
CONSERVATION AND MANAGEMENT OF *CYCLURA* IGUANAS IN PUERTO RICO

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Abstract.—Three species of iguanas in the genus *Cyclura* are or were once found in the Puerto Rican Archipelago including the native Mona Island Iguana (*C. stejnegeri*), the extirpated Anegada or Stout Iguana (*C. pinguis*), and the introduced Cuban Iguana (*C. nubila nubila*). These species are included in conservation and management plans within the Commonwealth of Puerto Rico aimed at recovery, reintroduction, and removal, respectively. To date, recovery efforts for Mona Island Iguanas include a fence to protect coastal nesting sites from feral pigs, a headstart program to improve population age structure and bolster recruitment, and feral cat control to improve juvenile survival. As a result of these actions, the population structure of *C. stejnegeri* has improved and all age classes are represented. However, full recovery of *C. stejnegeri* will require removal of feral mammals from Mona Island. As a first step toward reintroducing *C. pinguis* to Puerto Rico, numerous offshore islands were evaluated to determine their potential as reintroduction sites. Several suitable islands have been identified but most will require some restoration prior to reintroduction of *C. pinguis*. Exotic Cuban Iguanas on Magueyes Island have been identified as a species that should be removed. As such, they provide a unique opportunity to serve as surrogates for testing potentially risky conservation initiatives needed for some endangered *Cyclura* populations, such as the use of rodenticides on islands with native iguanas. The implementation of these conservation and management actions for all three *Cyclura* species will rely on funding, and for *C. pinguis* on the ability to acquire individuals for reintroduction.

Resumen.—Tres especies de *Cyclura* se encuentran o se han encontrado en el Archipiélago de Puerto Rico: la iguana nativa de Isla de Mona (*C. stejnegeri*), la extirpada iguana de Anegada o Robusta (*C. pinguis*), y la iguana introducida Cubana (*C. nubila nubila*). Estas especies forman parte de planes de conservación y manejo por parte del Estado Libre Asociado de Puerto Rico dirigidos a su recuperación, reintroducción, y remoción, respectivamente. Al presente, los esfuerzos de recuperación para la iguana de Mona incluyen una verja para proteger los sitios de reproducción costeros contra los cerdos asilvestrados, un programa de crianza asistida para mejorar las estructura de edades en la población y aumentar el reclutamiento, y un programa de control de gatos asilvestrados para mejorar la supervivencia de los juveniles. Como resultado de estas acciones la estructura poblacional de *C. stejnegeri* ha mejorado y hay representación de todos los estadios. Sin embargo, la recuperación completa of *C. stejnegeri* requerirá de la remoción de los mamíferos asilvestrados de la Isla de Mona. Como un primer paso hacia la reintroducción de *C. pinguis* a Puerto Rico evaluamos numerosas islas separadas de la costa para determinar su potencial como sitio de reintroducción. Varias islas han sido identificadas como adecuadas, pero la mayoría requerirán de alguna restauración antes de reintroducir *C. pinguis*. Las iguanas cubanas exóticas de Magueyes han sido identificadas como una especie que debe ser removida del lugar. Por lo tanto, ellas proveen una oportunidad única para servir como especies de reemplazo para experimentar iniciativas de conservación potencialmente riesgosas pero necesarias para otras *Cyclura* consideradas en peligro, como la aplicación de rodenticidas en islas con iguana nativas. La implementación de estas acciones de conservación y manejo recaerá en la identificación del financiamiento requerido y, en el caso de *C. pinguis*, en la disponibilidad de individuos fundadores.

Key Words.—headstart; invasive mammals; Mona; *nubila*; *pinguis*; reintroduction; *stejnegeri*

OVERVIEW

Iguanas in the genus *Cyclura* are among the largest terrestrial vertebrates and dominant herbivores native to the West Indies (Wiewandt 1977; Iverson 1979). They disperse seeds (Iverson 1985) and promote seedling germination (Hartley et al. 2000). Most species or subspecies are restricted to a single island or bank and face similar threats – competition and predation from

alien invasive mammals, and habitat modification (Alberts 2000). Centrally located in the West Indies is Puerto Rico, an island nation classified as a Commonwealth under the political jurisdiction of the United States of America.

As an array of several islands and cays, Puerto Rico harbors a high percentage of endemic species, particularly reptiles and amphibians (Rivero 1978; García et al. 2005; Joglar et al. 2007). U.S. state (New

Wildlife Act of Puerto Rico #241, Department of Natural and Environment Resources 1999) and federal laws (Endangered Species Act 1973, Title 16 United States Code, Sections 1531–1544) and regulations protect all of these species. *Cyclura* iguanas are a peculiar case because Puerto Rico harbors one endemic species, the Mona Island Iguana (*C. stejnegeri*) and one exotic species, the Cuban Iguana (*C. nubila nubila*). Moreover, another species, the Anegada or (hereafter) Stout Iguana (*C. pinguis*), was apparently once native to Puerto Rico (Pregill 1981). Today, the only extant populations of this species are in the British Virgin Islands (BVI; Perry and Gerber 2011), which are part of the Puerto Rican Bank and were contiguous with Puerto Rico during the last glacial maximum when sea levels were much lower (Pregill 1981). However, late Pleistocene fossils of *C. pinguis* from limestone cave deposits in northern Puerto Rico (Miller 1918; Pregill 1981), and remains from Native American middens on the island of St. Thomas in the U.S. Virgin Islands (Barbour 1919; Pregill 1981) suggest a much wider historical distribution. Exactly when or why the species became restricted to Anegada is unknown and is subject to considerable debate (Perry and Gerber 2011). We use Stout Iguana instead of Anegada Iguana since this latter common name does not represent adequately the biogeographical distribution of the species and limits its funding attractiveness from the Puerto Rican side. The species of *Cyclura* currently or previously found within the Puerto Rican Archipelago have been part of different conservation and management initiatives in Puerto Rico. Here, we describe efforts aimed at recovery of the Mona Island Iguana, reintroduction of the Stout Iguana, and removal of the Cuban Iguana.

MONA ISLAND IGUANA (*CYCLURA STEJNEGERI*)

Mona Island (5,301 ha) is a nature reserve, administered by the Puerto Rico Department of Natural and Environmental Resources (DNER). It is located approximately midway between the islands of Puerto Rico and Hispaniola but it is not part of the Puerto Rican or Hispaniolan Bank. The reserve is managed for mixed use (e.g., nature tourism, fishing, hiking, bird watching, and hunting) and there is a biological station for wardens and visiting scientists. While it lacks a permanent human settlement, it has experienced severe habitat modification in the past for guano mining, forestry, and agricultural purposes (Wiewandt 1977; García 2004). Rats, cats, pigs, and goats are established on the island, and coupled with habitat alteration, present major threats to the survival of Mona Island Iguanas. Hunting is allowed and encouraged, however, as a control measure for pigs and goats.

Cyclura stejnegeri is closely related to the Hispaniolan Rhinoceros Iguana (*C. cornuta*) and was previously

considered a subspecies of *C. cornuta* (Powell and Henderson 1999). Mona Island Iguanas are classified as Endangered by the Regulation to Govern the Endangered and Threatened Species in the Commonwealth of Puerto Rico (Department of Natural and Environmental Resources 2004), the IUCN Red List of Threatened Species (García et al. 2000), and considered Threatened by the U.S. Fish and Wildlife Service (USFWS). These classifications have permitted the allocation of state and federal funds for the recovery of this species since 1998. The first significant field research on the Mona Island Iguana occurred from 1972–1975 when Thomas Wiewandt studied this species for his doctoral dissertation (Wiewandt 1977). Among several findings, Wiewandt (1977) concluded that Mona Island Iguana numbers (2,000 individuals) and densities (0.33 iguanas/ha) were “abnormally low” for a *Cyclura* species. This laid the foundation for a recovery program that started approximately ten years later with several conservation initiatives undertaken or led by DNER.

The first conservation action aimed to increase the survival of Mona Island Iguanas was the installation of a fence on the coastal plain to protect nesting areas from egg predation by feral pigs in 1984. This structure lasted (although in poor condition) until 2005 when it was replaced by a fence of much higher quality and with a mesh size that excluded pigs yet allowed iguanas to pass through and nest in historic areas.

Despite the exclusion of pigs from coastal nesting grounds, investigators noted that Mona Island Iguanas exhibited a population structure composed mostly of adult and aging individuals (Wiewandt and García 2000). This was considered to be the result of years of predation on hatchlings by feral cats, and was later confirmed when research documented a 13% survival rate for hatchling iguanas during their first five months (Pérez-Buitrago 2000). To address predation of hatchlings by cats and bolster recruitment rates of the Mona Island Iguana population, a headstart (HST) program was established in 2000 by DNER. Hatchling iguanas emerging from nests were collected each year and transferred to a captive facility on-island for rearing to a less vulnerable size.

The Mona Island HST program has been very successful (García et al. 2007). Over the last 14 years, 316 headstarted individuals have been released back into the wild. Iguanas of 22.5 cm snout-vent length, a size deemed large enough to survive in the wild with cats, were produced within two years. Documented survival of released HST iguanas was at least 40.3% (García et al. 2007), but this is a conservative calculation as it is based on recapture rates. The density of mid-sized iguanas increased by 71% within the study site and HST iguanas 4–5 years of age were observed breeding (Pérez-Buitrago et al. 2008). Thus, the short-term goals of improving the population structure and bolstering

recruitment of Mona Island Iguanas were achieved with the HST program.

Despite the success of the HST program, it only serves as a stopgap measure. Since the primary threats to Mona Island Iguanas are invasive mammalian species, the focus is now on the eradication of feral pigs, cats, and rats. To accomplish this conservation objective, a collaborative relationship has been established with Island Conservation (IC), a non-governmental organization (NGO) devoted to island restoration through the removal of alien invasive species. The first step toward this goal was the completion of a feasibility study to eradicate feral pigs, cats, and rats from Mona Island. Cats have been eradicated from six islands larger than Mona and pigs from 11 larger islands. However, rats have not yet been eradicated from any tropical island as large as Mona (Island Conservation, University of California Santa Cruz Coastal Conservation Action Laboratory, IUCN SSC Invasive Species Specialist Group, University of Auckland, and Landcare Research New Zealand. 2014. Database of Island Invasive Species Eradications. Available from <http://diise.islandconservation.org> [Accessed 19 September 2014]). In addition to ecological and logistical challenges, a major hurdle will be securing the estimated 8.2 million US dollars required for eradicating pigs, cats, and rats (Island Conservation 2013). Feral goats are not part of the proposed eradications because they pose less of a threat to Mona Island Iguanas and are actively hunted, restricting the goat population so that minimal impact is noted on island vegetation (Joglar et al. 2007).

STOUT IGUANA (*CYCLURA PINGUIS*)

The only natural, extant population of *C. pinguis* is on Anegada Island (3,900 ha; Schomburgk 1832; Barbour 1917), located on the northeastern edge of the Puerto Rican Bank in the British Virgin Islands. Habitat degradation and alien invasive mammals have threatened the Anegada population of *C. pinguis* for centuries, (Carey 1975; Mitchell 1999; Island Resource Foundation

2013). To bolster low recruitment due to heavy predation of juveniles by feral cats, a HST program was established in 1997 (Gerber 2004). This program has been very successful (Bradley and Gerber 2006; Perry and Gerber 2011) and the wild adult population has doubled in size as a result. However, similar to *C. stejnegeri*, headstarting is a stopgap measure and not considered a permanent solution. Habitat protection and feral mammal removal are needed to safeguard the long-term survival of the Anegada population (Island Conservation 2006; Gerber and Pagni 2012). As a hedge against extinction on Anegada, *C. pinguis* has been introduced successfully to several private islands in the BVI. Unfortunately, all of the introduced populations stem from just eight founders moved from Anegada to Guana Island in the mid-1980s (Goodyear and Lazell 1994), raising concerns regarding inbreeding and genetic diversity (Perry and Gerber 2011).

A comprehensive management strategy for *C. pinguis* is needed and should include habitat protection and invasive mammal eradications on Anegada, genetic management of introduced populations in the BVI, and establishment of the species on the most suitable, protected islands elsewhere in the Puerto Rican Bank. The island of Puerto Rico is not appropriate for *C. pinguis* due to urban development, alien invasive species, and potential poaching. However, there are several small islands and cays near Puerto Rico where *C. pinguis* could be established to help secure the species' long-term survival.

We assessed seven islands and cays with the goal of determining their suitability to support *C. pinguis* populations (Table 1). The evaluated sites were: Caja de Muertos, Cayo Icos, Cayo Ratones, Cayo Diablo, Cayo Lobos, Culebrita, and Luis Peña. The first four belong to the national system of natural reserves administered by the Puerto Rico DNER, but Cayo Lobos is privately owned. Culebrita and Luis Peña are wildlife refuges under the administration of the Municipality of Culebra Island and the USFWS.

Caja de Muertos and Cayo Icos stand out as the best choices for introducing *C. pinguis*. Caja de Muertos is a relatively large (202 ha) limestone island, located off the

TABLE 1. Puerto Rican islands surveyed for their suitability to support *Cyclura pinguis*. Size and vegetation parameters were assessed rapidly during island visits. Size was determined in relative terms (large: > 200 ha; medium: 50–200 ha; small: < 50 ha) and vegetation was related to the overall condition (excellent = typical tropical dry forest vegetation similar in condition to the undisturbed sites on Anegada Island; good = disturbed tropical dry forest vegetation).

Island	Size	Vegetation	Substrate	Cats	Rats	Other	Common Green Iguanas	Designation	Facilities
Caja de Muertos	Large	Excellent	Limestone	No	Yes	No	Yes	DNER	Yes
Icos	Medium	Excellent	Limestone	Yes	Yes	No	Yes	DNER	No
Ratones	Small	Good	Limestone	No	No	No	Yes	DNER	No
Lobos	Small	Good	Limestone	No?	Yes	No	Yes	Private	No
Diablo	Small	Good	Limestone	No	No	No	No	DNER	No
Luis Peña	Medium	Good	Volcanic	No?	Yes	Goat	Yes	USFWS	No
Culebrita	Medium	Good	Volcanic	No?	Yes	Deer	Yes	USFWS	No

south-central coast of Puerto Rico, with dense tropical dry forest. It has abundant food resources and is the only island surveyed with facilities (dock and field station) and the presence of a resident biologist and DNER rangers. The only serious drawback to this island is the presence of non-native rats and Common Green Iguanas (*Iguana iguana*; refuge manager, pers. comm.), which must be removed prior to introducing *C. pinguis*. Cayo Icacos is a somewhat smaller (66 ha) uninhabited, limestone island located off the northeast coast of Puerto Rico. The vegetation structure is open tropical dry forest that is nearly identical to that on Anegada. Like Caja de Muertos, Icacos is inhabited by rats, Common Green Iguanas, and feral cats. At the very least, the Green Iguanas and cats would have to be removed prior to introducing *C. pinguis*. Nonetheless, in our opinion, Cayo Icacos has the best habitat for *C. pinguis* of all the islands we surveyed. Moreover, it is part of the Cordillera Cays Nature Reserve that includes three other small, suitable islands (Cayo Ratones, Cayo Lobos, and Cayo Diablo), which could be managed along with Cayo Icacos as a metapopulation for *C. pinguis*.

Caja de Muertos and Cayo Icacos beaches are both visited regularly by day-trippers. These tourists stay mainly on the beachfront, thus they are not expected to impact iguana habitat. We are aware of detrimental effects caused by the inappropriate habit of feeding iguanas from other islands in the region (Knapp et al. 2013). DNER intends to manage this practice with a comprehensive educational campaign that showcases this wildlife restoration initiative (i.e., *C. pinguis* introduction) and explains appropriate behavior towards the animals and the need for eradicating invasive species as a prerequisite.

Biosecurity protocols for both reserves, as in any eradication project, will have to be developed and implemented (Tershy et al. this volume). The partnership between IC and DNER will maximize the probability for success, as IC will provide needed expertise and DNER will carry out the implementation and the enforcement of the prescribed actions. Integrating the two private islands (i.e., Cayo Lobos and Palominos) within the Cordillera Cays Natural Reserve in the eradication program is critical, particularly for rats and Common Green Iguanas. Therefore, a proactive approach and invitation to the owners must be included in a management plan. Notwithstanding the usual challenges of implementing biosecurity measures, Caja de Muertos represents a relatively easier situation since it is more isolated and harbors a permanent staff (i.e., manager and rangers). We propose giving priority status to removing exotic mammalian vertebrates from Caja de Muertos and the islands of the Cordillera Cays Nature Reserve so that *C. pinguis* can be introduced to the Puerto Rican Archipelago. This international initiative will require the full cooperation and involvement of the

US Commonwealth of Puerto Rico DNER, the USFWS, and the United Kingdom Dependent Territory of the BVI National Parks Trust and BVI Conservation and Fisheries Department.

CUBAN IGUANA (*CYCLURA NUBILA NUBILA*)

Cuban Iguana (*Cyclura nubila nubila*).—In the late 1960s a small but unknown number of Cuban Iguanas (*C. nubila nubila*) escaped from a zoo in Puerto Rico, and were then introduced and became established on Magueyes Island (7.2 ha) located off the southwest coast of Puerto Rico (Rivero 1978). The Cuban Iguana is listed as Threatened by the USFWS but the Puerto Rican population is excluded from this designation (Office of the Federal Register 1983). Unfortunately, this duality has the potential to create confusion for law enforcement, as it is easy to mistakenly assume that federal laws protect the introduced Puerto Rican population. In the 1980s this isolated population was estimated at 167 iguanas and was experiencing predation from feral and pet cats (Christian et al. 1986). In the early 2000s population densities increased to 55–70 iguanas/ha after the implementation of a rat and cat control program on the island (Allan Lewis, pers. comm.; Ricardo López-Ortiz, pers. comm.). In 2005, 422 iguanas were counted individually on the island, which is equivalent to a density of almost 60 animals/ha (López-Ortiz unpubl. data). This population density is abnormally high when compared to the 5.3 ± 1.4 iguanas/ha reported for the natural populations found in the Guantánamo Naval Base in Cuba (Alberts et al. 2001).

The high density of Cuban Iguanas on Magueyes Island forced interactions with the personnel and students associated with the University of Puerto Rico's Department of Marine Science (DMS), which is located on the island. Iguanas were sometimes fed and subsequently began harassing people in search of food. Despite staff and visitor complaints about iguana attacks, most of the residents and visitors believe iguanas represent a cultural emblem of Magueyes Island. As the problems associated with human-iguana interactions intensified, the DMS administration requested intervention by the DNER, whose jurisdiction includes iguanas and departmental policies to support controlling exotic and invasive species. Furthermore, should iguanas disperse from the island and establish on the mainland, it could have profound impacts on the environment and tourism. As a consequence, the DNER granted a permit to a private collector to export 100 Cuban Iguanas from Magueyes in 2008. These animals were shipped to and arrived safely in Miami, but their current status or ultimate destination is unknown.

Managing the introduced population on Magueyes is complicated because local laws and regulations support its eradication, but the population also presents unique

opportunities for scientific research. Studies of Cuban Iguanas have been limited relative to other species (but see González et al. and references therein this volume). Alien invasive mammals are a major threat to *Cyclura* iguanas throughout their range, and eradication of alien invasive mammals from Caribbean islands has been amply recommended for the protection of iguanas and other native wildlife (see Tershy et al. this volume). However, several efficient techniques used to capture or kill cats and rats could potentially harm iguanas. For example, iguanas can enter box traps, get caught in leg-hold traps, or eat bait impregnated with rodenticide. Therefore, thoughtful evaluations of these techniques and how to adapt them for use in habitats with native iguanas are compulsory and timely. For this, the Cuban Iguana population on Magueyes represents a unique opportunity to serve as a surrogate for testing mitigation strategies for eradicating alien invasive mammals on other islands with iguanas.

CONCLUSIONS AND RECOMMENDATIONS

Implementation of the recommended actions suggested here depends principally on obtaining the necessary financial support. Invasive species eradications are expensive but necessary for further recovery of *C. stejnegeri* on Mona Island and reintroduction of *C. pinguis* to the Puerto Rican Archipelago. Therefore, we must strengthen fundraising capabilities, which require new approaches involving local, national, and international collaborations between NGOs and governments. In the specific case of *C. pinguis*, an agreeable position from the government of the BVI to allow the movement of animals outside its national borders is needed.

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