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STATUS OF THE CULEBRA ISLAND GIANT ANOLE (*ANOLIS ROOSEVELTI*)

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***Abstract.*—The Culebra Island Giant Anole (*Anolis roosevelti*) is known from only a few specimens, the last collected almost 80 years ago. In 1977, it was listed as an Endangered species and its "Critical Habitat" designated on the main island of Culebra. In 1986, after a year of almost daily systematic fieldwork on Culebra and adjacent islands, I found no specimens. Likely biological attributes and historical data on the species, including information on additional specimens discovered in museums, are presented as well as information from interviews. I believe that unconfirmed sightings of *A. roosevelti* during the 1970s and 1980s were due to residents of Culebra confusing them with young *Iguana iguana*. In view of the intensive field work I did on Culebra to find *A. roosevelti* during the year of this study and the lack of any sightings or collections in the quarter century since, I recommend that *A. roosevelti* be designated "Extinct" on Culebra. Further investigation is warranted on Vieques, St. John, and Tortola before consideration is given to declaring the Culebra Island Giant Anole, *A. roosevelti*, totally extinct in the Caribbean.**

Key Words.—Anolis roosevelti; Culebra Island Giant Anole; endangered; extinct; field study

INTRODUCTION

Since its discovery in 1931 by Chapman Grant, the Culebra Island Giant Anole (*Anolis roosevelti*) has remained elusive. In fact, there has never been a confirmed sighting on Culebra since the collection of the type specimen and a second specimen reported a year later by Grant (Grant 1931a, 1931b, 1932). In 1977 the U.S. Fish and Wildlife Service (USFWS) declared *A. roosevelti* Endangered under provisions of the federal Endangered Species Act and identified its "Critical Habitat" on the main island of Culebra, Puerto Rico (USFWS 1977). Five years later a recovery plan was developed (Campbell and Dodd 1982). In the mid-1980s, there were numerous reports of sightings of this lizard by Culebra residents and visitors from the main island of Puerto Rico, but none could be verified despite several attempts by local herpetologists and students to do so in the field. As of 1986, there had not been a thorough or systematic search of the Culebra Archipelago for *A. roosevelti*.

Culebra is the largest island of an archipelago within the larger island chain of the Puerto Rico Bank that extends some 300 km from Puerto Rico in the northwest to Anegada in the southeast. Culebra is located at 18.33°N, 65.33°W or about 27 km east of the big island of Puerto Rico mid-way between it and St. Thomas, U.S. Virgin Islands. Culebra is approximately 11 km long by 5.5 km wide and consists of a main island and 23 smaller islands that lie off its coast. The Culebra National Wildlife Refuge (CNWR) consists of approximately 610 ha including all of the 22 smaller public islands and cays (~ 280 ha) of this 2800 ha archipelago. The largest of these are Culebrita to the east, and Cayo Luis Peña and Cayo Lobo to the west. (Cayo Norte, to the north, is privately-owned and not part of the CNWR.) This archipelago, like other small islands in the area, is arid (rainfall 63–76 cm annually) and contains no rivers or streams. Culebra has an irregular topography and most of the main island is deforested, the main exception being some areas protected by the CNWR. The coast is marked by rocky cliffs, sandy coral beaches, and mangrove (*Rhizophora* spp.) and Sea Grape (*Coccoloba uvifera*) forests. The interior of the main island consists primarily of grasses, Gumbo-limbo (*Bursera simaruba*), Cupey (*Clusia rosea*), Fig (*Ficus laevigata*), and thorn brush (*Acacia* sp.) trees, and some areas of semi-xeric woods. The highest point on the island (200 m) is Mount Resaca, part of the lizard's critical habitat.

There are no primary forests on Culebra or any of the adjacent islands. Most of the main island of Culebra was deforested for its valuable *Lignum vitae* [Guayacan (*Guaiacum sanctum*)] and then used for livestock grazing until it became a military bombardment zone (see below). After the military left the island in the 1970s, the number of residential homes and businesses increased as people returned to Culebra from the main island of Puerto Rico. In the 1980s, there was a boom of retirement/tourism homes in previously undisturbed areas of the island that has continued with the increased interest in both local and international ecotourism. Many of these homes infringe on potential habitats for *A. roosevelti*.

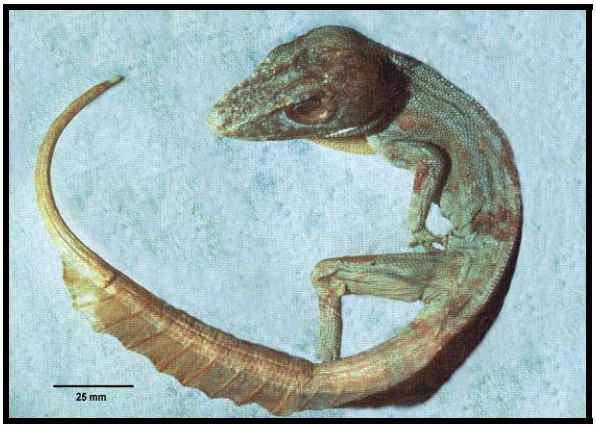

FIGURE 1. Culebra Island Giant Anole (*Anolis roosevelti*): Grant's type specimen MCZ 36136 (Grant 1931b) from the main island of Culebra. Photograph courtesy of Dr. C. Kenneth Dodd, Jr. and the Museum of Comparative Zoology, Harvard University. Original photograph taken by Dodd appeared in Dodd and Campbell (1982) and Dodd (2001). The photograph was digitally edited by the author to remove flash shadows surrounding the body and tail.

FIGURE 2. Culebra Island Giant Anole (*Anolis roosevelti*): Grant's specimen UMMZ 73644 (Grant 1932) from the main island of Culebra. Photographs courtesy of Gregory Schneider and the Museum of Zoology, University of Michigan. (Photographed by Gregory Schneider, September 2009). The photograph was digitally edited by the author to remove flash shadows surrounding the body and tail.

History and biology of Anolis roosevelti.—*Anolis roosevelti* is a species of Puerto Rico whose exact native range is unknown but can at least be said to be a Puerto Rico island bank endemic. It was named by Major Chapman Grant in honor of Theodore Roosevelt, Jr., Governor of Puerto Rico at the time of the lizard's discovery in 1931 on the main island of Culebra. At the time I began my study in January 1986, all information and descriptions of *A. roosevelti* were based on the only two known specimens. Both were from the main island of Culebra. These were collected for Grant in 1931 (1931a, 1931b) and 1932 (Grant 1932). The former (MCZ 36136) is deposited at the Museum of Comparative Zoology, Harvard University (Fig. 1), and the latter (UMMZ 73644) is in the University of Michigan, Museum of Zoology (Figs. 2 and 3).

Also in 1986, Gregory C. Mayer, a doctoral candidate of Dr. Ernest E. Williams at Harvard University, was exploring the British Virgin Islands for giant anoles and other reptiles and amphibians. As part of his dissertation, he compiled records on reptiles from the Puerto Rico Bank and discovered the existence of six additional museum specimens of *A. roosevelti* that had been misidentified [one in the U.S.A. (Cope 1861) and five in Scandinavia (Reinhardt and Lutken 1863)]. These came from Vieques, Tortola (British Virgin Islands) and St. John (U.S. Virgin Islands). Apparently, all of these specimens were originally misidentified as *Xiphosurus velifer*, *Anolis cuvieri*, or *A. velifer* (Gregory Mayer, unpubl. data; Mayer letter to USFWS, 8 July 1986 received by the author at PR DNR on 30 July 1986). Mayer later discussed and clarified the situation in his detailed dissertation (Mayer 1989): Cope (1861) identified his specimen from Vieques as *Xiphosurus velifer* and four specimens that were probably collected in the 1830s by A.H. Riise, a druggist in St. Thomas, and sent to Scandinavia from Vieques, Tortola and St. John, were described as *Anolis velifer* (Reinhardt and Lutken 1863). Mayer also discovered one additional specimen in Scandinavia. These specimens from the mid-l9th century extended the known geographical distribution of *A. roosevelti* from Culebra to Vieques, St. John and Tortola. All of these specimens were found in subtropical dry forest zones (Ewel and Whitmore 1973).

Grant (1931b) described *A. roosevelti* as brownish-grey in color, with a faint spot on its temple, and two light lines on each side. One line runs from the ear to

FIGURE 3. Head of the Culebra Island Giant Anole (*Anolis roosevelti*). Grant's specimen UMMZ 73644 (Grant 1932) from the main island of Culebra. Photograph courtesy of Gregory Schneider and the Museum of Zoology, University of Michigan. (Photographed by Gregory Schneider, September 2009)

the groin, and the other from the shoulder to the groin. The eyelids and the posterior quarter of its dewlap are yellow, and the tail is yellowish-brown, with the edge of the tail fin deeply scalloped. Its snout-vent length is approximately 160 mm and it has a bulky head (Fig. 3; Grant 1931b; Williams 1962; Rivero 1978; Dodd and Campbell 1982; Dodd 2001). Mayer (1989) re-described this species in more detail based on the examination of six of the only eight specimens every known to have been collected and preserved, including the two Grant specimens and four in Scandinavia.

Because data on the life history and behavior of *A. roosevelti* are lacking, generalizations based on inference from evolutionary radiation, ecomorphological concepts, and anoline phylogeny served as a guide for my study. *Anolis roosevelti* belongs to a series of giant anoles that includes *A. ricordii* of Hispaniola, *A. equestris* of Cuba, and *A. cuvieri* from the main island of Puerto Rico (Williams 1962, 1965, 1972, 1983, Losos 2009); its origin is definitely Greater Antillean.

According to Williams' (1983) concept of ecomorphs, Puerto Rico had two species of giant anoles; *A. cuvieri*, found on the main island of Puerto Rico, and *A. roosevelti*, found on the Puerto Rico Bank. Through inference and interviews with the person who found *A. roosevelti* for Grant (see below), *A. roosevelti* would be expected to be much like other giant anoles in that they are arboreal forest dwellers. Giant anoles have been known generally to be canopy inhabitants, although they also forage on the ground and sometimes sleep low on a tree trunk or on low vine tangles at night (Williams 1962, 1965, 1972, 1983; Perez-Rivera 1985). Among anoles, the males defend a territory that will generally include the territories of several females (Losos 2009). Territorial behavioral displays exhibited by the males (e.g. "pushups", rushing forward, and flashing their dewlaps at intruders) would make them very conspicuous and exposed to predators. In general, a large male *Anolis* would be more obvious than the females due to their behavioral repertoire.

In 1976, Carr (1977) reported that *A. roosevelti* was being seen by residents on the main island of Culebra and an interview with a farmer convincingly indicated their presence on Mount Resaca. In 1977, *A. roosevelti* was listed as Endangered under provisions of the Endangered Species Act of 1973 (USFWS 1977). Although the exact niche of this lizard was unknown, it was believed to possibly exist in the remaining forest of Mount Resaca on the main island of Culebra. This area was designated as its "Critical Habitat" simultaneously with its designation as an endangered species. Mount Resaca is part of the Culebra National Wildlife Refuge (CNWR), established in 1909 by President Theodore Roosevelt. In 1982, the USFWS developed a recovery plan for this giant anole (Campbell and Dodd 1982) that was approved in early 1983, but never funded (Kenneth Dodd, pers. comm.). In March 1984, a team of seven biologists from the USFWS and PR DNR spent two days on the main island of Culebra in order to survey the presumed habitat of *A. roosevelti* and confirm its existence. During this time, they interviewed Mr. Dimas Villanueva and were told that he had collected the type specimen of *A. roosevelti* for Grant "on a hilltop north of San Ildefonso in a forest containing 'corcho' (*Pisonia albida*) trees." Six members of the team surveyed this deciduous forest area of Mount Resaca but they were unsuccessful in finding any animals except for some common anoles and an *Alsophis* snake (USFWS memo 12 March 1984). In 1985, Dr. Richard Thomas of the University of Puerto Rico conducted a field survey for amphibians and reptiles on Cayo Luis Peña with a focus on endangered species, including *A. roosevelti*. Likewise, he did not find any of these lizards (pers. comm.).

Because the genus *Anolis* is widespread on the islands of the Puerto Rico Bank, where species occupy a variety of niches, finding *A. roosevelti* on a number of islands in the same general area was not unexpected. Grant (1931a, 1931b) recognized *A. roosevelti* as a new species of giant anole but likely overlooked the previous collections because these additional giant anoles had been erroneously identified as *A. cuvieri*. In Grant's (1932) herpetological checklist of Vieques, two specimens of *A. cuvieri* were mentioned. These were reported by Reinhart and Lutken (1863) and are likely the same specimens re-identified by Mayer. Others specimens found by Mayer were reported by Cope (1861). Based on Mayer's investigation, there are now eight known extant specimens: six in museums originating from Culebra (n=2), Vieques (n=3) and Tortota or St. John (n=1), plus two additional specimens, one from Vieques and one from an unknown island (Gregory Mayer, unpubl. data, *op. cit.;* Mayer 1989).

The purpose of this study was to determine if the Culebra Island Giant Anole still inhabited the main island of Culebra or any of the adjacent offshore islands including Vieques and St. John. Here, I report the results of that survey, the last known systematic field search for this species concentrated on the main island of Culebra, as well as some information from Mayer's (1989) doctoral thesis in which he discovered and re-described in detail several misidentified museum specimens collected during the 19th century from other islands in the Puerto Rico Bank.

MATERIALS AND METHODS

This study was conducted from 1 January through 31 December 1986 and consisted of interviews, seminars and field surveys. I conducted informal personal interviews of varying length ranging from 10 to 60 min in Spanish and/or English with over 20 local residents of

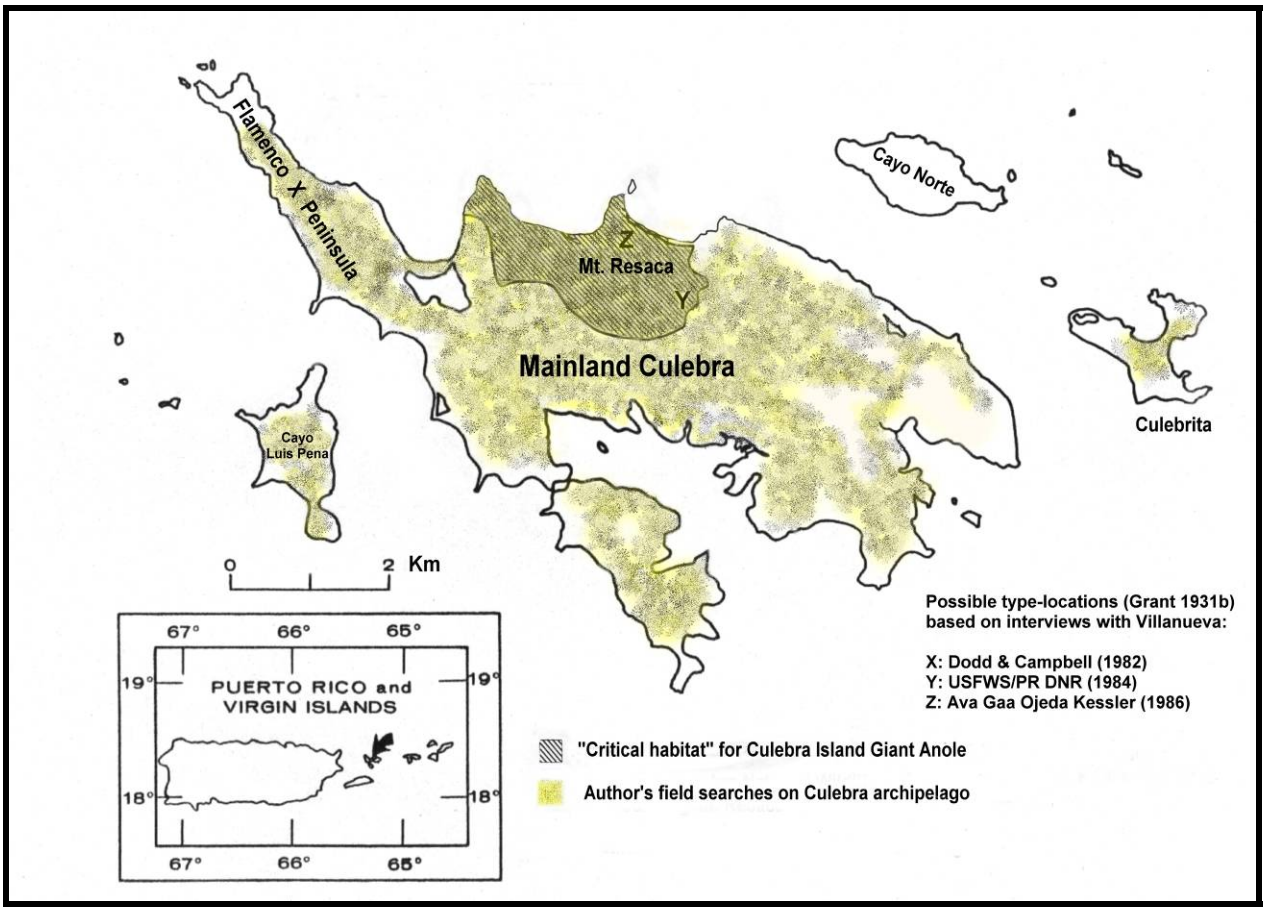

FIGURE 4. Map of the main island Culebra showing three of its major outlying islands: Cayo Luis Peña, Cayo Norte (privately-owned), and Culebrita. The shaded area with diagonal lines indicates a section of the Culebra National Wildlife Refuge that includes the "critical habitat" for *Anolis roosevelti*. All yellow/mottled areas, including the CNWR section, were searched by the author. Three possible type-locations for Grant's specimen (1931b) are indicated by X, Y and Z. Original map courtesy of USFWS from Campbell and Dodd (1982) was modified by the author to indicate the above.

Culebra using photographs from Rivero (1978) as well as live *Anolis* (*A. cristatellus*, *A. stratulus*, and *A. pulchellus*). An immature *Iguana iguana* was shown to interviewees to distinguish between potential sightings of *A. roosevelti* and young *I. iguana*. My interviews focused on citizens of Culebra who were older than 60 years of age because they would have been youngsters or older during the early 1930s when *A. roosevelti* was discovered and reported by Grant. These included former employees of the Puerto Rico Department of Natural Resources (PR DNR) and other retirees, elderly fishermen and, most importantly, Mr. Dimas Villanueva, who collected the original specimen of *A. roosevelti* for Grant in April, 1931 (Grant 1931). I also interviewed two other elderly men who collected lizards and snakes on Culebra for Grant. At the outset of this study, I gave a Spanish-language seminar and slide show on *Anolis* lizards of Puerto Rico at the Culebra public high school. I did this to educate students and to point out the differences between anoline lizards and *Iguana iguana*, a species that was introduced to the Caribbean from the mainland neotropics and Central America, and to find out if they had made any sightings.

Field searches.—I conducted extensive daily (approximately 0730–1700) weekday field searches on foot on Culebra or adjacent islands from 1 January through 31 December 1986. On the main island of Culebra, I drove a vehicle to the different search sites and then walked through the forest or brush marking my trail with plastic flags. I occasionally searched on Cayo Luis Peña and Culebrita accessing these islands by motorboat and then walking my search pattern. In total, I spent approximately 1500 hrs in the field searching for *A. roosevelti*. My search paths are indicated in Fig. 4 by a mottled-yellow appearance and included the entire "Critical Habitat" on the main island of Culebra. I also searched on Vieques (Puerto Rico) and St. John (U.S. Virgin Islands).

I used aerial photographs to locate potential patches of forested habitats such as mangroves, coastal forest, and other subtropical dry forest formations that might support this anole lizard. A systematic boustrophedon (serpentine) search pattern was used in combination with random parallel transects oriented from the top of a mountain to sea level and back to the top. This pattern was selected to survey and cover as much area as possible. It is now used extensively for efficient robotic, astronomic, and biological search patterns and statistical sampling (Choset 2000; Katz 1997; Ponty 2008; respectively). I carried out diurnal searches of the bushes and canopy with the aid of binoculars and nocturnal searches with a flashlight, the light of which would reflect from the light-colored bellies of lizards sleeping in the vegetation. For safety and efficiency during the nocturnal searches in the "boulder forest" of Mount Resaca, I flagged trees and I painted rocks with fluorescent paint during the day to mark the trails. I sometimes returned to the boulder forest at sunset and waited for night fall to start a particular nocturnal search.

Mount Resaca.—This area was the most extensively searched for it contains the semi-moist boulder and dry

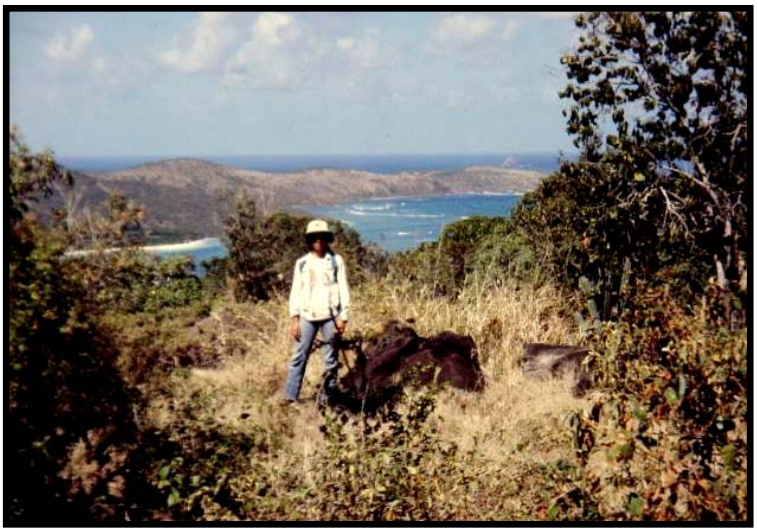

FIGURE 5. The author on the summit of Mount Resaca, Culebra, Puerto Rico, USA, where *Anolis roosevelti* has been found (see Fig. 4, point Z). Cayo Norte, an island in the Culebra archipelago, is visible in background. (Photographed by Matthew J. Kessler, February 1986)

FIGURE 6. Typical "critical habitat" of *Anolis roosevelti* on Mount Resaca, Culebra, Puerto Rico, USA. (Photographed by Matthew J. Kessler, February 1986)

forest believed to be *A. roosevelti*'s critical habitat. I searched this area both during the day and at night. I limited the night searches in this dangerous area to May, July, and August when I had an assistant from another study available to accompany me for safety and security reasons. The mountains on the north side of the island from Punta Flamenco to Punta Pavimento contain the largest part of what remains of the semi-moist boulder and dry forest habitat on Culebra (Figs. 5 and 6). The forest type from Flamenco to that of Mount Resaca facing Playa Resaca is more luxuriant than on the side of Mount Resaca facing Playa Brava. This is primarily due to the larger patches of boulders in the large deep ravines, greater rainfall and prevailing easterly winds. The boulder formations also hold moisture and rain water deep in the ravines. During the rainy season, cascading water runs below the boulders behind the Laguna Resaca area facing Bahia del Marejada. Boulder formations on the island are responsible for the semi-moist forest. The dominant trees in this area were Gumbo-limbo, Cupey, Fig, and a Thin Palm (*Coccothrinax alta*). It also contained various orchids, bromeliads, and Anthurium (*Anthurium acaule*). The boulder forest in front of Playa Brava was made up of smaller patches, few rocks, and shallow ravines. At sea level the dry forest in front of Playa Resaca gave way to a littoral forest, mostly Emajaguilla (*Thespesia populnea*) and vine tangles, before opening to the coast where Coconut Palms (*Cocos nucifera*), Sea Grape trees, and Milkweed (*Calotropis procera*) are abundant. The Laguna Resaca is surrounded by a small interior mangrove swamp except on its seaward side. In back of this lagoon lies the largest patch of semi-moist boulder forest on the island. The other lagoon in front of Playa Brava is surrounded by a smaller mangrove stand fringed by Manchineel (*Hippomane mancinella*) and Sea Grape trees. The dry forest that lies behind the mangroves has an area where the trees are covered by a thick canopy of vine tangles extending down to the ground.

San Isidro and Cerro Balon.—The area from Punta Pavimento to Punta Manchita is very xerophytic. Much of this area along with Cerro Balon was almost entirely deforested to provide grasslands for cattle grazing. This area is also the driest side of the island. Thorn-brush dominates this area and forms a very even canopy of secondary succession forest. Towards the coast on the cliffs, clumps of gumbo-limbo trees still crowd the mountain tops. Various types of cactus (including *Cephalocereus*) are also common in this area. The Laguna Zoni on the northeastern coast is surrounded on its interior side by a mangrove swamp, while its seaward side has a mixture of an old coconut grove and secondary forest with a dense mass of vine tangles hanging on the canopy. The area in front of the beach is covered with Sea Grape trees.

Punta Muleros, Punta Almodovar, Punta del Viento and Punta Vaca.—All of these sea-bound points are fringed with mangroves, except Bahia Mosquito. In the area behind Bahia Mosquito, there is a large watering hole on the lowland. There is a shallow ravine and around this area is a small patch of Guayacan (*Guaiacum sanctum*) forest. At the top of the mountains there are patches of Manchineel, Gumbo-limbo trees, thorn brush, and cactus scattered about coastal shrubs. Most of the high and lowlands here were also cleared for cattle grazing, but these areas now contain a dense canopy of *Acacia*.

Punta Carenero and Punta Padilla.—This area consists of patches of dry coastal forest, mostly Gumbo-limbo trees on the mountaintops and Manchineel on the seaward slopes. From Punta Cabras there is a large and extended mangrove system complete with channels. The southeastern peninsula (Playa Sardinas II) of Culebra is the most heavily populated by humans and thus the most deforested. There is a very small patch of semi-moist forest opposite the old ferry dock at Punta Aloe. There are extensive mangroves bordering Ensenada Dakity and Ensenada Malena, and on the southwestern side of Laguna Cornelio. Punta Soldado on the southwest coast contains dry coastal forest, mostly composed of Manchineel.

Cayo Luis Peña.—I made day searches on this large island off the southeast coast of the main island of Culebra in March and April. This cay contained a moist-type forest on its highest point on the northeastern coast. Most of the remaining cay consisted of a dry coastal forest, with a small lagoon and mangrove stand on its small cay.

Culebrita.—The vegetation on this island is generally very shrubby, with cactus and Sea Grapes. Because Culebrita does not contain the forest type that would sustain a giant anole, I only searched for one day in June.

St. John, U.S. Virgin Islands.—In August, I spent a few days in St. John performing daytime searches. During this tropical storm season of the year, the forested areas were especially lush due to the increased rainfall.

Vieques.—A small herpetological expedition team was assembled to conduct a week-long search for *A. roosevelti* on Vieques. The team consisted of Dr. Richard Thomas, two of his graduate students, and the author. The survey focused on Mount Pirata on the southwestern end of the island as this area contains the

forest types that would most likely harbor giant anoles. The Mount Pirata area held a large moist forest, much more lush, and well-preserved than any on Culebra. The lowlands and coastal zones contained many areas covered with mats of vine tangles hanging from the trees to the ground and over a stream. These areas were considered ideal for nocturnal sighting, capturing and identifying any giant anoles that might inhabit the area.

RESULTS

I did not find any *A. roosevelti* during this extensive year-long field study, nor did I uncover any evidence that this lizard still exists on the main island of Culebra or on the other islands that I searched. The interviews provided no scientific data or evidence of sightings of *A. roosevelti* within the 55 years spanning 1931 to 1986. However, they did indicate, without any doubt, that all those claiming to have seen *A. roosevelti* in recent years had been confusing it with *I. iguana*. Of particular interest and historical importance was the author's interview, in Spanish, with Mr. Dimas Villanueva (DV), the "Mr. Dumas" (sic) of Dodd and Campbell (1982). At the time, he was in his seventies and in failing health. DV collected the original specimen of *A. roosevelti* for Grant in April, 1931 (Grant 1931). By this time in his life, DV had become bothered by all of the biologists who had come to him over the years to get information about the Culebra Island Giant Anole he had collected for Grant. In order to interview him, I had to work through intermediaries and then become friends with his family and best friend. When the interview finally occurred, DV told me that back in the 1930s, Grant paid fifty cents, a significant amount then, for each lizard or snake delivered to him. He said that he and his cousin explored several places on the island together collecting lizards to take advantage of Grant's lucrative offer. DV vividly recalled having caught the "strange" large brownish-gray lizard with a big bulky head. He said that was the first and last time he ever saw this type of lizard or any other one similar to it. Even though Grant paid double for this lizard and offered to buy more, he never saw or was able to capture another specimen despite many searches of arboreal habitats. Contrary to what was reported by Dodd and Campbell (1982), DV said that he did not remember where on the main island of Culebra he caught this lizard, as he had collected lizards from several different places that day. He told me that he believed this *A. roosevelti* was caught around El Vijeya (a local alias for the Mount Resaca area). This area is indicated as possible type-location Z in Fig. 4. Two other elderly residents, who also collected lizards and snakes for Grant, were also interviewed. They both talked about the strange lizard DV had collected when they were boys. They also said that they never saw another one like it again. A few other elderly citizens also remembered seeing DV's strange lizard in the early 1930s, and, likewise, they had never seen another since. It was impossible to interview Mr. J.M. Ortiz, who supposedly caught the second *A. roosevelti* for Grant (1932), because he had died.

The seminar and slide show on *Anolis* lizards of Puerto Rico offered at the Culebra public high school was well received and stimulated much interest in the search among the students. It was given in Spanish, the primary language in Puerto Rico, to avoid any misunderstandings. The students and teachers who thought that they had seen the giant anole admitted to having confused it with *I. iguana*.

Field searches.—At the time this investigation was begun, the only known specimens of *A. roosevelti* came from Culebra and the intent was to search its critical habitat for other specimens. Therefore, I focused on finding *A. roosevelti* in the semi-moist boulder, dry, and littoral forests and mangrove areas on the main island of Culebra believed to have the best potential and/or critical habitats. I made special, meticulous, and repeated searches of the Mount Resaca area. During the day and night searches on Culebra and Vieques, the *Anolis* lizards *A. cristatellus*, *A. stratulus*, and *A. pulchellus* were the most common and abundant lizards that I found. They were seen in practically all locations. *Mabuya* and *Ameiva* were less common and were often restricted to certain areas. I only saw *Hemidactylus* at night when they came out to forage. *Anolis* lizards spent the night perched among the thorns of thorn-brush trees in dry forest areas, while in the semi-moist boulder forest Cupey, Cork (*Pisonia subcordata*), and *Anthurium* leaves or hanging vines were preferred. I found very few lizards sleeping at night in the vine tangles in the littoral areas on Culebra, perhaps because at night these places were teeming with Black Rats (*Rattus rattus*). I only observed *A. cristatellus* and *Ameiva* during the day I spent searching on Culebrita. On Vieques the Black Rats were less abundant and I found many *Anolis* lizards sleeping on vegetation in the littoral habitats at night. In Hispaniola, vine tangles hanging from trees are ideal locations to collect giant anoles at night (Williams 1962). During the day searches on Cayo Luis Peña and St. John, I only saw the common *Anolis* lizards, *Ameiva*, and *Hemidactylus*.

DISCUSSION

Nothing is directly known about the life history of *A. roosevelti*. However, published literature relating to the biogeography, evolution, biology and behavior of other giant anoles can be used to make inferences about the Culebra Island Giant Anole. The zoogeographical distribution of *A. roosevelti* would be subject to the changing environment through natural occurrences or by

human interference. Geological events, such as the fragmentation of the Puerto Rico Bank by rising sea levels during the Pleistocene accompanied by changing climates would considerably affect the distribution. Based on Mayer's (1989) dissertation, it is likely that *A. roosevelti's* distribution included all, or at least several, of the islands of the Puerto Rico Bank as it was once a single land mass. The *A. roosevelti* on Culebra were probably a relict of a once widely distributed giant anole population in xerophytic areas (Williams 1962, 1972, 1983; MacArthur and Wilson 1967; Pregill 1981; Pregill and Olson 1981).

On the main island of Puerto Rico, the Puerto Rican Giant Anole, *A. cuvieri*, occurs in mesic environments in widely scattered localities from sea level to the mountains, while its apparent ecomorphological vicar, *A. roosevelti*, seems to have preferred the more xerophytic eastern islands of the Puerto Rico Bank. The preference of *Anolis cuvieri* for mesic areas is also supported by the fossil record of the late Pleistocene. The fossil record documents numerous extinctions of species from arid habitats in Puerto Rico and these are believed to result from climate changes brought on by rising sea levels (Pregill 1981). Most fossils come from areas now too mesic to have supported these xerophilic species. Thus, those species that are currently restricted to these xeric habitats are thought of as relicts of an arid period and are considered by some to be ancestral (Pregill 1981; Pregill and Olson 1981). This hypothesis is supported by Mayer's discovery of specimens of *A. roosevelti* from the other xeric islands of the Puerto Rico Bank.

Human interference and environmental destruction, such as massive deforestation to clear land for cattle and construction, military activities, and major hurricanes have occurred around the islands that compose the Puerto Rico Bank including the main island of Culebra. An increasing human population and housing scattered throughout most of the island, except for the CNWR zones, and increased tourism have significantly reduced the potential habitat of *A. roosevelti* over the years. However, a recent comprehensive survey of Puerto Rican forests found that approximately 88% of the main island of Culebra contains immature recovering dry forest (Brandeis et al. 2003). Culebra has no virgin forest remaining (not even in the critical habitat of the Mount Resaca reserve), and cattle, goats, and chickens roam freely throughout the forests as do a small number of White-tailed Deer (*Odocoileus virginianus*) introduced in 1966. Feral and/or escaped domestic cats are abundant on Culebra; cats are known to prey on lizards as do rats, which are also common on the island. Dodd and Campbell (1982) reported that Culebra was free of mongoose, and this is still the case (pers. obs.).

As for military activities, in 1903 President Theodore Roosevelt established the Culebra Naval Reservation. With the outbreak of WWII in 1939, the Culebra Archipelago became the primary gunnery, firing range, and bombing practice site for the U.S. Navy. After WWII, the Navy expropriated 688 ha of land on the main island of Culebra for a bombing range. As an example of how this might have affected *A. roosevelti* and its habitat, in 1969 alone, Culebra came under naval gunnery fire for 123 days, was hit directly by missiles for 228 days, and planes made over 35,000 target runs on the island (McCaffrey 2002). These activities lasted until 1976 when the Navy moved some of these operations to Vieques. The effects, if any, of these military activities in Culebra on this species are unknown.

Finally, Culebra has been hit by hurricanes over the years. The most notable and destructive hurricane in recent recorded history was Hurricane Hugo of September 1989, which caused widespread habitat destruction that could affect lizards by downing numerous trees and defoliating the remainder. However, these episodic weather disturbances are less likely to affect lizard populations than predation, habitat stripping by grazing livestock, or human habitat destruction (Henderson 1992).

Anolis roosevelti appears to have been restricted to the more xerophytic areas on the Puerto Rico Bank Complex and is believed to have been a primitive form of recent giant *Anolis* lizard. To date, only eight specimens of *A. roosevelti* are known to have been collected. All were collected during the 19th century or early 1930's from Culebra, Vieques, St. John, and Tortola islands. There is no documentation as to exactly where on these islands any of the specimens were collected, but we do know that giant anoles are forest dwellers. Massive deforestation of these islands could have made them or their eggs more susceptible to predation by domestic animals, such as cats and goats, and wild animals such as birds of prey, snakes, and rats, as well as to habitat damage or direct strikes from naval and aerial bombardments.

The interview with Dimas Villanueva (DV) and his contemporaries support the idea that *A. roosevelti* was extremely rare on Culebra even in the early 1930s and that the probable type-locality might actually be on Mount Resaca, its designated critical habitat. It is interesting that documents indicate at least three different field survey teams interviewed DV and obtained three different stories about where he discovered the specimen. Information provided to Dodd and Campbell by PR DNR sources indicated that DV had found the specimen on the Flamenco Peninsula, which is reported as the "probable type-locality" in Campbell and Dodd (1982). However, in 1984 DV told the USFWS/PR DNR team, including Drs. Geoffrey Hammerson and José Vivaldi, that the specimen came from a hilltop north of San Ildefonso in a Cork forest. Finally, in 1986, he told me that it probably came from

Mount Resaca. He confided in me that he told some of these individuals stories just to get rid of them because they were a bother. I believe that what he told me was as accurate as his memory allowed because I went to interview him with a family member I had befriended. The three different sites divulged by DV are identified as "possible type-locations" X, Y and Z, respectively (Fig. 4).

Interviews with younger townspeople and with the teenagers at the public high school clearly indicated that all those claiming to have seen the giant anole were confusing it with *Iguana iguana*, a relatively common introduced exotic lizard species on Culebra. In part this confusion may have been because iguanas are polymorphic. Young iguanas appear very different from adults and are considered two different types of lizards by untrained observers.

During this year-long study, an experienced observer should have sighted at least one *A. roosevelti* on Culebra assuming that a reproducing population existed. Like all anoles, *A. roosevelti* is diurnal and would be expected to forage for food and carry out other activities in the forest during the daylight hours (Losos 2009). All potential forested habitats on Culebra were repeatedly searched during the day and at night. No specimens were spotted. Other islands and Cays surrounding the main island of Culebra that contained forested areas were also searched, albeit briefly, with no success. In view of the intensive field work done on Culebra to find *A. roosevelti* during the year of this study and the lack of any sightings or collections in the quarter century since (see Mayer 1989; Thomas and Joglar 2006; Losos 2009), I recommend *A. roosevelti* be designated as extinct on Culebra. Further investigation is warranted on Vieques, St. John, and Tortola before consideration is given to declaring the Culebra Island Giant Anole totally extinct in the Caribbean.

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