# Cuban Crocodile *Crocodylus rhombifer*

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**Common Names**: Cuban crocodile, cocodrilo, pinto, cocodrilo perla, criollo, legitimo, cocodrilo de Cuba

**Range**: Cuba, formerly the Bahamas and Cayman Islands

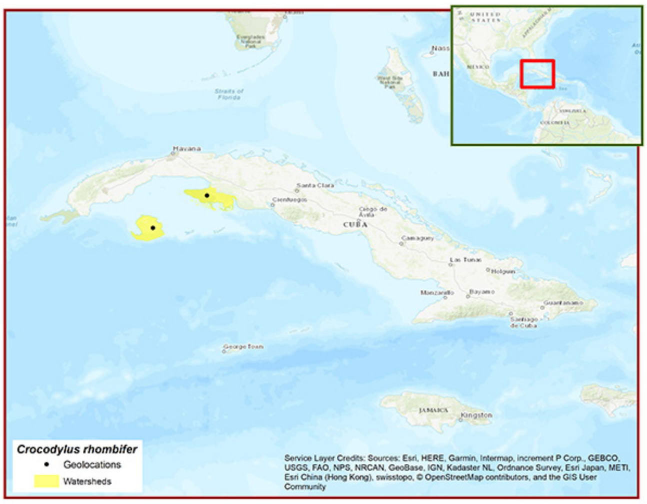

Figure 1. Distribution of *Crocodylus rhombifer* (Targarona *et al*. 2017).

## Conservation Overview

CITES: Appendix I

CSG Action Plan:

- Availability of survey data: Adequate
- Need for wild population recovery: Highest
- Potential for sustainable management: Moderate

2018 IUCN Red List: Critically Endangered (Criteria A2cde. Inferred population decline of >80% in 3 generations in extent of occurrence; reduction of habitat quality; effects of hybridization and illegal exploitation) (last assessed in January 2008; Targarona *et al*. 2017).

Principal Threats: dramatic Holocene range contraction, habitat alteration, ecological competition and hybridization with *Crocodylus acutus*, severe and systematic poaching, introduction of *Caiman crocodilus*, rising sea level

## Ecology and Natural History

Cuban crocodile habitat is composed of a limestone base characterized by deeply eroded edges (diente del perro) and karst, overlain with mud (tembladera) and dense vegetation. Sawgrass (*Cladium jamaicensis*) and cattail (*Typha domingensis*) dominate open, shallow water areas. Buttonwood (*Conocarpus erecta*) is found throughout the freshwater environment and is almost an indicator species for *C. rhombifer*. Densely vegetated hammocks are scattered across slightly higher ground throughout both swamps. Some low, pitted limestone escarpments harbor Caribbean dry forest communities, with trees like poisonwood (*Metopium toxiferum*), known locally as guao. Animal species found in association with *C. rhombifer* include apple snails (*Pomacea* spp.), mosquito fish (*Gambusia* spp.), introduced African cichlids (*Tilapia* spp.), catfish (*Clarias* spp.), a primitive endemic gar (*Lepisosteus tristochus*), an endemic boa (*Epicrates angulifer*), jicotea (*Trachemys decussata*), endemic woodpecker (*Xiphidiopicus percussus*) and hutia (*Capromys pilorides*) - a 6 kg semi-arboreal rodent.

Figure 2. Cuban freshwater marsh bordered by "diente del perro". Photograph: William McMahan.

Although some fossil crocodilians possessed horn-like squamosals, it is not a morphological character in modern crocodilians - except for *C. rhombifer*. The Cuban crocodile is the most heavily armored extant member of the genus *Crocodylus*. It has also been suggested that the dentition of *C. rhombifer* is unusual among modern *Crocodylus* because it can have 12 maxillary teeth, and possesses a carnassial, which differentiates it from other living *Crocodylus* species (F. Ross 1998). Although *C. rhombifer* is physically smaller than *C. acutus*, it is behaviorally dominant over the latter in

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captive situations (Gundlach 1880; Varona 1966, 1986; Neill 1971; Thorbjarnarson 1992).

The Cuban crocodile is an aggressive, athletic species. It is an adept leaper, quite capable on land, frequently using its muscular, strongly keeled limbs to rise rapidly and propel its body along the ground. It is capable of galloping (W. McMahan, pers. observ.). Tail drag marks have been observed in proximity to hutia trails in seasonal dry forest, some distance from water.

Stomach content analyses conducted in November 2000 on 20 *C. rhombifer* in Zapata Swamp, ranging in size from 1.40 to 2.05 m TL, indicated hutia was the most important prey item. By mass, this mammal accounted for over 90% of the total recovered stomach contents. Other prey items included land and aquatic crabs, apple snails and a bird (R. Soberon, pers. comm. 2001; Soberon *et al*. 2011). It has also been observed hunting and eating introduced African catfish (*Clarias gariepinus*) and bullfrogs (*Rana catesbeiana*) (R. Ramos, pers. comm. 2017). Like most crocodilians, the Cuban crocodile can consume a wide array of organisms, from arthropods and tiny fish as hatchlings, to reptiles, waterfowl and hutia. Only adult animals are capable of subduing large prey such as dogs (*Canis familiaris*) and whitetail deer (*Odocoileus virginianus*), and only the largest specimens take pigs (*Sus scrofa*), and on very rare occasions humans (Gundlach 1880; R. Ramos, pers. comm. 1997).

Figure 3. Male *Crocodylus rhombifer*. Photograph: aboutanimals.com.

If *C. rhombifer* essentially developed as a mammal specialist, exploiting abundant ground sloths during the Late Tertiary and Pleistocene, it should be noted a similar circumstance occurred in South America during the Tertiary with terrestrial sebecosuchian crocodilians (Langston 1965) and marsupials, until North and South America joined, which allowed placental mammals to sweep into South America. Following the relatively recent extinction of ground sloths, *C. rhombifer* may have been forced to revert to the much smaller hutia, which might explain why modern *C. rhombifer* are so much smaller than Pleistocene individuals, but that is conjecture. Although crocodilians are frequently regarded as generalists, selective forces on the island of Cuba, with its ample terrestrial food resource and lack of placental carnivores, provided optimal conditions for the speciation of a very different kind of *Crocodylus*: a heavily armored, widely divergent crocodile, preying on terrestrial ground sloths, filling an ecological niche marked by the absence of placental carnivores.

Mean size at sexual maturity for 100 captive-bred female *C. rhombifer* was approximately 1.90 ± 0.20 m TL. Most of these captive animals first reproduced at 6 (62%) or 7 (35%) years of age. Captive males are thought to reach sexual maturity at 6 years of age and about 1.97 ± 0.08 m TL (Ramos-Targarona 2000, 2013). These sizes at sexual maturity suggest a larger crocodile than what is now observed in the wild. Wild growth rates in the Zapata Swamp appear incremental, compared to captive animals (R. Ramos, pers. comm. 2000). Courtship and mating occurs from November to May, when water levels are low. Nest building coincides with the onset of the rainy season, which begins in mid-April and peaks in late May and early June. The Cuban crocodile is a mound-nesting species, but it may, in unsuitable captive environments which lack ample vegetation or loose soil, resort to hole nesting, but that is not the normal means of reproduction for this species (W. McMahan, pers. obs.; Ramos-Targarona 2013).

Figure 4. Female *C. rhombifer* on her nest at Louisville Zoo, USA. Photograph: William McMahan.

Nests may be more than 2.7 m in diameter and 1 m high. Average clutch size is 25.4 eggs in captivity and 14.5 eggs in the wild (Ramos-Targarona 2000, 2013). Hatching occurs in August and early September.

## Threats

The Cuban crocodile is a Pleistocene relict. Ironically, this tropical reptile was at its zenith during a period when mile-high ice sheets, woolly mammoths, saber-toothed cats and Neanderthals dominated the Northern Hemisphere. The abundance of fossil *C. rhombifer* material across central Cuba, the Bahamas and the Cayman Islands indicates a much more robust Pleistocene past; not just in terms of distribution, but also in size and abundance (Barbour and Ramsden 1919; Varona 1966; Neill 1971; Morgan *et al*. 1993; Franz *et al*. 1995; J.P. Ross 1998; Steadman *et al*. 2015). Today, *C. rhombifer* is restricted to just two small freshwater marshes: Zapata Swamp (300 km$^2$) in southwestern Cuba; and, Lanier Swamp (100 km$^2$) on Isla de la Juventud (formerly Isle of Pines) (Barbour and Ramsden 1919; Varona 1966; Ramos *et al*. 1994). Modern environmental conditions for *C. rhombifer*

- both natural and man-made - continue to deteriorate, and may no longer be suitable for the species' *in-situ* survival. These deleterious factors include:

1. Dwindling relictual range: The Cuban crocodile has the smallest, natural geographic distribution of the living crocodilians (<400 km$^2$). Pleistocene fossils indicate a much wider distribution across Cuba during that epoch (Leidy 1868; Brown 1913; Matthew 1918; Varona 1966; Neill 1971; McMahan 1993; O. Jimenez, pers. comm. 2000). Moreover, both the Bahamas and Cayman Islands have also yielded *C. rhombifer* material, underscoring a more extensive historical distribution (Morgan *et al.* 1993; Franz *et al.* 1995).

   During Quaternary periods of continental glaciation, sea levels were 80-100 meters lower than today. Consequently, much greater Caribbean island landmasses were exposed above sea level (Steadman *et al.* 2015). Ice Ages, averaging 70,000 to 90,000 years, characterized the Pleistocene, and produced much more extensive Caribbean freshwater marsh. Conversely, during shorter interglacial warming periods of 10,000-25,000 years, that freshwater marsh was submerged as sea levels rose again. These cycles alternated, and the Cuban crocodile's range contracted and expanded with successive continental ice sheets throughout the Pleistocene.

   Great Abaco, in the Bahamas, is underlain by limestone karst, like Zapata and Lanier Swamps in Cuba, and is home to blue holes or freshwater vents. Currently some 1200 km$^2$ in size, during the Late Pleistocene when sea levels were 80 m lower, Great Abaco was estimated to be 17,000 km$^2$ - 14 times greater than its present size (Steadman *et al.* 2015). More than 5000 Pleistocene fossils from 95 vertebrate species, including *C. rhombifer*, have been recovered from a blue hole on Great Abaco at depths 27-35 m below current sea level. Climate models, along with known fossil communities, indicate Pleistocene climates in the West Indies were somewhat cooler and more arid than today (Lin *et al.* 1997; Lea *et al.* 2003; Steadman *et al.* 2015).

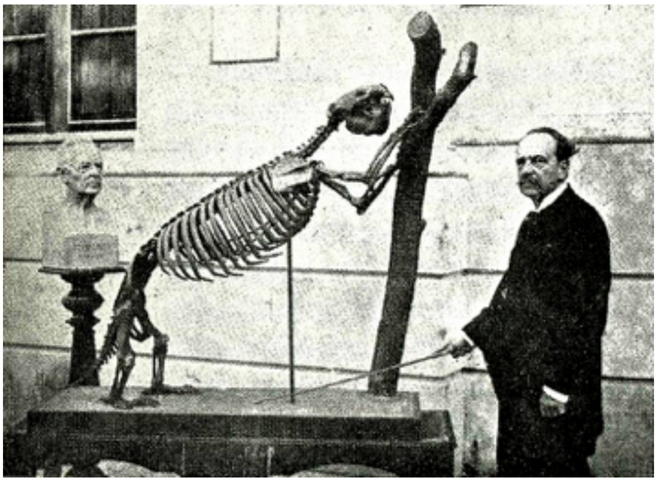

Figure 5. Carlos de la Torre with a Pleistocene Cuban ground sloth (*Megalocnus rodens*) (La Sociedad de Historia Natural "Felipe Poey").

   Of those 95 Pleistocene species found on Great Abaco, including *C. rhombifer*, 39 (41%) are now extinct there. Pine savannas were more common on Abaco during the Pleistocene, and freshwater marsh, the Cuban crocodile's preferred habitat, was far more extensive. In Cuba, that Pleistocene biotic community included a large ground sloth (*Megalocnus rodens*), frequently found in association with *C. rhombifer* at paleontological digs (Leidy 1868; Brown 1913; Matthew 1918; Varona 1966; Neill 1971; McMahan 1993).

   Pleistocene *C. rhombifer* fossils indicate individuals 5-6 m long, and some "may have been well >20 ft in total length" (F. Ross 1998), considerably larger than contemporary specimens. The Cuban crocodile was alleged in some 19th century literature to reach 4.9 m in length, but no modern worker has ever seen a specimen even approaching that size, and this may reflect some confusion with the American crocodile (*Crocodylus acutus*), because Humboldt (ca. 1804) called *C. rhombifer* "Caiman", the name typically used for *C. acutus* in Cuba (Gundlach 1880; Barbour and Ramsden 1919). That error was repeated by Pichardo and Tapia (1836), and again by Cocteau and Bibron in de la Sagra (1843).

   However, by the early 20th century, *C. rhombifer* was deemed a smaller species (Boulenger 1889; Ditmars 1910; Reese 1915). A 1993 expedition to assess the status of the species captured 179 *C. rhombifer* from three localities in Zapata, within the core of the species' remaining natural habitat. The largest proportion (>70%) of *C. rhombifer* were 1.2-1.79 m TL, and the largest wild *C. rhombifer* in that study measured 2.46 m (Ramos *et al.* 1994). Moreover, the two largest wild *C. rhombifer* measured in Zapata Swamp over the past 40 years were around 2.5 m TL (R. Ramos, pers. comm. 1996, 2000, 2017). However, males in captivity can exceed 3 m - with the largest captive specimens being 3.38 m and 2.80 m for males and females, respectively (R. Ramos, pers. comm. 2000, 2017). This suggests, along with other ecological data, that modern environmental conditions were suboptimal for *C. rhombifer* even before the species was severely impacted by anthropogenic forces.

2. Habitat alteration: The Cuban crocodile is now limited to two, small refugia in Cuba. Zapata Swamp, the larger of the two, hosts an extensive series of man-made canals, constructed from the marine coast, which penetrate into the swamp's freshwater interior. Unlike past episodes of Pleistocene range contraction, this anthropogenic series of features, thought to have been constructed around the time of the Spanish-American War in 1898 (R. Ramos, pers. comm. 1996), eliminated a natural ecological barrier which had served to separate *C. rhombifer* and *C. acutus* for some 2+ million years. These man-made canals allowed for the immigration of the widespread American crocodile into and throughout the Cuban crocodile's entire Zapata Swamp habitat. Both *Crocodylus* species are now completely sympatric there (Ramos *et al.* 1994) - a situation that is totally at odds with historic, allopatric descriptions (Humboldt 1827; Gundlach 1880; Barbour

and Ramsden 1919; Varona 1966; Neill 1971). It is also noteworthy, that no *C. acutus* material has been found at any of the *C. rhombifer* fossil sites in Cuba, the Cayman Islands or Abaco Island in the Bahamas (F. Ross 1998).

Figure 6. Distribution of *C. rhombifer* during Pleistocene (red; left) and Holocene (recent) (black dots; right).

3. Competitive exclusion and hybridization: The American crocodile is an ecologically adaptable species found in marine, brackish and freshwater environments in 18 New World countries. By contrast, the Cuban crocodile is limited to one-third of one percent (<400 km$^2$) of a single New World country (110,860 km$^2$).

   Ramos *et al*. (1994) stated that *C. rhombifer* and *C. acutus* could be literally captured, side by side in Zapata Swamp. At the three principal study sites (Rinconada del Canal Diez, Emetario and Jamon) surveyed at that time (1993), 2.5% of sampled crocodiles were deemed phenotypic hybrids. However, in 1996, hybrids comprised 8% of captured animals in those areas; and by 2012 and 2013, 37.5% and 27.7% respectively, were identified as phenotypic hybrids (R. Ramos, pers. comm. 2017).

   In 2014, molecular analysis conducted by the University of Havana and University of British Columbia, indicated 49.1% of wild *C. rhombifer* in Zapata Swamp were hybrids (Milian-Garcia *et al*. 2014; G. Amato, pers. comm. 2017). These differences may reflect the complex hydrology of that peninsular system, which allows varying degrees of introgression based on locality. A phenotypic hybrid was also documented at Brazo Sereno in Lanier Swamp (McMahan 1997). The relict distribution of *C. rhombifer* is so small now, that its entire range is essentially part of this hybrid zone.

   Hybrids, known locally as mixturados or cruzados, were first reported by Cuban crocodile hunters more than half a century ago (Varona 1966; Neill 1971). These hybrids are fertile, and perhaps better adapted to current environmental conditions than *C. rhombifer*, because hybrid numbers continue to increase (R. Ramos, pers. comm. 2017). By 2005, in some parts of Zapata, virtually 100% of examined animals were phenotypic hybrids (R. Soberon, pers. comm. 2005). Introgression with *C. acutus* is genetically swamping *C. rhombifer* in the wild. Whether *C. rhombifer* can maintain its genetic integrity *in-situ* remains to be seen, but the current rate of hybridization suggests it may soon cease to exist as a distinct species in the wild. This has proven to be an especially insidious factor in the Cuban crocodile's *in-situ* survival and its Critically Endangered status.

Figure 7. *Crocodylus rhombifer* (bottom) and hybrid/mixturado (*C. rhombifer* x *C. acutus*)(top) captured in Lanier Swamp in April 1997. Photograph: William McMahan.

4. Introduced species: In 1959, 9 babillas or brown caiman (*Caiman crocodilus fuscus*) were introduced to Isla de la Juventud from the El Dique Fluvial Repopulation Center (Varona 1976; Thorbjarnarson 1992). By the late 1990s, Cuban biologists estimated the population of babillas in Lanier Swamp in excess of 40,000 animals (D. Lopez, pers. comm. 1999). The degree of competitive exclusion imposed by this exotic alligatorid in Lanier Swamp is unknown, but resource competition with a decidedly freshwater form may have adversely affected *C. rhombifer* and its reintroduction prospects in this freshwater ecosystem.

5. Illegal hunting: Hunting crocodiles in Cuba for a burgeoning exotic leather industry began in earnest shortly after the construction of Zapata's man-made canals. Cosculluela (1918) noted that during a single 10-year period, more than 90,000 crocodiles were harvested from Zapata Swamp. It has been illegal to hunt *C. rhombifer* in Cuba since 1967. However, excessive hunting and poaching have been a chronic problem for this species for more than a century, and caused the extinction of the Cuban crocodile from Lanier Swamp in the early 20th century. This appears to have been repeated in the early 21st century, following a purposeful, large-scale reintroduction of *C. rhombifer* in Lanier Swamp in the 1990s. Workers at Cayo Potrero's farm have not found any wild *C. rhombifer* in that swamp since 2010 (R. Ramos, pers. comm. 2017). That reintroduction effort was accompanied by conservation education programs, literature in local schools, and a community *C. rhombifer* festival (Gianelloni 2002; Mohan *et al*. 2004).

   A public relations effort was made for *C. rhombifer* in Zapata, but illegal hunting continues virtually unabated there also. Packed boatloads of poached crocodiles could be seen on a video leaving Zapata Swamp on YouTube in 2017 (C. Harbsmeier, pers. comm. 2017). The Cuban crocodile is more highly esteemed for food than either the American crocodile or babilla, perhaps a result of the dietary preferences for each species and less wary nature of *C. rhombifer*.

It seems possible that the combined effect of habitat alteration in Zapata, coupled with excessive hunting during the early 20th century, may have exacerbated hybridization problems for *C. rhombifer* by selectively removing prime adult *C. rhombifer*. Constantly depleting the pool of animals that use the most selective behavioral, reproductive isolating mechanisms, may have created an environment which fostered less active reproductive discrimination, resulting in increased hybridization.

The Cuban crocodile has occasionally been spotted in more saline environments (Barbour and Ramsden 1919; Ramos-Targarona 2013), and excessive hunting may be a factor, but that is conjecture. A phenotypic hybrid has also been reported from an offshore cay (R. Ramos, pers. comm. 2017).

6. Rising sea level: Although freshwater marshes were far more prevalent throughout the western Caribbean during the Pleistocene, they are a rare habitat there today. Current Holocene climate models indicate rising temperatures across portions of the globe, and as the planet warms, sea levels rise, encroaching on coastal marshland and freshwater ecosystems (M. Eaton, pers. comm. 2017). Rising sea levels, in Cuba's Zapata Peninsula and Lanier Swamp, create especially unfavorable environmental conditions for *C. rhombifer*, as its scarce freshwater marsh subsides beneath salt marsh and red mangroves (*Rhizophora mangle*) as sea water intrusion expands. A warming climate model actually provides optimal conditions for *C. acutus* in Cuba, assisting in its competitive advantage. Using habitat maps for potential *C. rhombifer* distribution indicates there would be considerable loss of area projected for it in 2020 and 2080 (Ramos *et al*. 2008). The synergistic effect of these modern ecological problems suggests *C. rhombifer* may be particularly susceptible to extinction.

## Conservation and Status

The size of the wild Cuban crocodile population is not known. A conservative estimate of 3000 *C. rhombifer*, and likely around 5000-6000 animals, was derived by Ramos *et al*. (1994). Current estimates vary from 2000 to as many as 4000 animals (Wilkinson 2014). However, at this juncture (2018), it is possible there are more *C. rhombifer* in captivity than remain in the wild.

During the 1993 population census for *C. rhombifer*, Ramos *et al*. (1994) used morphology to identify crocodiles sighted - the same method used by Cuvier to formally describe *C. rhombifer* (and *C. acutus*) in 1807. Morphological characters for *C. rhombifer* include:

- a taller, wider, more robust skull than typical for modern *Crocodylus*
- the 5th maxillary tooth is the largest
- adults have highly elevated squamosals and dark eyes
- 6 thickset, perfect dorsal scale rows which run the length of the dorsum, between the limbs
- rounded, light colored, pearl-like scales surround the dorsum, sides and neck
- the limbs are quite muscular, with enlarged, keeled scales
- the fingers devoid of webbing
- a spotted or speckled pattern on flanks and back (rather than banded), especially in animals less than 2 m TL

Animals with strong *C. rhombifer* phenotypes are obviously expressing strong *C. rhombifer* genes. However, because of the rampant hybridization that plagues this species, most contemporary workers, especially those in Europe and America, no longer trust the use of morphological characters to identify *C. rhombifer*, insisting that each zoo specimen must be subject to genotypic analysis.

Molecular techniques are powerful tools, and offer great promise in the understanding of genetics in Caribbean *Crocodylus*. The University of Havana, University of British Columbia and the American Museum of Natural History are conducting molecular analysis on current *C. rhombifer*, *C. acutus* and hybrids. Fordham University is examining DNA from older, museum *C. rhombifer* specimens, some collected before the canals in Zapata were dug (G. Amato, pers. comm. 2018). This should provide a wealth of information regarding the *C. rhombifer* genome, and assist in the conservation and preservation of this enigmatic species. However, in using a molecular paradigm, it is not possible to verify the molecular identity of a crocodile using eyeshine, visual assessment or capture - standard modes for crocodilian survey work. After DNA is collected, it must be analyzed in a laboratory, which can take some time. That temporal span makes it difficult to conduct a conventional population census, which relies on visual assessment in counting crocodiles. We often regard vertebrate populations with long generation times as static, but on a cautionary note, in the decade following the 1993 survey, great numbers of those study animals, some monitored for 25 years, were decimated by poachers (R. Soberon, pers. comm. 2005).

In 1959, the Cuban Government constructed a facility at Guama, adjacent to Zapata Swamp at Laguna del Tesoro in Matanzas Province, to propagate crocodiles. It was primarily stocked with *C. acutus* and *C. rhombifer* from Zapata Swamp. This appears to be the earliest Latin American criadero to reproduce animals, and was so successful, that by 1965, was harvesting crocodiles. However, *C. acutus* and *C. rhombifer* were housed together, and hybridization became a serious problem during the initial operation of the farm (Thorbjarnarson 1992). In the early 1970s, with new management at the facility, a major emphasis was placed on *C. rhombifer* conservation. This resulted in the segregation of animals by phenotype in 1974, and a purge of thousands of hybrid crocodiles ensued during the late 1970s. During that time, Roberto Ramos and a team from the criadero began the first ecological studies on wild *C. rhombifer* in Zapata Swamp, and these efforts continued over the next 40 years, incorporating the Zapata Swamp National Park and Zapata Swamp Biosphere Reserve, and provided a great deal of biological information on the species.

The Empresa Nacional para la Proteccion de la Flora y la Fauna, began an ambitious project (spearheaded by Roberto Soberon) to reintroduce *C. rhombifer* into Lanier Swamp, following its extirpation there in the early 20th century. Crocodiles were carefully chosen by phenotype from the Zapata facility, held at the Havana Zoo, and ferried to Nueva Gerona on Isla de la Juventud in 1987 (R. Soberon, pers. comm. 1996; R. Soberon *et al*. 1996). A criadero at Cayo Potrero, adjacent to Lanier Swamp, was used for propagation purposes. More than 600 Cuban crocodiles of various ages, sexes and size classes were released into the swamp, beginning with 200 animals in 1994, and another 200 in 1995 (R. Soberon, pers. comm. 1996). Reproduction by reintroduced animals was later reported in the Lanier Swamp (McMahan 1999).

In January 2000 a Population, Habitat and Viability Analysis (PHVA) was conducted by the IUCN/SSC Conservation Breeding Specialist Group (Rodriguez-Soberon *et al*. 2000), which indicated the reintroduced population in Lanier Swamp was deemed at significant risk of extinction due to poaching. In order to reduce this risk, the PHVA concluded that no more than 15-20 *C. rhombifer* per year could be poached in Lanier Swamp, if the reintroduced population was to survive. Unfortunately, that number appears to have been greatly exceeded, and the persistence of the Lanier population is now in doubt.

Cuba's farm at Laguna del Tesoro holds the largest captive population of *C. rhombifer* in the world, numbering some 226 adults (35M:191F) and approximately 4500+ young animals (Perez-Fleitas *et al*. 2017). Based on preliminary work, 83.9% of sampled captive *C. rhombifer* there were not deemed to be hybrids (Milian-Garcia *et al*. 2014). Interestingly, some 30% of those animals had a unique subset of genes which they do not share with the rest of the farm population (Wilkinson 2014). These animals, in particular, may constitute the best of existing farm stock for preservation, as the *C. rhombifer* genome is not completely known at this time, and those rare genes may be important in the preservation of this species. In June 2017, the Lanier farm held 15 adult *C. rhombifer*, and 191 young animals (R. Ramos, pers. comm. 2017).

The Cuban crocodile has been maintained in a Species Survival Plan (SSP) by the Association of Zoos & Aquariums (AZA) in the USA since 1993. It is easy to propagate and manage in captivity, and displays well in zoos (McMahan 2008). As in Cuba, the SSP specimens were initially assessed and identified by morphological characters and phenotype. There are currently 74 (14M:36F:24Unk.) animals in the 2017 Cuban Crocodile SSP Master Plan (McMahan *et al*. 2017). The American Museum of Natural History has agreed to assess the genetics of this captive population (G. Amato, pers. comm. 2017) to ensure its genetic integrity. Outside of the New World, the European Association of Zoos and Aquaria (EAZA) maintains a studbook at Paignton Zoo (England) for 25 (2M:19F:4Unk.) *C. rhombifer* (M. Dainty, pers. comm. 2017). There are also 3 females and one male held at the Madras Croc Bank in India, as well as a pair in Saigon Zoo, Viet Nam.

In conclusion, *C. rhombifer* is now subject to a perfect storm of environmental and anthropogenic effects. Despite efforts to mitigate these factors, none of the problems facing the species have been resolved. In fact, several of these threats, such as a dwindling relictual range, hybridization and rising sea level are not reversible. Consequently, the Cuban crocodile is listed as Critically Endangered by the IUCN (Targarona *et al*. 2017), which underscores that *C. rhombifer* is now facing a high risk of extinction in the wild.

## Priority Projects

### High priority

1. **Establish pure captive *C. rhombifer* populations.** Due to rampant hybridization, serious consideration should be given to removing some pure *C. rhombifer* from the wild, genetically testing them for purity, and retaining suitable animals for captive breeding. It is not at all clear whether *C. rhombifer* will survive in the wild, and a compelling case can be made that it will not. Progeny would be available for possible reintroduction into suitable areas in Cuba (eg where *C. acutus* and hybrids do not occur), and perhaps other historical sites (eg Bahamas). Additional molecular work should be conducted on captive populations to insure the genetic integrity of program animals. Another Population and Habitat Viability Assessment should be considered, as current conditions for *C. rhombifer* have deteriorated since the last PHVA in 2000.

2. **Cessation of illegal hunting**. More stringent law enforcement is needed to eliminate poaching of the Cuban crocodile. Hunting caused the extinction of *C. rhombifer* in Lanier Swamp in the 20th century. Current evidence suggests that it has occurred again in the early 21st century, despite a large-scale reintroduction effort, accompanied by community educational programs. Moreover, scores of *C. rhombifer* study specimens from the most remote locations in the center of Zapata Swamp were decimated by poachers. This has been a chronic, intractable problem for *C. rhombifer* because much of the illegal hunting is for food.

3. **Reintroduction in Zapata**. The Cuban Government has initiated another reintroduction effort, this time in a section of Zapata Swamp where they believe no crocodiles currently live, and where reintroduced animals cannot be contaminated by exposure to *C. acutus* or existing hybrids.

### Moderate priority

4. **Monitoring of wild populations**. Recent evidence suggests that reintroduced *C. rhombifer* have been extirpated from Lanier Swamp, and more detailed monitoring is required to confirm the status of that population. Although standard surveying techniques for the crocodile population in Zapata Swamp provide information on the population as a whole, it does not allow the status of *C. rhombifer*, *C. acutus* and hybrids to be determined with certainty, as they are unable to be identified on the basis of external

characteristics alone.

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