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Cyclura rileyi rileyi, San Salvador Rock Iguana (see article on p. 212). *Photograph by John Binns.*

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Special Iguana Conservation Issue

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Conservation of Galápagos Marine Iguanas (*Amblyrhynchus cristatus*)

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Photographs by Martin Wikelski except where indicated.

Abstract.—Galápagos Marine Iguanas are highly abundant along many of the archipelago's shorelines. Total estimated population size varies between 37,000 and 280,000 individuals. Marine Iguanas have evolved in the absence of major predators, and their populations are regulated by cyclically recurring famine (El Niño) and feast (La Niña) events. Population declines are strongly density-dependent: the higher the population density, the higher the mortalities during El Niños (from 10–90%). Recovery after El Niños is rapid, as females compensate by reproducing younger and laying more eggs. Marine Iguana morphology differs between islands. Seven subspecies have been proposed, although only three major clades can be distinguished genetically. Twelve populations (approximately 74% of all Marine Iguanas) still live in pristine environments, whereas five populations (26% of all Marine Iguanas) suffer from anthropogenic influences. Major conservation problems arise from introduced predators (cats, dogs, rats, and pigs) and from combinations of natural events (El Niño) and anthropogenic disasters such as oil spills. The most recent oil spill in 2001 killed 62% of all Marine Iguanas on Santa Fe Island. Management requirements for the future include: (i) investigating population trends in Western Isabela and San Cristobal islands, (ii) investigating whether harbor areas are population sinks because of environmental contaminants, (iii) establishing a recovery program for oil-contaminated iguanas, especially their reinoculation with hindgut microsymbionts, and (iv) developing husbandry techniques and establishing a captive propagation program as a population backup plan (Marine Iguanas have not been bred in captivity).

Key Words: Marine Iguanas, *Amblyrhynchus cristatus*, South America, Galápagos Archipelago, Conservation, Oil Spill, Feral Predators

Introduction

When the Galápagos' most famous visitor, Charles Darwin, arrived on the rocky lava shores, he likened the islands to the entrance of Hell. He found myriads of "dirty black" Marine Iguanas (Darwin 1883). Young Charles found them "hideous in appearance, sluggish, stupid, and ugly." Nevertheless, like every modern visitor, he was fascinated by their sociality and their marine foraging style — Marine Iguanas are the only lizards known to feed exclusively on algae. Marine Iguanas live in dense clusters of up to 8,000 animals per kilometer of coastline. However, iguana colonies are distributed very patchily, and tend to occur only along the southwestern shores of the islands.

Amazingly, little has changed for Marine Iguanas on the uninhabited islands since Darwin's visit more than 170 years ago. However, although Marine Iguanas still occur in healthy population densities on the uninhabited islands, they face potentially serious threats on several inhabited islands.

Marine Iguana Natural History

Marine Iguanas are endemic to the Galápagos Archipelago, which belongs to the Republic of Ecuador. They feed exclusively on marine algae in the rocky intertidal zone (Darwin 1883, Carpenter 1966, Trillmich and Trillmich 1986, Wikelski et al. 1993, Wikelski and Hau 1995, Drent et al. 1999). Marine Iguanas possess an internal biological clock that is synchronized to the tides. This clock cues them to walk to the intertidal zone every day at low tide, when the algae are exposed (Wikelski and

Male Marine Iguana on Seymour Norte Island eating Saltwort (*Batis maritima*) on land. Some individuals supplement their food with land plants.

Marine Iguanas in the intertidal zone on Genovesa Island during the low tide, grazing on green algae (mostly *Ulva* sp.). This population is the smallest in body size and males with body mass as little as 500 g are seen diving.

Two sneaker male Marine Iguanas on Genovesa Island attempt to forcefully copulate with a female outside of a territory (on sand). The territorial male (right) left his territory and interrupted the copulation attempt.

A satellite male Marine Iguana forcefully approaches a female to attempt copulation.

Hau 1995). The largest iguanas of each island population also dive for algae (2–30 m depth; Buttemer and Dawson 1993). On Genovesa, males with body mass >500 g are seen diving, whereas on Fernandina usually only males >3500 g dive for food (Wikelski and Trillmich 1994). A few individuals supplement their food with land plants, in particular on Seymour Norte Island. Only highly salty land plants are ingested (primarily Saltwort, *Batis maritima*, but also other coastal succulents such as *Sesuvium portulacastrum*), presumably because Marine Iguanas possess very specialized hindgut micro-symbionts that help them digest their food and effectively break up cell walls (Mackie et al. 2003).

Marine Iguanas reproduce once a year during a month-long mating season. The precise timing of the mating season coincides with the highest abundance and best quality of food (Rubenstein and Wikelski, in preparation). Because the nutrient-rich upwelling from the Cromwell current affects all islands in the archipelago differently, mating seasons occur at different times (e.g., December on Santa Fe and Genovesa, January on Santa Cruz, February/March on Española). During the mating season, males defend small territories that contain no resources other than the males themselves, which prompted the description of the mating system as a lek, or mating arena (Trillmich 1983, Wikelski et al. 1996). Male Marine Iguanas use three different mating strategies. The largest males defend territories and court females using a slow, stereotyped head-bob courtship behavior. Male mating success is highly skewed and depends on body size, condition, and display rate (Wikelski et al. 1996, 2001). Male territories are generally clustered, but single territories also occur. Satellite males are smaller than territorial males and roam around territories, attempting to (forcibly) mate with females. "Sneaker" males are the smallest males, physically indistinguishable from females. Sneakers try to copulate with females "in secret" on territories of large males (Wikelski and Bäurle 1996). These three mating tactics appear to be partially regulated by plasma levels of testosterone, and can be manipulated by hormone administration (Wikelski et al., submitted).

Receptive females generally copulate only once after they have selected a specific male, which they do after long periods of mate choice. Mate choice is apparently costly for Marine Iguanas, as indicated by mass loss of females that visit many males, compared to those that visit only a few males or mate in low-density areas (Wikelski et al. 2001). Females leave the mating area shortly after copulation to lay one to six eggs in deep burrows in sandy areas. Eggs incubate for three months (Laurie 1990; Laurie and Brown 1990a, 1990b). Some females guard their nests for a few days after egg-laying, mostly to defend against other females that try to dig at the same spot. The entire clutch amounts to about 20–28% of a female's body mass. Both males and females typically reproduce every other year, replenishing their energy reserves in the year they do not reproduce. However, during periods of food abundance, females may reproduce annually (Laurie 1990).

Marine Iguanas have only one natural predator, the Galápagos Hawk (*Buteo galapagoensis*), which is generally unable to prey on healthy adults. However, hawks can capture weakened adult iguanas, such as starving individuals or females exhausted by nesting. They also can learn to capture juveniles or hatchlings close to the shoreline (Boersma 1983; personal observation, Santa Fe Island).

Natural Population Regulation via El Niño Events

Unpredictably recurring El Niño events can dramatically reduce the abundance and diversity of marine algae — Marine Iguanas' only food source — and can cause mass starvation (Laurie and Brown 1990b). During El Niño events, the cold, nutrient-rich upwelling ceases and warm water from the Gulf of Panama flows toward the Galápagos. The normal food algae (red *Gelidium* and

Centroseras species or green *Ulva* species) disappear when water temperatures become too high and are replaced by brown algae. However, brown algae are not as easily digested by the Marine Iguanas' hindgut bacteria, and they may also be toxic. The result is widespread starvation of Marine Iguanas throughout the archipelago. Individual animals are affected differently — the largest animals starve first (Wikelski and Trillmich 1997, Wikelski et al. 1997), presumably because they have the highest absolute calorie requirements. Therefore, natural selection favors smaller animals during food shortages. Interestingly, Marine Iguanas can shrink their body size during El Niño events and survive such conditions better (Wikelski and Thom 2000). How such shrinkage is achieved physiologically or whether and to what degree bone loss is involved is not clear.

Marine Iguana populations can crash dramatically. During the El Niño of 1997–1998, about 90% of all Marine Iguanas on Seymour Norte Island disappeared, thus reducing population size on this island to less than 150 individuals (Wikelski and Wrege 2000, Romero and Wikelski 2001). A similar situation occurred on Genovesa Island in 1991–1994, reducing the total population size from about 15,000 to approximately 900 individuals. However, Marine Iguanas have survived such dramatic natural selection events throughout their evolutionary history and apparently adjust to such situations. As soon as nutritious red and green algae reappear after an El Niño ceases, individuals face plentiful intertidal and subtidal foraging grounds. Iguanas quickly replenish their fat reserves and return to good body condition. They reproduce more frequently (every year), at a younger age (mostly females), and lay larger clutches (e.g., three instead of two eggs). The "rules" by which Marine Iguanas determine whether to breed and how many eggs to lay are still unclear.

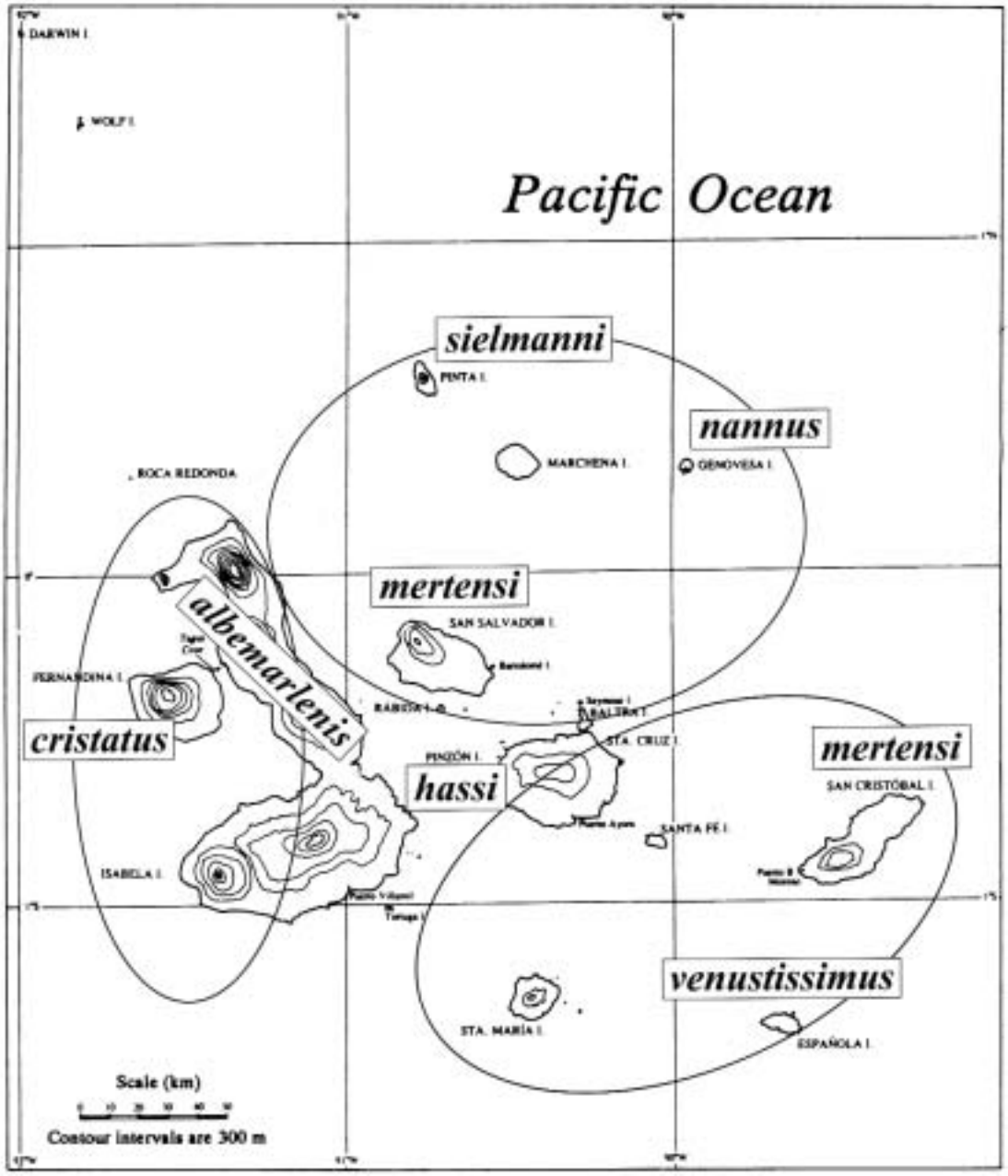
These adaptations allow Marine Iguanas to increase their numbers after dramatic population declines, such that mortality rates of 30–50% after an El Niño event can be compensated within four years. Even after enormously strong population declines (90%), Marine Iguanas congregate along the shoreline in small groups to reproduce (Wikelski et al. 1996). This gregariousness helps them to find each other after dramatic population declines that could otherwise cause individuals to scatter along the long lava shores of the islands.

Island Populations and Threats

Early naturalists discovered that not all Marine Iguana populations are alike (Fig. 1). For example, iguanas on Genovesa only grow up to a maximum of 900 g (subspecies: *A. c. nanus*, "the small ones"). Animals on Española are the most brilliant, at least during the mating season, when they display a bright red and green coloration (*A. c. venustissimus*). Fernandina iguanas have especially elaborate spines (*A. c. cristatus* subspecies). Although these populations differ very obviously on the phenotypic level, genetic dis-

Table 1. Rough estimate of Marine Iguana population sizes on the Galápagos Archipelago. Data are based on our own surveys, accounts by Galápagos guides, and data by Andrew Laurie (unpublished report to the Darwin Foundation, 1981). Minimum numbers indicate estimates for total island numbers after a strong El Niño famine. Maximum numbers indicate total numbers after several years of La Niña (cold, nutrient-rich) conditions. Maximum density estimates relate iguana numbers to the total size of the island. Please note that these are only very rough estimates.

ISLAND	SUBSPECIES	MINIMUM NUMBER	MAXIMUM NUMBER	MAXIMUM DENSITY (n/km^2)	THREATS
Fernandina	*cristatus*	15,000	120,000	187	Oil spill
Isabela	*albemarlensis*	5,000	40,000	9	Oil spill, dogs, cats, rats, pigs
Santa Fe		3,000	16,000	667	Oil spill
Floreana		2,000	16,000	92	Oil spill, cats, rats, pigs
Santa Cruz	*hassi*	2,000	13,000	13	Oil spill, dogs, cats, rats, pigs
Española	*venustissimus*	1,700	21,000	350	Oil spill
Genovesa	*nanus*	900	15,000	1071	Oil spill
Marchena		1,000	10,000	77	Oil spill
Pinta	*sielmanni*	800	6,000	100	Oil spill
Santiago	*mertensi*	450	4,000	7	Oil spill, cats, rats
Wolf		400	1,500	1154	Oil spill
Darwin		200	800	727	Oil spill
Pinzon		200	900	50	Oil spill
Rabida		200	2,000	408	Oil spill
Seymour Norte		100	1,500	789	Oil spill
San Cristobal		50	400	1	Oil spill, cats, rats, pigs
Remaining islands		2,000	10,000	NA	Oil spill
TOTAL		**~37,000**	**~280,000**		



Schematic map of the Galápagos Archipelago and the different subspecies of Marine Iguanas as described by Eibl-Eibesfeldt (1962; inset subspecies names). Superimposed (ovals) are the three genetically similar clades, based on nuclear and mitochondrial genetic analysis (Rassmann et al. 1997). Genetic and morphological information is not entirely compatible, indicated, for example, by the fact that the *Amblyrhynchus cristatus mertensi* subspecies is found in two genetically distinct clades (on San Cristobal and Santiago islands).

tinction of "subspecies" is less clear (Fig. 1; Rassmann 1997, Rassmann et al. 1997). Marine Iguanas reached the Galápagos archipelago as early as 10–15 million years ago. They presumably arrived by "leap-frogging" across now-sunken islands that are only detectable as sea mounts between the present-day Galápagos Islands and the South American mainland. From those early Galápagos Islands, Marine Iguanas dispersed to the present islands and split into northwestern, central, and southeastern clades.

Interestingly, the northwestern clade includes both the largest (on southwestern Isabela) but also fairly small iguanas (on Pinta), indicating that strong selection on body size is present, although not apparent in the genetic markers that were investigated (Rassmann et al. 1997). These distinct inter-island differences obviously indicate that all island populations should be conserved, although no immediate threat exists to most island populations. However, even the most pristine populations may suffer immediately and heavily from environmental disasters such as an oil spill, even if the contamination levels are very minor (Wikelski et al., in preparation; Charles Darwin Research Station, unpublished report on the January 2001 oil spill). On Santa Fe, approximately 60% of the entire Marine Iguana population disappeared as a consequence of low-level oiling when

Galápagos Hawk killing a hatchling Marine Iguana on Santa Fe Island.

the oil tanker "Jessica" ran ashore on nearby San Cristobal Island and spilled about 750,000 gallons of diesel and bunker oil. Consequently, oil contamination could pose a serious threat to all populations of Galápagos Marine Iguanas, even those that live far from human settlements and would otherwise be considered pristine. As to the specific mechanism of mortality, we suggest that hindgut endosymbionts are highly susceptible to oil in their digestive substrate. Marine Iguanas need these bacteria to digest algae fully, a process that can take up to two weeks. These specialized and highly effective gut bacteria probably suffered heavily due to the oil spill, which in turn caused failed digestion and widespread starvation among Marine Iguanas.

On at least five islands, Marine Iguana populations also are heavily impacted by human-introduced predators (Cayot et al. 1994). The most important predators are feral cats, dogs, rats, and pigs. We are currently uncertain whether those Marine Iguana populations already affected are jeopardized to an extent that their long-term survival is in question. Some populations on certain parts of western Isabela Island appear to be in immediate danger of extinction. During several research expeditions, we only found adult iguanas and very few young or hatchlings, indicating almost no recruitment, at least not along the shoreline of the main island. Nevertheless, some hatchlings and yearlings were seen on small offshore islets. A similar situation applies to Marine Iguanas on San Cristobal Island, where only several hundred iguanas survive. Thus, we would classify these populations as highly endangered, and recommend that immediate action be taken.

Management Needs for the Future

Four major problems exist for Marine Iguana populations, and we recommend the following conservation-related research projects to determine the causes of the threats and to elaborate possible solutions:

(i) We need to study population trends and identify threats to Marine Iguanas at sites where iguanas show no apparent recruitment. Those sites include western Isabela and San Cristobal Islands as mentioned above. We presently do not know where and when reproduction occurs, which predators are preventing recruitment of hatchlings, and to what degree big mammalian predators are responsible for the observed lack of recruitment. The most desirable conservation project would be to habituate feral cats to the presence of a researcher and follow them along their daily activities (H. Snell, personal communication). Such data would reveal the dangers that feral cats pose to Marine Iguanas and would allow us to study the impact of these fierce predators on other endangered coastal species. Dog predation could be a problem on other islands like San Cristobal, and this also needs further investigation (Kruuk and Snell 1981).

(ii) The second important project is to study the impact of human habitation and low-level environmental contamination on Marine Iguanas. We are particularly concerned about oil residues from boats around human settlements (e.g., the towns of Puerto Ayora on Santa Cruz Island and Villamil on Isabela Island). We currently do not know if areas around human settlements should be considered population sinks for Marine Iguanas or whether such areas still produce sufficient recruits to be considered viable populations. Based on the current information about the effects of a low-level oil spill in 2001, Marine Iguanas in oil-impacted areas conceivably will suffer long-term effects. Furthermore, our own observations in and around Puerto Ayora (the main harbor town on Santa Cruz Island) suggest that many of the hatchlings that pass through the town after hatching disappear from the harbor area, and may die due to human (or feral animal) actions. A long-term mark/recapture program could resolve such questions.

(iii) A third area of high interest for the management of Marine Iguanas is the planning and establishment of a program for rehabilitation of Marine Iguanas. This would include indi-

Adult female Marine Iguana from Genovesa Island; this single egg was laid about two hours prior to taking this picture.

Comparing two Marine Iguanas on Santa Fe Island showing how much individual iguanas can shrink. The iguana on the left could shrink in body length to the size of the individual on the right during an El Niño.

Bachelor male Marine Iguanas from Fernandina Island. Note the elaborate spines that are very prominent in this population of large individuals. On Fernandina, diving males usually exceed 3500 g.

viduals that suffered low levels of environmental contamination. Hindgut microbes probably die during anthropogenic disasters such as oil spills, and Marine Iguanas subsequently starve. Such a situation is comparable to what happens to other vertebrates when endogenous gut symbionts are eliminated, for example, by chemical contamination or antibiotic medication. In such situations, the gut fauna can be reinoculated using pills containing spores of endogenous gut symbionts. The horizontal transfer of gut symbionts from unaffected to affected individuals also is possible in Marine Iguanas. Thus, once we have established how many and what kind of hindgut endosymbionts Marine Iguanas possess, and how such symbionts work, researchers presumably could collect gut material from healthy individuals and treat suffering individuals.

(iv) The fourth and potentially most difficult research activity for the conservation of Marine Iguanas would be to try to breed animals in captivity. Astonishingly, this has never been attempted, and we are unsure whether it is even possible. The challenges for holding and breeding Marine Iguanas in captivity are manifold. First, Marine Iguanas have very specific dietary requirements. Only certain types of seaweed are preferred and eaten — as soon as the natural algae composition changes, we find dramatic mortality rates in the wild. Second, although early naturalists removed several Marine Iguanas from the Galápagos Islands and brought them into zoos, none of those iguanas ever tried to reproduce. Nevertheless, several Marine Iguanas were maintained for more than ten years. Marine Iguanas have a different breeding system than most other iguanids, and a fairly large colony may be required in order to stimulate mating activities. At the same time, we do not know how hatchling Marine Iguanas survive their first months, how they acquire their endogenous hindgut microsymbionts, and how they become recruited into the population. Marine Iguanas are the only Galápagos animal about which we are uncertain whether they can be kept and bred in captivity, should such a need arise. We would like to remind the reader critical of any effort to remove individuals from the wild that a combination of a strong El Niño event and even small-scale anthropogenic disasters (like a low-level environmental contamination) could effectively wipe out an entire island population. If our aim is to conserve each island population of Marine Iguanas because of their distinctive differences, we should seriously consider developing the husbandry practices necessary to rear Marine Iguanas in a captive setting.

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Dead Marine Iguana on Fernandina Island during the 1998–99 El Niño period. The likely cause of death was starvation.

Martin Wikelski holding a large male Marine Iguana on western Isabela Island.

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Adult Fijian Crested Iguana (*Brachylophus vitiensis*) from Yadua Taba Island, Fiji. *Photograph by Joe Burgess.*

Lost in the South Pacific: The Fijian Iguanas (Genus *Brachylophus*)

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Photographs by the author except where indicated.

Abstract.—Two species of iguanas occur in the South Pacific: the widely distributed Banded Iguana and the larger Crested Iguana, which is more restricted in its distribution. Abundance data are available only for the Crested Iguana Sanctuary island of Yadua Taba in Fiji, and suggest that in optimal forest habitat densities may approach 200 iguanas per hectare. No other island in the Pacific is known to possess such a dense population of *Brachylophus* and, on most islands where iguanas occur, sightings are rare or extremely uncommon. As the Pacific iguanas are not hunted, eaten, or traded, their rarity is most likely due to the combination of habitat loss and degradation from forest clearing, burning, and goat grazing, and the introduction of exotic predators such as cats, mongooses, and perhaps rodents.

Key Words: Crested Iguana, Banded Iguana, *Brachylophus*, Island Conservation, Habitat Loss, Fiji Islands

"Though the beautiful Banded Iguana was not uncommon as recently as 1915, it must now be considered rare, if not extinct, on many of the islands."

Arthur Loveridge
Reptiles of the Pacific World, 1945

Introduction

Of the eight living genera of lizards in the family Iguanidae, only *Brachylophus* occurs in the South Pacific. The Pacific Banded Iguana (*Brachylophus fasciatus* Brongniart 1800) and the Fijian Crested Iguana (*Brachylophus vitiensis* Gibbons 1981) have long been seen as biogeographical oddities, existing so far away from the seven iguanid genera of the Western Hemisphere. The family Iguanidae is regarded as a monophyletic group (all have descended from a common ancestor) and for many years were assumed to have evolved in the New World (Estes and Price 1973, Frost and Etheridge 1989). Phylogenetic work based on morphology (Etheridge and de Queiroz 1988) and a combination of morphological and molecular characters (Sites et al. 1996) both suggest that *Brachylophus* is a sister taxon to all other living iguanids.

How *Brachylophus* arrived in the South Pacific has been the subject of hot debate for decades. All other terrestrial vertebrates in the South Pacific are clearly derived from Indo-Malay and Gondwanan ancestors that arrived via over-water dispersal along the island chains of New Guinea and the Solomon Islands (Gibbons 1985a). Cogger (1974) and Gibbons (1981, 1985a) both suggested that long-distance rafting from the New World across the Pacific by ancestral *Brachylophus* was the most probable mechanism of colonization. They pointed out a series of biological and geographical traits that preadapted *Brachylophus* for this journey, including nasal salt glands for the excretion of excess salt, an extremely long egg incubation period, and the fortuitous direction of the South Equatorial Current. No one suggests that *Brachylophus* traveled the 8000 km from the Americas to the South Pacific in a single trip. More likely, the ancestors of *Brachylophus* island-hopped by occasional rafting events and colonized a series of islands along the way, many or all of which are submerged today or have been submerged at some time since the initial colonization of *Brachylophus*.

More recent paleontological findings now question the romantic vision of the half-starved, gravid iguana being washed ashore on a South Pacific beach, surviving months at sea clinging to a water-logged tree. The oldest known fossil iguanids (and the closely related agamids) are more than 63 million years old and have been found in the Gobi Desert of Inner Mongolia, China (Gao and Hou 1995). These predate Estes and Price's (1973) South American iguanid fossils by some 11–13 million years. Thus, the current dichotomous world distribution of the Iguanidae may be due to a New World invasion (and subsequent adaptive radiation) by the ancestral Mongolian iguanids, while the Pacific iguanas may represent the sole surviving descendants of a true stay-at-home Asian lineage. Nevertheless, ancestors of *Brachylophus* still had to cross wide ocean barriers to arrive at their current locations in the South Pacific.

Extant Pacific iguanas are both small when compared to most other iguanas and strongly arboreal. The Banded Iguana has a maximum snout-vent length (SVL) of 193 mm and a maximum weight of 207 g, whereas the Crested Iguana grows to 223 mm SVL and weighs as much as 404 g (Gibbons and

A Crested Iguana on Yadua Taba Island.

Watkins 1982). The two species do not co-occur on any island. Larger, probably more terrestrial species did occur in the recent past, but were eaten and exterminated by early human inhabitants in both Fiji (*Lapitiguana impensa*; Pregill and Worthy 2003) and Tonga (*Brachylophus gibbonsi*; Pregill and Steadman 2004).

The two extant species of *Brachylophus* are morphologically distinct. Based on allozyme genotypes, they show little genetic distance compared to other squamate species, but not when compared to other iguanians (Colgan and Da Costa 1997). Zug (1991) suggested that these two species might be the result of a Pleistocene speciation event in Fiji, possibly resulting from the ancestors of the Crested Iguana being isolated on the high, dry western islands of the Yasawas during an interglacial rise in sea levels. When sea levels later fell, the divergence was retained and reinforced, owing to the Crested Iguana's adaptation to drier island environments.

The Fiji Islands

About 360 islands with areas greater than 0.5 km^2 occur in Fiji, of which about a hundred are permanently inhabited. The two largest islands, Viti Levu and Vanua Levu, encompass 88% of the total land area of Fiji, and over 90% of the total Fijian population lives on these islands. The climate is tropical, with cyclonic storms and heavy rain occurring in the wet season (December–March) and the southeast trade winds influencing the dry season (May–October). High islands on the windward side of the Fiji island group invariably receive more rain than those on the leeward, western side. As in many countries in the Pacific, most of the land in Fiji today is communally owned by clans of indigenous people.

The large, high islands of Fiji reach over 1000 m above sea level, were emergent during the late Oligocene to middle Miocene and have been continuously above sea level for at least the last 16 million years (Chase 1971, Rodda 1994). Fiji has never been connected to a continental land mass. In the absence of any terrestrial mammals, several large flightless birds, giant amphibians, and an endemic crocodilian evolved. With the arrival of humans and commensal rodents about 3,500 years ago, many of these large endemic vertebrates disappeared (Worthy et al. 1999, Molnar et al. 2002).

The Pacific Banded Iguana

The Pacific Banded Iguana (*Brachylophus fasciatus*) is widely distributed in Fiji, occurs on four islands in Tonga (Gibbons and Watkins 1982), and a recently introduced population exists on the island of Efate in Vanuatu (Bauer 1988). The Tongan population appears to have been a late prehistoric human introduction from Fiji (<500 years ago), based on its total absence in the fossil record, where only the larger, extinct *Brachylophus gibbonsi* is found (Pregill and Steadman 2004). The Banded Iguana is listed by the World Conservation Union as endangered (IUCN 2003). Cahill (1970) reported that Banded Iguanas occurred on ten islands in Fiji, whereas Gibbons's 1981 distribution map suggests its presence on 24 Fijian islands, which increased to 31 islands on his most recent map (Gibbons 1985b). Many of these distribution records were based on verbal reports from students at the University of the South Pacific in Suva where Gibbons lectured, as well as from villagers and previous inhabitants from many of these islands. Gibbons suspected that many of these reports were based on old records or village folklore, and that the Banded Iguana might no longer exist on some of these islands (personal communication, 1985). Zug (1991) reported records for the Banded Iguana from 34 Fijian islands.

Banded Iguanas are slender and often brilliant emerald green in color. Adult males have two broad, pale transverse bands across the body and several more on the tail, whereas in females these bands are usually entirely missing or only barely visible. Today, the Banded Iguana appears restricted to islands with coastal and lowland forests, but historical evidence suggests

A gravid female Banded Iguana from the large inhabited island of Kadavu, where occasional sightings still occur.

that they once were also found throughout the highland rainforests on Fiji's largest islands (Gibbons 1984a, Williams 1858). The biological information available for this species is very scant, and is mostly inferred from captive studies. These lizards undoubtedly are mostly herbivorous, eating a selection of young leaves, flowers, and fruits from a wide range of plant species. In captivity, they also will eat insects, and some authorities have suggested that this species may be more insectivorous than the larger Crested Iguana (Gibbons and Watkins 1982).

Captive studies in Fiji suggest that Banded Iguanas lay eggs in the mid-wet season, from January to March (Gibbons and Watkins 1982). However, a wild-caught female that I examined on the island of Kadavu in mid-September 1989 was heavily gravid with shelled eggs. More likely, multiple clutches are produced in years of abundant food (as in captivity), and egg laying may occur at any time during the warmer months of October to March. In captivity, two to eight eggs have been recorded in a clutch. The incubation period is between 125 and 184 days, depending on temperature (Cogger 1974, Arnett 1979).

Only one population of Banded Iguanas has been surveyed to date. Two small, uninhabited limestone islands in the Lau group of Eastern Fiji, close to the large island of Lakeba, support a total population of 6000–8000 iguanas (Harlow 2003). The survival of this population may be because the remote and mostly inaccessible Aiwa Islands have remained free of introduced predators, invasive plants, and forest fires.

The Fijian Crested Iguana

The Fijian Crested Iguana (*Brachylophus vitiensis*) was first brought to the attention of the herpetological world in 1981, when John Gibbons recognized this species as being very different from the smaller Pacific Banded Iguana (Gibbons 1981). Its presence had long been known to the local Fijians, and the *Saumuri* (Crested Iguana) is well represented in legends, stories, and village folklore on the islands where it occurs (A. Biciloa, personal communication). Despite its relatively recent scientific discovery, today we know far more about the abundance, distribution, and biology of the Crested Iguana than we do about the Banded Iguana.

A Monuriki Crested Iguana with a temporary marking to avoid double-counting during a population census.

Yadua Taba Island photographed from Yadua island in 1979. The patches of grassland seen in this photo are now mostly covered by regenerating forest. *Photograph by John Gibbons.*

Crested Iguanas are more robust than Banded Iguanas and are easily distinguished by a high crest of enlarged middorsal scales from the nape to the base of the tail. Ground color in both males and females is green, with black-edged, narrow white transverse bands along the body and tail. Like the Banded Iguana, the Crested Iguana can change its background color from various shades of green to almost black in a matter of minutes. In captivity, the Crested Iguana can produce multiple clutches in a single season (Boylan 1989). Clutch size varies from two to seven eggs, with an average of four (Bach 1998). On the Crested Iguana Sanctuary island of Yadua Taba (pronounced *Yandua Tamba* in Fijian), lizards apparently lay only a single clutch each year in the mid-wet season (February to March), with the first hatchlings appearing at the end of October (personal observation). This suggests an incubation period of seven to eight months in the field, exceptionally long for any lizard. In captivity, incubation periods have ranged from 4 1/2 months (Boylan 1989) to 9 1/2 months (Bach 1998).

At the time of its discovery by Gibbons on the island of Yadua Taba in January 1979, most biologists doubted that the species existed anywhere else. Yadua Taba is a remote, uninhabited, 70-hectare island lying 120 m off the larger inhabited island of Yadua (1360 ha). Yadua Taba is rocky, mostly forested, about 1.2 km long, 500 m wide at its widest point, and reaches over 100 m in elevation.

A party searching for an idyllic island on which to film the original 1949 *Blue Lagoon* movie (staring Jean Simmons) briefly visited Yadua Taba in 1947. Although the island was not chosen for the film, Fijian resident Mr. A. C. Read collected an iguana on Yadua Taba. That individual appeared to be different than the Banded Iguana with which he was familiar, and he presented it to the Fiji Museum in Suva (Boylan, personal communication). The specimen was presumably preserved and added to the museum's reptile collection, but no locality data were recorded. This was 32 years before John Gibbons visited Yadua Taba and recognized the Crested Iguana as a distinct species.

In her 1970 Fiji Museum booklet on the Banded Iguana (the only Fijian species known at that time), Cynthia Cahill

referred to this specimen: "An old preserved specimen in the Fiji Museum certainly appears to be much more solidly built with a much larger crest than any of the present day specimens collected." The 1947 Crested Iguana is undoubtedly the paratype in the description of the species by Gibbons (1981), and referred to as "Fiji Museum (no number), one adult male, but no collection data."

Although only known from the island of Yadua Taba at the time, in August 1979, a Crested Iguana made a brief cameo appearance in the remake of the movie *Blue Lagoon* (starring Brooke Shields), which was filmed on the tourist resort island of Nanuya Levu in the Yasawa group, an arc of islands northwest of the largest Fijian island, Viti Levu, and about 90 km west of Yadua Taba. On becoming aware of this, John Gibbons traveled to the Yasawas and also visited the more southerly Mamanuca group of islands in search of Crested Iguanas — and confirmed that the species did occur on several islands within these groups (Gibbons 1984a, 1984b, 1985a, 1985b). He reported that the Crested Iguana was found on at least eight islands, but most of these records seemingly were based on verbal reports from villagers. He saw iguanas only on two islands: Matacawa Levu in the Yasawas and Monuriki in the Mamanucas. Tragically, John Gibbons, his wife Lily, and their two children drowned in a boating accident in Fiji in November 1986, and his notebooks and unpublished records were later destroyed.

In September 2000, I set out with a team of volunteers, staff, and students from the University of the South Pacific in Suva to verify these earlier distribution records of Gibbons and to investigate other potential islands where Crested Iguanas may still occur in the Yasawa and Mamanuca island groups. We surveyed eleven uninhabited and six inhabited islands for Crested Iguanas. All of these islands have large numbers of free-ranging domestic goats, and forest fires have occurred repeatedly on most of them over the last few decades. Our iguana survey transects were purposely placed through areas within beach forest remnants that had the maximum number and diversity of tree species known to be used by iguanas for food. Night searches for sleeping iguanas along a total of 11.2 km of beach forest transects were biased toward maximizing our chances of locating iguanas and were not designed to estimate average abundance. Groups of team members intensively searched the forest along each transect and collectively searched for over 123 hours at an average search rate of six meters per minute.

Our results suggest that Crested Iguanas are extremely rare or extinct on all of these islands. We found iguanas on only four of the 17 islands surveyed: three small, uninhabited islands (Devuilau, 0.23 km^2; Monu. 0.73 km^2; and Monuriki, 0.40 km^2) and a single large inhabited island (Waya, 22.0 km^2). We saw a total of six live iguanas on these four islands, plus one juvenile iguana that had been killed and partly eaten on Devuilau Island. Although the introduced mongoose does not occur on any island in the Yasawas and Mamanucas, feral cats are found on all inhabited islands, were seen on one uninhabited island, and probably exist on many of the other uninhabited islands we surveyed.

On many of the islands that we surveyed, beach forest remnants are restricted to steep valleys and along rocky ephemeral watercourses. The major part of these islands is covered by open grasslands or impenetrable thickets of Vai Vai (*Leucaena leucocephala*), a small exotic tree introduced for goat food, but not eaten by iguanas. We selected ten islands for forest vegetation surveys, and found great inter-island differences in the density and diversity of Crested Iguana food trees. All of the islands that we surveyed had goats, and islands with evidence of regular forest fires were typically dominated by only three or four non-edible (to goats and iguanas) tree species. Other islands, which showed little or no evidence of forest fires, show greater tree species diversity, and several support abundant iguana food trees (e.g., Tavewa and Devuilau). On these islands, Crested Iguanas either were not recorded or were found in very low numbers, even though food does not appear to be a limiting factor. We suspect feral cats to be the major reason for the small number of iguanas seen on these islands.

The September 2000 iguana surveys found that the Crested Iguana Sanctuary of Yadua Taba held larger Crested Iguana population densities than any other surveyed island. Even considering that our transects were placed in optimal habitats and were thus biased toward finding iguanas, none of the four islands where we recorded iguanas had population densities greater than about two iguanas per hectare in the best available forest habitat (i.e., along watercourses). Average population densities over the entire forest remnant were much lower.

Pita Biciloa with a Crested Iguana captured on Monuriki island.

A pair of Crested Iguanas on Yadua Taba Island sleeping in a *Diospyros phlebodes* tree, a favorite food species.

Although Fijian villagers in the Yasawa and Mamanuca islands told us that Crested Iguanas are still occasionally encountered on several inhabited islands where large beach forest remnants remain (Nacula, Matacawa Levu, and Naviti), these populations are unlikely to survive in the long term because of the presence of feral cats and continuing forest habitat degradation. Most of the smaller inhabited islands in these groups have little or no remaining beach forests, and the inhabitants have no living memory of Crested Iguanas being present (e.g., Yanuca, Tavua, and Tokoriki).

The importance of the Crested Iguana Sanctuary island of Yadua Taba for the long-term conservation of the Fijian Crested Iguana is obvious, and the resources of the International Conservation Fund for the Fijian Crested Iguana are increasingly being directed to the upkeep of the Crested Iguana Sanctuary (see below). In 1980, Yadua Taba was declared a wildlife sanctuary, an attempt was made to remove the free-ranging domestic goats (which belonged to the villagers on Yadua), and an honorary ranger was appointed. Initially, Gibbons (1984a) estimated the size of the total population of Crested Iguanas on Yadua Taba at 100–200 adults. Mark-recapture and mark-resighting surveys subsequently provided more accurate populations estimates for Yadua Taba. Cogger and Sadlier (1986) estimated a total population of 2,000–5,000, whereas Laurie et al. (1987) estimated a population size of 4,000–8,300. More recently, Harlow and Biciloa (2001) used line-transect surveys and estimated a total population size of 4,800–7,900 iguanas. About 25 ha of Yadua Taba are covered by beach forest habitat, in which Crested Iguanas occur in remarkable densities approaching 200/ha. Nighttime surveys of sleeping iguanas in this forest recorded an average of one iguana every five meters of transect searched (Harlow and Biciloa 2001).

The Future of Fijian Iguanas

Since European contact, Fiji has undergone massive environmental degradation, which has accelerated in the last few decades. The Indian Mongoose (*Herpestes auropunctatus*) was introduced in 1883 to the two largest islands, and the disappearance or extreme rarity of ground-nesting birds, large diurnal skinks, and Banded Iguanas was noted almost immediately (Pernetta and Watling 1978). Cats were introduced even earlier and are assumed to be responsible for the extinction or rarity of these same species on mongoose-free islands (Gibbons 1984). All inhabited islands have feral cats and, as Fijians occasionally dump unwanted kittens onto uninhabited islands to "keep the rats down," probably many uninhabited islands also have cats (personal observation).

In the 1970s and 1980s, a rapid increase in the value of goats meant that grazing uninhabited islands became a simple and lucrative farming technique. The typical regime of overstocking, often combined with regular dry season burning, has destroyed much of the native vegetation and caused catastrophic soil erosion on many islands. Selective grazing by goats on the seedlings of palatable tree species has resulted in the proliferation of unpalatable native species, as well as of invasive exotic species inedible to iguanas (Harlow and Biciloa 2001).

In Fiji, both species of Pacific iguanas can only be seen in captivity at Kula Eco Park near Sigatoka, on the South coast of the main island of Viti Levu. Although apparently widely distributed, even adventurous visitors to Fiji are unlikely to see an iguana of either species in the wild today, except on the sanctuary island of Yadua Taba. More likely, the visitor to an outer island who asks about iguanas will be told that one was seen a few months ago, or may be taken to a house where a pet iguana is tethered by string to a bush, or is living (temporarily) in a village Hibiscus or Tahitian Chestnut (*Inocarpus fagifer*) tree. Iguanas are rarely seen, often killed on sight, or occasionally captured and taken home as pets. On most inhabited islands where iguanas are found, encounters are such unusual occurrences that people will long remember the incident and its location, although not necessarily the year. Eighty-year-old men will tell a story about an unlikely incident with a *Vokai* or *Saumuri* (iguana), but after many bowls of kava (the popular and slightly analgesic Pacific drink) may admit it actually happened to their father or grandfather.

The fact that occasional sightings of iguanas still occur on many islands is reassuring. Both species of *Brachylophus* are arboreal and superbly camouflaged. As Fijians rarely venture into the forest at night (by far the best time to find iguanas), the rarity of encounters is not surprising. Arthur Loveridge's (1945; see introduction) suggestion that Banded Iguanas were rare and heading toward extinction in 1945 has seemingly not yet occurred. Whether the occasional sightings of *Brachylophus* today are indicative of low but stable population densities or represent populations that are slowly declining towards extinction is an unanswered question. If the latter is true, then the long-term conservation of Fijian iguanas will ultimately depend on having several well-protected populations of each species on small, uninhabited islands free of introduced predators and goats.

International Conservation Fund for the Fijian Crested Iguana (ICFFCI) (www.icffci.com)

The Fijian Crested Iguana is listed by the IUCN as Critically Endangered (IUCN 2003). Because recent surveys have confirmed that only one viable population of this species remains, international support is necessary to maintain the Crested Iguana Sanctuary island of Yadua Taba. Yadua Taba was declared Fiji's first wildlife reserve in 1980, but legal protection for the island was not assured until recently, when a 33-year lease was signed with the traditional owners.

The author on Yadua Taba with Crested Iguanas bagged for fecal collection as part of a dietary study. *Photograph by Pita Biciloa.*

ICFFCI was established in 1999 by a Memorandum of Agreement between the government department in charge of protection and conservation of Fiji's natural resources, The National Trust of the Fiji Islands, and the two recognized centers for the captive breeding of the Fijian Crested Iguana (Kula Eco Park in Sigatoka, Fiji, and Taronga Zoo in Sydney, Australia). The urgent need for this international conservation fund was perceived and its creation accomplished primarily by Carol Bach (Taronga Zoo) and Philip Felsted (Kula Eco Park). The objectives of the fund are to: Develop through education and public awareness programs a better understanding and appreciation of the Fijian Crested Iguana and its habitat; assist in the conservation of existing wild Fijian Crested Iguana populations and their natural habitat; and create, manage, fund, and maintain one or more new Crested Iguana sanctuaries in the Republic of Fiji.

In the five years since its creation, ICFFCI has organized and funded two major projects. An endangered species education program in Fiji featured the Crested Iguana and was delivered in areas where critical habitat exists. All parties to the agreement developed programs directed at school children and successfully brought the Crested Iguana conservation message to many people via television, radio, magazine, and newspaper coverage within and outside Fiji. Probably the most important result was the awareness that this program created among government officials in Fiji, who became instrumental in negotiating and funding the lease for Yadua Taba, despite politically difficult times. Because the proceeds of the lease for Yadua Taba do not benefit the nearby villagers on Yadua (who are not the traditional owners), a goodwill payment was made to the village school. A series of gifts to the village recognized the important role it plays in supporting the sanctuary. Since 2001, the Yadua school children have had an annual educational fieldtrip to the Yadua Taba Crested Iguana Sanctuary with a guided tour by the ranger. For many of these children, this was their first visit to the sanctuary island and their first view of a Crested Iguana, despite the fact that the village is only four kilometers away.

Conservation efforts continue to concentrate on the needs of the Crested Iguana Sanctuary on Yadua Taba. The sanctuary ranger, Pita Biciloa, Fiji's only wildlife ranger, visited Sydney in November 2000 for a two-week training program with local National Parks and Wildlife Service staff and vegetation regeneration specialists. In a joint funding arrangement with the National Trust of Fiji Islands, the fund paid for half of a new 28-foot sanctuary patrol boat and outboard motor.

Funding for these projects came from a variety of sources. Special recognition should go to the major sponsors, Bradley Trevor Greive and The Taronga Foundation, John Binns, Yamaha Motors of Australia, RandomBase Consulting, and the Australian Society of Zoo Keepers. The sale of Crested Iguana T-shirts, individual cash donations, and public donations of equipment and supplies all helped significantly. The immense time and effort contributed by volunteers and the staff of the parties to this agreement are priceless. Much more work needs to be done to guarantee the future of the spectacular and unique Fijian Crested Iguana, including the establishment of additional sanctuaries. The web page at www.icffci.com will contain further information and updates.

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Author Biography

Peter Harlow has worked as a researcher on the ecology and biology of a wide range of reptiles, including crocodilians, lizards, snakes, and turtles, for over 20 years. While the majority of this work has been concentrated on Australian species, other projects have included the biology of reptiles used in the commercial skin industry in Indonesia, the ecology of southern African snakes, and population surveys and conservation biology of Pacific iguanas. He completed his Ph.D. on the ecology of sex-determining mechanisms in Australian agamid lizards, investigating why egg incubation temperatures determine hatchling sex in some agamid species, when other, often closely related species, use genetic sex determination. At present, he is the manager of the Herpetofauna Division at the Taronga Zoo in Sydney, Australia.

Adult male Utila Iguana (*Ctenosaura bakeri*) relying on crypsis against a dead tree trunk in the mangrove swamps of Utila. *Photograph by John Binns.*

Conservation Status of Spiny-tailed Iguanas (Genus *Ctenosaura*), with Special Emphasis on the Utila Iguana (*C. bakeri*)

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Photographs by the author.

Abstract.—None of the species in the genus *Ctenosaura* are currently listed under the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). Despite their protected status by national law in México and most Central American countries, living specimens and eggs of the large species (e.g., *C. acanthura*, *C. pectinata*, and *C. similis*) can be found in markets or offered for sale along major roads by local people. An increasing threat to some of the smaller species is the international pet trade. Species of *Ctenosaura* with small geographic distributions are particularly vulnerable to these pressures, considerably more than their widely distributed congeners. The Utila Iguana (*Ctenosaura bakeri*), for example, is an endangered species endemic to Isla de Utila, which is located off the Caribbean coast of Honduras. To preserve the Utila Iguana in its natural environment, the "Conservation Project Utila Iguana" was founded in 1994. The main activities of the project include a broad education and information program for the local community, investigations into the biology of the species, a headstart program, and the protection of iguana habitat.

Key Words: Spiny-tailed Iguanas, *Ctenosaura bakeri*, México, Central America, Utila Island, Conservation

Introduction

Ctenosaura, commonly known as Spiny-tailed Iguanas, is a genus of Neotropical lizards in the family Iguanidae (Frost and Etheridge 1989), which corresponds to the iguanines of Etheridge and de Queiroz (1988). *Ctenosaura* includes 17 valid species that are distributed from southeastern Baja California and Sonora in western México and from Tamaulipas in eastern México southward along both the Pacific and Caribbean versants through most of Central America to central Panamá (Buckley and Axtell 1997, Grismer 1999, Köhler et al. 2000): *Ctenosaura acanthura* (Shaw), *C. alfredschmidti* Köhler, *C. bakeri* Stejneger, *C. clarki* Bailey, *C. conspicuosa* Dickerson, *C. defensor* (Cope), *C. flavidorsalis* Köhler and Klemmer, *C. hemilopha* (Cope), *C. macrolopha* Smith, *C. melanosterna* Buckley and Axtell, *C. nolascensis* Smith, *C. oaxacana* Köhler and Hasbun, *C. oedirhina* de Queiroz, *C. palearis* Stejneger, *C. pectinata* (Wiegmann), *C. quinquecarinata* (Gray), and *C. similis* (Gray), as well as at least one undescribed species in the *C. quinquecarinata-flavidorsalis* complex (Köhler and Hasbun 2001; Hasbun and Köhler, unpublished data).

Most ctenosaurs inhabit arid and subhumid areas in open habitats such as dry forests and savannas. In the humid Caribbean lowlands, *Ctenosaura* is relatively scarce and localized in dry and open habitats. One species, the Honduran endemic, *C. bakeri,* is exceptional because it lives exclusively in humid mangrove forests (Köhler 1995). Ctenosaurs feed mostly on plant matter, including leaves, flowers, and fruits. However, juveniles and, to varying degrees, adults also consume a variety of invertebrates (mostly insects, crabs, and spiders) and vertebrates (e.g., smaller lizards). All species reproduce oviparously with a single clutch per year (Wiewandt 1982). However, ctenosaurs in captivity have been observed producing two clutches 2–3 months apart (personal observation for *C. bakeri*). Whether multiple clutches per season ever occur in the wild remains unknown. Clutch size differs significantly between species: 2–4 eggs in *C. defensor*; 5–15 in *C. bakeri, C. clarki, C. flavidorsalis,* and *C. quinquecarinata*; 11–33 in *C. melanosterna*; and usually 30–50, exceptionally to 88 eggs, in large species such as *C. pectinata* and *C. similis* (Köhler 1996, 1997, 1998a). Duration of egg incubation varies little across species, usually taking around 90 days at a temperature of 29–31 °C (Köhler 1997, 1998a).

Conservation Status of Ctenosaura

No species in the genus *Ctenosaura* is currently listed under the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). In México, only four species (*C. acanthura, C. hemilopha, C. pectinata,* and *C. similis*) are listed in the NOM-ECOL-059-94, first published in the Diario Oficial de la Federacion on 16 May 1994. In this document, *C. similis* and *C. pectinata* are listed as "amenazada" (threatened),

Adult male *Ctenosaura pectinata* from Oaxaca, México.

Adult female *Ctenosaura pectinata* from Oaxaca, México.

whereas *C. acanthura* and *C. hemilopha* are listed as "sujeta a proteccion especial" (with special protection) (Victor Hugo Reynoso, personal communication). None of the other Mexican species of *Ctenosaura* are listed.

Meat and eggs of most *Ctenosaura* are consumed by local people throughout the Mesoamerican range of the genus (Fitch and Henderson 1977, 1978). Despite being protected by national law in most Central American countries, living specimens and eggs of the large species (*C. acanthura, C. pectinata,* and *C. similis*) can still be found in markets or offered by local people for sale along major roads (unpublished observations for Nicaragua, Honduras, El Salvador, and México, 1994–2001). Iguana hunters still commonly sew the animals' mouths closed and pull out tendons to tie the legs together.

Some of the smaller species, such as *C. quinquecarinata* and *C. defensor*, are considered to have medicinal properties if consumed. In northern Nicaragua, local people believe *C. quinquecarinata* to be venomous. As a result, they try to eliminate this lizard whenever it is encountered. For example, they use small rocks to block the entrance to *C. quinquecarinata* retreats in hollow fence posts, making it impossible for the animal to leave. This usually leads to the death of the trapped iguana, evidenced by piles of bones in blocked hollow posts (Hasbun and Köhler, personal observations).

An increasing threat to some of the smaller species (especially *C. quinquecarinata*) is the international pet trade. We found evidence of commercial hunting of this species in Nicaragua. Even protected species endemic to countries that do not allow ctenosaurs to be exported for the pet trade (e.g., *C. defensor* from the Yucatán Peninsula, México) show up in international trade due to smuggling. In August 2000, ten living *C. defensor* were confiscated at the Frankfurt airport by German customs agents. A Mexican citizen had illegally shipped the animals hidden in a wooden pyramid addressed to a German citizen. According to a written document found within the pyramid, similar illegal transactions had occurred before this shipment was confiscated (R. Simon, German Custom Investigation Service, Frankfurt Branch, Wildlife Prime Unit, personal communication).

Species of *Ctenosaura* with small geographic distributions are more vulnerable to the pressures mentioned above than their more widely distributed congeners. In light of this, the insular forms deserve special attention. Off the northern coast of Honduras in the Caribbean Sea is an island chain known as the Bay Islands. The smallest and most westerly of these islands is Utila, with an area of 41 km^2. Despite its small size, Utila supports an impressive endemic ctenosaur, *C. bakeri*. Although four juveniles of *C. bakeri* were collected in the late 1960s, the adults were unknown to science until the early 1990s (de Queiroz 1990). In 1994, *C. bakeri* was rediscovered during an expedition to Utila by the Senckenberg Museum (Köhler 1995). Subsequent research revealed that this species is threatened with extinction as a result of intensive hunting pressure by the local community.

The Utila Iguana (*Ctenosaura bakeri*)

Ctenosaura bakeri inhabits mangrove swamps on Utila, which cover approximately 6 km^2 (14%) of the island. Temperatures during the day range from 30–35 °C and nighttime temperatures vary from 25–27 °C. Relative humidity ranges from 70–80% during the day to 95–100% at night. Males reach a total length of 80 cm (maximum recorded snout-vent length = 31 cm; maximum recorded weight = 900 g); females are about 30% smaller. Given that *C. bakeri* prefers hollow branches and trees as retreats, the few remaining old mangrove stands on Utila with hollow branches and dead upstanding trunks provide the most important habitat for iguanas on the island. The diet of *C. bakeri* consists primarily of mangrove leaves, buds, and flowers (Black Mangrove preferred), but also includes insects and crabs (mostly Fiddler Crabs).

The breeding season for *C. bakeri* begins at the end of the rainy season. Copulation has been observed between mid-January and mid-March. During the nesting season (mid-March through late April), females migrate from mangrove to sandy coastal regions, covering distances up to a kilometer. The females spend several days digging before they complete their nest burrows. Burrows are composed of a tunnel approximately 40–60 cm long, reaching a depth of 25–40 cm, and ending in a nest chamber with a diameter of 12–15 cm. Females lay from 5–19 eggs before backfilling the hole and leaving an air space over the clutch. After egg deposition, females promptly return to the mangrove swamp. The eggs incubate at a temperature of 30–31 °C, and juveniles hatch after approximately three months. In contrast to the adults, young *C. bakeri* are usually observed on dead wood near the ground. With the onset of the rainy season, they start climbing higher in the vegetation. The uniform gray-brown coloration of the juveniles is remarkable for the genus, as juveniles of other *Ctenosaura* species exhibit either brown and green markings (*C. palearis, C. quinquecarinata*) or are almost entirely green (*C. acanthura, C. hemilopha, C. pectinata,* and *C. similis*). The absence of green coloration in juvenile *C. bakeri* is probably related to their preferred habitat. The young of this species are ground dwellers who inhabit the edges of mangrove swamps, where their gray-brown coloration provides excellent camouflage. Together with fallen trees, the abundant aerial roots of mangroves provide important hiding places for the juveniles (Köhler 1995).

An adult male *Ctenosaura similis* is about to be caught with a noose; Yoro, Honduras.

Bound *Ctenosaura pectinata* in a market in Tehuantepec, Oaxaca, México.

Conservation Project Utila Iguana

To preserve *C. bakeri* in its natural environment on Utila, I founded the "Conservation Project Utila Iguana" in 1994 in cooperation with the Honduran Nature Conservation Office (AFE-COHDEFOR) and German and international organizations. Since 1997, this project has been a joint project of the Zoological Society Frankfurt (ZGF) and the Senckenberg Nature Research Society (SNG), Frankfurt. The primary goals of the project are to: (1) develop a broad education and information program for the local community, (2) investigate the natural history and reproductive ecology of *C. bakeri*, (3) begin a headstart program, and (4) protect iguana habitat on Utila. In addition, a survey of the herpetofauna of Utila resulted in many new records for amphibians and reptiles on the island, as well as the discovery of two undescribed species of endemic anoles (Köhler 1998b).

With funding from the ZGF, the project's Iguana Research and Breeding Station was constructed and officially put into operation on 25 April 1998. The Station makes effective and continuous work possible, serves as a base for scientists and conservationists, and has become an important center for environmental awareness and education on Utila. In 1999, a headstart program was initiated with encouraging results. Our strategy is to capture gravid females on nesting beaches and to move them to enclosures equipped for nesting where they can deposit their eggs in a safe environment. When egg laying is complete, the iguanas are released at their site of capture. The spent females swiftly return to the protection of the mangrove swamps, where, without their eggs, they are of little interest to poachers. Using this strategy, we are able to improve the likelihood that these particular animals will survive the current nesting season and reproduce again the following year. The eggs are then artificially incubated in vermiculite at 28–32 °C. Half of the hatchlings are released into the mangrove swamp immediately after hatching, while the remainder is raised for 12 months to help surpass the period of maximum vulnerability to predators.

The Visitor Center on the ground floor of the Station offers an attractive presentation of information about the Utila Iguana, as well as other aspects of Utilan flora and fauna, to both Utilians and tourists. Informing the local people of the threats to their unique iguana is vital to the long-term success of the project. The people of Utila must become aware that this creature will disappear forever unless protective measures are implemented. This presents a challenge, particularly given that the islanders widely believe that replacement iguanas can be brought in from the mainland if those on the island should die out. Only through continuing education will local people become convinced that the Utila Iguana exists nowhere else in the world.

Raising environmental awareness in children is of particular importance to the project. Since 1994, we have visited the schools of Utila numerous times each year to work with teachers and pupils regarding nature and species conservation on Utila. Integrative tasks have been carried out with the students in addition to slide shows.

Subadult male *Ctenosaura flavidorsalis* from La Paz, Honduras.

Once the Station opened, groups of schoolchildren could visit and learn through public exhibits about the flora and fauna of Utila and their endangered status. The problem of waste disposal on Utila is also being addressed within the framework of the education program.

Given that hunting and habitat destruction still occur, a nature sanctuary will also be needed. Although the activities of the project have been important and positive steps, iguana hunting has yet to be significantly reduced. While legislation exists to protect the Utila Iguana, hunters are not actively deterred and hunting continues daily. We commonly observed hunters with three to eight adult iguana carcasses in their bags. During the egg-laying season, hunters not only kill gravid females, but also plow through beach sand to find iguana eggs.

Most recently, the Utila Iguana has become threatened by destruction of its habitat. A large-scale international airport has been opened on Utila, part of a rapid and extensive development program that neglects to take ecological considerations into account. Several new resorts and hotels are being built, as well as a four-lane highway from the airport to the town. On the north side of the island, where the most important iguana nesting sites are located, beach areas have been "cleaned" by burning and divided into marketable lots. Once the beach areas have been sold, the mangrove swamps will also be cleared and filled with coral debris and garbage, similar to past activity on the southern part of the island. Pristine sections of beach are crucial egg-laying habitat for female Utila Iguanas. Without these nesting areas, the Utila Iguana population will quickly decline as development eradicates their nesting sites. Because these iguanas have no other suitable place to lay their eggs, they will inevitably begin their journey into extinction.

If conservation areas of considerable size cannot be established in the face of this development, the future of Utilan animals and plants is not optimistic. Based on our field research and because of their outstanding ecological value, the regions of Iron Bound and eastern Rock Harbor would provide the most suitable core zone for a planned nature sanctuary. This core zone contains rocky coast, beach (behind the rocky belt), Caribbean dry forest, seasonal rain forest, and mangrove swamps. In this area, we have been able to record all vertebrate species identified on Utila to date (including the three endemic lizards), as well as the three species of mangroves. In no other location on the island are these five habitats found in such close proximity. The connecting corridor to the Turtle Harbor Reserve would protect other ecologically valuable and beautiful habitat, including the oldest Red Mangrove forest, the mangrove area with the highest density of epiphytes on the island, and extensive areas of wet savanna. Most of the total area comprising the planned nature sanctuary (the wetlands, mangrove, and wet savanna) is owned by the community of Utila, and chances are good that protection of this area can be negotiated. On the other hand, all of the beach areas and the Caribbean dry forest along the coast are privately owned and would need to be purchased to safeguard them from development.

Aside from its ecological and conservation benefits, the creation of a nature sanctuary on Utila, if properly managed, would provide the island with another tourist attraction. Through the use of nature trails and guided tours in protected areas, visitors could be given the opportunity to discover and observe a diversity of unique reptiles and other animals in their natural environment. Most tourism on Utila today is based on diving. By persuading tourists to spend more time on the island, the nature reserve would have a positive economic impact for the Utilan community, as well as for Honduras as a whole. Simultaneously, it would significantly enhance the long-term prospects for conservation of the biodiversity of Utila.

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Adult male *Ctenosaura bakeri* from Utila, Honduras.

Environmental education: School children participating in a workshop at the Iguana Station on Utila.

Frankfurt a. M., and the Senckenberg Nature Research Society (SNG), Frankfurt a. M. Thanks are especially due to the many volunteers who have done a wonderful job on Utila over the years. I would particularly like to express my gratitude to John Binns, Lutz Dirksen, Karoline Franz, Karsten Gees, Sven Knapinski, AJ Gutman, Alexander Gutsche, Lori King, and Sven Zoerner for the important work they are doing on behalf of the Utila Iguana. Without their help the Conservation Project Utila Iguana could never have taken place in its present form.

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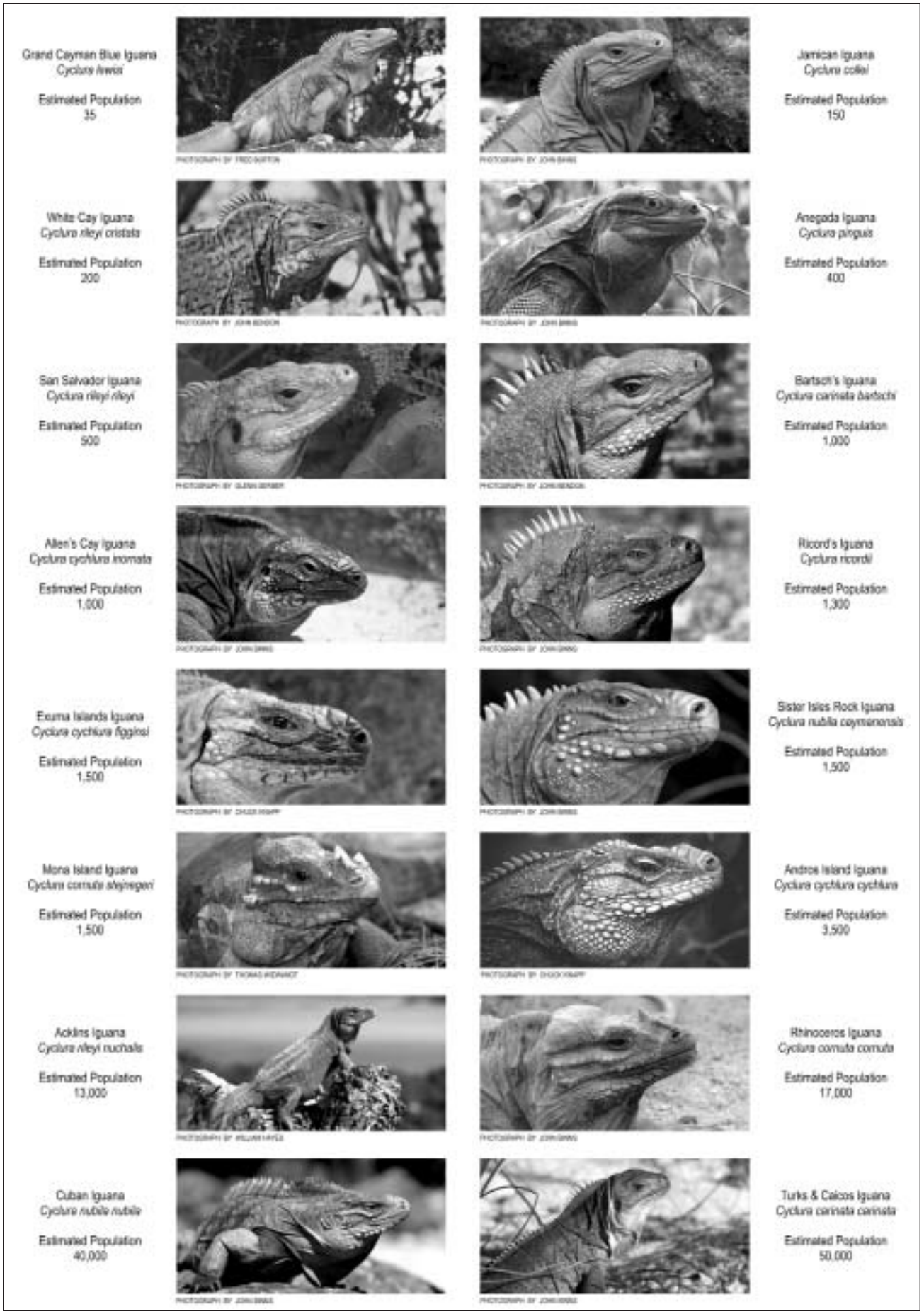

Estimated population sizes of wild Rock Iguana (*Cyclura*) populations. *Based on a graphic by John Binns.*

Conservation Strategies for West Indian Rock Iguanas (Genus *Cyclura*): Current Efforts and Future Directions

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Abstract.—As a result of habitat loss and the negative impact of introduced mammalian predators and competitors, West Indian Rock Iguanas (genus *Cyclura*) are among the most endangered lizards in the world. Because they are important seed dispersers for native plants, their loss has serious ecological consequences for dry tropical forest and scrub habitats. Six of the nine species of Rock Iguanas are considered critically endangered by the IUCN (the World Conservation Union), with *C. collei* and *C. pinguis* numbering only a few hundred individuals in the wild and *C. lewisi* fewer than 25 individuals. Conservation recommendations include further research to better understand population dynamics and ecological requirements, establishment of new protected areas and stronger enforcement within existing ones, control programs for introduced species, captive breeding and headstarting where appropriate, and public education at the local, national, and international levels.

Key Words: *Cyclura*, Rock Iguana, Conservation, West Indies, Introduced Species, Habitat Destruction

Introduction

As a result of prolonged geographical isolation, native mammalian species in the West Indies are few and consist mainly of bats and rodents. Birds, reptiles, and amphibians have undergone significant radiations and comprise the majority of the vertebrate biodiversity in the region. Most of the large islands are densely populated by people and suffer from the devastating effects of environmental degradation and introduced species (Case and Bolger 1991). As a result, a significant number of taxa, including many endemics, have disappeared or are on the brink of extinction.

West Indian Rock Iguanas (genus *Cyclura*) are among the largest and most impressive members of the family Iguanidae, yet they are also the rarest. All *Cyclura* taxa are currently protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Six of the nine species are considered to be critically endangered by the World Conservation Union (Hilton-Taylor 2000). Although exploitation of West Indian Rock Iguanas began long ago by native peoples, not until the arrival of Europeans did Rock Iguana populations begin their precipitous decline. In addition to the habitat loss and degradation that inevitably result from large-scale human settlement, the commensal species that accompanied human immigrants to the islands have had a devastating impact on iguanas and their ecosystems. Dogs, cats, pigs, and rats prey on iguanas and their eggs, while goats, sheep, cattle, and other livestock trample nest sites and degrade the unique plant communities on which iguanas and other native species depend. The introduction of the mongoose (*Herpestes javanicus*) in a futile attempt to control rats has instead resulted in heavy predation on many native reptilian species, including juvenile iguanas (Nellis and Everard 1983, Wilson et al. 2004).

West Indian Rock Iguanas inhabit dry subtropical thorn forest regions throughout the Greater Antilles and the Bahamas. Rock Iguanas are primarily terrestrial, depending heavily on the presence of rocky crevices to serve as retreats, and require sandy areas with appropriate soil conditions in which to lay their eggs. Most species live for multiple decades and may take several years to reach sexual maturity. Social organization ranges from systems in which adult males are highly aggressive and territorial, to large groups that appear to coexist peacefully (Martins and Lamont

Radiotelemetry has proven critical to understanding movement patterns and nesting ecology of Jamaican Iguanas (*Cyclura collei*) in the wild. *Photograph by Rick Hudson.*

1998). Mating is seasonal, with a single clutch per year usually laid in May or June. Raptors, cuckoos, herons, osprey, racers, and boas are the main natural predators of West Indian iguanas, usually only of juveniles (Alberts 2000a).

West Indian Rock Iguanas are almost exclusively herbivorous, consuming a wide variety of leaves, fruits, and flowers. The Turks and Caicos Iguana (*C. carinata carinata*) is known to feed on at least 58 plant species (Iverson 1979, Auffenberg 1982), the Cuban Iguana (*C. nubila nubila*) on 25 species (Perera 1985), the Grand Cayman Blue Iguana (*C. lewisi*) on 45 species (Burton and Gould, unpublished data), the Sister Isles Rock Iguana (*C. nubila caymanensis*) on over 40 species (G. Gerber, unpublished data), and the Mona Island Iguana (*C. cornuta stejnegeri*) on 71 species (Wiewandt 1977). Because digestion of plant foods is incomplete, seeds generally pass through the digestive tract intact (Iverson 1985). Hartley et al. (2000) dissected seeds from iguana scat collected in the Dominican Republic and compared their germination rates to seeds collected from beneath parent plants. They found that seeds that had passed through the digestive tracts of iguanas germinated more rapidly than seeds that had not, indicating that iguanas may provide significant benefits to native plants, particularly in xeric habitats with sporadic rainfall.

The Turks & Caicos Iguana, *Cyclura carinata carinata*, is one of six species of Rock Iguanas ranked as "Critically Endangered" on the IUCN Red List. As a result of the spread of invasive mammals, this species now occupies less than 10% of its historic range. *Photograph by Glenn Gerber.*

To test whether iguanas otherwise enhance plant regeneration, we conducted an experiment at the San Diego Zoo using Cuban Iguana scat samples. Half of each scat sample was dissected and all seeds removed, while the remaining half was left intact. Both the dissected seeds and the seeds contained in intact scat were planted under identical conditions. While neither the time to germination nor the total number of seeds germinating differed between groups, growth rates of seedlings produced from seeds left in iguana scat were approximately twice those of seedlings originating from seeds dissected from iguana scat (Alberts 2000b). In addition, the repetitive cropping of vegetation by iguanas may encourage additional shoot and foliage

Social organization of Rock Iguanas ranges from highly territorial systems to large groups, such as these Exuma Islands Iguanas (*Cyclura cychlura figginsi*), which appear to coexist peacefully. *Photograph by Rick Hudson.*

The robust population of Cuban Iguanas (*Cyclura nubila*) at Guantanamo Bay has been the subject of many years of field research by biologists in the San Diego Zoo's Applied Conservation Division. *Photograph by John A. Phillips.*

Like other Rock Iguanas, Cuban Iguanas (*Cyclura nubila*) help maintain the health of native plant communities through enhanced seed dispersal, germination, and seedling growth. *Photograph by John A. Phillips.*

development (Knapp and Hudson 2004) and that movement patterns may enhance dispersal of seeds into new microhabitats (Iverson 1985).

Current Status

West Indian Rock Iguanas are among the most endangered lizards in the world, in large part because of their exclusively insular distribution. As a result of their low metabolic rates and naturally high population densities, lizards in many mainland habitats are relatively resistant to extinction. However, the restricted ranges and small population sizes of lizards on islands render them highly susceptible to a variety of human-mediated threats. Pressure to exploit undisturbed natural areas is particularly strong in the West Indies, where leaving land unutilized is often perceived as economically undesirable (Barzetti 1993). Recolonization following local extinction on islands is likely to be rare because West Indian Rock Iguanas, like most other terrestrial reptiles, are probably poor over-water dispersers (but see Censky et al. 1998).

According to the IUCN (Hilton-Taylor 2000), three taxa of West Indian Rock Iguanas are considered "Vulnerable," four "Endangered," and nine "Critically Endangered" (Table 1). Two taxa, the Turks and Caicos Iguana (*C. carinata carinata*) and the Cuban Iguana (*C. nubila nubila*), are still fairly numerous in the wild. However, both have been nearly extirpated on the larger, more populous islands within their ranges, and today are restricted primarily to smaller, uninhabited islets or cays. Although both still occur over a wide area, they are subject to a variety of human disturbances, including habitat loss and negative interactions with feral mammals. The Turks and Caicos Iguana population has been reduced to 10% of its former range. The Rhinoceros Iguana (*C. cornuta cornuta*) and the Andros Island Iguana (*C. cychlura cychlura*), both ranked as vulnerable, inhabit increasingly fragmented ranges and are threatened by invasive exotic species.

The Bahamas supports seven taxa of Rock Iguanas, more than any other nation. The majority of Bahamian Rock Iguanas are restricted to a limited number of small islands or cays, often no more than a few hectares in area. While populations are generally stable, many of these islands are heavily visited by tourists and instances of illegal smuggling have been reported in recent years. Although very small, the single population of Bartsch's

Table 1. Current conservation status of West Indian Rock Iguana species and subspecies.

Taxon	Range Countries	Estimated Wild Population Size	IUCN Threat Classification
Turks and Caicos Iguana *Cyclura carinata carinata*	Turks and Caicos Islands	50,000	Critically Endangered
Bartsch's Iguana *Cyclura carinata bartschi*	Bahamas	1,000	Critically Endangered
Jamaican Iguana *Cyclura collei*	Jamaica	150	Critically Endangered
Rhinoceros Iguana *Cyclura cornuta cornuta*	Dominican Republic & Haiti	17,000	Vulnerable
Mona Island Iguana *Cyclura cornuta stejnegeri*	Puerto Rico (Isla Mona)	1,500	Endangered
Andros Island Iguana *Cyclura cychlura cychlura*	Bahamas	3,500	Vulnerable
Exuma Island Iguana *Cyclura cychlura figginsi*	Bahamas	1,500	Endangered
Allen's Cays Iguana *Cyclura cychlura inornata*	Bahamas	1,000	Endangered
Cuban Iguana *Cyclura nubila nubila*	Cuba	40,000	Vulnerable
Sister Isles Rock Iguana *Cyclura nubila caymanensis*	Cayman Islands	1,500	Critically Endangered
Grand Cayman Blue Iguana *Cyclura lewisi*	Cayman Islands	30	Critically Endangered
Anegada Iguana *Cyclura pinguis*	British Virgin Islands (Anegada Island)	400	Critically Endangered
Ricord's Iguana *Cyclura ricordii*	Dominican Republic	1,300	Critically Endangered
San Salvador Iguana *Cyclura rileyi rileyi*	Bahamas	500	Critically Endangered
White Cay Iguana *Cyclura rileyi cristata*	Bahamas	200	Critically Endangered
Acklins Iguana *Cyclura rileyi nuchalis*	Bahamas	13,000	Endangered

Iguana (*C. carinata bartschi*) in the Bahamas appears to be healthy and stable, supporting all age classes. However, this subspecies is restricted to one tiny cay with a high point of 6.2 m and most of its area less than 3 m above sea level. Under these conditions, environmental catastrophes such as a heavy hurricane is a very real threat. The White Cay Iguana (*C. rileyi cristata*) has only one small population remaining from which illegal smuggling has been confirmed, and populations of the San Salvador Iguana (*C. rileyi rileyi*) have been declining at an alarming rate.

Currently, the Jamaican Iguana (*C. collei*), the Mona Island Iguana (*C. cornuta stejnegeri*) the Sister Isles Rock Iguana (*C. nubila caymanensis*), the Grand Cayman Blue Iguana (*C. lewisi*), the Anegada Iguana (*C. pinguis*), and Ricord's Iguana (*C. ricordii*) are far below natural carrying capacity on the islands where they occur. The Jamaican Iguana was believed to be extinct until the 1990 rediscovery of a tiny remnant population in the remote Hellshire Hills. Since that time, a highly successful captive-rearing program involving over 100 juveniles has helped provide a hedge against extinction, but the wild population remains very much in peril. The Mona Island Iguana (*C. cornuta stejnegeri*) occurs only on the remote island of Mona, where it is scarce due to predation by feral pigs and cats, browsing by feral goats, and destruction of nest sites by feral pigs. The only remaining viable subpopulation of the Sister Isles Rock Iguana is on Little Cayman, and it is subject to a variety of threats including habitat loss and introduced predators. Analysis of recent genetic data indicated that the Grand Cayman Blue Iguana has probably existed at an extremely small population size for an even longer period than the Jamaican Iguana. Genetic variation among the remaining individuals examined thus far appears to be very low, and the remaining wild population may consist of as few as 30 individuals. The Anegada Iguana has undergone precipitous declines in recent years, primarily due to competition with feral livestock for food. The population of Ricord's Iguana, historically small and disjunct, is declining as a result of habitat degradation and introduced species.

The Mona Island Iguana (*Cyclura cornuta stejnegeri*) is the focus of a successful headstarting program managed by the Puerto Rico Department of Natural Resources and the Environment. *Photograph by Glenn Gerber.*

Jamaican Iguanas (*Cyclura collei*) were believed extinct until the 1990 discovery of a small remnant population still clinging to existence in the Hellshire Hills. This nesting female is one of only about 150 individuals remaining in the wild. *Photograph by Glenn Gerber.*

Table 2. Summary of recommended conservation action for West Indian Rock Iguanas.

Taxon	Surveys	Protected Areas	Predator Control	Livestock Control	Field Research	Genetic Studies	Education	Head-starting
Turks and Caicos Iguana	•	•	•	•	•	•	•	
Bartsch's Iguana	•	•	•	•	•	•	•	
Jamaican Iguana		•	•	•	•		•	•
Rhinoceros Iguana	•		•	•	•		•	
Mona Island Iguana		•	•	•	•		•	•
Andros Island Iguana	•				•		•	
Exuma Islands Iguana	•	•			•	•	•	
Allen's Cays Iguana					•		•	
Cuban Iguana	•				•			
Sister Isles Rock Iguana	•	•	•		•	•		
Grand Cayman Blue Iguana	•	•	•		•	•	•	•
Anegada Iguana	•	•	•	•	•	•	•	•
Ricord's Iguana	•	•	•		•		•	•
San Salvador Iguana	•	•	•		•	•	•	
White Cay Iguana	•	•	•		•	•	•	
Acklins Iguana	•	•			•	•	•	

Threats

The major threat to survival of virtually all West Indian Rock Iguanas is habitat loss. This process takes a variety of forms, including conversion of dry forests for mining, agriculture, charcoal production, timber extraction, tourist resorts, housing developments, and other real estate ventures. An inevitable consequence of this disturbance is the arrival of human-commensal species, which can act as unnatural predators or competitors for native species. While feral cats and mongooses primarily threaten juvenile iguanas, dogs are capable of preying on adults.

For some taxa, particularly the Jamaican, Grand Cayman Blue, and Anegada iguanas, predation by introduced species appears severe enough that population recruitment is very low. Wild populations of these species include few juveniles. Similarly, predation by introduced rats on juveniles and feral cats on all age classes can lead to depressed population growth among the smaller species of Rock Iguanas in the Bahamas and the Turks and Caicos Islands. Egg predation by feral pigs is a significant problem on Mona, Andros, parts of Cuba, and possibly Jamaica. Because they trample nesting sites and decimate the native vegetation on which iguanas depend, feral livestock also poses a serious threat, particularly on Anegada, Mona, Booby Cay in the Bahamas, and in parts of the Turks and Caicos and the Dominican Republic. On some of these islands, overgrazing has stunted vegetation and produced radical changes in species composition (Mitchell 1999).

Hunting also is a threat for several taxa. The reasons for this exploitation vary; in Haiti and the Dominican Republic, iguanas are hunted primarily for food, whereas in the Bahamas and the Turks and Caicos, illegal poaching for international trade is becoming an increasing concern. In addition, road casualties are a significant cause of death for both adults and juveniles on islands undergoing rapid urbanization, particularly the Cayman Islands.

Current Conservation Measures

All species of Rock Iguanas are protected internationally under Appendix I of CITES. Although most also receive some degree of national legislative protection in the countries where they occur, local enforcement of regulations is sporadic. Protected habitat, in the form of national parks, nature reserves, or sanctuaries, exists for approximately half of all West Indian Rock Iguanas. However, in many cases, these areas are very small or represent only a tiny fraction of the species' total range. Even in countries with fairly extensive reserve systems, such as the Turks and Caicos Islands, Cuba, and the Dominican Republic, limited resources for protected area maintenance hamper enforcement capability.

While some form of introduced species control is underway in the habitats of six West Indian Rock Iguana species, these pilot programs are local and aimed at single species (feral cats on Pine and Water Cays, Turks and Caicos Islands; goats on Booby Cay, Bahamas; mongooses in the Hellshire Hills, Jamaica; feral cats on Mona Island, Puerto Rico; rats on Low and White Cays, Bahamas). While the goal is complete eradication of feral cats and rats, other species such as mongooses will require continuous trapping to keep population numbers low in core iguana habitat (Vogel et al. 1996, Wilson et al. 2004). Fencing has successfully excluded feral goats and pigs from iguana nest sites, particularly on Mona Island. Because of the variety of threats posed

Coastal limestone terrace habitat, such as that shown here at Guantanamo Bay, Cuba, provides important refuges for Cuban Iguanas. *Photograph by Allison Alberts.*

The British Virgin Islands National Parks Trust is working closely with the IUCN Iguana Specialist Group and others to headstart juvenile Anegada Iguanas (*Cyclura pinguis*) in captivity until they grow large enough to defend themselves from feral cats. To date, 48 headstarted animals have been repatriated to the wild, with a survival rate exceeding 90%. *Photograph by Jeff Lemm.*

Little Water Cay, a nature reserve managed by the National Trust for the Turks & Caicos Islands, supports a healthy population of approximately 2,000 Turks & Caicos Iguanas (*Cyclura carinata carinata*) that is visited by thousands of tourists each year. Unfortunately, the island has been recently threatened by the invasion of feral cats from nearby Water Cay. *Photograph by Glenn Gerber.*

by invasive mammals to most species of West Indian Rock Iguanas, control programs will need to be expanded in the future and implemented on islands where they do not yet exist.

Field research is making a significant contribution to the conservation of many species of West Indian Rock Iguanas. Current studies range from population censuses to ecological and systematic investigations. These should provide the scientific data necessary to begin developing species conservation plans for many taxa. To date, recovery plans have been drafted for five of the most critically endangered West Indian Rock Iguanas: the Jamaican, Anegada, Grand Cayman Blue, Ricord's, and Turks and Caicos iguanas.

Education programs are critical to the success of conservation efforts on behalf of West Indian iguanas. Each year, the National Trust for the Cayman Islands holds a fair at which several thousand children have the opportunity to learn about iguanas and their habitat requirements. The National Trust for the Turks and Caicos Islands has produced a variety of educational materials, regularly provides information about iguanas to local schools, and has instituted a highly successful nature trail on Little Water Cay. The Jamaican Iguana conservation program involves education of local forest habitat users, particularly charcoal burners and pig hunters. In the Bahamas, signs informing tourists of the protected status and vulnerability of iguanas have been helpful, principally on small cays visited by private yachts. In 1997, the IUCN Iguana Specialist Group sponsored production of a color poster urging protection of West Indian Rock Iguanas and distribution of the poster in as many range countries as possible.

Secondary populations have been established for the Anegada Iguana (Goodyear and Lazell 1994), the Acklins Iguana (Hayes and Montanucci 2000), the Allen's Cays Iguana (Knapp 2000), and the Turks and Caicos Iguana (Mitchell et al. 2000; Gerber and Alberts 2000a, 2002). These satellite populations have the potential to serve as reservoirs should primary populations become extinct. Similar programs are planned for the Jamaican Iguana and the White Cay Iguana, but have yet to be implemented. Although habitat enhancement has the potential to contribute to conservation efforts for all West Indian Rock Iguanas, it has only been carried out for a few taxa. Clearing

patches of exotic forest has provided new nesting area on Mona Island, and removal of exotic vegetation to prepare a release site for head-started hatchlings is taking place on Grand Cayman. A dredging program has been proposed for Green Cay in the Bahamas in order to replenish nest site sand lost as a result of Hurricane Lily in 1996 (Hayes et al. 2004).

Ex situ captive programs currently exist for six populations of West Indian iguanas. For Jamaican and Grand Cayman Blue iguanas, genetically managed populations are in place in U. S. zoos. These ultimately should provide a hedge against extinction in the wild. Similar programs are in the initial stages for Ricord's and Anegada iguanas. For Cuban and Rhinoceros iguanas, the American Zoo and Aquarium Association has recommended a moratorium on further breeding due to space constraints, although these species are commonly used for display and educational purposes. *In situ* captive programs in Jamaica, Grand Cayman, Anegada, the Dominican Republic, and Mona Island in Puerto Rico are having immediate effects on population viability through the successful repatriation of headstarted juveniles.

Recommendations for the Future

For the majority of West Indian Rock Iguanas, further survey work is required in order to design effective management and recovery plans (Table 2). Existing data for some taxa are outdated, whereas for others only a limited part of the range has been adequately documented. In other instances, populations are known to be declining, but quantitative data on rates of population change and their demographic effects are lacking. For all taxa, standardized annual or biannual population monitoring is critical for updating conservation priorities. Detecting population declines before they have significant demographic impacts and while management intervention remains a viable option is increasingly important.

Many Rock Iguana populations remain without adequate protection because no habitat has officially been set aside for them or because existing legislation is only sporadically enforced. To ensure the survival of all taxa, enough suitable habitat to support minimum viable populations should be protected by national law in each country of origin. Because the social structure, reproductive ecology, and carrying capacity of these iguanas varies considerably across taxa, the amount of habitat required for adequate protection will need to be determined on a taxon-by-taxon basis.

Control of introduced mammalian predators and livestock is crucial to the survival of West Indian Rock Iguanas. Because they are such devastating predators, feral dogs and cats should be eliminated from core iguana habitats whenever they are encountered. Public outreach is essential to ensuring that new nonnative predators are not introduced to iguana-inhabited islands and cays. Although they do not result in complete removal, trapping programs for mongooses seem to be effective in keeping population numbers sufficiently low to reduce their impact on iguanas (Wilson et al. 2004). Fencing in and around iguana nesting areas is a relatively inexpensive means for excluding free-ranging livestock, and should be implemented wherever feasible.

Basic research is critical to many if not all of the proposed conservation initiatives for West Indian Rock Iguanas. In order to conserve and potentially augment wild populations, enough life history data from wild populations must be available in order to predict the long-term effects of alternate management strategies. Such data can help to assess the carrying capacity of proposed reserve sites and determine if reintroduction or translocation is warranted and feasible. Population modeling to estimate

Two adult male Turks & Caicos Iguanas, *Cyclura carinata carinata*, engaged in a display of dominance. Recent studies suggest that the behavioral ecology of Rock Iguanas is more sophisticated and complex than previously believed. *Photograph by Glenn Gerber.*

Sandy soils, such as those shown here in coastal Cuba, are essential in order for West Indian Rock Iguanas to nest successfully. *Photograph by Allison Alberts.*

Educational poster highlighting the need for protection of West Indian Rock Iguanas. *Courtesy of the IUCN Iguana Specialist Group.*

minimum viable population sizes and to explore the effects of head-starting is crucial to designing successful and practical conservation. Behavioral studies are needed to understand the conservation implications of variation across populations and to assess the influence of human impacts. A complete study of phylogenetic relationships among West Indian Rock Iguanas, including both molecular genetic and morphological data, is a necessary beginning in order to adequately assign priorities to conservation initiatives (Malone and Davis 2004). The availability of such data will contribute toward a better understanding of adaptive trends within the group and will permit informed extrapolations from one taxon to another.

As insurance against extinction in range countries, *ex situ* captive breeding programs are recommended for West Indian Rock Iguanas that have experienced significant population reductions, documented low population size or a severely restricted range, or have an extinction probability of at least 20% within five generations. In order to retain the genetic diversity needed to support these populations over the long term, husbandry and breeding techniques must be improved and the support and participation of additional institutions enlisted. For taxa in which reduced juvenile recruitment threatens the survival of the wild population, headstarting programs and rigorous predator control are recommended as interim measures to allow for population recovery.

Finally, for the survival of virtually all taxa of West Indian Rock Iguanas, public education is essential. Without effective education at the local, national, and international levels, other conservation initiatives are likely to prove futile. Educational needs range from discouraging people from feeding, hunting, and transporting iguanas between islands to inspiring local and national pride for these impressive lizards and their unique habitats. Raising public awareness regarding the vulnerability of iguanas to dogs, cats, pigs, and livestock is critical to preventing their intentional introduction to new islands. Iguanas represent a unique and irreplaceable component of the West Indian natural heritage that must be preserved for future generations. Only by working closely with local communities can we help foster the sense of pride and stewardship necessary to ensure the survival of West Indian Rock Iguanas.

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The preservation of quality habitat is essential to the survival of Rock Iguanas in the Turks & Caicos Islands (shown here) and elsewhere in the Greater Antilles and the Bahamas. *Photograph by Glenn Gerber.*

Although Cuban Iguanas (*Cyclura nubila*) are not recommended for breeding under the American Zoo and Aquarium Association's Rock Iguana Species Survival Plan, they play a valuable educational role by serving as ambassadors for their more endangered cousins. *Photograph by Allison Alberts.*

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Adult female Jamaican Iguana (*Cyclura collei*) covered with red dirt acquired while digging a nesting burrow. *Photograph by John Binns.*

Status of the Jamaican Iguana (*Cyclura collei*): Assessing 15 Years of Conservation Effort

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Abstract.—Following its rediscovery in 1990 in the remote Hellshire Hills, the Jamaican Iguana (*Cyclura collei*) has been the focus of a sustained conservation effort aimed at securing the species' short- and long-term survival. Major threats to the iguana's persistence include habitat destruction by humans and predation by introduced mammals such as dogs, cats, and the Indian Mongoose.

Beginning in 1990 with field surveys of the remnant *C. collei* population and the formation of the Jamaican Iguana Research and Conservation Group (JIRCG), a variety of conservation measures have been implemented. Protection and monitoring of known nesting areas have facilitated the collection of founder stock for captive breeding and "headstart" programs, and have resulted in the collection, mark, and release of hundreds of *C. collei* hatchlings. As hedges against extinction in the wild, breeding nuclei of *C. collei* have been established at the Hope Zoo in Kingston and also at six U. S. zoos (Central Florida, Fort Worth, Gladys Porter in Brownsville, Texas, Indianapolis, San Diego, and Sedgwick County in Wichita, Kansas). The first captive-bred hatchlings were produced in September 2004 at the Hope Zoo. Adult-sized, headstarted *C. collei* reared at the Hope Zoo have been successfully repatriated into the Hellshire Hills, and we have now verified post-release survival of up to eight years. Egg-laying has been observed in repatriated females, suggesting that this zoo-based augmentation effort is having a positive effect on the remaining wild population.

Ongoing exotic predator removal efforts seek to maintain a conservation zone that is largely devoid of non-native mammalian predators such as cats and mongooses. To date, hundreds of these invasive predators have been trapped and removed from the core *C. collei* area, and preliminary data suggest that the iguana may be benefiting from this predator control program. More recently (2003–2004), efforts to control feral dog and pig populations have been intensified.

Overall, the biological interventions directed at *C. collei* appear to have been highly successful. Unfortunately, *C. collei*'s dry forest habitat is at risk of ecological destruction. The remaining primary forest in Hellshire is under constant assault from the activities of illegal tree cutters, primarily charcoal burners. The JIRCG has protected a small portion of the forest in the vicinity of the known nesting areas and major iguana concentration, and attempts to discourage charcoal burners from penetrating farther into the undisturbed forest. If implemented, tabled government plans from the 1960s for large-scale commercial and residential development would likely cause the extinction of *C. collei*. Encouragingly, increased national and international appreciation of Hellshire's stature as one of the finest remaining examples of Caribbean dry forest, together with considerable interest in the iguana's plight, give hope that this unique ecosystem and its endangered occupants will receive adequate protection. Indeed, the Jamaican government's declaration of the Portland Bight Protected Area (PBPA) in 1999 (including the Hellshire Hills and the Goat Islands) and the recent (2004) delegation of management authority to the Urban Development Corporation (UDC) is a positive step in that direction.

Key Words: *Cyclura collei*, Dry Forest Herpetofauna, Endangered Species, Headstarting, Jamaica, Predator Control, Conservation

Introduction

Thought extinct for much of the last century, the Jamaican Iguana (*Cyclura collei*) was rediscovered by a pig hunter in the remote interior of the Hellshire Hills in 1990 (Vogel et al. 1996). Field surveys in the latter half of 1990 revealed a remnant iguana population persisting in the central portion of the Hellshire range, and also resulted in the identification of two active nesting sites (Vogel 1994). The adult population was estimated at 50–200 individuals, and low recruitment potential was inferred from the virtual absence of observations of young iguanas and the rarity of new females appearing at the known nesting sites (Vogel 1992, 2000). Considered at the time to be the

Nesting female Jamaican Iguana at one of the two known communal nesting areas in the central Hellshire Hills. *Photograph by Glenn Gerber.*

One of the two known communal nesting sites of the Jamaican Iguana. *Photograph by Peter Vogel.*

Byron Wilson processing a mongoose captured in the core iguana conservation area. *Photograph by Peter Vogel.*

"most endangered lizard in the world," *C. collei* appeared to be at the brink of extinction (Alberts 1993).

The 1990 rediscovery of *C. collei* led to a sustained recovery effort that began with the formation of the Jamaican Iguana Research and Conservation Group (JIRCG), a local organization comprising members from the University of the West Indies, the Hope Zoo, the National Environment and Planning Agency, and the Institute of Jamaica. Working with a variety of international conservation and funding agencies over the last 15 years, the JIRCG has endeavored to protect the remnant *C. collei* population and continues to lobby on behalf of both the iguana and its threatened dry forest habitat.

Threats to Iguanas

Because the small iguana population was persisting in a relatively large tract of undisturbed primary forest, predation by non-native mammalian predators was considered to be the primary cause for the species' apparent low recruitment potential and low population density (Alberts 1993, Vogel et al. 1996). Subsequent research and field observations have validated this early assessment. We now have definitive evidence that dogs, cats, and mongooses prey on *C. collei*. Dogs pose an obvious threat even to adult iguanas (Woodley 1980, Vogel 1992, Vogel et al. 1996), and feral cats have recently been identified as a serious threat to young *C. collei* (Wilson et al. 2004). Predation on young iguanas by the Indian Mongoose (*Herpestes auropunctatus*) is regarded as the single most important source of mortality (Vogel 1992, 2000; Alberts 1993, 2000; Wilson et al. 2004).

Other important threats to the *C. collei* population are social rather than biological, and present the most formidable challenges to the species' existence. At present, degradation of the forest by charcoal burners is reducing the remaining primary forest habitat to the point where the Hellshire Hills could be incapable of supporting a viable iguana population within the next several decades. In addition, previously tabled government plans for large-scale development in undisturbed sections of the peninsula have not been officially abandoned.

In response to these various threats, the JIRCG instituted an emergency conservation strategy to preserve the species. An immediate objective sought to divert traditional forest users away from the core iguana area and to protect the known nesting sites during the reproductive season. By 1992, the JIRCG formulated a management plan outlining a strategy both for reducing the risk of short-term extinction and for securing the iguana's long-term persistence in a protected conservation zone (Vogel 1992).

The original recovery plan outlined three general management priorities: (1) establishment of captive breeding and satellite populations as safeguards against extinction, (2) research and conservation efforts aimed at protecting the remnant wild pop-

ulation, and (3) long-term preservation of the iguana's habitat. Significant progress has been made; for example, we now possess a comprehensive set of biological management tools that have proven successful in the field. Unfortunately, social and political issues have so far prevented the implementation of a management system for the conservation of the dry forest habitat, despite the inclusion of the Hellshire Hills in the recently (1999) declared Portland Bight Protected Area (PBPA). As a consequence, in spite of some notable successes in recovering and protecting the species, the status of the wild *C. collei* population remains precarious. Below we summarize the progress of the *C. collei* recovery effort and comment on prospects for the species' long-term survival.

Captive Populations

As hedges against catastrophic loss in the wild and potential reservoirs of genetic diversity, the maintenance of captive populations can be a valuable tool in efforts to prevent extinctions. For *C. collei*, genetically managed captive-breeding programs have now been established at the Hope Zoo in Kingston and at six U. S. zoos. Mating or egg-laying has been observed at several institutions, and, in 2004, the first successful captive breeding of *C. collei* was confirmed at the Hope Zoo. Specifically, three healthy hatchlings were retrieved from one of the headstart enclosures. We anticipate accelerated production from these breeding nuclei as the captive cohorts mature into full reproductive stature and as improvements to breeding facilities are completed.

View of the Hellshire Hills, one of the last remaining stands of pristine dry tropical forest in the insular Caribbean. *Photograph by Peter Vogel.*

Satellite Populations:
The Goat Islands Iguana Reserve

Small offshore islands either lack invasive species or can be rendered completely pest-free (Tolson 2000), and human encroachment is constrained by access. Moreover, the biological interventions necessary to rehabilitate small islets are comparatively simple and correspondingly cost effective. Not surprisingly, such satellite islands have become valuable centers for biodiversity conservation in the Caribbean and elsewhere.

An important component of the original (1992) recovery strategy for *C. collei* was the establishment of a satellite *C. collei* population on Great Goat Island, off the western edge of the Hellshire Peninsula. Great Goat Island contained an iguana population at least until the 1940s, and has long been recognized as an ideal site for the creation of a biodiversity reserve featuring a repatriated *C. collei* population. Both Great and Little Goat Island form part of the Portland Bight Protected Area, and Great Goat Island is posted as a no (bird) shooting reserve. However, semi-feral goat populations overrun both islands. The goats are owned by private individuals based on the nearby mainland, who bring water to and occasionally harvest the animals. Other exotic species include rats, mice, and mongooses. The mongoose was apparently introduced to the Goat Islands by fishermen in the 1920s, in a misguided effort to reduce the Jamaican Boa (*Epicrates subflavus*) population (Lewis 1944).

A wild female Jamaican Iguana constructing a nesting chamber. *Photograph by Glenn Gerber.*

Mongoose trapped in the core iguana conservation zone. *Photograph by Byron Wilson.*

Due to proximity to a major city and area of coastal commerce (Old Harbor and Old Harbor Bay), the Goat Islands are readily accessible by boat, so security risks to equipment and field personnel are significant concerns. In addition, the removal of the goats will require the presence of a permanent and locally well-recognized management entity. Therefore, initiation of a conservation program for the Goat Islands will not be feasible until permanent security and enforcement capacities are operational. Importantly, the eradication of invasive species from the Goat Islands is a high priority objective of the Jamaican government's "National Strategy and Action Plan on Biological Diversity in Jamaica" (NEPA 2003).

View of the Hellshire forest and Caribbean Sea from a ridge in the core iguana area. *Photograph by Glenn Gerber.*

Profile of wild Jamaican Iguana (*Cyclura collei*). *Photograph by Peter Vogel.*

Great Goat Island, off the western edge of the Hellshire Hills, site of a planned re-establishment of a satellite iguana population. *Photograph by Glenn Gerber.*

The Portland Ridge Peninsula to the west of the Hellshire Hills represents another option for establishing a satellite iguana population. Narrowly connected to the mainland, the essentially unpopulated peninsula has retained significant stands of natural dry forest, and *C. collei* subfossils are known from several cave systems. Portland Ridge has benefited from the presence of bird shooting clubs that have actively prevented or minimized deforestation in various portions of the peninsula. Furthermore, Portland Ridge forms the western section of the Portland Bight Protected Area, so its remaining natural areas might benefit from future management policies.

Headstarting

The Hope Zoo in Kingston is coordinating an active headstart program, whereby hatchling iguanas collected in Hellshire are raised at the zoo to a size at which they are less vulnerable to introduced predators such as the mongoose. At this point, they are reintroduced into the wild. We have now released 51 headstarted individuals back into Hellshire, and post-release monitoring has demonstrated that captive-reared iguanas easily adjust to wild conditions and post-release survival rates have been unexpectedly high (Hudson 2000, Wilson et al. 2004).

Movement patterns, behavior, and short-term survival have been monitored with the use of radio telemetry, and long-term survival has been assessed through live trapping and observations of individually marked animals. We have documented survival of up to eight years following release back into the wild. Of the original 20 iguanas repatriated between 1996 and 1998, at least eight (40%) are known to have survived for over two years post-release (Wilson et al. 2004). Many of these captures were incidental to our mammal trapping program, so actual survival rates of repatriated *C. collei* are undoubtedly higher than these already encouraging figures.

Perhaps more significantly, we have also observed successful egg-laying among repatriated females. Together with observations of released males engaging in seemingly normal social interactions, these results suggest that repatriated iguanas have been successfully integrated into the reproductive population. Given the existing low levels of natural recruitment, this augmentation effort appears to be having a positive influence on the remnant population (Alberts 2000, Vogel 2000, Wilson et al. 2004).

Control of Non-native Mammalian Predators

Aside from habitat loss, the negative impact of introduced species is now regarded as the most significant threat to the maintenance of global biodiversity. On islands in the Caribbean, the impact of introduced mammalian predators has been devastating to indigenous faunas (Schwartz and Henderson 1991; Case et al. 1992). For *C. collei*, non-native mammalian predators are clearly the single most important factor preventing recruitment of new iguanas into the breeding population (Vogel et al. 1996, Vogel 2000, Wilson et al. 2004).

We have been conducting an extensive trap and removal program aimed at these pest species. To date, we have removed

Repatriated, "head-started" Jamaican Iguana perched on a bench at the field camp in the central Hellshire Hills. *Photograph by Byron Wilson.*

over 500 mongooses, several hundred introduced rodents, approximately 40 feral cats, and a growing number of feral dogs (three in 2004) and wild pigs (26 and counting in 2004). Encouragingly, field observations of juvenile iguanas have increased since initiation of this removal trapping effort, suggesting that exotic predator control enhances survival of young iguanas. Future monitoring efforts should confirm that predator control has enhanced survival and recruitment into the breeding population. Additional research in progress seeks to elucidate the long-term demographic responses of several other rare reptilian species to the removal of non-native mammalian predators such as the mongoose. These efforts use a combination of pitfall traps and mark-recapture studies to investigate long-term trends in ground reptile abundance on predator-infested versus predator-controlled plots.

Free-ranging, repatriated Jamaican Iguana wearing a radio-transmitter vest produced and donated by Nike. *Photograph by Joe Wasilewski.*

Threats to Iguana Habitat

The biological components of the recovery effort appear to have been demonstrably effective. The rediscovery and rapid assessment of the iguana population in 1990 have led to the subsequent implementation of successful captive and field-based conservation measures (Vogel 2000, Wilson et al. 2004). Unfortunately, the most serious threats to the iguana's persistence are social and socioeconomic, and are considerably less tractable than the biological issues. The remnant *C. collei* population and its remaining dry forest habitat are both at high risk of extinction due to anthropogenic influences (Vogel et al. 1996, Wilson and Vogel 2000).

The most immediate threat to the iguana's remaining habitat is illegal tree cutting, primarily for charcoal production (Wilson and Vogel 2000). Whereas traditional charcoal burners used machetes to fell trees, today's charcoal burners often use chainsaws, thereby accelerating the rate of forest destruction. Since the iguana's rediscovery in 1990, members of the JIRCG have attempted to divert tree harvesting away from the core iguana area, and these efforts have met with some significant successes (Vogel et al. 1996, Vogel 2000). In particular, the JIRCG's efforts undoubtedly have resulted in protecting the core *C. collei* nesting areas from otherwise likely destruction by charcoal burners. That said, diversion of tree-cutting activities away from the known nesting areas in no way signifies that the rate of iguana habitat loss has lessened in the species' remaining primary forest habitat.

Several factors render charcoal burning an unsustainable and damaging enterprise. Limited soil deposits and scanty rainfall severely limit the ability of dry forests to regenerate, and

Byron Wilson contemplating the problem of invasive species [introduced predators]; note the palm-shaded mongoose trap in the lower right-hand corner. *Photograph by Glenn Gerber.*

An introduced mongoose, shortly after a crash course on invasive predator control. *Photograph by Joe Wasilewski.*

increased solar penetration in clear-cut areas may also inhibit seedling germination and survival by reducing soil moisture (McLaren 2001). As a result, severely degraded areas may never recover to their original condition. With virtually no potential for a sustained yield harvest, charcoal burners necessarily focus their efforts on the remaining uncut, primary forest.

In addition to the charcoal industry, other ominous threats to the iguana's habitat exist. For example, government plans dating from the 1960s to develop a large residential complex across the eastern half of the peninsula, if pursued, would surely doom the iguana to extinction (Vogel et al. 1996). Although now unlikely to be implemented due to the iguana's rediscovery and the considerable local and international interest the species' plight has generated, these development plans have not yet been officially abandoned. The declaration of the PBPA and the recent delegation of management authority (see below) are positive signs that the area may ultimately receive the protection it so desperately needs.

Lessons from a Conservation Effort: The Fate of *Cyclura collei*

After a 15-year commitment to save the iguana, can we say that the species has been rescued from the brink of extinction? The answer to this question is maybe. A successful captive program has been established, and the wild population is showing some tentative signs of recovery. However, the iguana's imperiled habitat still does not enjoy any effective protection, and is very much at risk of ecological annihilation within the next half century.

Portions of the remaining pristine forest are disappearing daily. Nevertheless, we must remain optimistic that the enforcement necessary to halt this destruction will come before it is too late. Clearly, the charcoal burning industry threatens the iguana's persistence in a very immediate and pressing fashion. Predator control efforts and other biological interventions will be superfluous if the Hellshire forest ceases to exist. However, efforts to address critical conservation issues cannot await the initiation of optimal habitat management practices. Indeed, such efforts can provide the necessary foundation for the growth of more comprehensive and enduring conservation programs aimed at securing the persistence of both the iguana and its relictual habitat.

Active management and enforcement of tree-harvesting laws are urgently needed. One promising development was the declaration of the Portland Bight Protected Area (PBPA) on Earth Day 1999. This government-declared conservation zone includes all of the Hellshire Hills and therefore appears to provide a potential mechanism for protecting the iguana's remaining habitat. Unfortunately, the government lacks the resources to manage the PBPA. Now, fully five years after the celebrated and much publicized declaration of this new protected area, no tangible progress has been made toward habitat protection. However, the government has recently (2004) delegated the management authority for the area to the Urban Development Corporation (UDC) — the organization that owns most of the Hellshire Hills and all of the Goat Islands. One can only hope that the UDC acts quickly and decisively to stem the current wave of deforestation; otherwise, the PBPA will remain little more than a paper park, and the Hellshire Hills will soon become little more than a biological wasteland harboring a highly degraded forest containing greatly diminished biological diversity. Encouragingly, the UDC appears keen to preserve the remaining natural habitat and to rehabilitate the Goat Islands for the establishment of a repatriated iguana population.

Beyond Doom and Gloom: Does Hope Exist for the Hellshire Hills?

In large part due to the connection between environmental quality and basic living standards, conservation issues are attracting increased attention in Jamaica. Because Jamaica has long been recognized as a globally important biodiversity hotspot, the impetus for environmental action is now clear at both the national and international levels. The next two decades will be critical. The requisite political will, coupled with the cooperation of relevant conservation and funding agencies, might yet rescue this outstanding example of West Indian dry forest and its unique endemic fauna. The future roles of the UDC and relevant government agencies will ultimately determine whether this outstanding wild area retains its intrinsic biological value for future generations to appreciate.

Acknowledgments

We thank the many individuals and institutions that have contributed to the ongoing conservation effort directed at the

View of the dry tropical forest in the central Hellshire Hills. One of the two known nesting areas is located in the bottom of the depression; the other major nesting area is located on the western rim of the depression (to the right). *Photograph by Peter Vogel.*

Jamaican Iguana and its threatened habitat. For financial support we are especially grateful to the World Wildlife Fund, the Durrell Wildlife Conservation Trust, the Environmental Foundation of Jamaica, the American Zoo and Aquarium Association, and over 20 U. S. zoos. For critical funding for the 2002–2004 period, we are grateful to the International Iguana Foundation, the International Iguana Society, the Audubon Zoo, the Miami Metrozoo, the Houston Zoo, and Conservation International. A big thank you is due to Rick Hudson of the Fort Worth Zoo and Allison Alberts of the Zoological Society of San Diego; they have proven to be important sources of inspiration, expertise, and funding. Edwin Duffus, who rediscovered the iguana in 1990, is acknowledged for his indispensable assistance in the bush. Finally, we thank the other members of the Jamaican Iguana Research and Conservation Group, the National Environment and Planning Agency (NEPA), and the Institute of Jamaica for their continued support and involvement.

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"Slugger," an adult male Grand Cayman Blue Iguana, *Cyclura lewisi*, in the QEII Botanic Park.

Battling Extinction: A View Forward for the Grand Cayman Blue Iguana (*Cyclura lewisi*)

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Photographs by John Binns except where indicated.

Abstract.—The National Trust for the Cayman Islands has been implementing conservation efforts for *Cyclura lewisi* since 1990. Commencing with small-scale captive breeding, the program has expanded to include field research, large-scale captive breeding and head-starting, reintroduction and restocking, habitat protection and management, education, and awareness activities. A formal species recovery plan is in place. In the past 12 years, the size of the wild population appears to have declined from 100–200 to 10–25 animals and is functionally extinct. Principal causes for the decline are habitat loss, predation by introduced mammals, road kills, and continued exploitation by humans. Reproduction in the wild by animals released from the captive breeding population has been confirmed. However, in order to assure the greatest possible genetic diversity within the captive population, wild individuals with potentially distinct genetic constitutions must be captured and assessed before their genes become diluted as a consequence of interbreeding with released animals. Goals of 100 hatchlings and approximately 100 two-year-old iguanas for release annually are being approached. Options for restoring self-sustaining wild populations are limited to habitat islands, for which perimeter fencing will be essential to restrain iguanas and exclude predators. The recovery program is operating on institutional grants, program-generated income, and private donations, but we hope that this charismatic lizard will become able to support its own survival through carefully managed tourism activities and related commerce.

Key Words: *Cyclura lewisi*, Grand Cayman, Blue Iguana Recovery Program, Headstarting, Predator Exclusion, Conservation

Introduction

Conservation efforts for *Cyclura lewisi* led by the National Trust for the Cayman Islands have been underway on Grand Cayman since 1990 (Burton 2000). Commencing with small-scale captive breeding, the program has expanded to include field research, large-scale captive breeding and head-starting, reintroduction and restocking, habitat protection and management, education, and awareness activities. A species recovery plan was formalized in 2001 in collaboration with the IUCN-SSC Iguana Specialist Group. Now identified as the Blue Iguana Recovery Program, the work remains under the umbrella of the National Trust for the Cayman Islands, but operates with support from and strong links to the international conservation community.

Status

Population estimates of the unmanaged, wild population of *C. lewisi*, which is endemic to the island of Grand Cayman (Burton 2004), were conducted by the program in 1992–3 and in 2002. Over that period, the population appears to have declined from approximately 100–200 individuals to between 10 and 25 individuals (Burton 2002). In the same period, the range occupied by wild *C. lewisi* declined by 50%. In 2002, active breeding occurred at a single location, possibly representing a single breeding pair, with little evidence that any offspring were surviving to maturity. Overall, the population appeared very close to functional extinction. The species shares threats common to all *Cyclura* populations, notably predation by introduced mammals (rats, cats, and dogs), habitat loss, road kills, and (to a lesser degree) trapping.

Pilot Population Restocking

Over a similar period to this extreme decline in the wild population, a pilot release program in the Queen Elizabeth II Botanic Park was proving successful. Small numbers of two- and three-year-old, PIT-tagged, captive-bred *C. lewisi* have been released annually since 1995, with a proportion of these surviving and establishing home ranges at least partially within the Park (F. J. Burton and R. M. Goodman, unpublished data). Reproduction in the wild by this released population was inferred from the

Blue Iguana, "Yellow," at the edge of the large pond in the QE II Botanic Park.

appearance of hatchlings in 2001, and confirmed by direct observation in 2002. Currently, the restocked population consists of 29 individuals of known captive origin, plus one breeding female of as-yet unconfirmed origin. All known nests are excavated and the eggs incubated to yield hatchlings for headstarting.

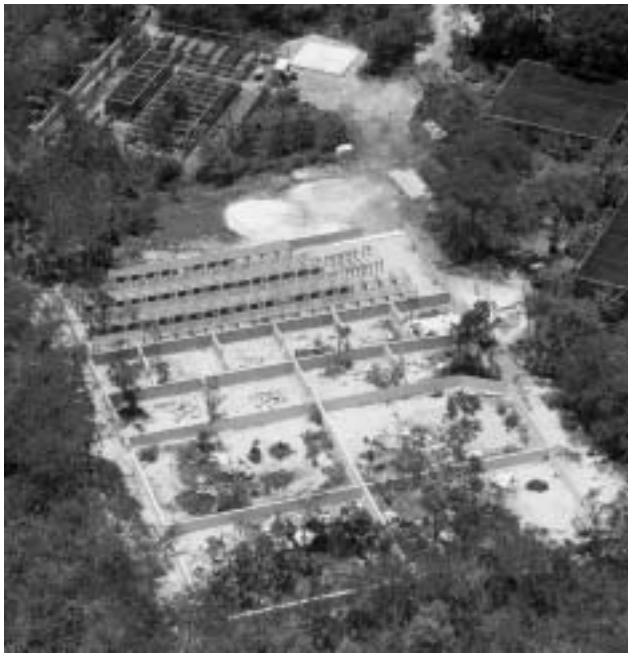
The QE II Botanic Park covers 26.3 ha, and has no perimeter fences capable of restricting immigration or emigration of iguanas. Much of the Park's area is sub-optimal *Cyclura* habitat under closed canopy forest or seasonal wetland, with the iguanas preferentially occupying human-modified areas with paths and gardens. With 30 individuals sharing this space, strong territorial aggression occurs between males, and subordinate males are being excluded to the extent that they spend most of their time outside the boundaries of the Park. Individuals that were released in the Park, but did not establish territories there, have now been recovered from locations 10 km away. The Park apparently is near to its unfenced carrying capacity and further releases must increasingly be expected to disperse into unprotected surrounding habitat.

Program Transition

The captive breeding and headstarting elements of the program have undergone a dramatic expansion in the last two years, with over 80 hatchlings in both 2003 and 2004 generated from captive-laid eggs and nests excavated in the QE II Botanic Park. This is close to the program's goal of 100 hatchlings per year, reared to supply approximately 100 two-year-old iguanas for release annually.

The first captive facility built in the Botanic Park shown at completion in 1996. The facility was funded by Milwaukee Country Zoo and its partner Foundation for Wildlife Conservation. The facility included 12 8 x 8 foot and 16 4 x 4 foot cages. *Photographer unknown.*

The facility was fenced to improve security in 1998.



The Blue Iguana captive breeding and headstarting facility today. Beginning at the bottom of the photograph are four large adult breeding pens, four small adult breeding pens, and six adult holding pens. Next are 102 4 x 4 x 2 foot headstarting cages. The original fenced facility cages are in the upper left of the photograph.

The restocking potential from the captive program now far exceeds reproduction in the unmanaged wild population, and is an order of magnitude higher than the average annual release to the QE II Botanic Park to date. Now that restocking techniques have been tested, adapted, and verified on a small scale, the time has come to put the lessons learned into practice on a scale that can reverse the population decline in this species.

In moving from pilot project to large scale population recovery, two important biological issues are unresolved and must be addressed in a wider context than QE II Botanic Park. These are management of continuing threats and the integration of the restocked population(s) with the remnant unmanaged wild population.

2002 population survey team (from left): Joe Wasilewski, Alberto Jamarillo, Fred Burton, and Joel Friesch. Not shown: Quentin Bloxam. *Photograph by Joel Friesch.*

Managing Threats

As evidenced by the 2002 population survey, the present and historic range of *C. lewisi* is occupied by feral cats, known as predators of juvenile *Cyclura* on a level capable of devastating entire populations (Iverson 1978). Semi-domestic dogs are roaming in areas that supported breeding *C. lewisi* in 1992–3. Vehicular roads are being extended within occupied Blue Iguana habitat, and road kills are reported annually. A heavily trafficked coastal road separates the remnant population from presumed historic coastal nesting sites. Restocking of a wild population of *C. lewisi* in this degraded environment would at best be buying time for the species, and offers no long-term solution.

Grand Cayman has no offshore islands suitable for establishing iguana populations free of these threats, and the Sister Isles, Cayman Brac and Little Cayman, are occupied by *C. nubila caymanensis*, and are thus not available for *C. lewisi* restoration work. Options for restoring self-sustaining wild populations of Blue Iguanas are therefore limited to habitat islands — areas within the larger landmass of Grand Cayman which are protected and within which the threats to *C. lewisi* are eliminated or reduced in a sustained way. In practice, to maintain eradication of feral cats, exclude dogs, and to retain iguanas within the safety of one or more habitat islands, perimeter fencing will be essential.

Suitable fencing in the extreme karst terrain characteristic of Grand Cayman's xerophytic shrubland presents particular challenges. Fencing specifications must be tested, adapted, and refined to arrive at the most cost-effective barrier design that is capable of excluding predators and retaining iguanas in this environment over long periods of time.

In late 2004, 24 captive two-year-old *C. lewisi* are scheduled for release into the Salina Reserve, a 250-ha protected area with diverse habitats, owned and managed by the National Trust for the Cayman Islands. These animals will be radio-tracked for at least six weeks after release and monitored at intervals there-

Rachel Goodman monitoring ground temperatures in 2002 as part of a study of iguanas released in the Botanic Park. *Photograph by Fred Burton.*

Blue Iguana, "Forest," on the road approaching the Botanic Park.

2004 season hatchling, "Crusoe," basking on a tree branch with his brother and sisters in the background.

after. Again, the release area, although fully protected, is not fenced, and predator control will be limited to cat trapping (dogs currently are unable to reach this area). The survival and dispersal of these animals will provide a baseline against which to compare releases into fenced areas, with more active predator controls, in the future: some 70–80 head-started *C. lewisi* will be available for release into the Salina Reserve in 2005.

The Unmanaged Wild Population

Three of the Blue Iguanas released in the QE II Botanic Park over the last nine years have been recovered in locations that suggest that they may have migrated through the area still occupied by the remnant, unmanaged wild population. An immature female tagged in the only remaining breeding area of wild *C. lewisi* in 2003 was captured on a coastal road in 2004 at a location that suggests that it may have migrated through the designated Salina Reserve release site. Both observations are indicative of a strong potential for genetic exchange between the restocked population and the unmanaged wild one.

Currently, the restocked population of *C. lewisi* is derived from eight captive founders of wild origin (two additional founders and four potential founders also are in captivity). To capture the widest possible genetic diversity for the breeding and head-starting effort, obtaining representatives of the remaining wild gene pool before it becomes interbred with restocked animals is desirable.

To achieve this level of genetic management without risking disruption of the fragile wild population requires more knowledge of these animals than is currently available. The 2002 population survey identified an access road to a fruit farm where very small numbers of yearling *C. lewisi* hide and feed. Annual turnover is indicated, with older individuals dispersing into the dense surrounding shrubland, and hatchlings of the year taking their place. Rats, cats, and dogs are present. Adults are almost never seen and the breeding site(s) have not been located despite extensive searching. We do not know if the population includes dispersed released individuals from the QE II Botanic Park or their progeny. The size of the population is poorly defined, survival of the young is in question, and the area of occupancy is unknown.

A research presence sustained over several months will be needed to address these unknowns, using a network of trap and radio-tracking to identify and monitor an increasing proportion of the population during a period running into the breeding season, when adult females can be tracked to nesting sites. The environment is exceptionally difficult to traverse and presents severe challenges to tracking and sighting unhabituated iguanas, so this will inevitably be a resource-intensive project.

This detailed investigation of the unmanaged wild population is now an urgent priority. Identifying individuals and nesting sites will enable strategic, low-impact capture of the remnant wild gene pool before this population merges with increasingly numerous animals of captive origin in the neighboring Salina Reserve in 2005 and thereafter.

The Long Term

The most severe long-term challenge to the Blue Iguana Recovery Program is the protection and ongoing management

A two-year-old wild Blue Iguana at the Captain Charles Farm in 2002. *Photograph by Fred Burton.*

Adult male *C. lewisi* courting a female during breeding season inside the QE II Botanic Park grounds.

The Salina Reserve interior, extreme karst terrain with a small soil patch in the foreground where we hope iguanas will nest.

of sufficient *C. lewisi* habitat to sustain a wild, breeding population of at least 1,000 individuals. Work to date has demonstrated that, at a technical level, this goal is almost certainly achievable, and this offers a very real hope for the future of what is currently the world's most endangered iguana.

Cyclura lewisi is a flagship species for Grand Cayman's xerophytic shrubland habitat, which supports a wide range of regionally and locally endemic animals and plants. This environment is underrepresented in the Cayman Islands' protected area system and vulnerable to ever-expanding human impacts ranging from rock quarrying to residential settlement. More than enough suitable shrubland habitat still exists to support 1,000 Blue Iguanas, but the majority is currently unprotected and in private ownership. Conservation land purchases and landowner agreements will be essential steps for achieving the program's ultimate goal.

The Blue Iguana Recovery Program is presently operating on institutional grants, program-generated income, and private donations totaling approximately $150,000 per annum, and the investment required to save this species and its habitat may ultimately run into millions of dollars. Once the major work is completed, we hope that this charismatic giant blue lizard will support its own survival through carefully managed tourism activities and related commerce for conservation.

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Author Biography

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Surprisingly little is known about the natural history and behavior of Lesser Antillean Iguanas (*Iguana delicatissima*). This is an adult female from St. Eustatius. *Photograph by Robert Powell.*

Conservation of Iguanas (*Iguana delicatissima* and *I. iguana*) in the Lesser Antilles

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Abstract.—Lesser Antillean iguana populations include at least two species, *Iguana delicatissima* and *I. iguana*, the latter of which may actually represent several species-level taxa. *Iguana delicatissima* is endemic to the region, as are at least two unique populations of *I. iguana*. Other populations in the region may have arrived naturally from South American by means of over-water dispersal, been introduced by Amerindians within the past 7,000 years, or been introduced within the past several decades as a by-product of the international pet trade. Although most extant populations of *I. delicatissima* are critically endangered, declines have been documented for several, and the gene pools of others have been contaminated as a consequence of hybridization with introduced populations of *I. iguana*, the species is considered only "vulnerable" according to IUCN Red List criteria. *Iguana iguana* is not listed. Protection is afforded both species under the auspices of CITES Appendix II, which lists all iguanids, but which includes provision for the harvest and export of *I. iguana* from many nations without consideration of the genetic distinctiveness of any population.

Most island populations are small, which renders them vulnerable to natural or human-mediated, stochastic or non-random events. In addition to hybridization, development-related habitat destruction and alteration, introduction of alien plants, predators, and competitors, and ongoing hunting pressure contribute to the precarious state of most populations. Conservation plans must be implemented and will have to include provisions for surveys and field research, establishment of protected areas within which livestock must be controlled, predator control strategies in some instances, extensive educational efforts, and, in at least the instance of the St. Lucian Iguana, a captive-breeding and headstarting program.

Key Words: Lesser Antillean Iguanas, *Iguana delicatissima*, Green Iguanas, *Iguana iguana*, Lesser Antilles, Conservation, Habitat Degradation, Mammalian Predators and Competitors, Hybridization

Introduction

Iguanas in the Lesser Antilles comprise a mosaic of two species with populations of varying antiquity and origins. Although the ancestors of extant and extirpated populations undoubtedly arrived in the islands from South America or offshore continental islands, some apparently managed the voyage by natural over-water dispersal via rafts of vegetation originating in flooding South American rivers. Other populations evidently had a helping hand from humans. Endemic Lesser Antillean Iguanas (*Iguana delicatissima*) appear to have been established since long before Amerindians began their trek north from South America some 7,000 years ago. Effectively isolated from their ancestors, they diverged and eventually colonized as many as 17 major islands on eight island banks. Similarly, some insular populations of Green Iguanas (*I. iguana*) appear to predate human arrival in the archipelago, with those on St. Lucia and Saba (and maybe Monserrat) developing sufficient genetic and morphological differences (Malone and Davis 2003) that they might warrant taxonomic distinction. Populations on the southernmost islands (e.g., Grenada, St. Vincent and the Grenadines) also probably originated from ancestors that arrived by natural means, and the lack of distinction from mainland ancestors may merely reflect geographic proximity, occasional recruitment by means of more recent rafting events, and similar selective pressures. However, some evidence suggests that Amerindians, may have translocated iguanas from island to island, establishing populations destined to serve as sources of food during later trips. In addition, large numbers of individuals have been released on islands either intentionally or accidentally in association with the international pet trade. Consequently, individual island populations include interbreeding mixtures of animals of both species, and at least some Green Iguana populations may include both descendants of ancestors predating human settlement and others from released or escaped pets within the past several decades.

Status of *Iguana delicatissima*

The species is listed in CITES Appendix II and as "vulnerable" in the most current IUCN Red List (Hilton-Taylor 2000). All populations are protected from hunting, although enforcement ranges from non-existent to sporadic. The species' original range extended from Martinique in the south to Anguilla in the north. However, populations have been extirpated on Barbuda, Saint Kitts, Nevis, Antigua, Les Îles des Saintes, Marie-Galante, and St.-Martin/St. Maarten. Breuil (2002) recently listed the populations on Dominica, Îles de la Petite Terre, and La Désirade as vulnerable. Apparently only that on Petite Terre is stable and

only that on Dominica is of even moderate size (Anonymous 2004a). However, even the "stable" population on Petite Terre suffered greatly during a prolonged drought in 2001 (Breuil 2002 and references therein). Breuil (2002) listed populations on Basse-Terre, Îlet Chancel (Martinique), and St.-Barthélemy as endangered, and those on Antigua, Anguilla, Barbuda, Île Fourchue and satellites (St.-Barthélemy), Grande-Terre, Martinique, St.-Martin, and St. Eustatius as critically endangered — and those on Antigua, Barbuda, and St.-Martin/St. Maarten have already disappeared (Fogarty et al. 2004), along with populations on St. Christopher (St. Kitts), Nevis, and Marie-Galante.

A Lesser Antillean Iguana (*Iguana delicatissima*) from Anguilla. Note the lack of an enlarged subtympanic scale, which distinguishes this species from *I. iguana*. *Photograph by Glenn Gerber.*

Adult Saban Iguanas (*Iguana iguana*) are melanistic and become completely black with age. *Photograph by John S. Parmerlee, Jr.*

The most obvious feature distinguishing St. Lucian Iguanas (*Iguana iguana*) from those on other Lesser Antillean islands is the prominent "horns." *Photograph by Matt Morton.*

Status of *Iguana iguana*

Because of the species' broad continental range, which extends from México through Central America and much of northern South America, and a general lack of recognition of genetic variability among populations, protective measures are considerably less stringent than for *I. delicatissima*. *Iguana iguana* is listed in CITES Appendix II, but export quotas exist for many countries, primarily for live animals (pet trade) or products (leather goods and meat). No distinction is made for native versus introduced or for continental versus insular populations. Hunting is usually prohibited, but enforcement of laws is lax at best. In Grenada, Green Iguanas are considered game animals (Powell 2004), with a "regulated" hunting season and bag limits. Both are routinely ignored by local hunters.

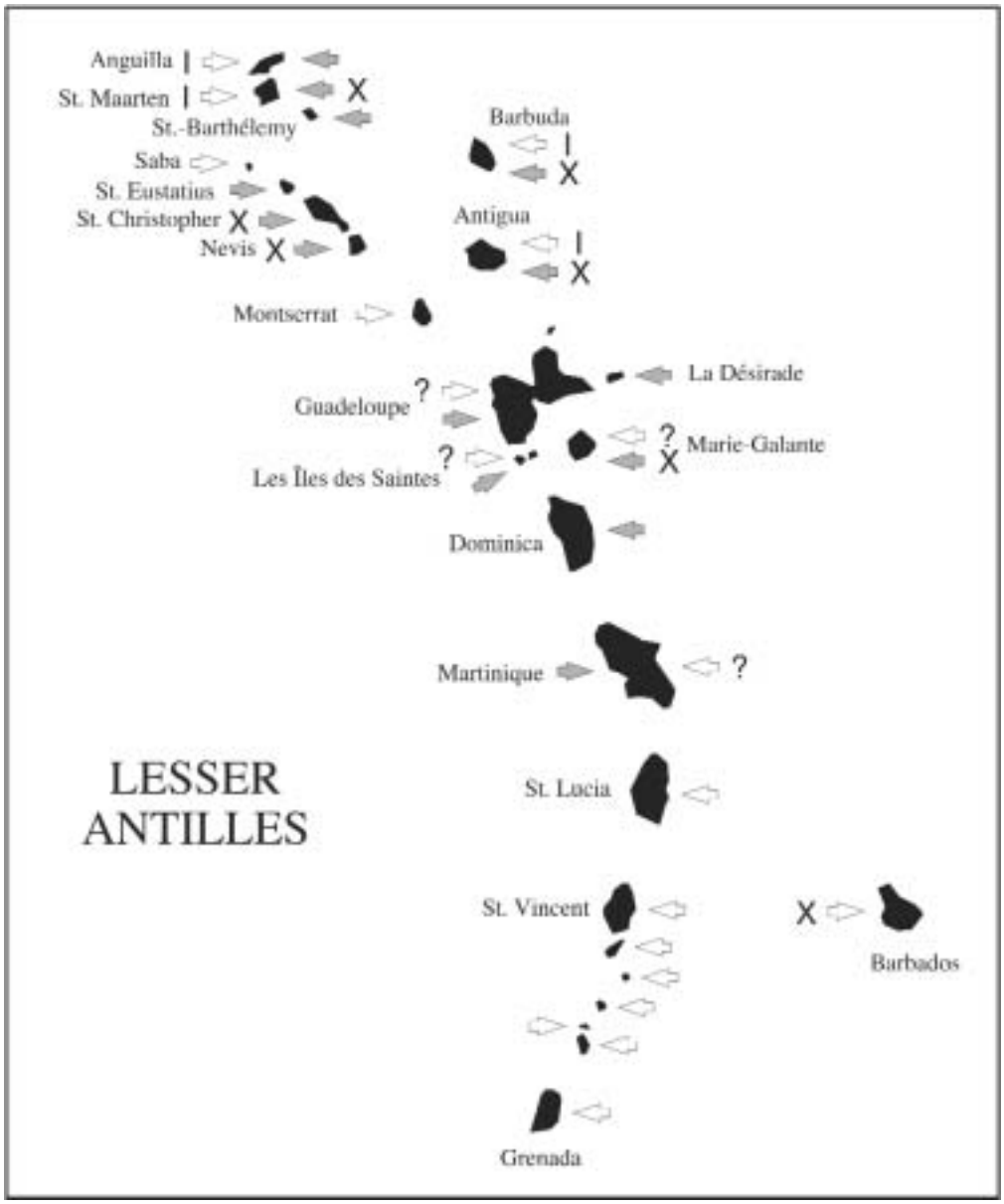
In the Lesser Antilles (Breuil 2002, Schwartz and Henderson 1991), presumably native populations occur on Grenada, St. Vincent and the Grenadines, St. Lucia, Saba, and Montserrat. Populations of unknown or mixed origin are on Martinique, Guadeloupe, Les Îles des Saintes, and Marie-Galante; and populations presumed or known to be introduced occur on Antigua, Barbuda, St.-Martin/St. Maarten, and Anguilla. A population on Barbados is extirpated (Breuil 2002).

Island Populations and Threats

As for all island species, especially those on small islands, populations are at constant risk of extirpation. Many Lesser Antillean islands can provide suitable habitat, but often are less than ideal for large animals vulnerable to extinction. Most islands are small, which inevitably leads to small population sizes and an increased risk of extirpation due to natural or human-mediated, stochastic or non-random events. Human population growth with accompanying improvements in infrastructure, often associated with increasing demands of tourist-related development, leads to habitat destruction and alteration. In addition, introduction of alien predators and competitors and ongoing hunting pressure all contribute to the iguanas' plight.

These threats and their impact on iguana populations are essentially similar to those facing populations of Rock Iguanas (*Cyclura* spp.) in the Bahamas, Cayman Islands, and Greater Antilles, and have been discussed previously in this issue by Alberts (2004), Burton (2004a), and Wilson and Vogel (2004). However, two additional, separate threats face populations of *I. delicatissima* on St. Eustatius and on Martinique, Guadeloupe, and possibly Anguilla. Mexican Creeper (*Antigonon* sp.) was introduced onto St. Eustatius as an ornamental garden plant, but has escaped and covers entire regions of the island, where it actively threatens native vegetation (Fogarty et al. 2004). No effective means of control has been identified. Even goats find the Creeper unpalatable and will eat it only in the absence of any alternatives. The impact on plants consumed by iguanas has not been assessed, but the danger is obvious.

The second threat facing populations of *I. delicatissima* on Martinique and Guadeloupe is the possibility of hybridization with introduced populations of *I. iguana*. The possibility of previous, "natural" contact between the two species on various Lesser Antillean islands cannot be disregarded, despite the fact that the natural distribution of the two species appears to be allopatric. Fossil remains of *I. iguana* are known from Grande-Terre (Guadeloupe), where *I. delicatissima* presumably occurs naturally. Also, Breuil (2002) noted that the one figure in Seba (1734) that was not an illustration of *I. iguana* and on which Laurenti (1768) largely based his description of *I. delicatissima* was probably a hybrid, indicating that contact between the two species is not a recent phenomenon (see Pasachnik et al. 2005 for a complete list of pertinent references and an extensive discussion of the species' nomenclatural history). Intermittent contact, with the possibility of introgression into native populations of either species, quite possibly occurred on several islands (although the statement in Anonymous 2004a that "Dominica, La Désirade and La Petite Terre are the only islands where just *Iguana delicatissima* is thought to live" is not warranted or accurate, as no reason exists to doubt the "purity" of populations on Anguilla or St. Eustatius). Regardless, in recent years, human-mediated introductions of *I. iguana* onto islands inhabited by *I. delicatissima* and reductions in the extent of suitable habitat caused by human encroachment have dramatically magnified the frequencies of contact between the two species on Martinique and Guadeloupe, where populations of "pure" *I. delicatissima* have essentially disappeared.



Distribution of Lesser Antillean iguanas. Islands on which *Iguana delicatissima* has been found are indicated by gray arrows, whereas those on which *I. iguana* has been found are indicated by white arrows. Arrows with an X indicate that the population has been extirpated, those with an I indicate an introduced population, and those with question marks indicate populations of unknown origin (see text). Note that no island is known to have ever supported two native populations of different species.

In 1995, as a consequence of Hurricane Luis, a floating mat of logs and uprooted trees carried at least 15 *I. iguana*, presumably from Guadeloupe, to Anguilla (Censky et al. 1998), providing irrefutable evidence of over-water dispersal by rafting. Although the "raft" landed near the eastern tip of Anguilla, far from the areas occupied by native *I. delicatissima* (Hodge et al. 2003), a decision to catch and destroy any Green Iguanas was implemented in order to avoid any possibility of contaminating the native gene pool. Although recent reports indicate that Green Iguanas still occur on Anguilla (Hodge 2003), no evidence exists that hybridization has occurred.

Looking to the Future

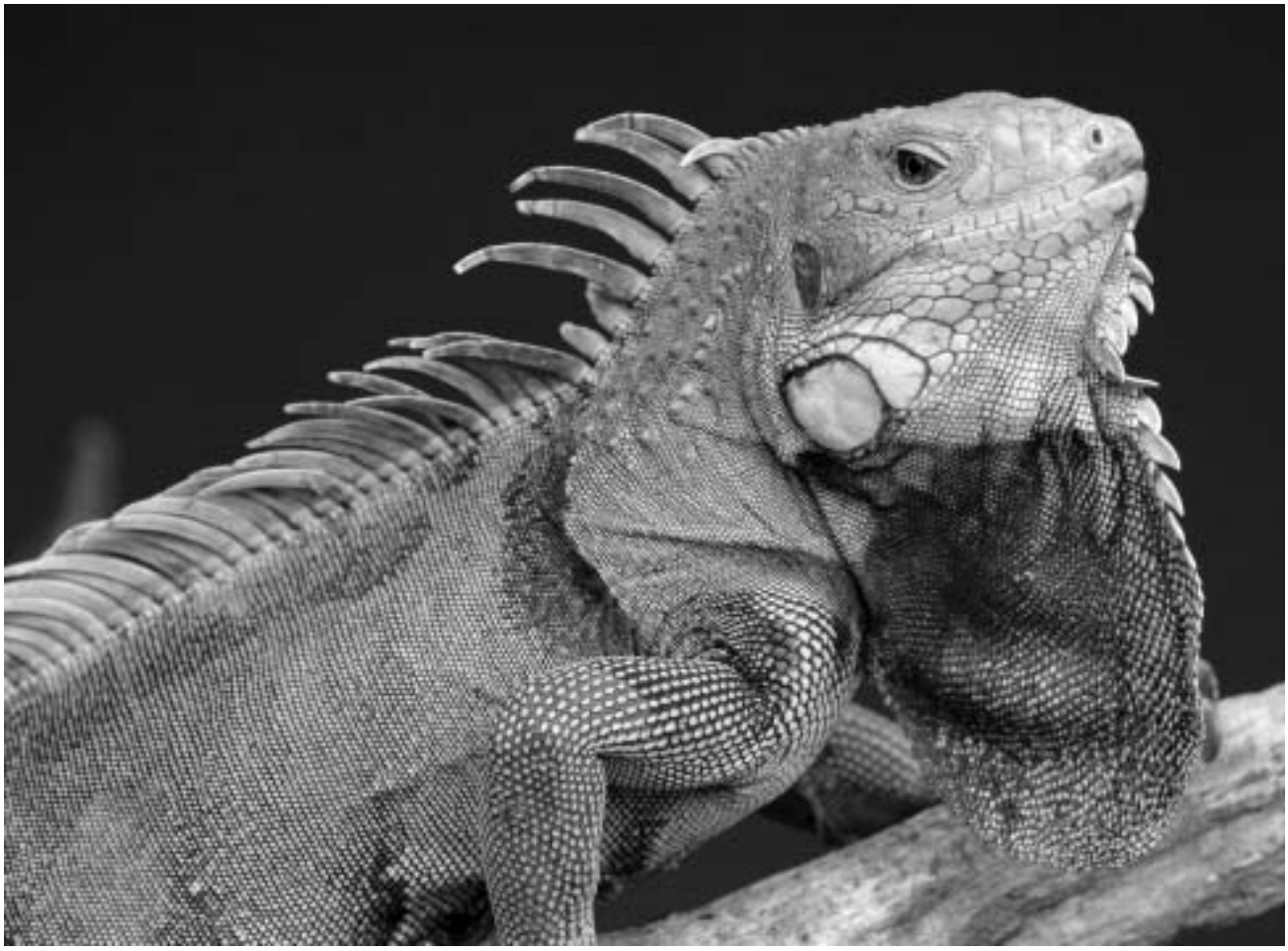
Unlike essentially all other West Indian iguanas, management strategies developed for the conservation of Lesser Antillean populations face the possibly insurmountable hurdle of involving a number of different governmental entities in any development and implementation of species recovery plans. Complicating matters even more is the reality that needs vary considerably from island to island. However, some generalities apply. If *Iguana delicatissima* and unique insular populations of *I. iguana* are to be saved, plans will have to include surveys and field research, establishment of protected areas within which livestock must be controlled, predator control strategies, massive educational efforts, and, in a few instances, captive-breeding and head-starting programs.

We know surprisingly little about the abundance and distribution of Lesser Antillean iguanas. Basic surveys have utilized various methods, many of which are not comparable. Also, because iguanas often are confined to the most rugged and remote regions of the respective islands on which they occur, many populations have not been surveyed recently — and some not at all. Furthermore, the basic biology of most populations has not been examined and many of the available studies may be compromised to varying degrees by focusing on animals acclimated to some degree of human activity. Assumptions that each population requires substantially the same essential resources may or may not apply. We simply lack the information necessary to make that determination. Consequently, we can only

Like most other populations of *Iguana delicatissima*, that on Anguilla is critically endangered. *Photograph by Glenn Gerber.*

The unusual pattern of this juvenile *Iguana iguana* from Saba provides support for the contention that this island population is specifically distinct. *Photograph by John S. Parmerlee, Jr.*

St. Lucian Iguanas, like those from Saba, are morphologically and genetically distinct from populations on the South and Central American mainland and the more southerly Lesser Antillean islands. *Photograph by Matt Morton.*



An adult male Green Iguana (*Iguana iguana*) from St. Maarten. All iguanas on St. Maarten are descendants of escaped or released pets. The Lesser Antillean Iguanas (*I. delicatissima*) endemic to the island have been extirpated. *Photograph by John S. Parmerlee, Jr.*

guess at changes resulting from recent development or at the impact of hurricanes on populations occupying increasingly smaller parcels of suitable habitats. Any effective management plan must include provisions for a single administrative entity that will be responsible for establishing guidelines for surveys and for training participants to assure the comparably reliable data that will be necessary for establishing priorities.

Basic surveys are most necessary on Montserrat, where the status of the *I. iguana* population is unknown and on islands, such as St. Vincent, the Grenadines, and Grenada, from which we have no current data on the populations. In addition, surveys on islands where *I. delicatissima* is in gravest danger of extinction (e.g., Anguilla, Île Fourchue and satellites, and St. Eustatius) should be implemented on a recurring and regular basis. Populations of iguanas on Guadeloupe and Martinique, which may represent hybrid "swarms," need to be monitored in order to evaluate ongoing interactions between the two species in order to better understand the relevant dynamics in anticipation of possible contact between them elsewhere. Field research on the basic biology of populations are needed for all populations, but priority should be given to better understanding the unique populations of *I. iguana* on Saba and St. Lucia (Morton 2004) and those populations of *I. delicatissima* in gravest danger of extinction (see above).

An adult female *Iguana delicatissima* on a Tamarind Tree in St. Eustatius, a favorite food tree. *Photograph by Robert Powell.*

Human encroachment on iguana habitats is inevitable unless protected areas are established and their boundaries enforced. The situation is least critical on islands (e.g., Saba and Dominica) with established reserves and rugged terrains that defy development in many areas. The needs are greatest on islands already heavily developed (e.g., St.-Barthélemy), with essentially no public land (e.g., Anguilla), or where protected

areas exist, but are being degraded rapidly by invasive plants and free-ranging livestock (e.g., St. Eustatius). Establishing satellite populations to reduce the threat of stochastic events, which has been implemented, for example, for several Rock Iguanas (see Alberts 2004), is not practical in most instances. Either satellite islands with suitable habitat do not exist or they are privately owned and unavailable. Also, many of the possible candidates support populations of feral dogs or cats or introduced mongooses (*Herpestes javanicus*), which would have to be eliminated at considerable cost in money and effort.

Education is critical for any conservation effort. Local residents of many Lesser Antillean islands are unaware that native iguana populations are endangered, that populations on several islands are unique, or that populations on other islands are composed entirely of individuals that are descended from escaped pets. That lack of awareness translates into a lack of support for conservation plans and a lack of concern for ongoing exploitation of iguanas for food, often by guest workers from other nations where iguana harvesting is a well-established tradition. This can be countered only by extensive educational programs. Current efforts are sporadic and vary in effectiveness. Anguilla, for example, has issued commemorative stamps and the National Trust successfully solicited funding for a book on the island's reptiles and amphibians (Hodge et al. 2003), which is being used in educational programs. A consortium of private and public entities on Saba has established a month-long "Sea & Learn" program (http://www.seaandlearn.org/), during which resident and visiting "experts" provide educational programs and outings for residents, students, and tourists. The St. Eustatius National Parks (STENAPA) Foundation regularly visits the nation's public and private schools and provides opportunities for students to learn about conservation both in and out of the classroom. In addition, with financial support from the International Iguana Society, signs promoting iguana conservation have been posted across the island (Anonymous 2004b, 2004c; Fogarty et al. 2004). On St. Lucia, the International Iguana Foundation and the Durrell Wildlife Conservation Trust have funded signs asking people to keep dogs on leashes in areas occupied by iguanas (Bendon 2003).

Captive-breeding programs for *I. delicatissima* exist at the Jersey Zoo in the English Channel Islands and the Memphis and San Diego zoos in the United States. However, success has been limited, with only the Jersey Zoo producing offspring (one in 1997 and eight in 2000). To the best of my knowledge, no captive-breeding programs for any Lesser Antillean Green Iguanas exist. Some discussion on Anguilla has addressed the possibility of headstarting individuals in anticipation of establishing a satellite population on an offshore island, but concrete plans are yet to be completed. On St. Lucia, iguana nests are monitored and protected, but no headstarting program exists. The St. Lucian Iguana, however, is a prime candidate for headstarting and for an *ex situ* captive breeding program. The principal impediment appears to be a general lack of recognition that this population is unique and worthy of such efforts.

Malone and Davis (2003) eloquently discussed the sometimes tragic consequences of establishing conservation priorities on taxonomies that do not reflect true phylogenetic relationships, citing the extinction of all but one population of the Tuatara (*Sphenodon guentheri*), that mistakenly had been considered but a subspecies of the more widely distributed *S. punc-*

An emaciated Green Iguana (*Iguana iguana*) after an over-water arrival on Anguilla via a floating mass of vegetation. *Photograph by Judy Dudley.*

This young adult Saban Iguana is mostly black, but retains some markings on the head. *Photograph by Robert Powell.*

This gravid female Saban Iguana was quite tolerant of humans. *Photograph by Robert Powell.*

tatus and, consequently, for which no protection was afforded. Malone and Davis (2003) also provided data indicating that similarly erroneous taxonomies exist for West Indian iguanas. The elevation of *Cyclura lewisi* to full species (Burton 2004b) effectively corrected one error, but any formal recognition of distinctive clades within *I. iguana* has not been addressed.

Management plans must be developed and implemented for Lesser Antillean iguanas, but two substantive barriers exist: (1) Governmental agencies and non-governmental conservation organizations must recognize the value of the unique insular populations currently classified as *I. iguana* and move ahead with conservation plans without waiting for the erroneous taxonomy to be formally corrected. (2) Those same entities must realize the precarious situation facing *I. delicatissima*, in spite of the fact that, as a species, it is merely "vulnerable" according to the current IUCN Red List (Hilton-Taylor 2000). In light of the precarious existence of nearly all populations, the extirpation of several, and observed declines and genetic contamination in others, those that remain must be afforded effective protection now, before the situation deteriorates further. In the meantime, educational efforts must be expanded or developed and implemented, with a particular emphasis on the potential harm to current and future conservation efforts if no consideration is given to the genetic distinctiveness or innate biological value of populations of either species.

Adult St Lucian Iguanas feature distinct bands of black or dark gray on a pale background. *Photograph by Matt Morton.*

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HUSBANDRY

Reptile Quarantine

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Photographs by the author.

The "animals are in quarantine" is a term often used by veterinarians — but what is the purpose of quarantine? Why is it important to herpetologists? What are the important components of an effective quarantine protocol?

Quarantine can serve as a time for animals new to a population to adjust to a new environment and diet and to recover from the stresses of translocation. However, more importantly, quarantine isolates a sick animal from healthy ones and serves to prevent the introduction of an infectious disease into one reptile population from another. The introduction could be from one private or public collection to another, pet shop to a private collector, one zoo to another, wild caught animals to a captive population, or captive animals being reintroduced into the wild. Many infectious diseases pose a risk to reptiles. Because effective therapy does not exist for many of these disease organisms, preventing their introduction into a population is very important. Diseases or infectious agents of concern include ticks, mites, coccidiosis, cryptosporidiosis, amoebiasis, roundworms, herpesvirus, paramyxovirus, mycoplasma, and inclusion body disease.

Reptiles from different regions of the world (e.g., Western versus Eastern hemispheres) should not be placed in the same enclosure. Their gastrointestinal tracts may support a different

Weighing a Mona Island Iguana; body weight is a crude but accurate indicator of condition. Low weight may indicate poor prior care of a health problem that must be identified and treated.

Drawing blood for a complete blood count, chemistries, and serological tests should be part of any pre-shipment, post-shipment, and release from quarantine protocol. Here blood is drawn from a vein on the underside of the tail of a Mona Island Iguana.

flora or suite of organisms, and their immune systems may be naïve toward each other's disease organisms.

Quarantined animals must be physically isolated from any other populations at risk. Ideally, housing is in a separate building or outside pen. If not in a separate building, animals are sufficiently isolated in order to prevent physical contact, aerosol or drainage contamination, and transmission of disease-producing agents via bedding, tools, or other inanimate objects. When feasible, animals should be housed individually. The area should be self-contained and easy to clean and disinfect. The animal caretaker should not be in daily contact with the rest of the reptile collection. If designating a separate caretaker is not feasible, care for quarantined animals should be scheduled at the end of the day, after all others are serviced. A separate set of feeding and cleaning utensils are used only in the quarantine area. Protective clothing such as disposable gloves, coveralls, and boot covers are worn at the quarantine location.

When possible, animals should be examined by a veterinarian before translocation to quarantine. Shipment and adjustment to new environments stress animals in many ways. Only healthy animals should be shipped, but this precaution is not always enforced. Prior to shipping, each animal should be identified, given a complete physical examination, weighed, feces checked for parasites, and blood drawn for a complete blood count, chemistries, and serological tests. Any disease concerns are addressed before animals are shipped, preferably with a medical history documenting any problems and all treatments.

Upon arrival at the quarantine facility, every animal should again be examined, weighed, and have its medical history reviewed. Any transport materials such as crates, cloth bags, and packing materials are disinfected immediately or discarded. Each animal is provided a proper thermal and light environment, shelter, hiding spots, basking locations, appropriate climbing structures, and enrichment items as appropriate. Introduction

Corneal lesions, such as on this Mona Island Iguana (*Cyclura cornuta stejnegeri*), can be symptomatic of several different health problems that should be diagnosed and treated during quarantine.

Conducting an ophthalmic examination on a Mona Island Iguana.

Conducting an oral examination on a Mona Island Iguana.

to the diet is done gradually by replacing food items from the previous diet with new ones.

A quarantine period of at least 90 days is recommended. This is usually enough time for clinical signs of disease to be manifested. Ninety days also allows time for seroconversion (development of antibodies in response to natural infection or to the administration of a vaccine) in those animals where a serological test is available to determine if exposure to a disease has occurred. For example, blood is routinely drawn from snakes twice during the quarantine period to check for the presence of antibodies to paramyxovirus. The best program is also one in which all new animals come into the facility at the same time and leave at the same time.

During the quarantine period, at least two additional fecal samples should be evaluated. After animals have adjusted to their new surroundings, medical tests not completed during the preshipment exam are performed or, in some instances, repeated. Medical records are updated. Daily observations are recorded for food consumption, fecal characteristics, abnormal behaviors, and body condition. An animal that dies in quarantine should be submitted for a necropsy, including the submission of tissues from various organs for histopathology evaluation, in order to identify the cause so that steps can be taken to prevent reoccurrence.

At the end of the quarantine period, animals are weighed and given another physical examination. Only healthy animals leave quarantine. If needed, the quarantine period may be extended until all disease concerns are addressed.

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HISTORICAL PERSPECTIVES

Observation on Habits of the Cuban Iguana[1]

Mario S. Buide

The Cuban Iguana (*Cyclura macleayi* [= *C. nubila*]) is a very agile and extremely wary animal, more dependent upon its vision than upon sound for protection. It generally catches sight of possible enemies before being seen. When off guard, as in eating or while sunning itself, it may be surprised, if one approaches carefully; but once alarmed and on guard, it cannot be approached successfully.

In its departure from threatened danger this reptile almost never covers the entire distance to its hiding place in one dash, unless absolutely forced to do so. Usually it advances or withdraws in short spurts of fifteen or twenty yards, poising then like a dog on the alert, listening for any sound. It stretches the neck upward and bobs its head in a rhythmical and comical movement. When it again scents or sights danger, it makes another dash of similar length, and so on until it reaches its hiding place, which in general is a hole or pocket in the rocks. Here it hastens to take refuge and settles down in fancied security. If the hunter finds it in a rather shallow hiding place not affording complete concealment, the Iguana opens its mouth in threatening fashion and gives voice to a disconcerting hoarse noise.

The mobility and agility of this lizard is astonishing to one who has only seen it traveling at ease, with no cause for fright or alarm. It then seems heavy and slothful dragging its belly along the ground and leaving a track or furrow formed by the long, heavy tail. It is so agile, however, that with a few strides it can climb up a twenty-five foot stone wall or a tall tree, which it often does to satisfy its appetite. When surprised aloft it makes a single leap to the ground, and then sets out at high speed.

Adult Cuban Iguana (*Cyclura nubila*). *Photograph by Thomas Wiewandt.*

Unlike most Cuban reptiles, which are active during the hours of darkness, the Iguana, like a few other lizards as the 'Chameleon' [= Anoles, genus *Anolis*] and 'Bayoya' [Curly-tailed Lizards, genus *Leiocephalus*], is active during the middle of the day, when the sun is highest. Rarely is it seen before nine o'clock in the morning or after five in the afternoon. If found at such times, it is slow and lethargic. On cloudy or rainy days, it is not seen.

The Iguana may live in areas which completely lack water for drinking even in pits or hollows that might collect rainwater. It is found also on very small areas of land, such as keys and tiny islands. Fishermen from regions of numerous small islands tell me that they have seen the Iguana moving from key to key, crossing narrows of more than two hundred yards in width by swimming on the surface with the tail employed in the manner of a sculling oar.

The Iguana is an animal that prefers a solitary life, never being found naturally in groups; however, it tolerates collective life when constrained to live so. I keep large numbers together and have never witnessed a single fight amongst them. On cool nights they even huddle together presumably for the purpose of warmth conservation.

Cyclura macleayi reaches a very considerable size; I have had specimens up to 60 inches in length. In these lizards the tail is a most important organ, from the standpoint both of health and resistance. A fat tail on either a young or old specimen is a sign of good health, and that the individual can endure long enclosure and long voyages. However, the tip of the tail is so fragile that is will readily break off in the grip of the incautious handler. The teeth are small and sharp, the bite powerful enough to crush small bones.

The Iguana is omnivorous, eating fruits, vegetables, and ripe bananas, varied in captivity with left-overs from the table such as cereals, meat, and fish.

[1] Translated by Dr. D. F. Munro. Reprinted with permission from *Herpetologica* 7:124 (1951). Bracketed names were added and one typographical error corrected.

Notes on the Cuban Iguana[1]

Jerry D. Hardy, Jr.

Barbour and Ramsden (1919, Memoirs Mus. Comp. Zool., Harvard Univ., 47[2]: 72–213) list six mainland localities for the Cuban iguana, *Cyclura macleayi macleayi* Gray [= *C. nubila nubila*], and comment on the gradual extirpation of the species. Their records represent all the Cuban provinces with the exception of Santa Clara, now Las Villas.

During September, 1955, Mr. Daniel Lyons, of the Natural History Society of Maryland, and the author observed a number of iguanas on the Cuban mainland near the city of Trinidad, Las Villas Province. These observations add a new provincial record to the list of Barbour and Ramsden.

Five individuals were observed on the mainland in typical limestone associations as described by Sutcliff (1952, Notulae Naturae, Acad. Nat. Sci. Philadelphia, 243 1–7) in his discussion of the species as observed on Cayo de la Piedra. In such areas dense vegetation occurs on a thin soil lying over a limestone base. Prickly pear and trailing cactus are typical plants. Iguanas occupying such areas live in natural cavities of the limestone.

Observations were made on Cayo Macho de Tierra on September 12, 1955. The island is approximately one-quarter-mile long and reaches a width of 200 yards. It consists of a low, sandy hill almost completely surrounded by dense mangrove swamps. Vegetation is sparse in the open, sandy central area and consists chiefly of beach grasses. Besides the iguanas, numerous aquatic birds, land crabs, and *Anolis sagrei* were distributed throughout the area. A small colony of *Ameiva auberi* occupied a sandy beach on the west end of the island.

A total of seven iguanas was observed between 10:00 A.M. and noon, five of which were captured. In all cases they were flushed from thick clumps of beach grass.

There are apparently no accounts of *Cyclura macleayi macleayi* entering water as a means of escape. Two individuals entered burrows whereas the other island-dwelling iguanas sought escape by entering the sea. Each one ran parallel to the shore, sometimes for more than one hundred yards, then, turning swiftly, entered the water, swimming out about twenty yards, and remaining motionless beneath eight to ten inches of water. One individual entered the water from an open beach, but in an area where heavy wave action was inhibited by a thick growth of seaweed. The others entered the mangrove swamps in which the water was clear and quiet.

The island-dwelling iguanas inhabit long, shallow burrows similar to those dug by large land crabs. Burrows were observed in the more elevated regions of Cayo Macho de Tierra as well as on three small unnamed islands southeast of Casilda, and could be distinguished from crab burrows by their larger size and the long groove-like tail marks at their entrances.

Of the three burrows opened, two contained iguanas. All ran downward at a moderate angle for about two feet and then continued parallel to the surface for six or eight feet. Two ended blindly, whereas the third was found to have two entrances approximately eight feet apart. The actual dwelling place of its occupant was a small tunnel extending no more than two feet from one of the entrances.

Local observers insist that iguanas invariably leave the burrows tail first. This is perhaps true in view of the size and structure of the burrows, the diameters of which vary from four to eight inches throughout their length. In no case was an enlarged terminal room observed. Both of the individuals found in burrows were facing down-burrow in very tight quarters and were collected by grasping the tail.

[1] Reprinted with permission from *Herpetologica* 12:323–324 (1956).

Adult male Cuban Iguanas facing off in a territorial dispute. *Photograph by Glenn Gerber.*

IGUANA NEWSBRIEFS

Iguana Specialist Group and Fiji National Trust Co-Sponsor Conservation and Management Plan Workshop for Fijian Iguanas

Rick Hudson, Co-chair of the IUCN SSC Iguana Specialist Group, with a Crested Iguana on Yadua Taba, Fiji. *Photograph by Jone Niukula.*

On 10–11 November 2004, the IUCN SSC Iguana Specialist Group and the Fiji National Trust co-sponsored a Conservation and Management Plan workshop for Fiji's native Crested (*Brachylophus vitiensis*) and Banded iguanas (*B. fasciatus*). The workshop was held on the Laucala campus of the University of the South Pacific, and was attended by 50 participants from both within and outside Fiji. The purpose of the workshop was to develop a comprehensive strategy to guide the conservation of Fiji's native iguanas by identifying and prioritizing the actions needed to ensure their future survival. For Crested Iguanas, participants identified a series of key objectives, including prioritization of islands most suitable for long-term survival, implementation of a comprehensive management plan for the Yadua Taba Crested Iguana Sanctuary, recommendations for field research on iguanas and their habitats, development of captive breeding and reintroduction strategies, and establishment of education, awareness, and ecotourism programs. For Banded Iguanas, about which much less is currently known, participants developed a research agenda that focuses on collection of baseline data, genetic studies, and education needs. Results of the workshop will be published early next year.

Following the workshop, participants had the opportunity to visit a traditional Fijian village on Yadua Island, home to the custodians of the Crested Iguana sanctuary on nearby Yadua Taba. Following a traditional sevusevu ceremony, permission to visit the sanctuary was given, and participants had the rare treat of viewing an extraordinarily dense population of Crested Iguanas in the wild. After return-

Participants in the Conservation and Management Plan workshop for Fiji's native iguanas at the Laucala campus of the University of the South Pacific. *Photograph by Joe Burgess.*

ing to the main island of Viti Levu, the Iguana Specialist Group met in Suva on 15 November. The meeting centered on planning discussions for a number of key taxa, as well as special sessions on public relations and the media, iguana friendly development guidelines, and funding priorities for 2005.

Allison Alberts and Rick Hudson
Co-Chairs, IUCN SSC Iguana Specialist Group

Residents of Boca Grande Seek to Exterminate Introduced Spiny-tailed Iguanas

Citizens attending a meeting of the Gasparilla Island Conservation and Improvement Association overwhelmingly favored ridding the island of the increasingly numerous Spiny-tailed Iguanas (*Ctenosaura similis*), which they regard as no better than rats. Jerome Jackson, a scholar at the Florida Gulf Coast University, believes the iguanas pose a serious threat to several endangered species, consuming everything from turtle hatchlings, mice, and native vegetation to the eggs of Gopher Tortoises and birds. Suggestions for exterminating the animals included rounding them up and selling them to high schools for dissection or selling the meat as an exotic delicacy and hides for purses. Bob Janes, Lee County Commissioner, said that no timetable had been established, nor were cost estimates or formal plans for the removal of iguanas in place. According to one study, iguanas on the island number around 10,000 (see also IGUANA 11(2):130).

Gopher Tortoises and Feral Iguanas do not Compete for Food

Ray Ashton of the Ashton Biodiversity Research and Preservation Institute (www.AshtonBiodiversity.org) is the author of a forthcoming book on Gopher Tortoises (*Gopherus polyphemus*). He recently was asked whether the increasing number of feral iguanas in Florida poses a threat to the endangered Gopher Tortoise by competing for the same food plants. Ray reported that he is frequently asked this question by individuals concerned about possible ecological consequences of feral iguanas in

Florida Gopher Tortoise (*Gopherus polyphemus*) diets probably are not affected by the presence of introduced iguanas. *Photograph by Joe Burgess.*

southern Florida. He further stated that his in-depth studies on the diet of Gopher Tortoises (in press) indicate that the average tortoise forages on 80–165 species in a yearly cycle and that more than 400 species of forage plants are documented in its range. Furthermore, coastal diversity studies indicate that about 120 species are commonly available for tortoises on Florida beach strands. By bulk, about 80% of the diet of tortoises (all size classes) is composed of grasses and sedges. He concluded: "I doubt very much that there is competition with the lizards."

Long Island Reptile Museum Closed

The Long Island Reptile Museum in Hicksville, New York went out of business on 9 November when the unheated building was condemned. Workers from the Suffolk County SPCA and volunteers from a number of rescue organizations evacuated 182 reptiles and amphibians, including two 6-foot alligators, a 250-pound Aldabra Tortoise, and over a dozen venomous snakes and lizards. The International Fauna Society housed animals temporarily until they could be released legally to adoptive homes.

The closure of the Museum was the culmination of more than two years' effort on the part of reptile rescue groups in New York and Connecticut working in cooperation with local police and SPCA officials (see also IGUANA 11(1):72–73). A recent article on iguana rescue (IGUANA 10(4):121–126) euphemistically referred to the Museum as the "Alternative Reptile Institution" while describing the horrific conditions in which iguanas had been kept. Another 19 Spiny-tailed, Rock, and Green iguanas still resided at the Museum until the recent closure. All of these iguanas are currently in rehabilitation or have been placed in permanent adoptive homes.

Digger, a "Cuban" Iguana rescued from the Long Island Reptile Museum, proved to be a hybrid Blue Iguana once he was cleaned and examined carefully. *Photograph by Carole Saucier.*

Spiny-tailed Iguanas (*Ctenosaura similis*) are considered pests by some residents of Boca Grande. *Photograph by John Binns.*

Remarks

Craig Hassapakis, editor of *Amphibian and Reptile Conservation* (*ARC*), originally conceived the idea to devote a special publication entirely to iguana conservation. Allison Alberts organized the topics and authors. The first five articles in this issue were subsequently reviewed and edited by Craig, his associate editor, Jack Sites, and the editorial team at *ARC*. They thank the following individuals for their service in reviewing and/or editing those articles: Mark Goodwin, Malcolm McCallum, Gad Perry, Michael Dreslik, Csilla Csaplar, John McVay, Stephen Johnson, Deahn Donner Wright, Bethany Meisinger-Reiff, and Craig Snyder. Due to an impacted publication schedule at *ARC*, *IGUANA* kindly offered to publish the special issue. This solution exemplifies the cooperation being exhibited in herpetology, and *ARC* and the authors of the articles are grateful to the editors of *IGUANA* for their foresight and generosity in accommodating this material.

Editorial Note.—In Powell (2004. *IGUANA* 11(2):108–113), the author commented (figure caption, p. 109) that "*Cyclura carinata bartschi* is not genetically distinct from the nominate subspecies," citing Malone and Davis (2004. In: Alberts et al. (eds.), *Iguanas: Biology and Conservation*). In fact, the genetic composition of the Booby Cay population has yet to be compared to populations in the Turks & Caicos Islands that are assigned to the nominate population. We thank Glenn Gerber for bringing this to our attention.

Statement of Purpose

The International Iguana Society, Inc. is a not-for-profit corporation dedicated to preserving the biological diversity of iguanas. We believe that the best way to protect iguanas and other native plants and animals is to preserve natural habitats and to encourage development of sustainable economies compatible with the maintenance of biodiversity. To this end, we will: (1) engage in active conservation, initiating, assisting, and funding conservation efforts in cooperation with U.S. and international governmental and private agencies; (2) promote educational efforts related to the preservation of biodiversity; (3) build connections between individuals and the academic, zoo, and conservation communities, providing conduits for education and for involving the general public in efforts to preserve endangered species; and (4) encourage the dissemination and exchange of information on the ecology, population biology, behavior, captive husbandry, taxonomy, and evolution of iguanas.

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Iguana, the Journal of The International Iguana Society, is distributed quarterly.

Individual and Organizational Annual Membership Dues:

U.S. or Canada (hard copy) $25.00
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Membership questions? Call AJ at 860-236-8203, or write to: The International Iguana Society, Inc., 133 Steele Road, West Hartford, CT 06119

Solicitations

Members of the I.I.S. are encouraged to contribute articles, letters to the Editor, news items, and announcements for publication in *IGUANA.* General articles can deal with any aspect of iguana biology, including conservation, behavior, ecology, physiology, systematics, or husbandry. Submission of photographs to accompany articles is encouraged.

Manuscripts may be submitted via e-mail (send to ctenosaura@cyclura.com). For any contribution, please include your name, address, phone number, and e-mail address. Authors of one page or more of print will receive a free copy of the journal in which their contribution appears, and will receive a PDF file of their article for distribution.

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LETTER FROM THE PRESIDENT

This year, the IUCN Iguana Specialist Group met in a geographic area other than the Caribbean for the first time, meeting in Suva, Fiji. The nation of Fiji is located in the South Pacific and is composed of several hundred islands, of which about a hundred are permanently inhabited. Two species of iguanas are native to these islands: the Pacific Banded Iguana, *Brachylophus fasciatus*, and the Fijian Crested Iguana, *Brachylophus vitiensis*. Both are endangered as a result of essentially the same factors faced by other insular species of iguanas. The Fijian species are spectacular animals, bright green with blue bands in the banded form and white bands in the crested form. Banded Iguanas are documented from 34 Fijian islands and the Crested Iguanas from only four islands.

The meeting in Suva consisted of two days of intense discussions and workshops. The Iguana Specialist Group, along with officials from the University of the South Pacific, The National Trust of Fiji Islands, and Kula Eco Park, collected preliminary information that will be used to produce a management plan for *Brachylophus vitiensis*.

In addition to the privilege of working on the Conservation & Management Plan for the Fijian Crested Iguanas, I felt honored to see them in their natural state. At 3:30 a.m. of the morning following the meeting, the group visited the island of Yadua and stayed in the village of Denimanu. We had to be accepted into the village as guests prior to visiting Yadua Taba, the home of the Crested Iguana. Once we were accepted as a group, each individual was adopted by a family from the village and we were set for an in-depth cultural experience.

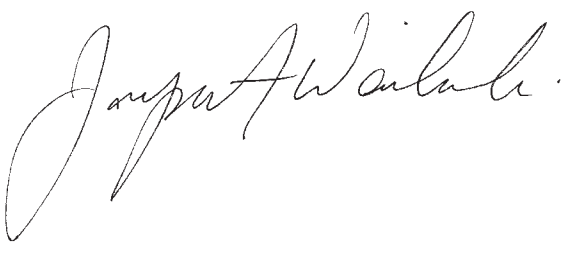
The village has no electricity (other than a small gasoline generator supplying power for a few fluorescent lights) or running water. Most of the people live in grass huts, which also became our homes for a few days. All of our meals were prepared fresh, primarily from fish harvested from the offshore reef. The reef itself has been monitored for the past four years by a conservation group from the UK called Greenforce. Their study indicates that this is one of the few remaining pristine reefs in the world and that the harvest is sustainable. Without refrigeration, the people take only enough to supply their immediate needs.

Although a local Fijian language exists, most people speak English, especially the children, who attend school on the island until the eighth grade, and are then sent to the larger islands for further education if their parents are able to afford it. We were surprised to find no tables or chairs in the village; everyone sits on the floor (or ground) with their legs crossed. Hats and sunglasses are not permitted and, while alcohol is banned, smoking is not. Women wear calf-length skirts and men wear a Sulu (or sarong) during any important event, which seemed to occur daily. The featured social activity is centered around a drink called Kava, which is considered a sort of analgesic. Our group brought Kava root as a gift to the village. The root is pounded into a paste, which is then added to water. Even drinking Kava has rules; when it is offered and you wish to partake, simply clap your hands once, then proceed to drink the entire cup. After drinking, you hand the cup to the presenter and clap your hands three times. This gesture assures you of another round. If one leaves the Kava circle, one must touch the Kava bowl. Never point your legs (which are supposed to be crossed anyway) toward the Kava bowl. The drinking bowls were coconut-shell halves, some small and some quite large. Our scientific curiosity piqued, many in the group were prompted to partake of this unique cultural activity until the wee hours of the morning.

This photograph of Joe feeding an 800-lb crocodile earned him great respect from Fijian villagers. *Photograph by Stephanie Saybolt.*

The villagers are quite proud of their native iguanas, although they are somewhat afraid of them, thinking their size (maximum SVL of 223 mm and weighing up to 404 g) rivals that of mythical dragons. Knowing this, Peter Harlow meant to ask the group to bring along photos of themselves with some of the huge reptiles some of us have the pleasure of handling on a daily basis. Unfortunately, he forgot. I had brought along some photos of different iguana species (*Cyclura*), but they lacked references to size. Included among my photos was one showing me feeding an 18-foot long crocodile that weighs 800 lbs! That photo earned me a great deal of attention — and a few more Kava bowls.

I thank Peter Harlow and the many Fijian naturalists, who are quite proud of their natural heritage and are willing to work to preserve it for future generations, for working tirelessly to make this meeting happen. To the people of Denimanu village, who most graciously invited us back for a future visit, be careful what you wish, it may come true — I will return…



Adult Saban Iguanas (*Iguana iguana*) are melanistic; this gravid female retains some elements of juvenile color (article on p. 238). *Photograph by Robert Powell.*

Galápagos Marine Iguanas (*Amblyrhynchus cristatus*) from Isla Espanola (= Hood Island)(see article on p. 190). *Photograph by Thomas Wiewandt.*