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Community engagement and human perception in crocodile conservation: preliminary steps in Sian Ka'an Biosphere Reserve

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Introduction: Wildlife tourism is important for the conservation of protected areas, endangered species, and to empower local communities. Nevertheless, when guidelines and practices are not clear and correctly executed, tourism may have a negative impact.

Methods: We carried out semi-open interviews ($n = 34$) and several workshops ($n = 50$) with locals and tour guides in the village of Punta Allen in Sian Ka'an Biosphere Reserve, Mexico. Data were organized in tables in Excel®, and statistical analysis was conducted with IBM® SPSS® Statistics software. *A priori*, exploratory data analysis was carried out to identify the general pattern of the data, and *a priori* data normality test (Shapiro–Wilks) and χ^2 test were carried out to find out if there were differences in the frequency of a response depending on socioeconomic variables.

Results: Most respondents (69%) dedicated 2–10 min to crocodile observation, one quarter (25%) spent 11–20 min, and the remainder (6%) 21–30 min. The majority (97%) of respondents mentioned that when they see a crocodile, they approach at a 5–10 m distance and wait for the occupants of the boat to take pictures, and then leave; only one respondent (3%) said that they feed crocodiles to attract them to the boat. Most respondents (89%) said that crocodile observation does not need to be improved, and it is fine the way it is currently carried out; the remaining 11% said that it could be improved. Workshops were received positively and allowed us to share information on crocodile species, their conservation, and good tourism practices.

Discussion: It is necessary to enlighten tourism service providers about the biology and importance of crocodilian species, to promote conservation and provide services with an educational impact/focus for visitors to the reserve. There is a need to develop a communication program that provides accurate information for new service providers and renews and reinforces concepts for established providers. Additionally, we need to continuously monitor and evaluate wildlife observation activities to enhance current practices in our study area, and to determine if they are having a negative impact on crocodile behavior and biology.

KEYWORDS

wildlife tourism, *Crocodylus acutus*, *Crocodylus moreletii*, educational outreach, science communication, Mexican Caribbean, protected natural areas

1 Introduction

There are two crocodile species in Mexico: the American crocodile (*Crocodylus acutus*) and the Morelet's crocodile (*Crocodylus moreletii*). The distribution of the American crocodile extends from the southern tip of Florida, along both the Atlantic and Pacific coasts of Mexico, Central America, and northern South America, as well as the Caribbean islands of Cuba, Jamaica, and Dominican Republic (Kushlan, 1988; Thorbjarnarson et al., 2006; Ponce-Campos et al., 2012). The habitat of *C. acutus* consists mostly of brackish water coastal habitats, coastal lagoons, and mangrove swamps, but also includes freshwater located well inland, such as rivers and reservoirs (see Rainwater et al., 2022 and references therein). In Mexico, *C. acutus* has faced several threats including hunting and habitat destruction; nevertheless, recent evidence suggests a population recovery (Rainwater et al., 2022). This species is listed as Vulnerable in the IUCN Red List (Rainwater et al., 2022) and under Special Protection (Pr) in Mexico (SEMARNAT, 2010).

Morelet's crocodile distribution includes freshwater ecosystems and less frequently saline environments from Petén in Guatemala, Belize, and southeastern Mexico (Ross, 1998; Cedeño-Vázquez et al., 2006; Platt et al., 2010; Corado-García et al., 2020). Past excessive hunting of *C. moreletii* in the wild caused the depletion of populations throughout their entire range (Powell, 1973; Álvarez del Toro, 1974; Platt and Thorbjarnarson, 2000). In Mexico, both species live along the coastal line of Quintana Roo on the Yucatán Peninsula. One of the key areas for crocodiles on the Caribbean coast is the Sian Ka'an Biosphere Reserve (SKBR), which is one of Mexico's largest protected areas, and harbors large marine, coastal, and terrestrial biodiversity (Claudino-Sales, 2019). The SKBR is situated in a region that is a popular international tourist destination, and receives hundreds of visitors per year (Lozano, 2016; Damián, 2020). This species is listed as Least Concern in the IUCN Red List (Platt et al., 2023) and under Special Protection (Pr) in Mexico (SEMARNAT, 2010).

Many human settlements around the world have been established near vast places with resources that can sustain their populations, which influences their relationship with the environment (Morales and Damián, 2006; Briceño-Ávila, 2009). Expansion into protected natural areas is now a common occurrence (Balaguera-Reina and González-Maya, 2009). This has forced humans and crocodiles to frequently interact in a negative or positive way, depending on the impact that one group has on the other (Frank, 2016; Nyhus, 2016). These events are influenced by previous experiences or the transmission of these, and when the needs and goals of humans are negatively impacted, these actions can be a great risk, mainly for fauna (Madden, 2004; Frank, 2016). Crocodiles in Latin America are feared, due to a history of attacking humans, livestock, or pets. They also face threats such as competition for resources, and from leather, meat, and fat markets, despite conservation programs and protective legislation (Pooley et al., 2021).

To resolve potential conflicts between humans and crocodiles, the interests and needs of local people should be considered. As a result, it is critical to investigate the perspective and knowledge of local communities and include conservation and coexistence

strategies to enhance the wellbeing and conservation of crocodylian species. Communitarian engagement and educational programs have an important impact on the conservation of wildlife species (Campbell et al., 2023), especially with correct planning strategies that encompass conservation, natural resources, and cultural and socioeconomic issues (Kamrowski et al., 2015; Sutter et al., 2023).

Perception is often constructed collectively and is very important in the valuation and meaning of the humans' relationship with the environment (Fernández, 2008; Manzano-García and Martínez, 2017). One way to document and identify perceptions and local ecological knowledge is through the use of surveys. These provide information directly from a sample population. Furthermore, studies that include human communities are of great value for conservation and wildlife management research (Escobedo-Galván, 2004; Balaguera-Reina and González-Maya, 2010).

Consequently, the main objective of this study was to document the local knowledge and environmental perception of crocodile interactions in Sian Ka'an, especially those related to touristic activities. This is a critical step to enhance and promote a positive coexistence between humans and crocodiles. We hypothesized that people residing within SKBR would be very knowledgeable about the biology and ecology of crocodiles inhabiting the reserve. Our study identifies a new approach concerning how locals perceive and interact with crocodiles and attempt to enhance community commitment with crocodile conservation and responsible interactions. This is important to improve interactions with wildlife during tourism activities.

2 Methodology

2.1 Study area

The SKBR is located on the Mexican Caribbean coast (Mazzotti et al., 2005). The main human settlement inside the reserve is Punta Allen (PA) village, and most of its inhabitants are dedicated to offering tourism activities. PA is located at the end of a peninsula (19° 47' 59" N; 87° 28' 35" W) (Figure 1), almost 50 km south of Tulum, Quintana Roo. Approximately 469 people live in PA (294 over 18 years old). There are three educational centers (kindergarten, elementary, and middle school), which means each person has an average of 7.5 years of schooling (Instituto Nacional de Estadística y Geografía (INEGI), 2010). The main economic activities developed in the community are sport fishing, sustainable use of the spiny lobster (*Panulirus argus*), and tourism focused on wildlife observation (INEGI, 2010; Ley-Cooper et al., 2013; Cabrera-Borraz et al., 2018).

2.2 Surveys

From August to October 2019, and from November 2020 to January 2021, we performed semi-structured interviews with permanent residents of PA who were older than 18 years of age

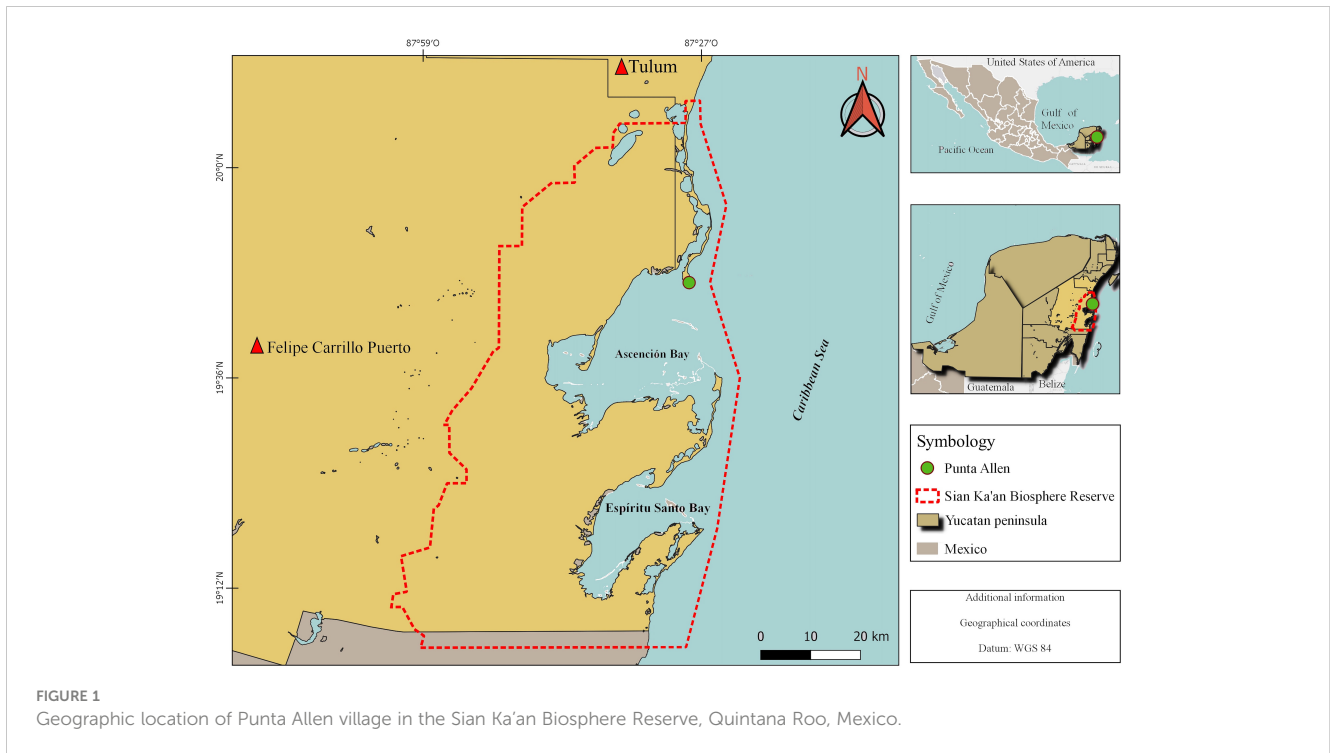


FIGURE 1
Geographic location of Punta Allen village in the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico.

indiscriminate of sex, occupation, or educational level. The interviews were carried out while the respondents were at home or at work. The sample size was calculated considering the total size of the population in the community, with a 10% error, 90% confidence, and securing at least 10% of the total population. During a semi-structured interview, the interviewer asks a few predefined questions while the rest of the questions are not planned (Longhurst, 2003). This way, the interview unfolds in a conversational manner, so that the interviewee feels comfortable expressing additional opinions on the main topic he/she considers relevant to mention (Vela, 2001; Tarrés, 2004). Our semi-structured interviews included four sections: (1) consent notice, (2) general data of the interview (date, hour, and locality), (3) knowledge about the biology of crocodiles (Table 1), (4) perception on crocodiles, and (5) how tourism activities involve crocodiles and how they are carried out (Table 1).

2.3 Workshops and community engagement

Two workshops about the biology of crocodiles and their importance and conservation were carried out during September–October 2019. These were mainly aimed at tourism service providers. Information about identification, and development of tourism activities with crocodiles was exchanged during these workshops (Figure 2). At the same time, we conducted a workshop with elementary school students about the biology of crocodiles, their importance, and coexistence strategies (Figure 3). In 2021, we organized workshops for children with interactive activities about the diet of crocodiles, their importance, and behaviors (Figure 4). The information and results of the first stage of this project as well as

infographics on the American and Morelet's crocodiles were given to tourism service providers (Figure 5).

2.4 Data analysis

Data were organized in tables in Excel[®], and statistical analysis was conducted with IBM[®] SPSS[®] Statistics software. *A priori*, exploratory data analysis was carried out to identify the general pattern of the data. In the case of open questions, the percentage of mention was used to analyze the relative frequency of a particular response. For example, to determine the importance of an item in the crocodiles' diet, we divided the number of respondents who mentioned such an item, by the total number of respondents. When delving into specific questions (i.e., importance, danger, and general feelings about crocodiles), *a priori* data normality test (Shapiro–Wilks) and χ^2 test were carried out to find out if there were differences in the frequency of a response depending on socioeconomic variables (i.e., gender, age, economic activity, and educational level).

3 Results

3.1 Tourism service providers surveys

A large number of respondents are dedicated to tourism activities, particularly wildlife observation and sport fishing. Therefore, a series of questions ($n = 34$) were directed specifically at this fraction of the population. The majority (69%) dedicate between 2 and 10 min to crocodile observation, 25% said they spend between 11 and 20 min, and, finally, 6% said they spend between 21

TABLE 1 Themes addressed and activities carried out during interactions with locals, through interviews and workshop sessions.

Public	Theme	Activity	Goal
Adults and adolescents	General information about crocodiles <ul style="list-style-type: none"> • Taxonomic classification (family level) • Physical characteristics • Habitat • Diet 	Informative/participative workshop	Provide information for locals about crocodiles, covering general basic aspects, the importance of these reptiles, and proper coexistence.
	Importance <ul style="list-style-type: none"> • Ecological • Economic Threats		
	Behavioral aspects Guidelines for proper coexistence		
	Crocodile species in México <ul style="list-style-type: none"> • <i>Crocodylus acutus</i> • <i>Crocodylus moreletii</i> 		
Children	Photographic plates on crocodiles	Look at pictures of crocodiles and discuss generalities.	To understand the different characteristics of crocodiles, their families, and species.
	What does Danilo the crocodile eat?	The children choose from a set of items, what they think crocodiles eat.	Identify children's perception and knowledge of crocodile diet.
	What does a crocodile eat according to its age?	The children match different types of prey with the corresponding life stage of crocodiles.	Identify children's perception and knowledge of crocodile diet.
	Where do crocodiles live?	The children will make several mazes to bring a female crocodile to her nest.	Identify the various semi-aquatic ecosystems where crocodiles live and nest.
	How to react if I have an encounter with a croc?	The children draw themselves on a sheet of paper where a crocodile is already printed.	Identify how the children perceive themselves in the presence of a crocodile and what they would do in case of an encounter.

and 30 min. When they see crocodiles, 97% of respondents mentioned that they approach crocodiles to within 5 to 10 m and wait for the occupants of the boat to take pictures of the specimens (Figure 6), and then they leave. Only one respondent (3%) said they feed individuals to attract them to the boat.

In reference to how tourism activity could affect the crocodiles, 75% of the respondents said that it does not affect them at all, 14% said that it could affect them, and 11% did not know if it could affect them. In terms of how frequently they see crocodiles during tours, 60% said it was not frequent, 20% said it was, 5% said they did not



FIGURE 2

Workshops directed at a citizen science group. The workshops were about crocodile identification, their importance, and good practices in wildlife tourism.



FIGURE 3

Workshop directed at middle school students. The goal was to inform the students about the biology, importance, and coexistence with crocodiles.



FIGURE 4

Workshop directed at children. The goal was to enhance their appreciation and knowledge about crocodiles through ludic, educational, and interactive activities.

know how frequent it was, and the remaining 15% did not answer the question. Most respondents (89%) said that crocodile observation could not be improved and that it was fine the way it is. The remaining 11% said that it could be improved through workshops and training. The analysis of results regarding the socioeconomic variables did not show significant differences.

3.2 Workshops and community engagement

Fifty persons attended the different activities during the workshops, including children. A set of infographic materials and leaflets were also handed out to tourism cooperatives, to share



FIGURE 5

Divuligation work. Infographic material was delivered to tourism service providers to show visitors some basic information about crocodile species inhabiting the Sian Ka'an Biosphere Reserve.



FIGURE 6

Crocodile observation during a tour near the Boca Paila bridge at Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico. Note an adult crocodile in the lower right margin of the photograph. Photo by Grecia Valadez Huerta.

information with tourists and locals about the importance and conservation of crocodiles (Figures 2–5). The workshops were met with positive reception by locals, especially tourism service providers. As a result, a citizen science group was formed and received training regarding important native species (including both crocodile species) present during their tourism activities. In subsequent visits, it was notable that some tour guides were able to provide visitors with a better explanation of the importance of crocodiles and positive coexistence.

Although parents encouraged their children to attend the workshops, they did not show the same interest in the activities. However, they recognized efforts to include children and locals in these divulgation activities. The infographics were positively received by the tourism service providers, and they exhibited them in their offices and boxes for visitors to view.

4 Discussion

4.1 Tourism service providers surveys

Respondents who are part of the tourism sector (tour or fly fishing) described what they do when they spot a crocodile. This activity is not very popular, nor is it offered regularly as in other places on the continent such as in Tárcoles River, Costa Rica (Lemos, 2017; Porrás-Murillo and Cambronero, 2020) or Florida, USA (Jones, 2015; Cohen, 2019). However, when observing crocodiles, they await long enough for tourists to take pictures. They assume that this activity does not affect crocodiles because it is not a common occurrence, and they keep their distance. Only one respondent said that they feed the crocodiles to attract them. This is prohibited and is not recommended because it can cause alterations in the behavior of wild species (Orams, 2002; Moorhouse et al., 2015; Macdonald et al., 2017; Madrigal-Vargas, 2020). Most tourism service providers seem to be managing wildlife observation tourism responsibly, at least with crocodiles. This may be different for other more attractive species such as dolphins or manatees. Similarly, this type of tourism promotes the conservation of many different species and, with the adequate methodologies, it can be key to wildlife conservation (Ballantyne et al., 2009; Moorhouse et al., 2015; Burns, 2017). Additionally, respondents do not believe that this activity can be improved, mainly because tourists do not ask to see crocodiles and they can be difficult to observe during daytime.

4.2 Workshops and community engagement

The workshops that took place during 2019 and 2021 also allowed us to determine the strengths, weaknesses, and gaps in the knowledge and perception of the locals of PA. The information about crocodiles provided during the workshops highlighted their importance in the ecosystem and their conservation status. In addition, infographics and triptychs with general information about the biology of crocodiles were prepared and handed out to the tourism cooperatives and locals. These actions were the first to provide the local population with scientific information and environmental education. Sharing scientific information must continue and needs to be carried out long term for the construction and appropriation of knowledge to be effective (Cueto-Gómez, 2019).

These strategies of divulging scientific information and environmental education to locals are needed to generate social change in terms of the use of resources and the relationship between humans and the environment (Zamora-López, 2005). In

the case of crocodiles, [Madrigal-Vargas \(2020\)](#) implemented environmental education strategies in Costa Rica to address negative interactions between humans and crocodiles. At first, locals positively accepted workshops (81%). However, this author still considers that it is necessary to coordinate greater efforts to increase participation further. [Madrigal-Vargas \(2020\)](#) prepared informative guides that included basic aspects of the biology of crocodiles and their positive coexistence with humans to spread information. Additionally, the author developed a children's story addressing topics related to crocodiles that should be included in formal education in the country.

People will also choose to not participate in activities if they are not interested in the topic of crocodiles ([Skupien et al., 2016](#)). Additionally, these authors could not determine what the long-term effects of their educational program were. This indicates that these types of programs should be constant and planned with future actions in mind. In Mexico, specifically in Tabasco, educational programs for children were implemented to determine their perception towards crocodiles. Apparently, local knowledge is obtained by their proximity to these reptiles and the frequency of sightings ([Ocampo-González et al., 2021](#)). This has also been reported in Campeche ([Padilla and Perera-Trejo, 2010](#); [Rodas-Trejo et al., 2018](#)).

5 Conclusions

The attitude of the villagers towards the workshops, informational products, and other activities was positive. They were quite receptive and even interested in continuing to receive information on the subject. This positive response will allow us to establish a strong connection with the locals, and even develop a permanent environmental education project. However, these first steps are not enough to ensure a long-term commitment. It is necessary to assess the level of knowledge and perception, and strengthen communication and training with tourism service providers. Our main goal is for locals to correctly manage resources and tourism activities on their own, even if public or governmental services are not in constant cooperation with them. Additionally, more environmental education activities and the importance of resource ownership need to be imparted to middle and elementary school students.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The animal study was approved by Comité de Ética en la Investigación de El Colegio de la Frontera Sur. The study was

conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

JB-M: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. JC-V: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. DC-M: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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