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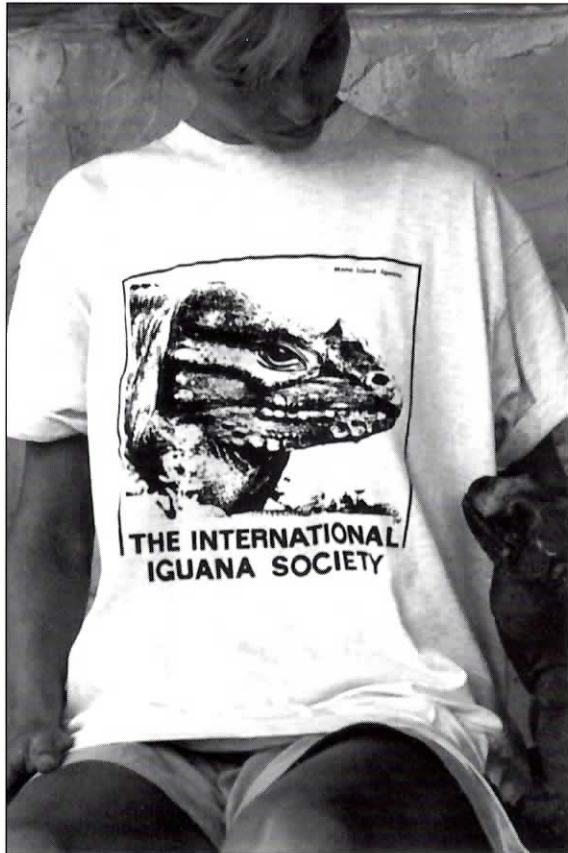
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Adult Jamaican iguana, *Cyclura collei*, basks
at the Hope Zoo in Kingston, Jamaica.
Photograph: Jeff Lemm

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Photograph courtesy of Jayme Gordon

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LOST AND FOUND: HOPE FOR THE JAMAICAN IGUANA

BY TANDORA GRANT AND JEFF LEMM, RESEARCH ASSISTANTS
CENTER FOR REPRODUCTION OF ENDANGERED SPECIES (C.R.E.S.) - SAN DIEGO ZOO

As researchers studying large endangered lizards, we were extremely excited to hear of the rediscovery of the Jamaican iguana, *Cyclura collei*. In June 1990, Edwin Duffus was hunting feral pigs in the limestone forests near his home outside of Kingston, Jamaica, when his dogs surrounded a large iguana. Edwin had heard stories from other hunters and forest users who claimed to have seen the legendary lizard but remembered from elementary school that they were believed to be extinct since the 1940's. By rescuing the lizard from his dogs, Edwin quickly became a local celebrity and brought the 115 km² area known as the Hellshire Hills into the conservation spotlight.

After Edwin brought the iguana to the Hope Zoo in Kingston, Zoo Director Rhema Kerr and Dr. Peter Vogel (University of the West Indies) formed the locally-based Jamaican Iguana Research and Conservation Group. Later, interest was rallied from a number of international zoos and individuals to participate in a Jamaican iguana Population and Habitat Viability Assessment meeting. Our involvement began when our supervisor, Dr. Allison Alberts, Head of the C.R.E.S. Comparative Physiology Division, Dr. John Phillips, and Jeff Lemm traveled to Kingston in 1993

to attend this conference. Among the many topics discussed, the delegates decided that hatchling iguanas and eggs should be collected from the wild and "headstarted" in safety at the Hope Zoo and later at zoos in the United States. The first importation of iguanas to the U.S. in 1994 brought twelve animals (6 males, 6 females) to three facilities: Gladys Porter (Texas), Fort Worth, and Indianapolis Zoos. To add to these founders, a second group of twelve juveniles were ready to leave Jamaica in April 1996, destined for Central Florida Zoo, Sedgwick County Zoo (Kansas), and the C.R.E.S. lizard research facility at the San Diego Zoo.

Endangered animals rarely travel without their human guardians and paperwork, so we packed our cameras and iguana crate and headed for Kingston. Fred Antonio, Curator at

Photograph: Jeff Lemm



Central Florida Zoo, and Rick Hudson, Assistant Curator at Fort Worth Zoo, met us at a hotel near the Hope Zoo. As Chair of the American Zoo and Aquarium Association's Lizard Advisory Group, Rick has been organizing funds and providing enormous support for both the Jamaican and Grand Cayman Island iguana conservation projects. The following day was spent touring the zoo, sampling the local cuisine, and meeting with Rhema Kerr and Peter Vogel to discuss recent project news and our importation permits, still pending. Dr. Vogel suggested we could hike into the Hellshire Hills to see the project site but that would mean we would have to stay an extra day and Jeff would miss a few more of his college classes at home. It wasn't a difficult decision.

Our adventure into the Hellshire Hills started at six the next morning. Already Jamaicans were busy crowding the bus stops, walking to work, and tending to rows of crops. An hour outside of Kingston, we stopped to pick up Edwin Duffus, who is no longer a pig hunter but a key field researcher for the conservation project. Since his initial discovery, he has spent countless hours studying the iguana's reproductive cycle, habits, and range. Edwin's fellowship with local forest users has been invaluable in persuading them to use only the northern edge of the forest and not penetrate south into the iguana's remaining habitat.

After loading up on bug repellent, sunscreen, snacks, and a gallon of water each, we were ready to head into the forest. Looking at our cameras, Edwin reminded us that it is extremely rare to see a wild iguana in the non-breeding season. Nevertheless, our cameras were kept busy as Dr. Vogel guided us along the trail and taught us about the

fascinating plants, birds, and reptiles inhabiting the area, many of which are Jamaican endemics. Hellshire comprises a peninsula of dense wooded hills fringed with wetlands and beaches. Unlike the rain forests in the mountains, it is among the driest areas of Jamaica with annual rainfall averaging below 100 centimeters. The limestone floor is rugged and honey-combed with hollows and crevices. We walked directly south through the area of the forest used by charcoal burners where the vegetation averaged only 3 meters in height with a few Gumbo Limbo trees rising high above like candles in a table decoration. At one of the many small blackened clearings, Dr. Vogel



The Hope Zoo in Kingston, Jamaica, where Edwin Duffus brought the first Jamaican iguana to be seen since the 1940's. Today the Hope Zoo is involved in extensive research on the Jamaican iguana. *Photograph: Tandora Grant*

explained how large trees and shrubs are gathered in a heap and partially burned to make charcoal, which is sold as fuel. Gumbo Limbo are spared because they are not useful charcoal producers. After four hours of walking, the forest abruptly rose to 9+ meters above us and the understory species changed and thinned. A kilometer later, the charcoal burner/pig hunter trail turned sharply ninety degrees west; a direct result of Edwin Duffus' educating prowess. We stepped off the trail to continue south along a narrow path that gave us a greater feeling of adventurous bushwhacking.



The Hope Zoo has been involved in educating the public about the Jamaican iguana since its rediscovery. Tandora Grant is pictured here next to a unique sign in front of the Jamaican iguana exhibit. Photograph: Jeff Lemm

Hot and sweaty, we reached the field base camp around one o'clock. Edwin was already waiting, had cooked a meal, and made coffee. We all sat for a long rest as hummingbirds and todies darted about and small Anolis lizards displayed their dewlaps denouncing our invasion of their territories. Eager to continue, Edwin took over guide duty to lead us to the iguana's nesting sites. Along the way our education continued about the habits of iguanas and their forest. Dispensing with scientific names, we learned to identify plants which we could eat, smoke, use to soothe rashes, or make tea from with names like 'hog doctor' and 'touch-me-not.' In about half an hour, we reached two red soil clearings, 6 and 13 meters in diameter, respectively. It was at these two sites in June of 1991 that six female Jamaican iguanas were observed laying the first-documented clutches of eggs. These clutches were collected and incubated at the University of the West Indies in Kingston where their survival was more assured.

The small iguana population faces many threats to its continued survival. Initial surveys estimate there are probably no more than 100 adult animals and a paucity of juveniles. Introduced Indian mongoose and feral cats prey heavily on eggs and juveniles and are believed to be the major factor contributing to the iguana's

decline and its top-heavy (aged) demographics. The Hellshire Hills also support a large population of feral pigs which destroy vegetation and have been documented eating *Cyclura* eggs on other Caribbean islands. These pigs are in turn hunted by humans whose tracking dogs are able to kill adult iguanas, as a number of such attacks have been confirmed in recent years. Habitat destruction by charcoal burning has already degraded as much as one-third of the northern region of the Hellshire Hills, while the eastern half is the target of a development proposal to build housing, resorts, and limestone quarries.

We poked around the brick red soil and found a few leathery eggshell remnants from previous years' clutches. There are at least nine female iguanas that have been observed laying their eggs in among three known sites. Because suitable nesting soil in Hellshire is comparatively rare, gravid females compete for space and aggressively defend their nests up to 16 days after laying. Most of the females begin laying an average



Young Jamaican iguana. Photograph: Jeff Lemm



The dry, limestone forest known as the Hellshire Hills is the last stronghold for the Jamaican iguana. Charcoal burning and development are major threats to this area and the existence of the Jamaican iguana.
Photographs: Jeff Lemm

of 17 eggs in early June which hatch after roughly 85 days. Edwin showed us the nets they are now using to cover the nests and capture emerging hatchlings so they can be raised in safety at the Hope Zoo. “Dem mongoose dey wait en wait by d’nest fer dem babies come up da wole en grab dem by

d’necks.” Edwin’s beautiful Jamaican sing-song accent is thick but we had no trouble understanding his meaning on this subject.

Climbing out of the valley floor, we headed for the most recently discovered nesting site on the mesa. We paused to check the cracks in the steep limestone cliff and found tail tracks at the entrances. At the last nest clearing, a blind had been set up for observation and probes placed at varying depths to record incubation temperatures. At the surface, the soil can reach temperatures above 130° F, while three feet below the eggs remain in the eighties. Edwin began to scoop the soil from an old burrow looking for eggshells and buried his arm to the shoulder. The cloying clay-



like soil clung to his skin and most of our clothes as well. The quality of the soil in Hellshire explains why Jamaican iguanas appear red. Underneath the persistent layer of dirt, adult iguanas are really dark brown or gray, while juveniles can have blue-gray, aqua, and yellow highlights. Throughout the forest Edwin pointed out red smears on the white limestone rocks where an iguana had passed, perhaps drinking from small pools of water.

Our imaginations were wild with visions of nesting iguanas as we hiked along the ridge back towards the base camp. Suddenly, Edwin turned and grabbed us by the shoulders, crouched into a huddle, and whispered, “guana!” Peering beyond

him, we searched the dense brush for several frantic moments whimpering, "where?" and "I don't see it!" Finally, twenty meters away, an adult Jamaican iguana close to a meter in length came into focus. In record time, Jeff and Fred switched lenses and snapped off a few pictures before the impressive animal slowly raised his head and chest and silently disappeared into the forest. We were chattering with excitement, floating on a high similar to any adrenaline-inducing sport. The normally exhausting hike back to the car now seemed easy with the memory of one of the earth's most endangered lizards powering our feet.

Back at the Hope Zoo, Rhema Kerr had spent most of the day securing our export permits from Jamaica's Natural Resources Conservation Authority. Rick Hudson was also busy capturing, identifying, and preparing twelve young iguanas for our flight in the morning. The previous night we had spent hours studying the genetic analyses from Dr. Scott Davis' lab at Texas A & M University. Based on gene markers at four different loci, we chose animals that would provide the

most allelic diversity for both the exported founder and Hope Zoo populations. Captive propagation of the iguanas is necessary to serve as a genetic reservoir safeguarding against catastrophic loss at any one site, provide progeny for repopulation in the wild, and generate data relevant to survival in captivity and the wild. Some of the participating zoos are also exhibiting the iguanas which increases public awareness and will hopefully stimulate donations of needed conservation dollars for the project.

In Jamaica, the iguana conservation project is moving forward with emergency recovery procedures. More than one hundred juveniles are being raised in enclosures built by a team from the Fort Worth and Hope Zoos. By raising the hatchlings to a larger size in captivity before reintroduction to the wild, it is hoped that more juveniles will reach adulthood. Attempts to reduce the mongoose population and other exotics in the area have also begun. Radio tracking has started for the juveniles released in Hellshire and will begin for mature females nesting next season. Finally,



An adult male Jamaican iguana, *Cyclura collei*, basks at the Hope Zoo in Kingston Jamaica. This species has not yet been bred in captivity as the Hope Zoo's 4-year-old animals are the oldest in captivity. Photograph: Jeff Lemm



Edwin Duffus and Jeff Lemm search for eggshell remnants at a Jamaican iguana nest site deep in the Hellshire Hills. Photograph: Tandora Grant


Edwin Duffus, Dr. Peter Vogel and biologist Richard Nelson from the University of West Indies continue to expand our knowledge of the iguana's biology.

The future for conservation in Jamaica is hopeful. Due in part to the educational efforts and media exposure made possible by the Hope Zoo, there have been recent increases in the public's environmental awareness. Upon our departure from Jamaica, we were pleased to learn that the receptionists for Air Jamaica knew all about the story of the rediscovery of their iguana. Environment shows are now regularly aired on radio and television. For the first time in Jamaican history,



The body color of young Jamaican iguanas is extremely variable. Colors may range from gray to blue-green. Photograph: Jeff Lemm

the government is working on implementing a national park system with Hellshire Hills among the first sites in line. The Jamaican iguana conservation project has the potential to be a flagship recovery program for other threatened Jamaican species, including the Jamaican boa (yellow snake) and Jamaican hutia (coney). The program incorporates all the elements necessary for success, including

both *in situ* and *ex situ* conservation schemes, educational outreach in the local community and abroad, habitat protection, and involvement with local forest users encouraging limited sustainable use. Though most species become endangered at the hand of man, with help from many concerned hands we are hopeful the Jamaican iguana will not join the list of extinct species. 

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GENETIC STUDIES OF THE JAMAICAN IGUANA

BY SCOTT DAVIS
TEXAS A&M UNIVERSITY

Most captive breeding programs for critically endangered animals are initiated with whatever individuals are available, which often are very few in number. These founders may not be representative of the species as a whole, thus limiting the genetic base of the captive population and jeopardizing its long term viability. Even worse, many founder groups are related, perhaps consisting of a single family, which not only limits their genetic variability but also leads to serious problems with inbreeding depression.

The Jamaican Iguana program presented us with the opportunity to begin in the right way by choosing founders to maximize genetic diversity and minimize relatedness. Shortly after rediscovery of the species, eggs deposited by wild females in the Hellshire Hills were collected to establish the captive breeding program. Only three clutches of iguana eggs were collected in 1991 and three more in 1992. At the worst, these six clutches might have represented the offspring of three females mated to a single male, while at best they represented the offspring of six different females mated to six different males.

To distinguish between the various possibilities, Edward Louis and Tana Wheeler worked in my laboratory to develop DNA markers for *Cyclura*. These markers, known as microsatellites, provide powerful tools for distinguishing individuals and determining parentage. They are

the same type of markers used to produce "DNA fingerprints" of humans for criminal cases.


Using these microsatellite markers, we were able to show that the three clutches in 1991 and 1992 were laid by the same three females, but that those females had mated with two different males. This allowed the captive breeding programs in the Hope Zoo and in U.S. zoos to begin with hatchlings from a balanced representation of all five founders.

Subsequent analyses of 1993 and 1994 hatchlings revealed two additional wild founders nesting in the Hellshire Hills. Therefore, offspring



Rick Hudson collecting blood from a Jamaican iguana at the Hope Zoo.
Photograph: Jeff Lemm

from their clutches were later incorporated into the captive breeding program to further increase genetic diversity.

These genetic markers are also being used in the captive breeding program for the Blue Iguana, *Cyclura nubila lewisi*, and are providing new insights into the structure of wild *Cyclura* populations throughout the Carribean. 

CYCLURA FOREST HABITAT

The dry forests of the West Indian Islands that evolved in association with rock iguanas

ROBERT W. EHRIG

Xerophytic forests inhabited by large herbivorous lizards have existed in the West Indies for millions of years. They have survived drastic climatic variation, geological activity, and rising and falling sea level throughout their existence. With the arrival of man, this habitat has been changed forever.

The dry forests of the West Indian islands are some of the most endangered habitats of the region. They evolved under harsh conditions and are often less tolerant of disturbance than other vegetation communities. They occur on limestone substrate in areas with highly seasonal rainfall patterns. They are short in stature as a result of their exposure to salt laden winds. Dry forests grow slowly in sand or in sparse rocky soils. They thrive in areas of erratic rainfall and frequent drought conditions. They not only survive hurricanes and tropical storms but quickly recover if they are in good condition. The dry forests of the West Indian islands are tremendously efficient systems, capable of capturing nutrients from infrequent cycles of abundance and able to survive long periods of few resources. These xerophytic plant communities contain some of the world's hardest woods, they harbor many spectacular bird species, and the earth's largest saurian herbivores.

Xerophytic vegetation communities contain plants that are structurally adapted to growing under very dry conditions. Xerophytes often have greatly reduced leaf surfaces to avoid water loss. They are thick and fleshy to facilitate water storage. Many species of plants have hairs, spines, or thorns to provide shade on their surfaces. They are perfectly adapted for the areas where they occur.

The rock iguanas of the genus *Cyclura* are the ideal vertebrate inhabitants of the West Indian dry forest. They are strongly heliothermic and survive long periods of time without fresh water. Rock iguanas thrive on a diet of rough fibrous leaves but

are well suited to take advantage of abundant but short-lived crops of flowers and fruits that most of the plants produce. *Cyclura* inhabit the many holes in the limestone substrate and create their own burrows in areas of sand.

In modern times, the West Indian dry forests have suffered a steady decline. On the larger islands and in populated areas these forests are mostly gone. Some excellent examples do survive in remote or sparsely populated areas, primarily in Cuba and the Bahamas. Excellent fragments remain in a number of other areas but most are under intense pressure and are in danger of being lost in the near future.

This type of habitat has been historically referred to as "Thorn Forest." This is due to the presence of cactus, agave, airplants, thorny or spiny trees and shrubs and the low canopy typical of this forest. Stem densities are extremely high, which helps reduce water loss. This makes moving through this habitat difficult for humans but not iguanas. The surface may be sandy, but more often is sharp pitted limestone full of holes and crevices. Solution holes and sinkholes are common, caused by rain dissolving softer areas in the rock over thousands of years. Sand and organic soils accumulate in these pockets providing places for trees and shrubs to grow. Larger holes may be kept open by the nesting activities of iguanas. Some sinkholes may contain pockets of a lateritic soil, especially on older and larger islands (Dominican Republic, Hellshire in Jamaica). Many of these soils were deposited by winds blowing dust off of Africa over the eons.

The rough nature and appearance of West Indian dry forest along with the heat and rocky terrain have made few people lament its destruction. The absence of permanent fresh water has been the main factor that has prevented destruction. On large islands the availability of water for irrigation has enabled agricultural development.



Giant Columnar Cacti, *Cephalocereus swartzii*, in the Hellshire Hills, August 1990. Photograph: R.W. Ehrig



Jamaican Silver Palms, *Coccothrinax jamaicanensis*, in the Hellshire Hills. Palm fruit provides desirable iguana food. August 1990. Photograph: R.W. Ehrig

Limestone mining has destroyed large areas in Cuba, Puerto Rico, and Jamaica. Woodcutting for the production of charcoal has destroyed vast areas in many countries. Few realize that Haiti was covered with rich dry forests containing massive quantities of mahogany and oak since these forests are 99% destroyed. Most of the soil has washed into the sea, thus depriving the island of its cover. The Hellshire Hills in southern Jamaica (the largest and most biologically diverse dry forest currently in existence in the region) is being consumed at present and will cease to exist in approximately 15 years at the present rate of deforestation.

Goats, burros, sheep, cattle, and other free ranging and feral mammalian browsers have caused untold damage. They have prevented natural regeneration of vegetation in many cases. In many degraded xeric forests non-native trees

such as Australian pine, (*Casuarina equisetifolia*) and jumbie bean, (*Leucaena leucocephala*) will become the dominant species. These trees have very low value for wildlife. Early successional native species such as *Acacia macracantha* will become major components of the forest at the expense of species diversity. Lower diversity of plants translates to reduced food resource for wildlife, which in turn leads to loss of more specialized organisms. The northern border of the Hellshire Hills, Jamaica was a tall dry forest with a 12-15 meter canopy until 1965, (E. Duffus, pers. com.). In 1990 this vegetation was composed of *Acacia macracantha* and *Haematoxylum campechianum* 2-3 meters in height. Although most large tracts of West Indian dry forest have already been destroyed, there are notable exceptions.

The Bahamas, Cuba, Dominican Republic, Virgin Islands, Florida Keys, and the Cayman Islands all have protected areas. In most cases these areas protect only parts of these habitats. Larger areas must be protected and reserves must be established in countries that do not yet have them if viable populations of *Cyclura* and other species are to survive.

Conservation of rock iguanas will be difficult in the face of growing poor human populations. The continued survival of these vegetation communities is the primary factor that will be responsible for the future survival of the West Indian rock iguanas. No other organism is more representative of West Indian dry forest and the continuing survival of both will be dependent on the same factors.

Coexistence of Forest and Iguanas

Cyclura presently survive in scattered locations in the Bahamas, Cuba, the Cayman Islands, Haiti and some offshore islands, Dominican Republic and some offshore islands, Jamaica, Mona Island, Magueyes Island, Anegada, and Guana Island. It is believed that they had a much larger natural range than at present. Lucayan, Caloosa, Taino, and Arawak Indians probably all utilised *Cyclura* as food and had a negative impact on populations. The arrival of Europeans precip-

itated drastic declines in iguana populations and the destruction of the habitats. The arrival of exotic predators and competitors caused drastic declines and extinctions even where habitats were left intact.

Rock iguanas may survive in habitat that is degraded. Mona Island has suffered from grazing by goats for hundreds of years. Iguana densities only appear to be extremely high in areas that are still pristine or very close to pristine. Areas where *Cyclura* naturally occur all have common characteristics. They have limestone as a substrate and a distinct seasonal rainfall pattern. They occur at latitudes between 25° and 16° north. The vegetation is dry West Indian forest with many of the same species and is influenced by the sea.

The vegetation contains cactus, *Opuntia*, *Cereus*, and *Cephalocereus* and *Agave*. It contains xeriphytic palms, *Coccothrinax*, *Thrinax*, and *Pseudophoenix*. Most of the trees and shrubs produce seasonal crops of flowers and fruits which are extremely desirable to iguanas. Some produce flushes of growth of leaves after rains which are

also utilized as food. The reason iguanas have been so successful in this habitat is that they are able to use the resources without damaging the plants. They easily survive the periods of drought. Introduced mammals may survive but with disastrous impacts on the habitat.

There is compelling evidence that herbivorous land iguanas have a positive effect on the dispersal of the seed of many of the plants. The distribution and frequency of many of the iguanas favorite food plants are enhanced by the iguanas foraging. Iguanas and the White Crowned Pigeon are the main seed dispersers in this habitat. Large fruited trees such as 7 year apple, *Casasia clusifolia* and wild dilly, *Manilkara bahamensis* are found growing on the tops of hills where iguanas occur. Without transport by iguana these species would have a very difficult time reaching such sites. When the droppings of iguanas are examined they commonly contain seed of these plants. The scats resemble cigars, sometimes containing whole leaves, making identification of plant species possible.



San Salvador iguana, *Cyclura rileyi*, on Green Cay among the Sea Ox-Eye Daisy. Photograph: Rena Burch

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The International Iguana Society, Inc. operates as a non-profit, international organization dedicated to the preservation of the biological diversity of iguanas through habitat preservation, active conservation, research, captive breeding and the dissemination of information.

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Manuscripts based on original research are solicited to communicate recent findings not only to other scientists but to the general public as well. We wish to instill in our readers a greater appreciation for scientific research and a better understanding of how it can contribute to the conservation of threatened iguana populations or the well-being of captive specimens.

Research Articles will be subjected to peer review, and should be fairly general in scope (i.e., manuscripts having extremely detailed theoretical or statistical bases should be submitted to more appropriate journals). Manuscripts of any length will be considered, and must be accompanied by an abstract of corresponding length. Authors can expect rapid turnaround time for the reviews and quick publication of acceptable material. Research articles will be cited as appearing in the *Journal of the International Iguana Society*, and will be forwarded to the major citation and abstract journals.

Research Updates should be comparatively brief and written in non-technical language. They will not be subjected to peer review. Submission of photographs to accompany research reports is encouraged.

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Large male *Cyclura rileyi rileyi* on
Low Cay in Morning Glory vine
growing on Seagrape. This habitat
was affected by Hurricane Lili.
Photograph: Deborah Neufeld

