhabitats with low environmental changes and an adequate areas in land likely for temperature regulation and nesting (Carvajal *et.al*. 2005). Whereby, it is important to collect information of the biotic and abiotic factors that influence the abundance and distribution of *C. acutus* in the country to understand the real implications of the change in the land-use on this species. Studies about ecology and habitat use are source to make decisions and implement strategies that ensure the survival of the species (Thorbjarnarson, 2010).

CONCLUSIONS

- The majority number of sightings were in April and May mainly of class I (transects 1 and 4) because our study overlapped with the nesting period in the area. This influences the relative densities registered across the study (Tables 1-2).
- The Visible fraction of the population based on the PS method was higher (42.71 %) than the value obtained with MPV method (25.76 %) showing a significant difference between them (Table 2).

- Population size based on PS and PSL methods were closer in size and variation. On the other hand, MPV show the lowest value.
- The demographic structure showed a large number of Class I and Class III and low values in Class V, VI and II. This population showed an upward tendency due to the presence of infants and adults (Figure 2).
- Removing Class I animals, transect 2 (rocky coastline and mangrove) showed the highest relative densities in February. Class V and IV was registered in general in rocky coastline habitats (Transects 3 and 4) being likely an important habitat for adults (see figure 3).
- Class II and III were found in a more kind of habitats (generalist) than classes I, IV and V, seemingly showing less selectivity.
- Level of tide showed the strongest influence on the relative densities across of our study (PCA analysis). On the other hand, although salinity showed a stronger influence in the study, this was likely due to the presence of Class I animals, which were observed only in creeks (Figure 5 and 2).
- Mangrove was the habitat category where we found the majority of sightings (50 %) followed by beaches (25.6 %) and creeks (17.3 %).
- Habitats categories did not show independency for classes, months and transects based on the relative densities registered.
- Distribution sightings were in general dispersed (transects 1, 3, and 4) likely related to the habitat conditions and the categories present (Figure 5).

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