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Source: South American Journal of Herpetology, 16(1) : 26-33

Published By: Brazilian Society of Herpetology

URL: <https://doi.org/10.2994/SAJH-D-18-00076.1>

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Analysis of the Interactions Between Humans and Crocodiles in Costa Rica

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Abstract. The habitat of crocodiles (*Crocodylus acutus*) and caimans (*Caiman crocodilus*) has been subjected to pressure due to human expansion. Habitat reduction, coupled with the simultaneous growth of the crocodile population, increases the number of interactions between crocodiles and humans. There is currently no official and systematized interactions database, but it is necessary to know the magnitude and nature of the interactions and establish management measures. The objective of the work was to systematize and evaluate the interactions between crocodiles and humans in Costa Rica. Historical information was collected from several sources. A total of 99 records, dated between 1990–2017, were found from press reports and the Integrated System for Processing Environmental Complaints of the Ministry of Environment and Energy (SITADA). The Fire Department recorded 123 events in 2017. All Fire Department records corresponded to encounters or sightings. Of the SITADA incident records, 35.4% were non-fatal, 27.3% were fatal, 21.2% were encounters and sightings, and the remaining 16.1% were miscellaneous situations. Most interactions occurred during the day, a fact potentially explained by human behavior of being in bodies of water or on adjacent shoreline while the sun is out. Most interactions occurred in the Central Pacific, followed by the Caribbean and then the South Pacific. The information available is brief but allows to establish management measures. The country needs to create a national database of interactions and to encourage individuals to report their interactions. Further research should continue to analyze the data for trends with the goal of building recommendations to prevent an increase in negative interactions.

Keywords. Attacks; *Caiman crocodilus*; *Crocodylus acutus*; Encounters; Sighting.

INTRODUCTION

Crocodylian populations in Costa Rica (species: *Crocodylus acutus* [Cuvier, 1807] and *Caiman crocodilus* [Linnaeus, 1758]), as well as in the rest of the world, were reduced almost to extinction due to hunting before 1960 (Salas, 1985; Thorbjarnarson et al., 2006). The 1956 law *Ley de Conservación de la Fauna Silvestre* (Wildlife Conservation Law) was a major, official milestone of crocodylian protection at the national level. Furthermore, global initiatives emerged to protect all crocodile species. In the 1970s, *Cr. acutus* (crocodile) was listed in Appendix II and thus declared protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Jelden, 2004), which resulted in significant and reasonably successful government, conservationist, and research efforts to recover the populations in many countries. However, with population growth came an increase in negative interactions between humans and crocodylians, so species recovery has not always been seen in a positive way by the local people (Hutton and Webb, 2003; Caldicott et al., 2005).

Human expansion has put pressure on crocodylian habitats by reducing the physical natural space available. Despite this pressure, and in part thanks to law enforce-

ment and conservation efforts, crocodile populations (*Crocodylus acutus*) have rebounded in the last two decades. The unfortunate corollary is that proximity to humans has also increased (Bolaños, 2012; Carrillo-Rivera, 2013; Peraza-Estrella, 2015). This proximity has produced a tourism economy around activities such as the feeding of crocodiles, an activity developed in the Tarcoles River for 20 years (Lemos, 2017) that has spread to other areas of the country. Feeding crocodiles can habituate them to humans, which can then lead crocodiles to initiate interactions. This bold behavior has led locals to pressure national wildlife authorities to control crocodile populations by eliminating animals.

In Costa Rica, little research has been done on interactions between humans and crocodiles. What work has been done has focused on *Crocodylus acutus* since it has caused serious injuries or death in people (Aranda-Coello et al., 2015). Valdelomar et al. (2012) evaluated the perception and knowledge about crocodiles in some areas bordering the Tempisque River. They reported that although people are conscious of the large number of crocodiles in the area, they have little knowledge about the biology of the species. Carrillo-Rivera (2013) evaluated the interactions between crocodiles and humans in the same area and identified human-crocodile conflicts in 22 villages and a mix of

How to cite this article: Murillo L.P.P., Cambroner E.M. 2020. Analysis of the interactions between humans and crocodiles in Costa Rica. *South American Journal of Herpetology* 16: 26–33. <http://doi.org/10.2994/SAJH-D-18-00076.1>

negative and positive perceptions towards crocodiles. The conflict, according to Carrillo-Rivera (2013), is generated mainly by fear passed through generations that is relived every time there is a negative interaction, typically an attack whether fatal or not, between humans and crocodiles. Barrantes (2010) pointed out that between 1990 and 2009 there were 40 attacks of *Cr. acutus* on people in Costa Rica. Eleven attacks ended in the death of the victim, most of them located in the Pacific region, and the size of the crocodiles, when it could be estimated, was equal to or greater than 3 m. In the case of *Caiman crocodilus*, information on interactions has not been collected, and it is possible that in some instances the species involved was not correctly identified and reported as a crocodile.

It is not possible to track the number and severity of interactions between crocodiles and humans if there is no concerted effort to monitor new reports of interaction and log data. This situation is not exclusive to Costa Rica; countries such as Australia and several countries in Asia and Africa are also facing crocodile species attacks, but incident rates are unknown due to a lack of reporting (Caldicott et al., 2005).

In Costa Rica, reported interactions are mainly handled by the Fire Department, Public Police, and, on a smaller scale, by wildlife officers of the Ministry of Environment and Energy (MINAE). There is no uniform, systematized format to report each interaction; in fact, for most interactions, the species, place, and time of occurrence are unknown. Analyzing the historical interactions in the country and maintaining a constant record will give policy makers the necessary tools to implement solutions and prevent accidents as the country does not have a defined protocol to deal with the conflicts generated by the interactions between fauna and humans. We expect that an analysis of historical data on interactions between humans and crocodiles will help to reduce interactions, especially those that result in both fatal and non-fatal accidents (Pooley, 2015). The objective of this work was to systematize and analyze the interactions between crocodiles and humans in Costa Rica and to provide basic information for decision making regarding the management of crocodiles in the country.

MATERIALS AND METHODS

The research consisted of three phases: 1) looking for data on interactions between humans and crocodiles in Costa Rica; 2) the construction of an Excel database; and 3) data analysis and digital cartography. We collected historical data on crocodile–human interactions, which we defined as all reported encounters, interactions, and attacks, regardless of physical contact. Information on interactions was collected from the following sources: on-line media reports of attacks and encounters; complaints

reported to the Integrated System for Processing Environmental Complaints of the Ministry of Environment and Energy (SITADA/MINAE), and case reports handled by the Fire Department of Costa Rica. Data from the Fire Department of Costa Rica included records only from 2017, so they were analyzed separately. All reports were reviewed for date, location, and details to ensure that each represented an independent, separate incident.

The database included the following data: date, species, location, description of the site, coordinates (X, Y, using CRTM05 projection), size and sex of the crocodile, number of crocodiles, management of the crocodile, age and sex of the person, type of interaction and activity at the time of the interaction, and type of injury. Interactions were classified as: sightings, encounters (encounters and sightings: when people saw crocodiles in the natural habitat of crocodile or found them when they were in a water body or at the shore), non-fatal attacks, fatal attacks, and others (e.g., when people reported illegally captive crocodiles, animal abuse including death, or undetermined cases). Information was not available for all variables in all cases.

To determinate the geographic coordinates of each case, we used the addresses originally reported; however, in cases where no location was reported or was reported inaccurately, we used the coordinates of the central point from the district where interaction occurred to standardize information at district scale (a district is a third-level political division).

We conducted a qualitative analysis including type of interaction, frequency of attacks per year, per month, per sex of the victim, and other relationships between variables we could extract on each case. Also, we did digital cartography on ArcGIS 10.5 using points for each interaction and counting by district using a national districts map at scale 1:5.000.

RESULTS

All the reported cases in which the animals were identified named them as crocodiles (*Crocodylus acutus*), but that does necessarily not mean that caimans do not interact with humans. Some records did not specify the species involved in the interaction, and others reported crocodiles when people did not recognize the species, simply because it is known that interactions with crocodiles are more common. Nevertheless, we are confident that all the attacks reported, both fatal and non-fatal, correspond to crocodiles.

A total of 99 records were found from 1990 to 2017 from the press and SITADA. The Fire Department recorded 123 events in 2017. All of the records from the Fire Department were encounters or sightings, although they were reported as emergencies. From cases reported in the national press and SITADA, 35.4% ($n = 35$) were non-fatal

Table 1. Number of attacks per sex in Costa Rica (1990–2017).

Type of attack	Number of attacks per sex	
	Women	Men
Non-fatal	5	29
Fatal	1	24
Total	6	53

attacks, 27.3% were fatal ($n = 27$), 21.2% ($n = 21$) were encounters and sightings, and 16.1% ($n = 16$) were others. Among 62 attack reports, 9.78% were against women, 85.5% against men, and 4.8% undetermined (Table 1). In 18 attacks in which the sex of the crocodile was reported (identified by palpation of the genitals), most (82%) were adult males of at least 2.5 m total length.

Most of the interactions, especially fatal and non-fatal attacks, occurred during the day and while people were in the water (swimming or fishing) or on the adjacent shoreline. In most cases, there is no information about the management of the crocodiles involved in the interaction, but a few cases report translocation or local retaliation resulting in the animal’s death. The frequency of interactions has increased since 1990 (Fig. 1). Notably, the months between March and May have more non-fatal and fatal attacks (Fig. 2), and September shows a high number of non-fatal attacks. The Central Pacific region has the most interactions between humans and crocodiles in the country, followed by a portion of the Caribbean, South Pacific, and Northern Pacific regions (Fig. 3). Non-fatal attacks were more frequent in Jaco, a district of the Central Pacific region, followed by Tamarindo, a district of the Northern Pa-

cific (Fig. 4), while fatal attacks were more frequent in the Central Pacific region, mainly in the Parrita district (Fig. 5).

DISCUSSION

We found that reports of interactions with crocodiles have increased. We also know that crocodile populations are growing. People started using the SITADA system in 2013 (when it was created) to report negative situations involving crocodiles, and it currently includes reports on sightings, animal abuse, crocodile feeding, death, and violation of the wildlife conservation law, among others. Also, widespread access to social media makes interactions more visible and creates a public record of nearly real-time reporting. The recovery of some of the crocodile population in the country in the last 25 years (Bolaños, 2012; Peraza-Estrella, 2015) has resulted in an increase in human–crocodile interactions, which has also been reported in other countries (Caldicott et al., 2005; Fukuda et al., 2011; Fukuda et al., 2014). However, that trend might be artificially inflated, as we found that not all the records correspond to attacks.

The Fire Department handled many cases in 2017, but the data should be treated with caution because, although they were reported as emergencies, they correspond to sightings or encounters involving crocodiles that are within their habitat. Taking this into account, we centered the discussion on non-fatal and fatal attacks. The pattern of attacks described in Costa Rica is similar to human–crocodile interactions described in other countries. In the U.S. between 1948 and 1995, American alli-

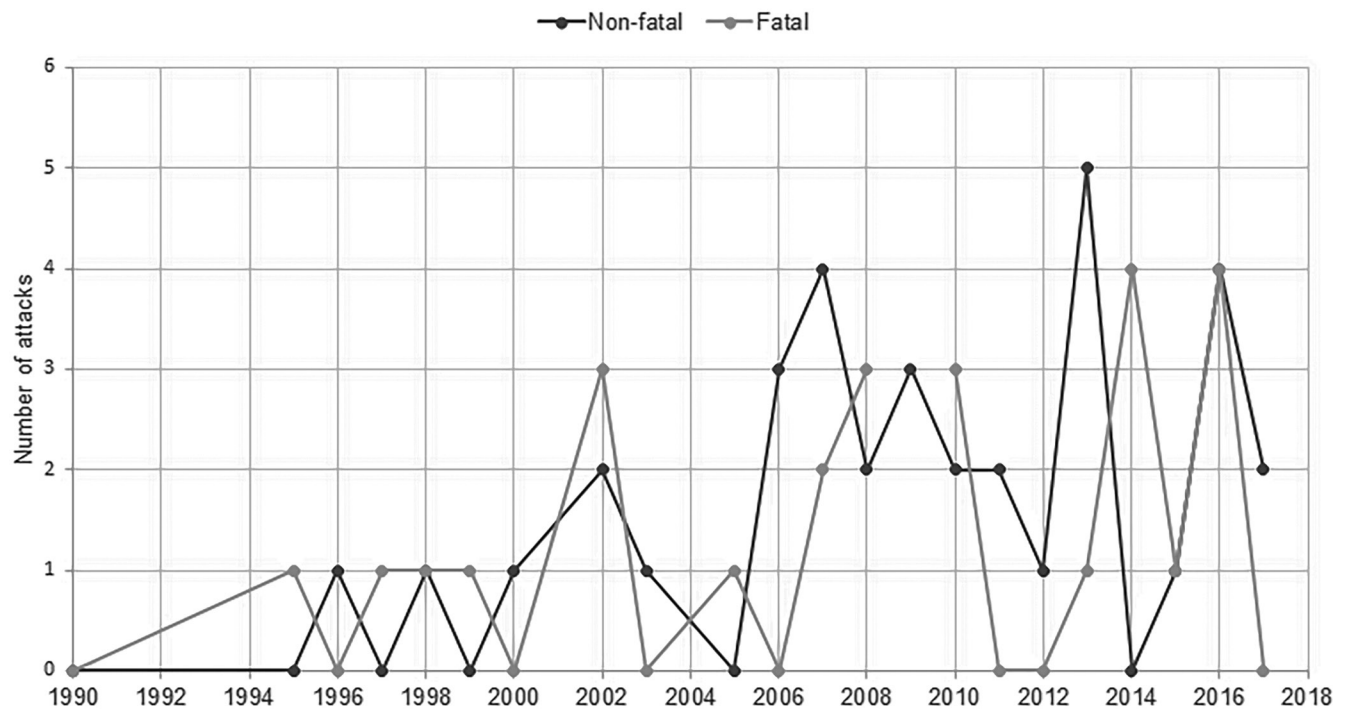


Figure 1. Number of crocodile attacks per year in Costa Rica (1990–2017).

gators attacked people in the water or at the water's edge (Conover and Dubow, 1997). Data from Nile crocodiles in Africa (Fergusson 2004) show that most of the people attacked were also close to water. Caldicott et al. (2005) found in Australia that most attacks occurred when people were in bodies of water or at the edge, especially fatal attacks, all of which happened when people were in the water. Similar data have been reported for American crocodiles in Mexico (Cupul-Magaña et al., 2010).

Most of the attacks (fatal and non-fatal) involved men. There were 53 attacks on men and only 6 attacks on women, which is a similar to the findings of Fukuda et al. (2014). Also, as reported by Fergusson (2004) and Caldicott et al. (2005), most of the attacks took place during the day. According to Caldicott et al. (2005), most attacks occurred during the day because of human behavior (as most people do not go swimming at night).

Most non-fatal attacks occurred in March, April, or May. This coincides with the hottest months in the country and with Easter week, a period when people vacation at beaches and rivers. Pooley et al. (1992) pointed out that crocodiles are more active and hungrier during the hotter months and proposed three reasons why crocodile attacks are seasonal. We add to this explanation the fact that, in those months, people in Costa Rica visit bodies of water more frequently. There was also a slight increase in attacks during September and October, and, during those months, male crocodiles defend territories for reproduction (Thorbjarnarson, 1989).

In Costa Rica, as well as in the other countries, the frequency of attacks has increased over time. This pattern coincides with the increase in some crocodile populations

and the human population, which leads to increased human activities close to crocodile habitats. This behavior is also reported in other crocodile species in other countries; for example, Ponce-Campos (2014) and Andau et al. (2004) explained how the increased number of several crocodile species resulted in an increase in human–crocodile interactions and attacks.

Incident reporting is not yet in mainstream culture, so interactions go unreported. For example, we know that in the Northern Pacific Cost, men went to the hospital but did not report their injuries as resulting from crocodile attacks in order to maintain their masculinity. As such, the information available is limited, but it allows us to establish management measures. For more accurate and standardized information, the country needs to create a national registry of interactions that, together with information on the status of crocodile populations (the country also needs a national monitoring program), would support policymakers as they grapple with crocodile management.

We need to monitor crocodile populations and behavior, especially in the hot-spot areas identified in this research. Information that should be collected includes population size and structure, seasonal movements, behavior, and human activities that affect crocodile activity (Botha et al., 2011; Pooley, 2015).

According to Caldicott et al. (2005), it is uncommon for crocodiles to attack and eat humans, and data reported here showed that most attacks are caused by the intrusion of a person into crocodile habitat. Understanding the underlying causes behind the increase in human–crocodile interactions will require careful logging of the events

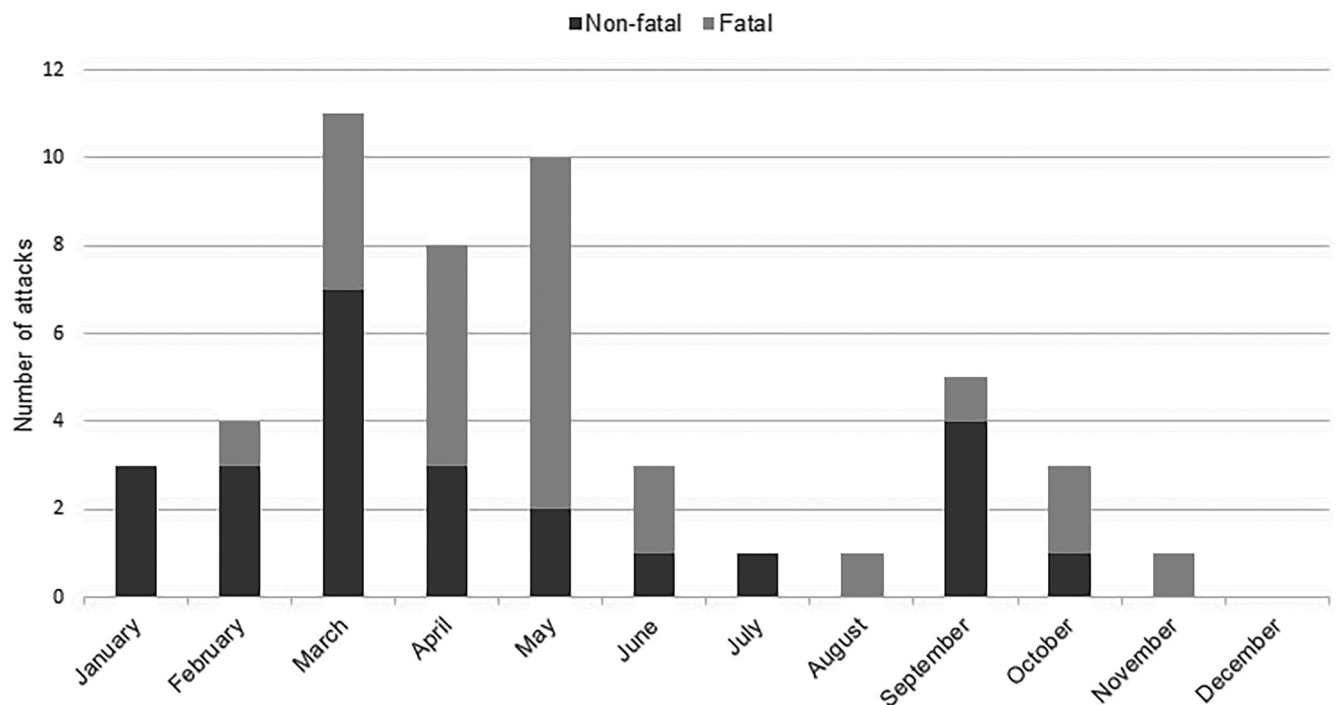


Figure 2. Number of crocodile attacks per month in Costa Rica (1990–2017).

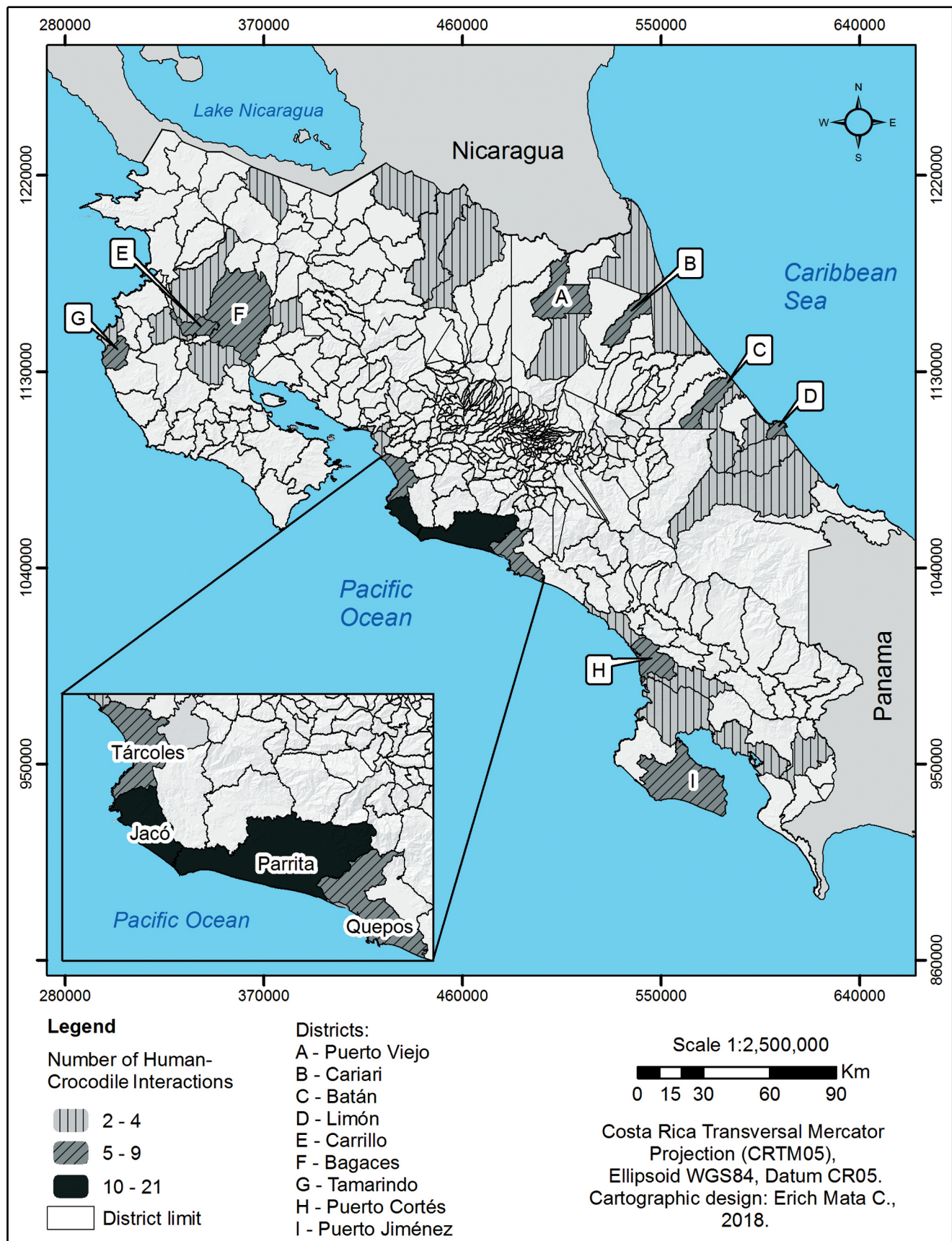


Figure 3. Interactions between humans and crocodiles by district (1990–2017).

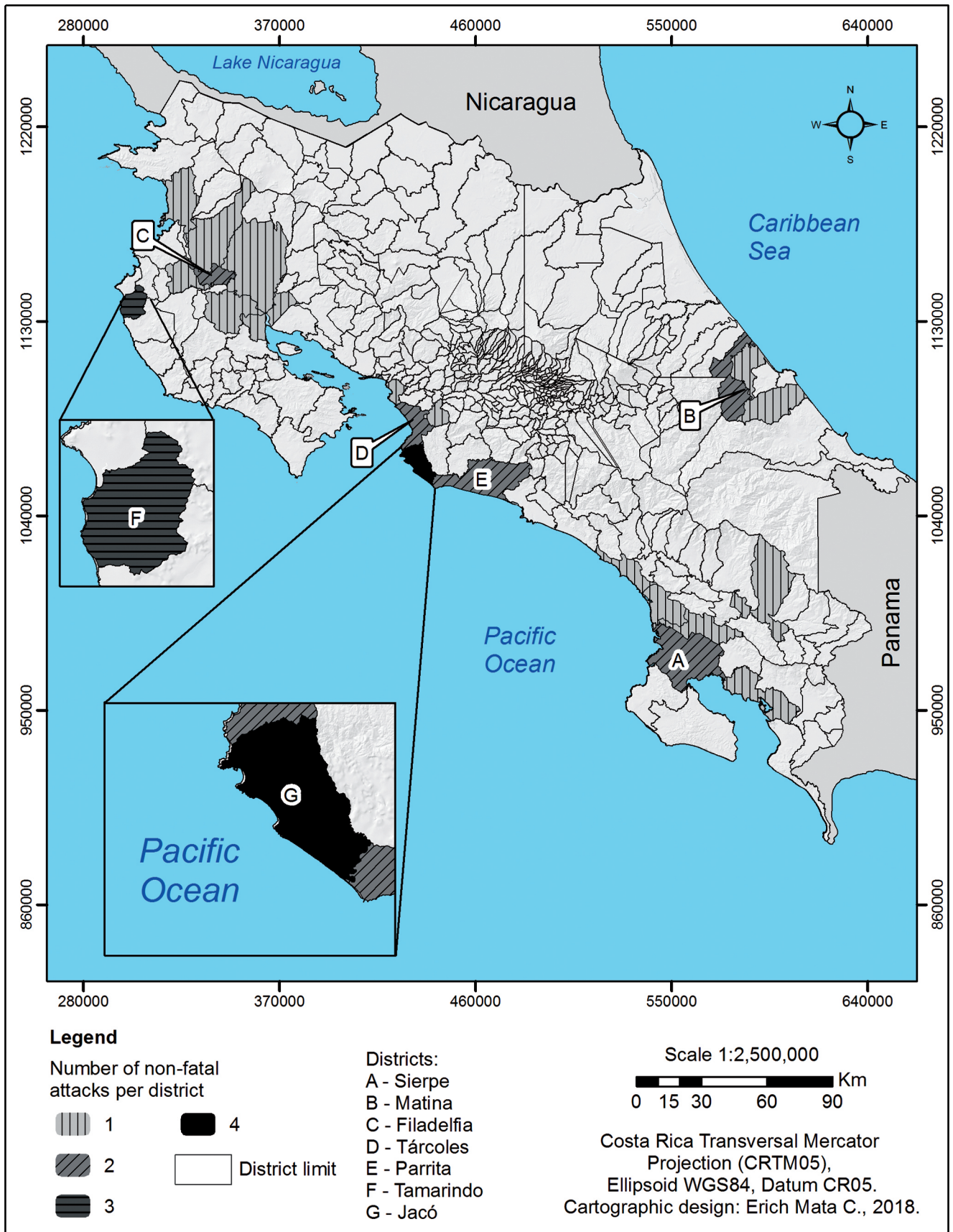


Figure 4. Non-fatal crocodile attacks by district (1990–2017).

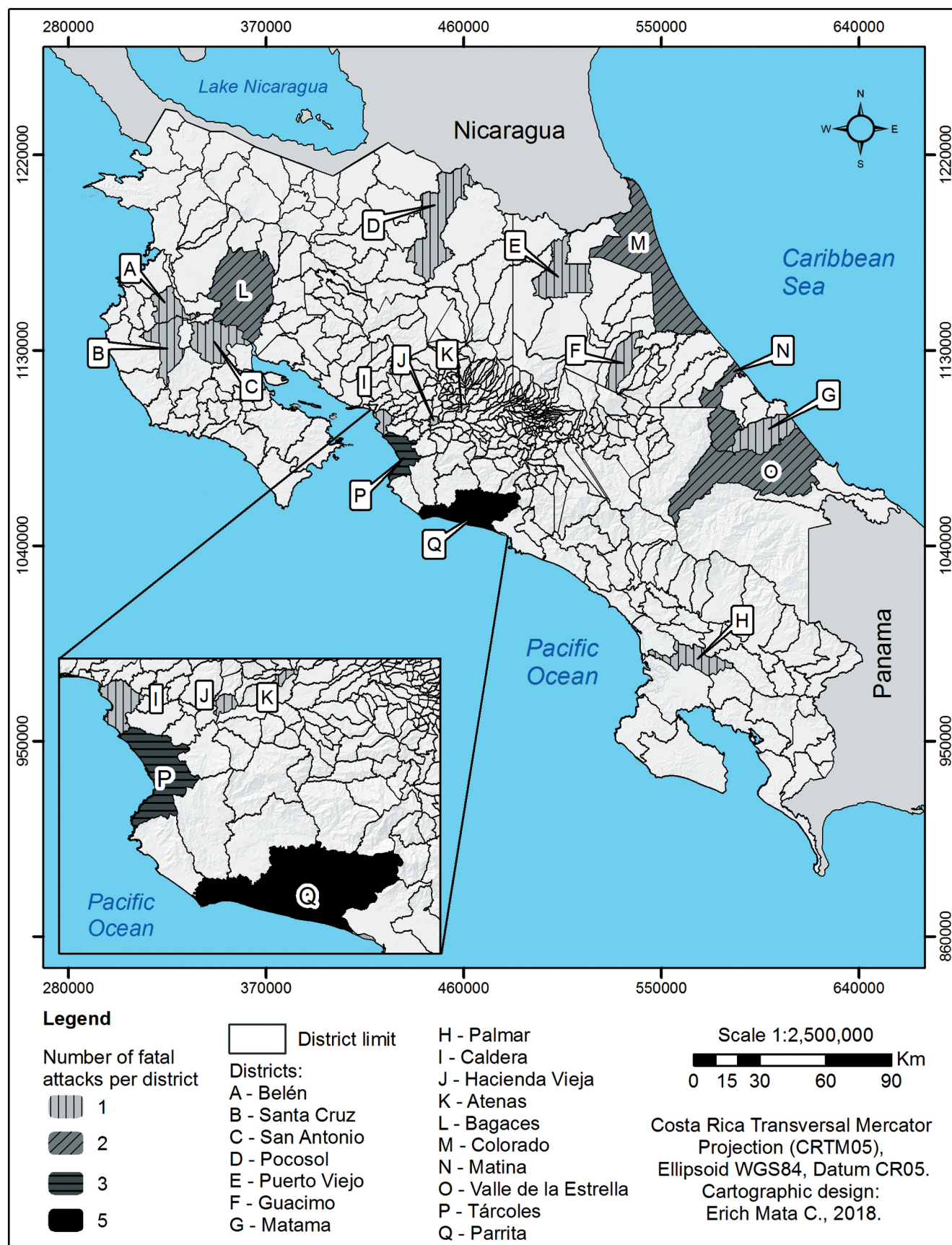


Figure 5. Fatal crocodile attacks by district (1990–2017).

leading up to each interaction, which is why a national, standardized database is so important.

A complete dataset would also help authorities identify priority areas for tourism, environmental education, awareness, signage, and population monitoring. As noted by (Caldicott et al., 2005: 154): “Primary prevention involves minimizing contact between humans and crocodiles. A wide variety of factors bring the two parties together, including the growing populations of both humans and crocodiles. In the developing world, circumstances can force humans into proximity with crocodiles.”

We already know that attacks are most commonly against men, during the day, and when people are in or adjacent to water. We also know the localities and months in which attack records are most frequent. From our results, we believe that the environmental and tourism authorities have enough information to develop solutions for prevention and coexistence rather than focusing solely on controlling crocodile populations. We suggest community discussion, engagement, and training for authorities and wildlife managers, public relations and outreach, education, proactive development of policy including signage, barriers to separate people and crocodiles, changing people’s behavior and expectations, relocation of problematic crocodiles and, in some instances, population control achieved by sustainable measures to ensure conservation of crocodiles in appropriate habitats and not complete isolation and elimination because of people’s intolerance. We must use the information already available to transform negative interactions and conflict into coexistence between crocodiles and humans.

ACKNOWLEDGMENTS

The Fire Department of Costa Rica provided information about human–crocodile interactions.

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