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## CONTRIBUTED PAPER

# Human–crocodilian interactions in Latin America and the Caribbean region

Simon Pooley<sup>1,2</sup>  | Pablo Ariel Siroski<sup>3,4</sup> | Lucía Fernandez<sup>4</sup> |  
Brandon Sideleau<sup>5</sup> | Paulino Ponce-Campos<sup>6</sup>

<sup>1</sup>Department of Geography, Birkbeck University of London, London, UK

<sup>2</sup>School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

<sup>3</sup>Laboratorio de Ecología Molecular Aplicada, LEMA-ICIVET-CONICET Facultad de Ciencias Veterinarias, Universidad Nacional del Litoral, Santa Fe, Argentina

<sup>4</sup>Proyecto Yacaré - Laboratorio de Zoología Aplicada: Anexo Vertebrados (FHUC-UNL/MAYCC), Departamento de Ciencias Naturales, Facultad de Humanidades y Ciencias, Universidad Nacional del Litoral, Santa Fe, Argentina

<sup>5</sup>CrocBITE – Worldwide Crocodilian Attack Database, Thousand Oaks, California

<sup>6</sup>Bosque Tropical, Investigación para la Conservación de la Naturaleza, Zapopan, A. C. Jalisco, Mexico

## Correspondence

Simon Pooley, Department of Geography, Birkbeck University of London, 32 Tavistock Square, London WC1H 9EZ, UK.

Email: s.pooley@bbk.ac.uk

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## Abstract

Mitigating harmful interactions with wildlife requires an understanding of the interactions between predators, domesticated animals and humans. Large-scale transformations of crocodilian habitats across the Latin America and Caribbean region, alongside significant use of crocodilians as a resource, and retaliatory killing of crocodilians following (or to prevent) attacks on humans and their animals, are generating significant conservation challenges. This matters because this is the world's most biodiverse region for crocodilians. Because there is little information on specific situations across this vast and complex region, in 2018 we initiated a biannual questionnaire survey to establish a reporting network. In this article, we summarize the findings of surveys conducted in 2018 and 2020. We triangulate this feedback with croc attack data, and consultation with regional experts, to produce this very preliminary overview. We identify trends in negative human–crocodilian interactions at country level, the most reported causes of these, and identify the key species and regions of concern. We surveyed attitudes to management policies and responses to negative interactions including direct action and outreach activities. We acknowledge (and clarify) knowledge gaps, and motivate for improved regional cooperation with regard to policies and management (notably monitoring and evaluation) and data collection and sharing.

## KEYWORDS

caiman, Caribbean, conservation priorities, crocodile, human-wildlife conflict, Latin America, management, policy

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## 1 | INTRODUCTION

Large-scale encroachments into and transformations of crocodylian (crocodiles and caimans) habitats across the Latin America and Caribbean region (LA&C), alongside significant use of the region's crocodylians as a resource, and retaliatory killing of crocodylians following (or in anticipation of) attacks on humans and their domesticated animals, are generating conservation challenges. This is significant because this is the world's most biodiverse region for crocodylian species. However, we have very little detail on local situations for many countries across this vast and complex region.

Although the IUCN SSC Crocodile Specialist Group (CSG) has a good membership across the LA&C region, there has never been an active and constant network to report on negative interactions with crocodylians or conflicts over how to manage these. We have therefore initiated a biannual questionnaire survey to establish a reporting network. In this article, we report on the findings of the first (2018) and second (2020) of our questionnaire surveys. We triangulate this feedback with croc attack data from the online database CrocBITE (2013), and consultation with regional experts, to produce this very preliminary survey.

## 2 | STUDY REGION AND SPECIES

This is a vast and varied region, with species of the crocodile and caiman families (four true crocodiles and all seven caiman species) inhabiting a huge range of habitats (Supplementary Information Map S1; Appendix S2). The most widely distributed species are the American crocodile (*Crocodylus acutus*) and the subspecies of the common (or spectacled) caiman (*Caiman crocodylus*). Species limited to regions include Morelet's crocodile (*Crocodylus moreletii*) found in northern Central America, Black caiman (*Melanosuchus niger*) found across the Amazon basin, Guyana and French Guiana (Thorbjarnarson, 2010), and *Caiman yacare* and broad-snouted caiman (*Caiman latirostris*) found in the central and south-eastern regions of crocodylian distribution in South America. The Orinoco crocodile (*C. intermedius*) is found only in the Orinoco Basin in Venezuela and Colombia (Balaguera-Reina et al., 2018). The Cuban crocodile (*Crocodylus rhombifer*) has the most restricted geographical distribution within the order Crocodylia (Alonso-Tabet et al., 2014), existing in the wild only in c.360km<sup>2</sup> in the Zapata Swamp, with an introduced population confined to c.35km<sup>2</sup> in Lanier Swamp on Isla de la Juventud (Isle of Youth).

## 3 | METHODS

In 2018 and again in 2020, we emailed a questionnaire (see Supplementary Information Appendix S1) devised by co-authors S. P., P. S., and L. F. to CSG members across the region, and asked them to forward it to relevant persons. We sought information on the extent of attacks, conflict over crocodylians and perceived causes of conflicts, local attitudes and responses to crocodylians, favored policy and management responses and their perceived effectiveness. We also requested recommendations for relevant literature, published or unpublished.

The surveys were sent as lists of defined and open-ended questions in Word documents in English, Spanish and Portuguese. Subsequently we sought contacts for countries we did not receive replies from through online sources and existing contacts. We summarized the replies in Excel documents organized according to associations in items in the responses (subcategories of: country/author; human-croc conflict; local attitudes; management; education/outreach), and this enabled some basic enumeration of preferences and frequencies of mention (e.g., species most named in connection with attacks). We distinguish where relevant between the number of respondents offering assessments and the number of countries for which particular findings were made.

We supplemented (and compared) the questionnaire information with data from CrocBITE (2000-May 2020), the online database of crocodylian attacks worldwide compiled by co-author Brandon Sideleau (CrocBITE, 2013). We consulted known regional experts on the status of particular species identified as of conservation concern, and also cross-checked with the CSG's Action Plans and Red List assessments.

There are several limitations to an exploratory study of this kind. The questionnaire will be further developed based on initial responses and findings. We asked about the availability of data on crocodylian populations, and incident data, rather than for the data itself, and do not attempt to definitively quantify negative human-crocodylian interactions across the region. Although we attribute responses to particular countries, not all respondents discuss the situation in that entire country. Qualifications are made where relevant. Though cross-checked with existing data and publications (see Pooley, 2020), our questionnaire results are impressionistic responses from a vast region. Much grey literature exists, which we have not accessed.

## 4 | RESULTS

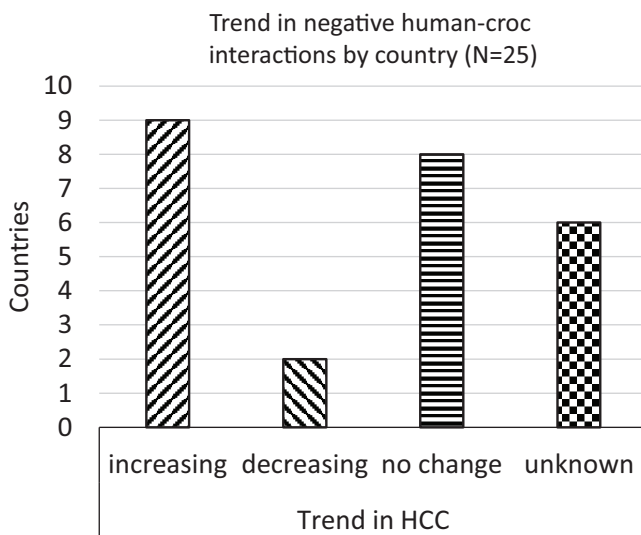
We received a total of 47 responses from 23 countries: 5 Caribbean nations, 8 from Central America, and

10 from South America (see Supporting Information Figure S1 and Table S1). These included countries we previously had little information for (Puerto Rico and Ecuador), and countries we had no information for (French Guiana, Guyana, Suriname and Trinidad). We received most responses from Mexico (7), which reports the most attacks in the region (with a growing literature, e.g., García-Grajales & Buenrostro-Silva, 2019). References to respondents' answers to the survey preface the year of response with an "s" (e.g., s2018) to differentiate them from references to published literature.

#### 4.1 | Incidence and trends in negative interactions

The overall trend in negative human–crocodile interactions including attacks and other threats to crocodilians (see Supplementary Information Table S1), was judged to be increasing or stable by respondents from most countries where data were available (see Figure 1). Upward trends are recorded for Colombia, Costa Rica, Guyana, Honduras, Jamaica, Mexico, Panama, Puerto Rico, and Trinidad. Regionally, only in Central America (compared with the Caribbean, and South America) did the majority of respondents (71%,  $N = 7$ ) think that crocodilians were endangered by killings of crocodilians.

Comparison of questionnaire data with attack data is limited as conflicts are about many things in addition to attacks (see Supplementary Information Table S2). However, records of attacks provide some corroboration of



**FIGURE 1** Trends were assessed for particular regions of countries by respondents. For two countries, respondents offered different assessments: Costa Rica (increasing, and no change); and Trinidad (increasing overall, and decreasing around Nariva Swamp); hence  $N = 25$

some of the trends noted above. Table 1 (CrocBITE data for all countries with >10 reported attacks since 2000) reveals most attacks in this period have been recorded since 2010, suggesting an overall upward trend.

No attacks on humans were reported for Bolivia, Cuba, Dominican Republic, Puerto Rico and Suriname, though CrocBITE records 6 in Bolivia since 2010 (none since 2018), 1 in Cuba in 2018, 1 in Suriname and confirms none in Dominican Republic or Puerto Rico. In addition, CrocBITE has no attacks recorded for Haiti or Uruguay (we received no feedback from these countries). In all cases, apparent trends may be artifacts of the data, for example, CrocBITE receives little attack reporting for Cuba, Guyana and Panama (pers. comm. Sideleau 2020).

#### 4.2 | Species involved

Seven species (3 crocodiles and 4 caiman species) attack humans, livestock, or pets (Supplementary Information Figure S2)—confirmed by CrocBITE data (Table 2) which includes also 1 incident involving Cuvier's dwarf caiman (*Paleosuchus palpebrosus*). The American crocodile accounts for 50% of all listings (see Supplementary Information Figure S2). The other key species are Morelet's crocodile, black caiman, and common caiman.

#### 4.3 | Killing of crocodilians

Respondents from 20 out 23 countries noted that crocodiles were killed by humans (Figure 2) for a variety of reasons, not all in retribution for attacks (only in Venezuela was no killing of crocs reported). Retaliatory killing was reported for 13 countries: Brazil, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Peru, Puerto Rico, and Trinidad. Then, 25 respondents (15 countries) thought crocodilians were threatened as a result of such croc killing, 17 (14 countries) did not, and 5 were uncertain (Figure 2).

##### 4.3.1 | Attributed causes of negative interactions

Negative interactions arise from a variety of causes in addition to attacks (see Supporting Information Table S2 for a summary of attributed causes). The main categories were attacks, fishing-related interactions, hunting, and utilization, with less commonly named causes including reckless behavior, in/direct feeding and habitat reduction.

**TABLE 1** Bite records for countries with >10 bites since 2010, with total reported bites from 2000 where available, from CrocBITE data. Data is to end May 2020. Continuous coverage beginning in 2000 is not available for Colombia and Panama

Country	Continuous coverage/years with no bites	Highest incidence of reported bites	Total reported bites in period since 2000	Total reported bites since 2010
Belize	2000–2020/2000, 2002–2007, 2009–2010, 2015	2001, 2014, 2016 (all 3)	19	15 (2 fatal)
Brazil	2000–2020/bites reported in every year	2012 and 2016 (both 10)	95	76 (17 fatal)
Colombia	2009–2020/2011, 2017, 2020	2012 (5), 2013 (5)	No records prior to 2009	28 (3 fatal)
Costa Rica	2000–20/2000, 2001, 2003, 2004, 2020	2016 (8)	50	32 (5 fatal)
Mexico	2000–2020	2015 (30) >20 p.a. from 2014 to 2017 >10 p.a. since 2010	217	188 (24 fatal)
Panama	2003–2020/2004, 2006, 2008, 2011, 2012, 2016, 2018–2020	2013 and 2014 (4 each)	18	13 (3 fatal)

**TABLE 2** CrocBITE data on species responsible for bites of humans across the study region

Species	Bites	Fatal	Nonfatal	Countries
<i>Crocodylus acutus</i>	176	27	149	Belize (4), Colombia (10), Costa Rica (30), Cuba (1), El Salvador (3), Honduras (1), Jamaica (1), Mexico (113), Nicaragua (2), Panama (11), Venezuela (1)
<i>Crocodylus moreletii</i>	76	10	66	Belize (10), Guatemala (7), Mexico (59)
<i>Crocodylus intermedius</i>	1		1	Venezuela
<i>Melanosuchus niger</i>	69	18	51	Brazil (55), Colombia (1), Ecuador (3), French Guiana (1), Guyana (3), Peru (6)
<i>Caiman crocodilus</i>	30	1	29	Brazil (11), Colombia (14), Costa Rica (2), Mexico (2), Suriname (1)
<i>Caiman yacare</i>	11		11	Argentina (1), Bolivia (3), Brazil (6), Paraguay (1)
<i>Caiman latirostris</i>	4		4	Argentina (2), Brazil (3)
<i>Paleosuchus palpebrosus</i>	1		1	Brazil (1)

#### 4.4 | Attitudes toward crocodylians

Nineteen respondents reported that locals particularly dislike or fear crocodylians. Nine reported that some locals valued them. Besides Argentina and Cuba, for all countries where respectful attitudes were reported (Belize, Brazil, El Salvador, Guatemala, Guyana, Mexico, and Venezuela), dislike was also registered.

#### 4.5 | Education and outreach options

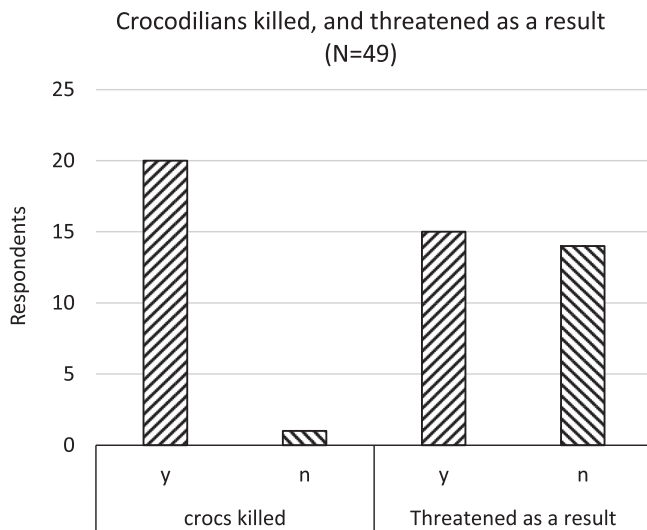
More respondents favored media campaigns and talks than printed materials (posters, books and pamphlets), or warning signs, though all approaches are used (see Supplementary Information Figure S4). One respondent noted reading material was little used in their rural part of Mexico, where presumably education levels are low.

Seven respondents reported that warning signs are ignored, or stolen for firewood or other uses, or because they hindered tourism.

#### 4.5.1 | Policies and management interventions

Respondents were asked how effective they thought a set of management interventions are (see Supplementary Information Figure S3). Response rates were low because only 8 of the 23 countries surveyed have official management policies (see Supplementary Information Table S1) for dealing with negative incidents involving crocodylians: Belize, Colombia, Costa Rica, Cuba, El Salvador, Honduras, Mexico, and Panama.

Removal/relocation (18 in favor) was the most favored and implemented management intervention,



**FIGURE 2** In 6 countries (Argentina, Bolivia, Brazil, Colombia, Trinidad, and Venezuela), crocodilians were judged to be threatened as a result of killing by humans in one region of the country, but not in another, so entries for these countries registered a “yes” and a “no”

judged ineffective only by respondents from Colombia, Mexico (2/7; 5 in favor), Puerto Rico, and Trinidad (1/3). Lethal control was rated effective by 7 respondents from 5 countries: Belize (only used once); Bolivia; Costa Rica; Mexico (2 of 7 in favor); Puerto Rico and Trinidad. Protective structures have been little tried, with recommendations only from: Argentina (1 in favor, another not); Belize; Jamaica; Mexico (2/7); Panama (judged effective but expensive); and Venezuela.

## 5 | DISCUSSION

It is concerning that for 74% of the 23 countries surveyed, negative interactions between humans and crocodiles was rated increasing or unchanged, with 39% experiencing an upward trend. The nine countries with increasing trends include Colombia, Costa Rica, Mexico, and Panama (also noted on CrocBITE data as high-incidence for attacks); Guyana, Puerto Rico, Trinidad (little previous data), and Honduras and Jamaica (negative interactions are reported but infrequently include attacks on humans). CrocBITE data (Table 1) shows notable increases in (reported) attacks for Brazil and Belize, decade on decade.

### 5.1 | Crocodilian species most involved in negative interactions

The widely distributed American crocodile is responsible for by far the most reported attacks (176; 27 of these fatal

according to CrocBITE) across the region (14 countries reported in the survey). It is a large crocodile, adult males growing to 4–4.5 m (Thorbjarnarson, 2010), well able to tackle a human or domestic animal, and a higher percentage of fatal attacks is recorded for adults  $\geq 3$  m (Ponce 2014).

The other significant species are Morelet's crocodile (76 attacks across 3 countries), black caiman (69 across 6 countries, causing more fatalities than Morelet's crocodile) and common caiman (30 across 5 countries, only 1 fatality). Morelet's crocodile is a medium-sized crocodile, attaining around 3–3.5 m in adulthood. The black caiman is the largest caiman with a massive skull, large adult males attaining 4–4.5 m in length (Thorbjarnarson, 2010), perhaps explaining why it is responsible for the highest proportion of fatal attacks for any species in the region (26% of attacks are fatal, next highest being *C. acutus* with 15%; percentages may be artifacts of data availability).

The common caiman is a medium-sized species, large adult males attaining 2–2.5 m (Balaguera-Reina and Velasco (2019)), with most bites on adult humans unlikely to result from deliberate predation behavior. They are very widely distributed and adapt well to human-altered landscapes, resulting in high encounter rates.

### 5.2 | Killing of crocodilians and attributed causes

Respondents from 20 countries said locals killed crocodilians, for a variety of reasons (see Table S2), and 25 respondents (15 countries) fear crocodilians are being endangered as a result. The main reasons given include attacks on humans, livestock, and pets, competition for fish and damaging of fishing gear, and hunting and utilization for a variety of purposes. Attacks resulting in retaliatory killing result mainly from natural predation behavior, reckless human behavior in crocodilian habitats, increasing encounters due to habitat encroachment or destruction, and prey reduction.

### 5.3 | Attitudes toward crocodilians

This is a very complex area, as evidenced by the response from Belize which lists the varying attitudes of 8 different communities in the country (Tellez s2020). The questionnaire responses provide only impressionistic assessments. It is however concerning that respondents from 19 countries thought that locals particularly disliked crocodilians. While no dislike for crocodiles was noted for Cuba (there

are very few attacks, and no-one lives near *C. rhombifer* habitat in the Zapata Swamp), the literature suggests dislike is a problem for conservation efforts there (Alonso-Tabet et al., 2014).

There are few published studies of human attitudes toward crocodilians in the region. Balaguera-Reina et al. (2018) found that 67% of reporting about crocodiles in Colombia (by media, environmental and government agencies, and scientists) focused on negative interactions. A study of knowledge about and attitudes toward crocodilians in and around Tayrona National Park (Balaguera-Reina et al., 2019) revealed locals knew little about crocodile biology or ecology and crocodiles were widely feared. Espinosa-Blanco and Vargas-Clavijo (2014) researched cultural attitudes to and use of crocodilians in Venezuela. In Costa Rica, there is a general perception that there is an overpopulation of crocodiles, resulting in attacks. The “lagarteada,” a ceremony involving the capture and display of a crocodile by community men in Ortega was still performed as recently as 2018, though the crocodile was no longer sacrificed on Easter Sunday (Siroski, Llobet, & Velasco, 2018).

#### 5.4 | Education, outreach, and other attempts to promote tolerance

Survey participants reported negative attitudes toward crocodilians in many regions, and rated public and school talks, and media campaigns highly as a means of addressing this. In Mexico, national and regional media communications and educational talks are given (Ponce-Campos s2020).

In a few places, for example, Argentina, sustainable use programs have improved attitudes to crocodilians (Siroski s2020), and ecotourism run by the community-owned eco lodge Caiman House has similarly achieved this on a stretch of Guyana's Rupununi River (Holland s2020). There are ongoing efforts to regulate and make sustainable existing subsistence use and local trade in crocodilians, for example, in Bolivia and Peru (Morales-Franco, Rodriguez-Cordero, & Franulic-Quaino, 2018; Vásquez Ruesta et al., 2017).

Workshops and training courses for community groups are being tried in Chiapas, Mexico and community conservation initiatives tried in the Mexican states of Campeche, Chiapas, Jalisco, Nayarit, and Oaxaca (Ponce-Campos, pers. comm. 2018). Engaging and involving the public is part of an official strategy for crocodile conservation in the country (SEMARNAT, 2018b). Attempts have been made to involve locals in research and monitoring in Belize (Tellez s2020) and Costa Rica (Ramírez s2020). Successful conservation

programs have garnered positive media coverage in Colombia (Balaguera-Reina & Farfán-Ardila, 2018).

#### 5.5 | Current policies and management interventions

There is a need to develop policies and management protocols for use in countries and regions across LA&C, and devise and provide appropriate training. Management strategies should be monitored and evaluated. It is concerning that the interventions rated most effective (relocation) is not regarded by most crocodile experts to be a good intervention because of crocodilians' well-known homing instincts (Fukuda et al., 2019). It is unclear from responses whether removal is to secure facilities (as is the case for, e.g., in Mexico; Ponce-Campos s2018) or not, something which future questionnaires can clarify. Lethal control is not widely supported, though sometimes necessary (best avoided for endangered species). Protective structures have been little tried despite some evidence of success in South Asia (e.g., Whitaker, 2008), though this also needs evaluation.

The most in-depth policy and management framework in the region has been developed in Mexico, which faces the most widespread and serious challenges relating to negative interactions with crocodilians. There is a national protocol recognized by the Federal Government which integrates efforts across different sectors and levels of governance (SEMARNAT, 2018a, 2018b). There is a technical working group, Grupo S.O.S. Crocodile, and problematic situations are investigated by federal environmental and conservation agencies, with the working group. Incidents are handled by their staff and first-response authorities including police, civil protection and municipal authorities (Pecero s2020). Resources are a major challenge for responders.

A common model with state nature conservation agencies with limited resources or expertise is to partner with other agencies and NGOs, for example, in Belize (Tellez s2020) and Jamaica (Miller s2020). Where there are no dedicated conservation services, other agencies (often Forestry) step in, but lack relevant training, for example, in Peru (Vasquez Ruesta s2020). In some areas, for example, Central Rupununi in Guyana, and no doubt in many remote regions, such problems are handled by local communities (Holland s2020).

Further work is required to investigate conflicts over management of negative impacts of crocodilians. This is distinct from the negative impacts themselves. Crocodilians may also be the proxies for other conflicts between locals and conservation authorities, and intolerance and killing may be the result of indirect impacts such as opportunity costs.

Finally, it will be worth investigating where coexistence with crocodilians occurs and what may be learned from where this exists. Crocodilians are utilized by indigenous and local peoples in many regions (Ouboter s2020; Morales-Franco et al., 2018), and attempts to regulate this would benefit from an understanding of practitioners' knowledge and beliefs about the species they utilize.

## 6 | CONSERVATION STATUS AND PRIORITIES

This discussion focuses on the species identified as most involved in negative interactions with humans in the questionnaire survey, chiefly American crocodile, Morelet's crocodile, black caiman and common caiman, though other species of conservation concern are noted.

### 6.1 | Central American region

Although widely distributed (18 countries), the American crocodile remains Vulnerable (Balaguera-Reina et al. 2015). On Mexico's Pacific Coast (see Map 1), hybridization is a

threat to the "pure" American crocodile population where Morelet's crocodile have escaped from farms and established populations outside of their natural distribution, for example, at Lagunas de Chacahua National Park in Oaxaca, in the Laguna de Alcu zahue in Colima, and Villaflores in Chiapas (Sigler & Gallegos, 2017; Thorbjarnarson, 2010).

On Mexico's Pacific Coast, in Jalisco State, American crocodiles are killed for breaking fishing nets (and drown in them), when humans encounter them in irrigation canals used for farming and aquaculture, or water courses and estuaries used for recreation (Sahagún s2020). Such areas include the River Tomatlán, Laguna de San Juan, Ramsar sites Majahuas and Xola-Paraman and Puerto Vallarta. Attitudes toward crocodiles are largely negative with negative interactions increasing (Sahagún s2020; Rubio s2020). Attacks on humans and pets around Puerto Vallarta and in neighboring Nayarit State, ignoring of safety measures by locals, and habitat reduction are causing rising negative interactions (Pecero s2020). In Chiapas State, indirect feeding of crocodilians is increasing nonfatal incidents. Divers (spear-fishing) who secure fish to their waist, and those trying to illegally catch crocodilians for sale as pets, are bitten. This together with attacks on domesticated animals, and



**MAP 1** Map of Central America and the Caribbean region including areas with significant crocodilian populations, places and waterbodies noted for human-crocodilian interactions



perceived competition for fish, results in locals killing crocodilians, and nests are looted.

Attempts are being made to train locals to deal with problem animals, barriers are being considered to improve safety, and attempts are made to capture and remove problem animals (E Sarmiento Marinas s2020; Y Sarmiento Marinas s2020). On Mexico's east coast, in Tamaulipas State, negative interactions with Morelet's crocodile are perceived to be increasing, in response to attacks on humans (Leal s2020).

Belize's population of American crocodiles is slowly decreasing due to loss of nesting habitat and increased illegal hunting. Hybridization with *C. moreletii* is a threat to the "pure" *C. acutus* population here, as it is on most of the Gulf coast and the Yucatán Peninsula. Some Morelet's inland are hybrids too (Tellez s2020; Pacheco-Sierra et al., 2018).

In Guatemala, while some appreciate crocodiles at a distance, others fear attacks by American crocodiles on humans and livestock, with many suggesting shooting crocodiles: there are no official policies (García s2018; Anleu s2020). In Honduras, people living near water sources fear attacks especially on children, and complaints are increasing. People request removal of crocodiles, done by the Department of Wildlife with other organizations (Acosta s2020). In Nicaragua, denser populations of crocodilians are noted in protected areas where rangers are present; poaching for skins and eating of crocodilians occurs. Community participation in conservation and sustainable use are recommended (Chamorro s2020). In El Salvador, *C. acutus* are regarded as threats to children, fishermen, and dogs, though some value them for their ecological role and for ecotourism (Dueñas s2020).

In Costa Rica, attacks on people, domestic animals including pets, and presence in tourist areas and around aquaculture activities is resulting in negative interactions. Recreation in crocodilian habitats, expansion of tourism, farming and urban areas are exacerbating the problem, with feeding of crocodiles for tourism causing loss of wariness and heightened chances of attacks (Hernández s2018; Ramírez s2020). The public fear crocodiles and want them controlled through hunting (Porrás s2020). Districts with highest negative interactions extend from Tárcoles to Parrita on the Pacific Coast (Porrás Murillo & Cambronero, 2020).

In Panama, migration of indigenous Kuna people to the mainland has exacerbated human–crocodile problems with fatal attacks on the Island of Coiba and in the Panama Canal Basin. There is concern over effects of the expanding canal and of beach tourism projects (Siroski et al., 2018). American crocodiles (and *C. c. fuscus*) are often found in home gardens and streets, due to urban expansion. There are increasing problems with American crocodiles in

Panama and Colon provinces, with increasing presence in urban areas and attacks on fishermen, particularly in the canal area (no data are kept). Even Ministry of Environment staff know little about crocodiles, and in general, many myths are believed. Crocodiles caught in fishing nets are killed (Venegas-Anaya s2018).

## 6.2 | Caribbean region

Hunting has been a problem on several islands (see Map 1) including Cuba (Freitas s2020), Jamaica, the Dominican Republic at Lago Enriquillo where they are disliked, caught, and eaten (Espinal s2020) and possibly on Haiti (Ponce-Campos, Thorbjarnarson, & Velasco, 2012; Siroski et al., 2018; Brocca s2018). In Cuba, the Cuban crocodile is categorized as Critically Endangered (Targarona et al., 2008). The main threats are habitat deterioration, lack of suitable nesting sites, disruptions caused by invasive species and tourist activities, and illegal hunting. Another major threat is hybridization with *C. acutus*, particularly in Lanier Swamp on the Isla de la Juventad (Alonso-Tabet et al., 2014; Siroski et al., 2018). Locals seldom encounter the species, so knowledge comes from former times or illegal hunters: most are respectful (Freitas s2020).

On Jamaica, there are many unprovoked attacks on (American) crocodiles due to fear, and some out of machismo. Crocodiles are harvested illegally for meat. NEPA remove crocodiles when locals complain, which is often done in hope of compensation or media attention, and some outreach is done together with Hope Zoo. Those benefiting directly from ecotourism (e.g., at Black River) value them, but in general they are disliked and crocodile numbers appear to be falling. The island requires a policy on attacks (Miller s2018; 2020; Picking s2020).

On Puerto Rico, all reported bites were by captive caiman. There have been complaints and requests for removal of caiman, for example in the vicinity of Tortuguero Lagoon, and swampy land at Dorado. A large crocodilian was reported on a northern beach in 2018, and sensational media coverage and public hysteria ended in the torture and killing of the animal, to general public approval. Management responsibility is unclear and resources are limited. Lethal control is regarded as effective (Joglar s2020).

In Trinidad, common caiman are widely distributed and populations stable, while the status of the recently discovered *P. palpebrosus* population is unknown. Humans kill caiman for food (it is legal to hunt them) or out of fear especially in the rainy season when drains flood and caiman approach settlements (Auguste s2020).

Caiman are killed when they venture onto farms to eat small domestic animals, or enter pond-based aquaculture farms (tanks are better), for example, at Nariva. Attitudes are regarded as generally aggressive and negative to crocodilians (Rattansingh s2020; Mohammed s2020).

The conservation implications of Pacheco-Sierra et al.'s (2018) recognition of two distinct lineages (separate species) for Mexico's *C. acutus*, in the Pacific and the Mexican Caribbean, along with deep histories of hybridization with *C. moreletii*, and Milián-García et al.'s (2018, p. 11) positing of "distinct phylogenetic affinities and high genetic divergence between Antillean and continental *C. acutus* populations," remain to be worked out.

### 6.3 | South America

In South America (see Map 2), Colombia is a priority conservation area, where *C. acutus* is regarded as Endangered except in the Bay of Cispatá (Morales-Betancourt et al., 2015). The species involved in negative interactions are American crocodile, common caiman (attacks on people and farm animals) and black caiman (attacks on people) (Balaguera-Reina s2020). A conservation priority is the unusual inland riverine American crocodile population in the Magdalena and Cauca river basin.

In Parque Nacional Natural Macarena, Meta Department, Orinoco crocodile get entangled in fishing nets and as they are large crocodiles, fishermen kill them. In this department, they are hunted in retaliation for attacking humans or pets. Since a guerrilla was killed by a caiman (unidentified) in the Dudas River in 2019, there is an order for guerrillas to kill large crocodilians (Morales s2020).

American crocodile populations are recovering slowly on Colombia's Caribbean coast. Balaguera-Reina et al. (2019) found little knowledge of crocodiles here, widespread fear of large animals (but tolerance of those <2 m), and reporting in the Colombian media in general focuses on negative interactions. They are regarded as threatened by killings here (Balaguera-Reina s2020).

Small populations of American crocodiles persist in the Gulf of Gayaquil in southern Ecuador and the Tumbes Department in the northernmost corner of Peru. In Ecuador, there are negative interactions around estuaries where people swim, and around shrimp farms. They are feared and disliked, sometimes shot, or captured and removed (Puig s2020).

In Peru, American crocodiles are threatened by coastal mangrove destruction by shrimp aquaculture, extractions of shells and crabs, as well as intense agricultural activity in the middle and upper Tumbes River

(Vásquez Ruesta et al., 2017). Negative interactions are reported in the lower Tumbes River (fishing area and rice paddies) because of attacks on pets particularly working dogs, with suspected retaliatory killing (Ruesta s2020).

Efforts continue to reestablish American crocodiles in coastal Venezuela, where there is concern over disruption to the population around Turiamo Bay resulting from military exercises (Hilevski s2020). Similar efforts involve the Orinoco crocodile, which remains Critically Endangered (Balaguera-Reina et al., 2017). It is a concern that fears persist despite no reported attacks, attributed to folklore like the song *Mercedes* sung by Simón Díaz. Arteaga (s2020), however, reports locals mostly accept their reintroduction onto private ranches.

In Region 9, Central Rupununi in Guyana, black caiman do attack domestic animals notably dogs, but attacks on humans are rare (none since 2006). Fishermen resent damage to their nets and there is possibly a slight increase in negative interactions as human and caiman populations grow, notably over damage to nets and perceived competition over fish. Fishermen dislike caiman and some locals kill them for meat, but many tolerate them because of the ecotourism benefits (tourists participate in caiman mark-and-recapture) and the outreach efforts of Caiman House (Holland s2020; Taylor s2020; Spellen s2020).

In Suriname, large common caiman occasionally attack poultry and pets, and most people fear them. They are hunted for meat, especially by indigenous peoples, but no caiman species is regarded as threatened (Ouboter s2020).

Perhaps the most threatened population of black caiman is that of the Kaw wetland of north-eastern French Guiana, in the Réserve Naturelle Nationale de Kaw-Roura. Hunting for hides decimated the region's population. This remaining population is declining due to little conservation control, poaching, and pollution from nearby gold mining. No attacks by black caiman are reported. Both species of dwarf caiman appear to be decreasing too (Lemaire s2020).

The highly vegetated, shallow water bodies broad-snouted caiman favor are under great anthropic pressure throughout their distribution (see Supporting Information Map S1). Key threats include habitat destruction resulting from agriculture, cattle ranching and dam building. In Brazil, this includes the wetlands and mangroves this species inhabits in the Atlantic forest region (pers. comm. Verdade 2020). Attacks on domestic animals are occasionally reported. In Rio, urban expansion is destroying this caiman species' habitat and food sources, and negative interactions are increasing around Jacarepaguá Lake (Filho s2020).



MAP 2 Map of key waterways and places notable for human-crocodilian interactions in South America

In Amazonas State, there are incidents involving humans and caimans (mostly black caiman), due to ignorance of caiman behavior and attacks on humans, livestock, and pets. There are negative interactions (not attacks) involving common caiman and even Schneider's dwarf caiman in urban areas. There is no systematic data collection, but both crocodilian populations and trends in negative interactions are judged stable. Mostly, people dislike caiman, kill them and destroy nests. Widespread killing of crocodilians in Brazil are not considered a serious conservation concern, though data is patchy (Filho s2018; da Silveira s2020).

The black caiman population in Bolivia is widespread but sparse (Rodriguez-Cordero, Balaguera-Reina, & Densmore III, 2019), and retributive killing occurs. There are attacks by black caiman (feared) and very occasionally by *Caiman yacare* which are killed for various uses (Ten s2020). In the south of the country, broad-snouted caiman are killed when found in water bodies used for recreation, to protect domestic animals and children (though no attacks are reported). Killing is regarded as a threat to this species here. Lethal control is regarded as an effective management response (Aparicio s2018).

In Argentina, attacks by broad-snouted caiman and *C. yacare* on smaller domestic animals are frequently reported. Except for those benefiting from sustainable use of these species (Proyecto Yacare pays to collect eggs on locals' land), most see caiman as a threat, despite limited attacks. There is a history of killing caiman and destroying nests, but this may be changing due to economic benefits, involvement in field studies and outreach (Siroski s2018, s2020; Ciocan s2020, Simoncini s2020).

## 7 | CONCLUSION

This article presents the results of the first region-wide surveys of human–crocodilian interactions for Latin America and the Caribbean region, with remaining gaps including Cayman Islands, Haiti, Paraguay and Uruguay. For 74% of countries surveyed, the trend in negative interactions was judged to be stable or (in 39% of cases) increasing. Crocodilians were considered most widely endangered by killings in Central America.

Triangulation of sources suggests priority countries for human–crocodile interactions work include (but are not limited to): Mexico, Costa Rica and Panama in Central America; Cuba, Puerto Rico, Jamaica and Trinidad & Tobago in the Caribbean; and Colombia in South America.

The American crocodile is by far the most frequently mentioned species in connection with negative interactions with humans. The other key species include

Morelet's crocodile, the black caiman and the common caiman (various subspecies).

The attributed causes of killings of crocodilians were identified (Table S2). The major cause is croc attacks (or fear of attacks), on humans, livestock, and pets. Other key threats include: habitat destruction resulting from agriculture and cattle farming, aquaculture, dam building and urban expansion; illegal hunting for food, skins, medicines and pet trade; conflicts related to perceived competition for fish and damaging of fishing equipment; hybridization resulting from natural range overlaps and introduction of non-native species; retributive killing; and pollution.

Only eight countries have management policies for handling negative human–crocodilian interactions. There is a need for policies, management protocols and training, especially as limited resources mean official conservation agencies often rely on assistance from NGOs and other agencies, and in remote areas local people handle incidents.

Media campaigns and educational talks are favored for mitigating negative interactions. More studies of attitudes toward crocodilians, cultural dimensions of human–crocodilian interactions, and public communications about crocodilians would be useful. Evaluations of outreach activities would help to inform and focus future efforts.

Mitigation activities include sustainable use programs (e.g., Argentina), regulating local trade (e.g., Bolivia and Peru), ecotourism (Guyana), community training and research projects (e.g., Mexico, Belize, and Costa Rica), and engaging the media about successful conservation programs (Colombia). Systematic monitoring, evaluating, and sharing lessons from these programs across the region is recommended.

We have identified species, regions and countries of particular conservation concern, for example, American crocodile populations on South America's Pacific coast and Colombia's Caribbean region, Cuban and Orinoco crocodiles, and black caiman in French Guiana's Kaw wetland. However, we acknowledge the difficulties of prioritizing meager conservation resources considering very variable survey data on the status of crocodilian populations in many areas, or on local human–crocodilian interactions. This study provides a basis for beginning to fill in some of these gaps, and future surveys and analysis.

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## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## AUTHOR CONTRIBUTIONS

**Lucía Fernandez, Simon Pooley, and Pablo Siroski:** Designed the study, which was coordinated and processed by **Pablo Siroski** and **Lucía Fernandez**, with additional information collected by **Simon Pooley** and **Pablo Siroski**. **Simon Pooley:** Drafted the paper, with contributions from **Paulino Ponce Campos, Pablo Siroski, and Lucía Fernandez**. CrocBITE data contributed by **Brandon Sideleau**, with additional information from **Paulino Ponce Campos**.

## DATA AVAILABILITY STATEMENT

The data that supported the findings of this study are available from the corresponding author in English, or Spanish and Portuguese from P. S., upon reasonable request.

## ETHICS STATEMENT

No sensitive questions requiring ethical clearance were asked, respondents were notified of the nature and purpose of the questionnaire in advance, with no minors or animals involved in this study.

## ORCID

Simon Pooley  <https://orcid.org/0000-0002-0260-6159>

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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