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A large male spiny-tailed iguana, *Ctenosaura conspicuosa*, basks atop a cardon cactus, *Pachycereus pringlei*, on Isla San Esteban, a small island in the Gulf of California.
Photograph: L. Lee Grismer

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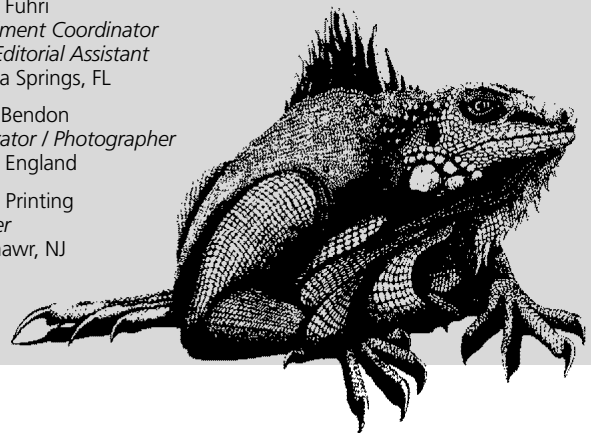
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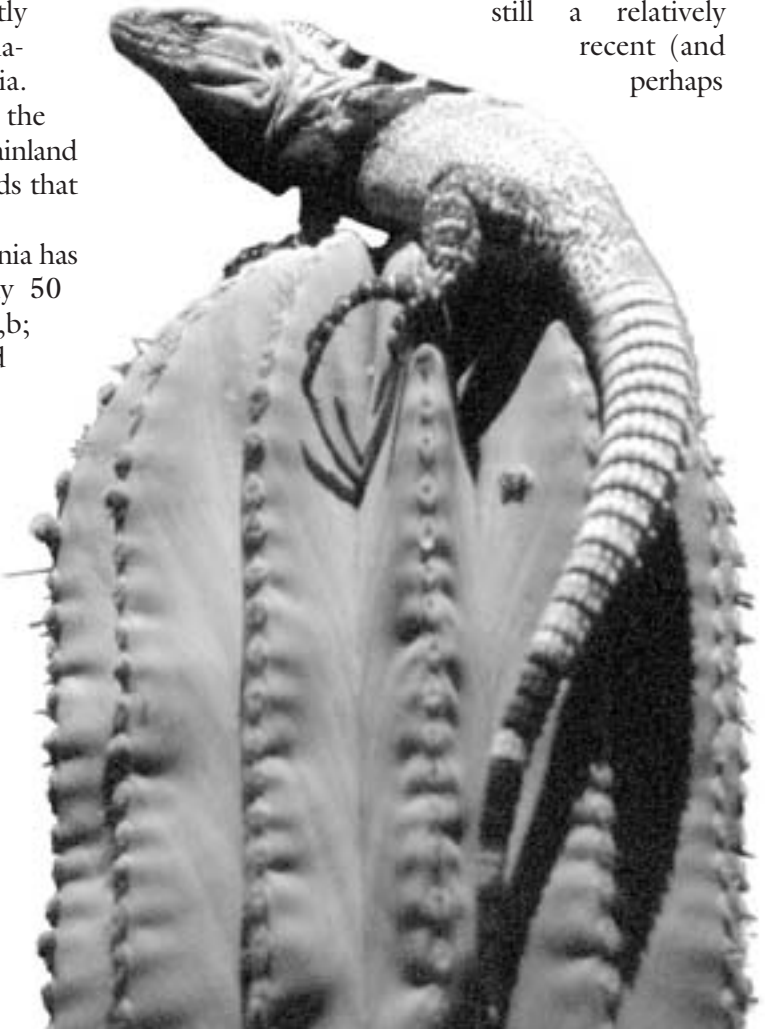
Spiny-tailed Iguanas, Insular Evolution, and Seri Indians: How Long Does it Take to Make a New Species and Does it Matter Who Makes it?

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A general paradigm among many biologists and lay people alike is that “millions of years” are required for species to evolve. In many cases this is true, but numerous endemic species on young landbridge islands from throughout the world are only thousands of years old, indicating that the speed of evolution is not constant across or within taxonomic boundaries. Population genetics has shown us that evolutionary rates vary according to population size and the selection pressure on that population. Such phenomena are most efficiently studied and best exemplified in island populations such as those in the Gulf of California. This 1000-km-long inland sea lies between the Baja California Peninsula and continental mainland México and harbors a diverse array of islands that vary in geological origin, age, and size.

The herpetofauna of the Gulf of California has received considerable attention for nearly 50 years (e.g., Case 1975, 1983; Cliff 1954a,b; Dixon 1966; Grismer 1994a,b,c,d 1999a,b,c; Hews 1990a,b; Hollingsworth 1998; Murphy 1975, 1983a,b; Murphy and Ottley 1984; Petren and Case 1997; Radtkey et al. 1997; Robinson 1972, 1974; Savage 1960; Soulé 1964, 1966; Soulé and Sloan 1966; Upton and Murphy 1997; Wilcox 1978). Recently, Cryder (1999) presented a phylogeny of the four species of spiny-tailed iguanas of the *Ctenosaura hemilopha* group (*sensu* Grismer 1999a) based on

mitochondrial DNA sequences of portions of the cytochrome b and cytochrome oxidase III genes (Fig. 1). These species are endemic to the circum-Gulf of California region of northwestern México and occur on a number of islands in the Gulf of California (Grismer 1999b; Fig. 2). Cryder's (1999) results supported previous hypotheses concerning the human-facilitated origin of *Ctenosaura* on Isla San Esteban (Grismer 1994b) and indicated that overwater dispersal by ctenosaurs to other islands is still a relatively recent (and perhaps



Ctenosaura conspicuosa.
Photograph: L. Lee Grismer

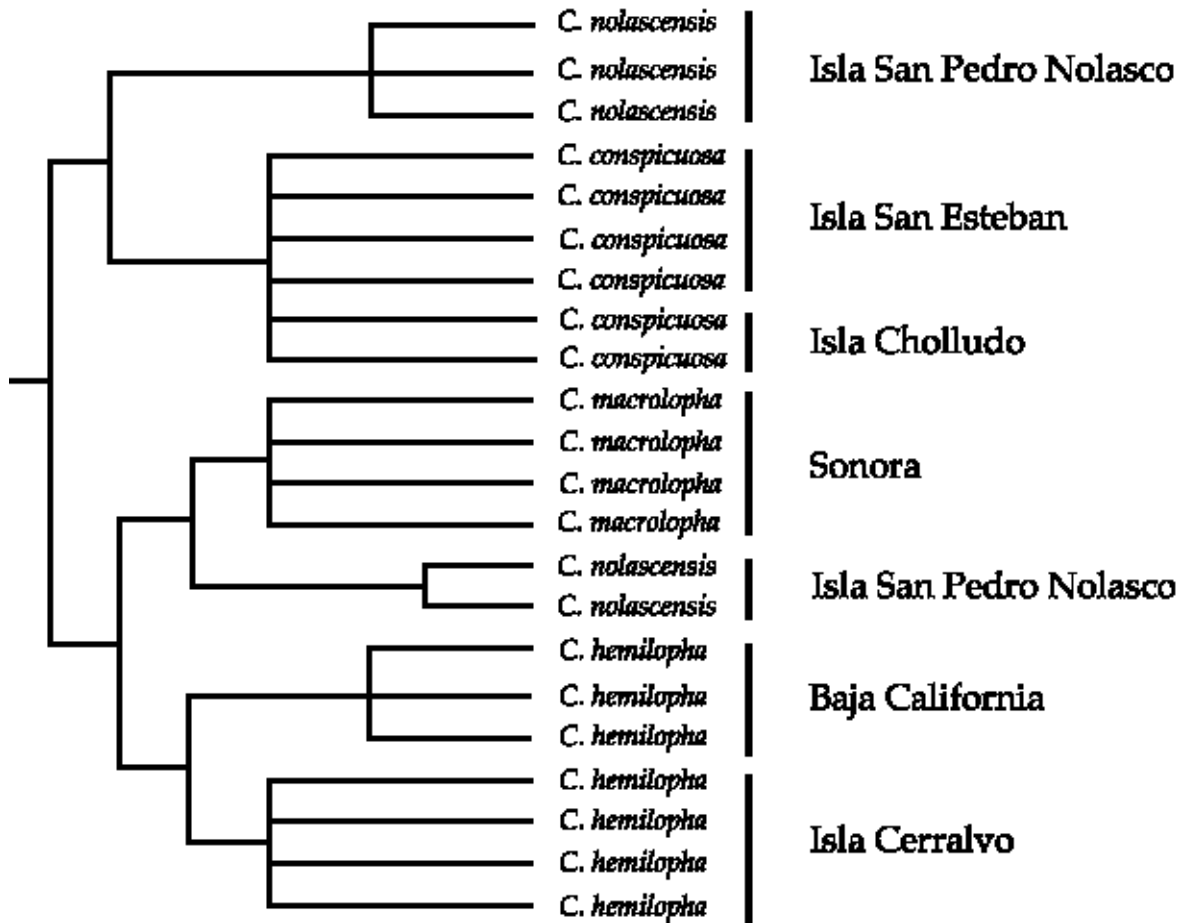


Figure 1. Relationships of the *Ctenosaura hemilopha* group based on cytochrome b and cytochrome oxidase III.

ongoing) phenomenon. Cryder's (1999) study used individual lizards from each of the four recognized species as the unit of analysis. Because his data were obtained from the maternally inherited mitochondrial genome, the resulting branching diagram produces a tree depicting the relationships between individual lizards. These relationships are then inferred to represent the relationships of the species to which those individuals belong.

The relationships between *Ctenosaura nolascensis* of Isla San Pedro Nolasco, *C. conspicuosa* of islas Cholludo and San Esteban, and *C. macrolopha* of mainland México (Fig. 1) provide the fodder for some intriguing and inextricably related issues concerning the consequences of insular isolation, human introduction, and species concepts. All individuals of *C. conspicuosa* analyzed grouped together (i.e., they were more closely related to each other than to any other individuals

of other species). Grismer (1994b) hypothesized that the population of ctenosaurs on islas San Esteban and Cholludo were introduced by Seri Indians. This was based on a number of circumstantial lines of evidence. First, the coastal distribution of *C. macrolopha* (a presumable continental source) in mainland Sonora approaches Guaymas at its northern extent (Smith 1972), approximately 115 km south of the nearest coastal mainland locality adjacent to Isla San Esteban. The absence of *Ctenosaura* on the large, geographically intermediate island of Tiburón (Fig. 2) suggests that, if *Ctenosaura* had ever occupied more northerly areas of coastal Sonora, it would be present on Isla Tiburón, as is every other species of reptile that occurs on the adjacent Sonoran mainland (Grismer 1994c). If the presence of *C. conspicuosa* on Isla San Esteban is a natural occurrence, then a hypothesis is necessary to explain its absence from

Isla Tiburón and adjacent mainland México. Second, Isla San Esteban is the only island in the Gulf of California where the chuckwalla (genus *Sauromalus*) and *Ctenosaura* are sympatric. The potential sympatry of these large, herbivorous genera exists on at least 13 other major islands in the Gulf of California given the continental and peninsular distributions of these genera (Fig. 2). Two of these islands (San Pedro Nolasco and Cerralvo) have only *Ctenosaura*, whereas the other 11 islands (Espíritu Santo, Partida Sur, San Francisco, San José, San Diego, Santa Cruz, Santa Catalina, Monserrate, Carmen, Danzante, and Coronados) have only *Sauromalus* (Grismer 1999b). Third, the genetic data of Cryder (1999) were consistent with the Seri Indian introduction hypothesis in that *C. conspicuosa* was most closely related to another insular endemic, *C. nolascensis*, rather than a peninsular or continental population, which would have more likely been a source of origin had its continental distribution been farther north. We know that the Seri Indians collected and transported both *Sauromalus* and *Ctenosaura* as food sources (e.g., Case 1982, Felger and Moser 1985) and would release them on small islands where

they could easily be recaptured (see Grismer 1994b for discussion). Fourth, and most compelling, is Gary Nabham's work on the ethnoherpetology of the Seri Indians (book manuscript in press). Nabham learned the Seri language and interviewed Seri elders about their use and views on the local herpetofauna. They informed Nabham that the Seri had always collected iguanas from Isla San Pedro Nolasco as a food source and brought them back to their families living on Isla San Esteban. This provides the best explanation to date for the presence of *Ctenosaura* on Isla San Esteban and the close relationship of *C. conspicuosa* and *C. nolascensis* (Fig. 1) on islands that are separated from one another by 146 km (Fig. 2) and share no common geological history.

Another paradigm often associated with insular biogeography is one in which island colonization is considered to be something that has happened rather than something that is happening. Wong et al. (1995) demonstrated recent colonization of zebra-tailed lizards (*Callisaurus draconoides*) on Isla Danzante in the Gulf of California. Cryder (1999) demonstrated that all individuals of *Ctenosaura macrolopha* from main-



Ctenosaura hemilopha. Photograph: L. Lee Grismer

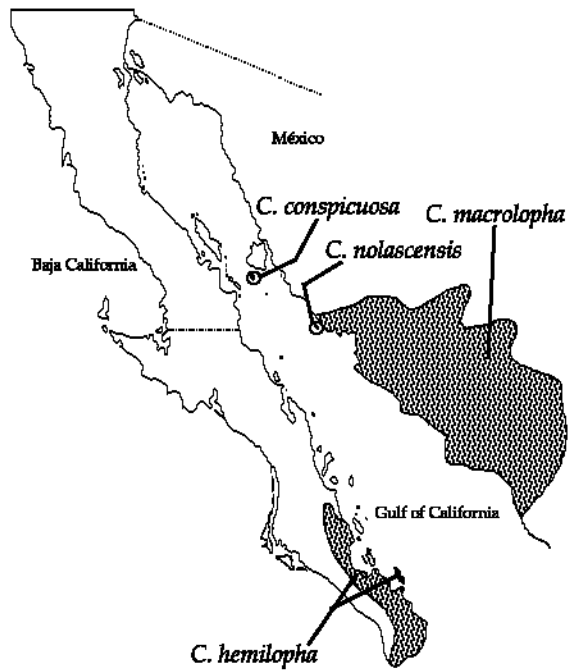
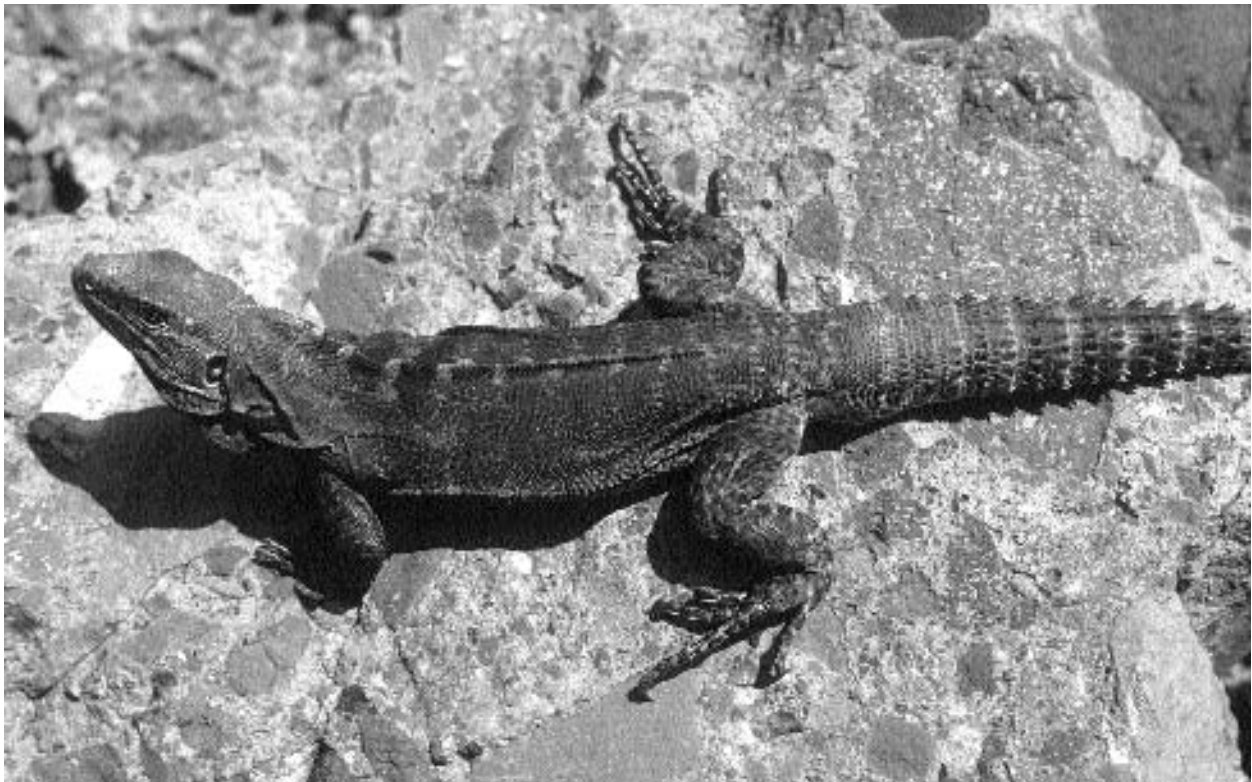


Figure 2. Distribution of the species of the *Ctenosaura hemilopha* group.

land México grouped together, but found that two individuals of *C. nolascensis* from Isla San Pedro Nolasco were more closely related to the individuals of *C. macrolopha* than to the other individuals of *C. nolascensis* (Fig. 1). The most parsimonious interpretation of these data is that these two individuals represent recent colonizers from the adjacent *C. macrolopha* gene pool on mainland Sonora to Isla San Pedro Nolasco. Isla San Pedro Nolasco lies 12 km off the coast of Sonora opposite significant drainages that purge large quantities of jetsam into the Gulf of California following heavy storms. A large arboreal lizard rafting on floating vegetation for short distances is not inconceivable.

The most debatable issue concerning ctenosaurs and man is how long does it take for a species to evolve? And, if such an event is the result of a human introduction, does it make it any less a natural event — especially if the human population was living as an aboriginal entity of nature. In part, this depends on one's concept of a species. In elevating the subspecies of *Ctenosaura hemilopha* to full species, Grismer (1999a) was using a lineage-based concept, emphasizing a population's inde-



Ctenosaura macrolopha. Photograph: L. Lee Grismer


pendent evolutionary history (as determined by its possession of unique characteristics) and its potential to continue to evolve separately from all other populations (as a result of its allopatry) as evidence for species status (see Grismer 1999a for discussion). Under this species concept, *C. conspicuosa* is recognizable as a valid species. Does it matter that the population may be the result of human introduction? My opinion is no. The genetic consequences of allopatric speciation are going to proceed as a mechanistic process of recombination operated on by selection unmindful of the cause of that selection process. Of course, one can take this to levels of absurdity and opine that fruit flies in a bottle could be considered valid species under this model. The uselessness of this extreme is obvious, but it does touch on more realistic issues such as those presented above. I do not know where the line should be drawn, but I do believe it lies somewhere between the two examples. Birds (a natural entity of nature) frequently contribute to seed dispersal on islands and I see no difference between this entity and aboriginal human populations.

The next issue is one of time. Some “experts” are of the opinion that thousands of years may be too short a time period for a species to evolve. Indeed, I have been criticized for describing as new some of the most distinctive and bizarre species from landbridge islands in the Gulf of California. The critique was not one of character analysis but one of time, in that landbridge islands are too young (8–10 thousand years) to have species (but they could have subspecies!). This implies that evolution happens at a constant rate for all taxa. However, evolution will proceed as fast as necessary within the genetic capabilities of the population in order to avoid the extinction of that population. The potential competition between two large herbivorous lizards on a small desert island could potentially be severe and serve to drive evolutionary change. Case (1982), however, noted little in the way of competition between *Sauromalus varius* and *Ctenosaura conspicuosa*. The change in *C. conspicuosa* may simply be genetic drift following a severe bottleneck.

The beauty of Cryder’s (1999) work is that it provides us with an insight into the evolutionary history of this group of spiny-tailed iguanas that, using a morphological data set, was unobtainably imbedded in its phylogeny. Combining phylo-



Ctenosaura nolascentis. Photograph: L. Lee Grismer

geography with natural history, plate tectonics, and ethnoherpetology, we can begin to piece together a coherent scenario from a vast diversity of sources whose corroboration strengthens our interpretations of this group’s history. 

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Comments on a Phylogeny of Iguanid Lizards

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In a recent study of the phylogeography of *Cyclura*, Malone et al. (2000) presented a phylogram (Figure 1) that resulted from an analysis of mitochondrial DNA sequence data. In concurrence with other recent molecular studies (Sites et al., 1996; Norell and de Quieroz, 1991; Petren and Case, 1997), these data strongly support the monophyly of the Iguanidae (*sensu strictu*) and the antiquity of *Brachylophus*. *Dipsosaurus* resolved as the sister group to a clade composed of *Cyclura*, *Ctenosaura*, *Conolophus*, *Amblyrhynchus*, *Sauromalus*, and *Iguana*. *Cyclura* also is supported as a monophyletic lineage, equally related to *Ctenosaura*, *Conolophus*, *Amblyrhynchus*, *Sauromalus*, and *Iguana*. Within the latter assemblage, the data strongly support that *Iguana* and *Sauromalus* are sister taxa, contrary to the conclusions of Wiens and Hollingsworth (2000, and references therein), who suggested that *Iguana* and *Cyclura* were so related. Within *Iguana*, lineages from different geographical areas were highly differentiated (not shown here), and may result in taxonomic distinctions with further study.

As expected, endemism was extremely high within *Cyclura*, with each lineage restricted to one island or island group. Hispaniola is the only

island that supports two distinct lineages, possibly reflecting separate origins on the two paleoislands that joined to form the current island. The distinct lineages cluster geographically (Figure 2). An "eastern" clade is composed of *C. pinguis*, the oldest extant lineage, which historically inhabited most of the Puerto Rico Bank. A "central" clade is composed of *C. cornuta* from Hispaniola and Isla Mona and its sister group, containing *C. ricordii* from Hispaniola and *C. carinata* from the Turks and Caicos Islands. A "western" clade is composed of *C. collei* from Jamaica, *C. rileyi* from the western Bahamas, *C. cyclura* from the eastern Bahamas, and *C. nubila*, as traditionally defined, from Cuba and the Cayman Islands. This contradicts the topology of Schwartz and Carey (1977),

who considered the *C. ricordii* + *C. carinata* group basal and clustered *C. cornuta* with *C. rileyi*, *C. collei*, *C. nubila*, and *C. cyclura*. This data set also brought to light the need for further inquiry into the relationship between *Cyclura nubila lewisi* from Grand Cayman and populations presently considered to be conspecific, *C. n. nubila* from Cuba and *C. n. caymanensis* from Little Cayman and Cayman Brac. Also noteworthy are the very close associations between populations currently recognized as

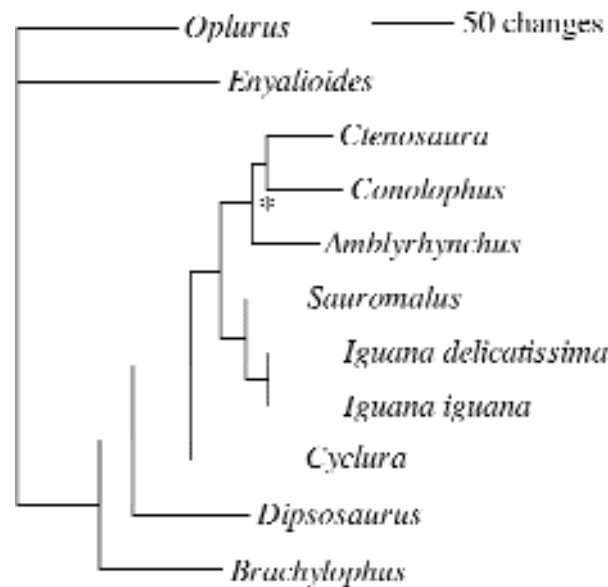


Figure 1. The maximum-likelihood estimate of relationships among iguanid lizards represented as a phylogram. The asterisk (*) indicates that support for this node is weak and that, pending further data, the relationship between *Ctenosaura*, *Conolophus*, and *Amblyrhynchus* might be considered a trichotomy.

Phylogeography of *Cyclura*

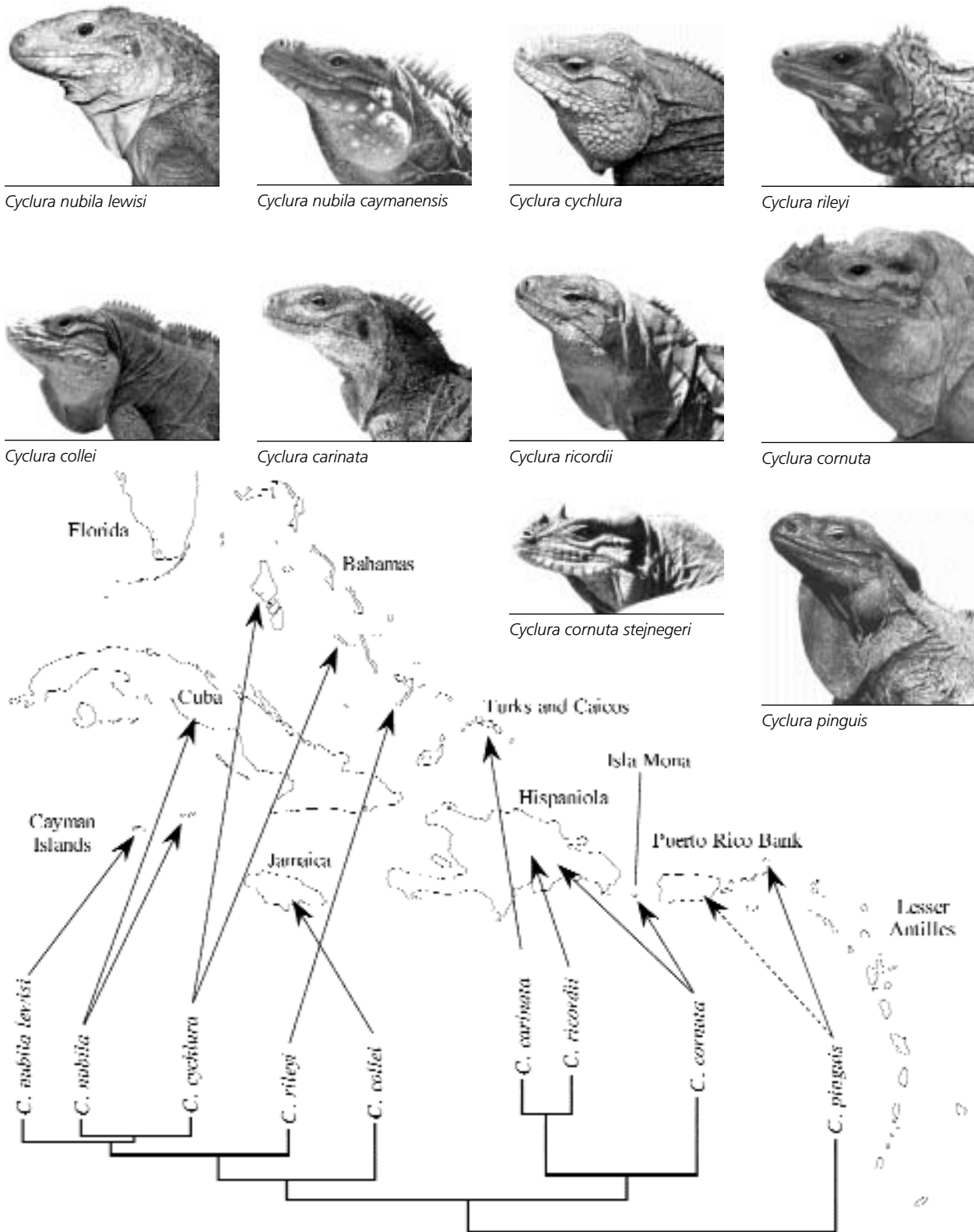


Figure 2. A phylogeographic distribution of the genus *Cyclura*, with the maximum likelihood estimate of historical relationships within *Cyclura* superimposed onto a map of the Greater Antilles, Bahamas, and Turks and Caicos Islands. The dotted arrow represents the probable historic range of *C. pinguis* on Puerto Rico proper. Photographs by John Binns (*Cyclura nubila*, *C. collei*, *C. carinata*, *C. ricordii*), Carl Fuhri (*C. cyclura*, *C. rileyi*), Robert Powell (*C. nubila lewisi*, *C. cornuta*, *C. c. stejnegeri*), and Glenn Gerber (*C. pinguis*).

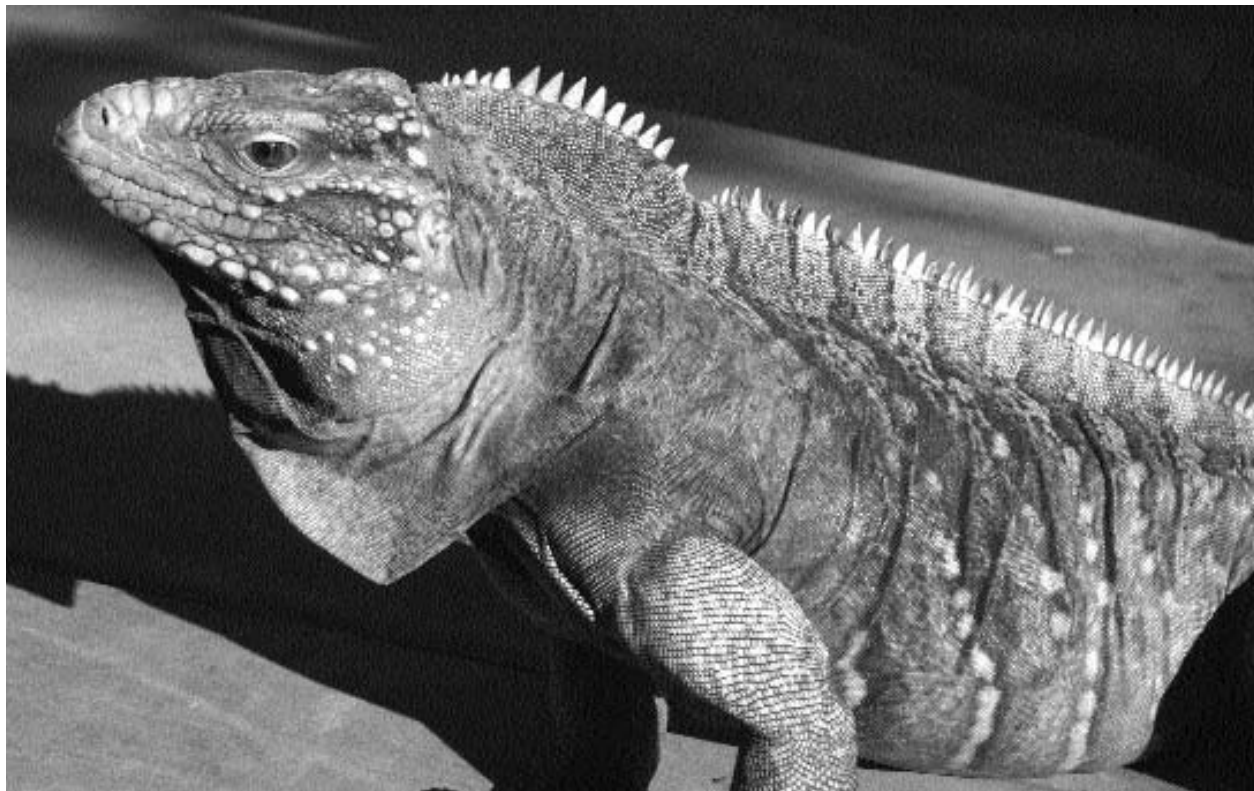
subspecies of *C. cyclura*, *C. rileyi*, and *C. cornuta*; with these data arguing strongly against species-level recognition of populations of the latter from Hispaniola and Isla Mona (e.g., Powell and Glor, 2000).

Forthcoming work involves a closer look at the relationships within the *Iguana iguana* complex, within *Ctenosaura* (C.R. Hasbun, pers. comm.), and between *C. cornuta* from Hispaniola and Isla Mona. Until these data are adequately analyzed, we suggest that the phylogram presented herein constitutes the best currently available representation of relationships among iguanid lizards.



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Cyclura nubila nubila (above), *C. nubila caymanensis*, and populations in the *C. cyclura* complex appear to be more closely related to one another than to *C. nubila lewisi*, which probably is a distinct species. *Photograph by John Binns.*

Sun, Students, and Scratches: Research on Allen's Cays Iguanas

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0730 h, temp 72°F, wind NE at 15 knots,
seas 2–3 feet

A group of Earlham College students yawn, rub their eyes, and awaken to the aroma of breakfast aboard the *Bahamas Star*. The boat has completed the five-hour journey to a set of remote islands located in the northern portion of the Exuma Island chain of the Bahamas. Here students will learn the essentials of herpetological fieldwork while working with the endemic iguanas.

Characteristic of lizards in general, the iguanas do not start their day until the sun's rays warm the sand on this group of three islands, known as the Allen's Cays. Consequently, the students' day will follow the same pattern, initially by waiting for the first iguana to make its way onto the beach to

bask. A leisurely breakfast is followed by the application of sunscreen and the packing of personal gear: sunglasses, more sunscreen, a towel, durable shoes, snorkeling equipment, Joy dishsoap (for an ocean-friendly scrub), Neosporin for scratches (on people and iguanas), photocopied maps of the island, and a Sharpie. Also loaded into the transport dinghy are rulers, scales, PIT-tagging equipment, large scissors, nooses, nets, pillowcases, and bait. These are the tools that the crew, headed by Dr. John. B. Iverson, will use to capture and examine *Cyclura cyclura inornata*.

Dr. Iverson began this study in 1980, a year in which some of the students who are currently participating in the adventure were not yet alive, and the rest were too young to have relevant recollec-



Figure 1. *Cyclura cyclura inornata* on the beach at Allen's Cays (photographs by Lynne Pieper, May 2001).



Figure 2. John Iverson measures an iguana; size is just one bit of data he and the students gather for each individual (photograph by Lynne Pieper, May 2001).

tions. In this ongoing natural history study of the endangered iguanas (C.I.T.E.S, Appendix 2), Earlham College students annually get an opportunity to be a part of this important research endeavor, learning about the iguanas whose story they're helping to document. Issues regarding this species' habitat, learning about other native species, the "challenge" of living on a boat in the Caribbean, and tourism are all parts of this expedition to the Exumas.

Cyclura cyclura inornata is a large iguana, reaching more than 120 cm in total length and often living for more than 30 years. Breeding populations, until recently, have occurred only on Allen's Cays. Here, they are found predominantly on Leaf Cay (4 ha) and U Cay (3 ha), although 11 individuals have been recorded from Allen's Cay (7 ha) (Iverson, 2000). The latter are all at least 10 cm larger than the largest individuals on the other islands. This is not only an amazing sight to behold but also a phenomenon yet to be

explained, although one may speculate that a difference in diet and/or reduced intraspecific competition might play a role. Between 1988 and 1990, eight individuals were transferred to Alligator Cay (1.8 ha), located in the Exuma Cays Land and Sea Park, Bahamas. This was done as a safeguard against the Allen's Cays population being destroyed by a stochastic event such as a hurricane, an epidemic, or the introduction of a feral mammalian predator. Since their introduction, these individuals have been very prolific and were, at last count in 1998, close to carrying capacity (Knapp, 2001).

For 21 years, Dr. Iverson has been taking groups of students to the Exumas from the small liberal arts college in Richmond, Indiana, where he teaches biology. Collectively, these expeditions have been able to gather data essential to understanding the life history and survival of this species. Eventually he would like to be able to document life expectancies, age classification, mating schedules, reproductive parameters, causes of death, and the means of their prevention. Basically, he wants to know just about everything one can learn with a minimum amount of intrusion. As part of this long-term data-collection project, temperature recorders (tidbits) are placed on the island in various habitats to monitor year-round environmental conditions. Dr. Iverson recently (June 2001) launched a more intensive study of the iguanas' reproductive behavior and capacity by spending the month-long mating season on the islands.

0830 h, and temps have risen

Iguanas become visible as dark masses peppering the sandy shore. The crew is ready for the day, and 11 former or current students and Dr. Iverson head to land to begin their work. Some members wait for a ride in the dinghy; others, eager to begin, load their bags into the boat and plunge into the water to swim the 150 meters to shore. Fifteen minutes later, catching begins in earnest. Students work quickly, walking the beach singly or in pairs, and looking especially at sites where iguanas aggregate while waiting for tourist handouts. Many of these iguanas have become accustomed to the tourists who travel in boatloads to see them, leaving their vessels for 10 minutes in order to throw some food scraps to these fascinating creatures before taking off for another island.

This feeding obviously is not a natural event, and its effects are something that Dr. Iverson hopes to someday understand. The massing behavior triggered by these handouts appears to have eliminated much of the territorial behavior that probably characterized the iguanas' ancestors. Also, the food, though easy to obtain, is not kind to these animals' digestive systems, often passing through their guts less completely digested than their normal diet of leaves and fruit (J.B. Iverson, unpubl. data). Whether this altered diet has an effect on the life span of this species is something that recently collected data comparing iguanas from different sites will hopefully be able to determine. Because limited areas of each island receive visits from tourists, detailed locality data will allow comparisons of growth rates between individuals receiving altered diets and those that are not affected by tourism.

In the short term, tourists are both helpful and a hindrance to the researchers. The familiarity of the iguanas with humans makes them initially easy to capture. Many can be approached easily, and the friendliest individuals can be captured with a sweep of the net. Others are a bit more cautious, and need to be lured with bait. Small rocks or shells found on the beach are sometimes enough, the falling objects possibly mimicking ripe fruit falling from a tree. For the most wary individuals, leftover food from the boat works well. Orange peels with their strong citrus smell and bright orange coloration are favorites; however, grapes, apples, bread, and lettuce all work well. More renewable than the food are "swing baits," which were invented by Dr. Iverson and his crew a decade ago. Large red Legos® tied to string can be tossed repeatedly to fall with just the right force to interest an iguana, and the red color is also thought to



Figure 3. Too heavy for the scales, handling this huge iguana, caught after hours of stalking by boat Captain Bruce on Allen's Cay, required two people, in this case John Iverson and Geoff Smith. For unknown reasons, iguanas on Allen's Cay tend to grow much larger than those on Leaf or U Cays (photograph by Lynne Pieper, May 2001).



Figure 4. Students Colin Meeks and Stephen Jones “touch, catch, chase, and harass” a young iguana, ignoring the sign in the background that prohibits such activities — but it’s all in the name of science (photograph by John Iverson, March 2000).

excite them. An added advantage of the swing baits is that they can be pulled in slowly, luring reluctant individuals from the bushes to a net lying on the ground, which is flipped over the distracted lizard. The struggling iguana is then extracted from the net. This is often a two-person task, especially for larger individuals, and painful scratches have been known to result from the effort. Eventually, the lizard is placed into a pillowcase, which is tied and placed in the shade until processing. Variations on the catching theme are numerous, with each student developing his or her own technique over the course of the week. Large nooses of heavy cord attached via fishing swivels to extendible golf ball retrieving rods are sometimes more successful on particularly cautious animals. Their curiosity at the swinging cord often causes them to sit patiently while the noose is adjusted. Occasionally the animals will virtually noose themselves as they attempt to bite the cord.

Regardless of capture technique, the bagged *Cyclura* are taken to a workstation where they are processed. Each lizard is weighed, sexed, measured (both tail and snout-vent lengths are recorded), marked, and released. Marking is done in a variety of ways. All captured iguanas are toe-clipped and

many, depending on size, are PIT-tagged. Passive Integral Transponders are tiny glass beads with wire coils inside. They are injected subcutaneously, allowing the animal to be identified with the sweeping of a reader which shows an identification code, much like the system used by supermarkets to ring-up prices on groceries. Together, these two methods of marking provide very reliable identification (Iverson, 2000), even allowing dead and decaying animals to be recognized. Prior to release, the iguanas are marked temporarily with non-toxic paint. This identifies them as previous captures and eliminates wasted time chasing animals for which data have already been recorded.

The response of tourists to this fieldwork varies from wanting to be a part of the effort to extreme anger. A few folks become quite offended by the marking of individuals, possibly because it destroys otherwise perfectly natural looking pictures. However, because they too want to help preserve these magnificent animals, others comment on the researchers’ intrusive methods, and cite signs on the islands that threaten dire consequences to those who interfere with these vulnerable creatures. Dr. Iverson, in fact, was instrumental in putting up the very signs that the tourists quote,



Figure 5. After more than an hour of trying to coax this iguana out of the brush using every type of bait available, student Chaundra Schofield was on the verge of giving up when the previously reluctant beast came running down to eat a grape out of the hand of a newly arrived Italian tourist. A quick sweep of the net and two people to help detangle it, and the year's largest iguana from Leaf Cay was in hand (photograph by Samantha Larimer, May 2001).

and the research he is undertaking has been approved by all of the appropriate permit-granting agencies. Still, we were pleased that tourists acknowledge the protection afforded these animals and are willing to take action.

Although many people encountered in the field are doing what they can to help protect these animals, many others are still causing harm, sometimes unknowingly. Humans are the only significant threat to this species, whether it is in the form of feeding by tourists, poaching, or illegal exploitation for international trade. Each action has its own serious effects. This species is protected under national Bahamian Law, but enforcement is lacking because no warden works in the area and these islands are extremely secluded (Iverson, 1999). As



Figure 6. Students James Rose and Brendan Gallagher mark an iguana with car touch-up paint to avoid recapturing the same individual later that trip. The paint is eventually shed with the skin and causes no permanent damage (photograph by Lynne Pieper, May 2001).

for the future, conservation plans include additional studies of the introduced individuals on Alligator Cay and possible captive-breeding programs at the Ardastra Zoo in Nassau and the Nature Centre Different on Abaco (Iverson, 1999). These are hopeful prospects, but actions taken by individuals are even more important for the preservation of this species. Taking time to report illegal treatment of this species and educating oneself and others are methods by which everyone can help save the endangered Allen's Cays Rock Iguanas.

1800 h, temperatures are dropping

The crew piles into the dinghy to return to the boat for dinner. Many have spent the entire day on the island and this will be the first time since breakfast that they will be back onboard. After dinner,



Figure 7. An iguana, excited by a rock that fell onto the sand, comes running to investigate, only to fall prey to a net lying on the ground near the well-placed stone (photograph by Samantha Larimer, May 2001).

students gather on deck to listen to Captain Ron, John, and alumni tell stories of past trips, laughing and gasping appropriately. Although most students participate in only one week of this long-term study, these stories allow them to grasp all that goes on in a research project of this intensity and duration. This undoubtedly is a new concept for some, as each party is composed of a wide age-range of individuals with varied interests and backgrounds in science. For some, this will be their only exposure to science-in-action (as opposed to merely learning about it from books or television).

Besides the interesting stories, students lounging on deck also entertain themselves with good books, decks of cards, or by recording the day's experiences in their personal journals, jotting down recollections and impressions of the day's exciting events. The iguana-catching process itself is thrilling. It gives students an opportunity to relive

their childhood fantasies of exploration and adventure, their survival dependent upon outsmarting the wild animals they stalk. However, students do more than work, taking occasional short breaks to explore tide pools, go snorkeling, or try their luck at retrieving coconuts from trees. Finally, with heads filled with images of the day's experiences and eagerly anticipating tomorrow, the students make their way to the bunks to rest in preparation for the next day's exhilarating activities, dreaming about that one iguana that just couldn't be caught, new capture techniques, a section of the island yet to be explored, whether or not enough iguanas can be captured to shatter last year's record, ...

Note: Stesha Pasachnik and Samantha Larimer were participants on trips in March 2000 and May 2001, respectively. They thank Bob Powell and John Iverson for comments on this paper, and the latter for making such trips available to students.



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Understanding Animal Classification

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(parts I, III, and IV were adapted from an essay by E.O. Wiley. 2001. *Kansas Biology Teacher* 10:14–17)

I. Binomial Nomenclature.

The classification of animals began in a rather haphazard manner. In the early days (prior to Linnaeus), most creatures were given a descriptive name. Unfortunately, such names varied according to the language used and even by the circumstances that prevailed when the organism was “discovered” — often independently by several different people. Consequently, the names that applied to the same type of animal might equal the number of persons who had encountered it. Some feel for the confusion that prevailed is evident when people from different parts of the world try to communicate while relying exclusively on common names. For example, Europeans speak of an “elk,” which North Americans call a “moose.” The animal called an “elk” in America is referred to as a “wapiti” by Europeans — and the “Irish elk” is a different beast altogether. All “robins” are birds, but English “robins” are quite different than those found in the Western Hemisphere (which are called “wandering thrushes” in Europe). A German herpetologist might speak of a “Wüstenleguan,” to the consternation of an English speaker, who would refer to the same animal as a “desert iguana” (*Dipsosaurus dorsalis*).

Such an unwieldy system soon became overburdened when Europeans, during the “Age of Discovery,” began to carry back from their voyages samples of wildlife from all over the world. A remarkably simple and flexible alternative was developed and popularized by Carl Linné, a Swedish botanist (Linnaeus was the Latinized version of his name under which he published his many volumes on the plants and animals of the world). In his system, organisms are ordered in a hierarchical manner, based largely on the number of common traits possessed by various forms. Thus, animals sharing but a few fundamental similarities were placed in the same higher category but were segregated at the next lower rank. Only those individuals that were essentially alike shared

the full gamut of categories and were placed in the same “species.” Linnaeus’ system was easily adapted to the vast quantities of new knowledge merely by adding additional categorical ranks.

Fundamental to the Linnaean system is the “binomen” (= two names), which is used to designate any species (this is the reason we refer to a “binomial system of nomenclature”). The first part of the name is that of the genus to which the animal belongs. Genera (the plural form), according to Linnaeus, were groups of species which shared more characteristics with each other than with species placed in any other genus. The generic name is a proper noun and should always be capitalized (as should all names of higher categories). As nouns, generic names have gender, which accounts for many of the different endings (e.g., many “feminine” nouns end in *-a*). The second half of the name is the trivial or specific name. Used to distinguish species within a genus, these



Subadult *Iguana delicatissima* from Anguilla. The critically endangered Anguillian population represents the northernmost extent of the species’ range. The meaning of this species’ trivial name is self-evident. Interestingly, although considered a delicacy throughout most of its range, Anguillian animals have not been exploited for food by local inhabitants. The precarious state of the population is due almost entirely to habitat alteration and competition with feral livestock. *Photograph: Stesha Pasachink*

names are adjectives or possessives that modify the generic name. Trivial names must agree in gender with the generic name and should never be capitalized. The entire binomen is always set off in some distinct way, usually italicized (in print) or underlined.

An additional feature of the Linnaean system is that all names are Latin (or Latinized; many actually are derived from the ancient Greek or even from various modern languages). Because Latin is no longer the vernacular of any culture, it is an extremely stable language and the grammatical rules are fixed. Consequently, a Pole or an Argentinean could name a species, and the other would immediately recognize it as a scientific name and maybe even understand its meaning — even though they might otherwise be totally incapable of communicating.

Applications of this system give us names like *Dipsosaurus dorsalis* (the “desert iguana”). “*Sauros*,” the root of the generic name means “lizard” in Greek. “*Dipsos*,” also from the Greek, means “thirsty,” an obvious reference to the desert habitats in which these lizards are found. The trivial name “*dorsalis*” is an adjectival form of “*dorsum*,” a Latin word that means “back,” an allusion to the crest of enlarged scales that runs down the middle of the back in these animals. “*Iguana*” presumably was modified from an Amerindian word meaning a kind of large lizard; “*delicatissima*” is from the Latin, meaning “very delicious.” Descriptions of new species should include an etymology, which provides the origin and meaning of the new name. Unfortunately, at the time when many common species were first described, the ‘rules’ were not always observed; as a result, we’re often forced to guess the meaning of a name if its derivation is not obvious.

Although daunting when first encountered, mainly because the Latin (or Latinized) names appear to defy pronunciation, the system makes a lot of sense. Compare the binomial to a person’s name. The surname (at least in English-speaking cultures) is equivalent to the generic name (the family to which a person belongs is analogous to the genus to which a species is assigned), and a person’s first name equates to the specific name (identifying that individual much like the trivial name identifies a unique species).

II. Rules of Priority.

In Part I, I mentioned the confusion that could arise when different people at different times gave different names to the same animal. Unfortunately, this problem is not unique to common names. On more than one occasion, several properly constructed scientific names have been given to the same species. This may have occurred because someone was unaware of an earlier description, possibly published in an obscure journal, maybe even in another language. Other reasons have included descriptions as different species of males and females of the same sexually dimorphic form, or descriptions as different species of different stages in a life cycle (tadpole versus metamorphosed amphibian or a juvenile with a distinctly different appearance than adults of either sex), or descriptions as different species of individuals from different regions or merely individuals demonstrating the considerable variation known to occur in some animals. Regardless of the reason, the problem of multiple names led to the necessity for synonymies, lists of all of the names that have been applied to a particular taxon. Usually, the first name is given precedence over all subsequent names, but exceptions sometimes occur. The “rules” that govern animal classification are enforced by an International Commission on Zoological Nomenclature, and the Commission must approve any exceptions. Better than a prolonged explanation is a relevant example taken from a recent issue of the *Bulletin of Zoological Nomenclature* (2001. 58:37–40), the formal publication of the Commission (reproduced below in its entirety, except for the list of references and the addresses of the authors):

Case 3143

Euphryne obesus Baird, 1858 (Reptilia, Squamata): proposed precedence of the specific name over that of *Sauromalus ater* Duméril, 1856

Richard R. Montanucci, Hobart M. Smith, Kraig Adler, David L. Auth, Ralph W. Axtell, Ted J. Case, David Chiszar, Joseph T. Collins, Roger Conant, Robert Murphy, Kenneth Petren, Robert C. Stebbins

Abstract. The purpose of this application is to conserve the long used and well known specific name of *Sauromalus obesus* (Baird, 1858) for the chuckwalla (family IGUANIDAE) from the southwest of North America by giving it precedence over the little used name *S. ater* Duméril, 1856.

Keywords. Nomenclature; taxonomy; Reptilia; Squamata; IGUANIDAE; *Sauromalus ater*; *Sauromalus obesus*; chuckwallas; southwestern North America.

1. In 1856 Duméril (p. 536, pl. 23, figs. 3 and 3a) described a new genus and single new species of iguanid lizard as *Sauromalus ater* on the basis of a single specimen presented by Lieutenant M. Jaurès to the Muséum National d'Histoire Naturelle, Paris. The holotype (MHNP 813), which lacks locality data, was collected somewhere in western Mexico during a world circumnavigating voyage of the French frigate *La Danaïde*.
2. The absence of a type locality for *Sauromalus ater* has remained an acknowledged problem for systematists working with *Sauromalus* (see Schmidt, 1922; Shaw, 1945; Hollingsworth, 1998). Shaw (1945, p. 273), unable to study the holotype due to political conditions in Europe, drew upon descriptive information in Duméril & Bocourt (1870) and Mocquard (1899), and concluded that the holotype must

have originated from one of the islands off the southern coast of the Baja California peninsula. Hence, in referring to the type locality, Shaw (1945, p. 284) stated: 'Not definitely known but undoubtedly one of the several islands in the southern part of the Gulf of California where this species is known to occur', Subsequently and without justification, Smith & Taylor (1950) further restricted the type locality to Isla Espiritu Santo.

3. Two years after Duméril, Baird (1858, p. 253) described the new genus and single new species *Euphryne obesus* and noted that it was 'abundant in the canons of the Colorado, of California, collected by Maj. Thomas, Mex[ico] Boundary Survey, and Lt. Ives' Expedition'. The type specimen was given as USNM 4172 in the U.S. National Museum, Washington. Subsequently, Baird (1859, p. 6, pl. 27) indicated the locality of USNM 4172 as 'Fort Yuma'. Van Denburgh (1922) and Shaw (1945) correctly noted the location of Fort Yuma in California. Montanucci (2001) discussed the confusion caused by Baird's piecemeal publication of data and clarified the particulars relating to the collector and type locality. Cope (1864) commented that the name *Euphryne* Baird, 1858 was a synonym of *Sauromalus* Duméril, 1856, but both generic names continued to be used in the literature until Cope (1875) and Coues (1875) placed



Subadult *Cyclura nubila* from the U.S. Naval Base at Guantanamo Bay, Cuba. For many years, this species was thought to contain three subspecies; however, new evidence indicates that the Grand Cayman population is distinct at the species level.
 Photograph: Robert Powell

Euphryne as a synonym of *Sauromalus* (see Hollingsworth, 1998, p. 40). *Sauromalus* has been used since that time.

4. Prior to 1922, the name *Sauromalus ater*, and not *S. obesus*, was used in most papers, including checklists and distributional accounts. Most notable among these publications are Cope (1875, 1900), Stejneger's (1891) description of a new species of *Sauromalus*, the checklists of Yarrow (1882) and Stejneger & Barbour (1917), and Van Denburgh's (1922) *The Reptiles of Western North America*. The recognition of *S. ater* and *S. obesus* as separate species came with publication of Schmidt's (1922, pp. 640–641) study of the amphibians and reptiles of lower California, and was followed by the later checklists of Stejneger & Barbour (1923, 1933, 1939, 1943). The taxonomic treatment of the genus *Sauromalus* by Shaw (1945) reinforced the concept that *S. ater* and *S. obesus* are separate species, a view held by virtually all subsequent workers except Hollingsworth (1998).
5. In his recent monographic revision of *Sauromalus*, Hollingsworth (1998) placed *Sauromalus obesus* in the synonymy of *S. ater*, and restricted the type locality of *S. ater* to southern Sonora. However, Montanucci (2000) argued that Hollingsworth's analysis to determine the provenance of the type specimen was unconvincing due to limitations in his statistical data, leading to ambiguous results and an unsubstantiated conclusion. Accordingly, Montanucci (2000) concluded that, in the absence of any new, compelling information, the type locality of *S. ater* remained open to speculation and conjecture.
6. The literature using the name *Sauromalus obesus* is substantially more abundant and significant than that using the name *S. ater*. Beaman, Hollingsworth, Lawler & Lowe (1997) listed 626 titles of technical and popular articles pertaining to the genus *Sauromalus*. Out of this total, the name *S. ater* is used in about 46 papers; most of these (34) were published before 1950, and nearly all pertain to taxonomy and/or distribution. The literature for *S. obesus* is profoundly more extensive by comparison, being conservatively estimated to be about 90% of the total literature for the genus as a whole, or some 550 papers. The name *S. obesus* is used, almost to the exclusion of *S. ater*, in the literature dealing with physiological ecology and thermoregulation of chuckwallas (about 133 papers), most of the basic ecological works (about 71 papers), as well as morphological studies (about 92 articles). Over 100 papers dealing with distribution use the name *S. obesus*. While the name *S. ater* has been little used and is essentially restricted to publications in technical journals, the name *S. obesus* appears in numerous papers, magazines and books, ranging from technical to popular. Clearly, the name *S. obesus* has had a long history of usage to the present, and is deeply entrenched in both the scientific and popular literature. Hence, any proposed change of this long-recognized name would certainly create extensive confusion and instability.
7. We propose that, if the names *Sauromalus ater* Duméril, 1856 and *S. obesus* (Baird, 1858) are considered to be synonyms, *obesus* should be conserved for the combined taxon by giving it precedence over *ater*. If the two names are considered to refer to different taxa (species or subspecies), then both names are available for use. If the application is approved by the Commission both names will be placed on the Official List. As mentioned in paras. 1 and 3 above, the holotypes of both nominal taxa are in existence.
8. The International Commission on Zoological Nomenclature is accordingly asked:
 - (1) to use its plenary power to give the name *obesus* Baird, 1858, as published in the binomen *Euphryne obesus*, precedence over the name *ater* Duméril, 1856, as published in the binomen *Sauromalus ater*, whenever the two are considered to be synonyms;
 - (2) to place on the Official List of Generic Names in Zoology the name *Sauromalus* Duméril, 1856 (gender: masculine), type species by monotypy *Sauromalus ater* Duméril, 1856;
 - (3) to place on the Official List of Specific Names in Zoology the following names:
 - (a) *obesus* Baird, 1858, as published in the binomen *Euphryne obesus*, with the

endorsement that it is to be given precedence over the name *ater* Duméril, 1856, as published in the binomen *Sauromalus ater*, whenever the two are considered to be synonyms;

- (b) *ater* Duméril, 1856, as published in the binomen *Sauromalus ater*, with the endorsement that it is not to be given priority over *obesus* Baird, 1858, as published in the binomen *Euphryne obesus*, whenever the two are considered to be synonyms.

Comments on this case are invited for publication (subject to editing) in the *Bulletin*; they should be sent to the Executive Secretary, I.C.Z.N., c/o The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (e-mail: iczn@nhm.ac.uk).

III. Changing Paradigms.

Throughout most of history, animals were grouped into categories using as criteria readily observable morphological similarities. Nearly all early naturalists, who were educated in systems based on literal interpretations of the Bible, viewed classification as a means to better understanding God's plan. The underlying basis for the resulting groups, however, has changed. In the latter half of the 19th century, almost entirely in response to Charles Darwin's work, the interpretation of classification by most scientists changed dramatically from one based on similarity and a revelation of God's plan to one based on "descent with modification." That one could switch from interpreting the existing Linnaean system of classification as a scheme of similarity to one based on an evolutionary history is testament to the system's innate flexibility.

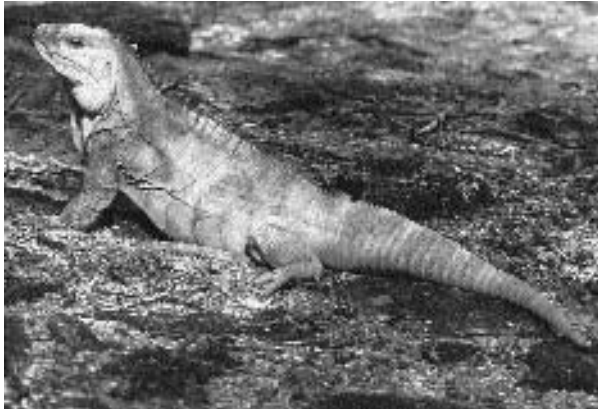
Yet, even today, the transition from one school of thought to the other is incomplete. This is predicated by the reality that animal classification contains two distinct and sometimes mutually exclusive entities: (1) a purely technical aspect concerned with establishing a set of rules that define how classifications will be implemented (and which is unconcerned with the philosophy of the person describing a new taxon), and (2) a conceptual aspect that seeks, above all, to determine just what a classification means (i.e., identifying and understanding the underlying factors responsible for the relationships that a classification



Subadult *Iguana iguana* from southern Veracruz, México. Traditionally considered a single, widely distributed species, new evidence suggests that *I. iguana* actually constitutes a species complex. As details are resolved, these new data will eventually be reflected by taxonomic changes that more closely approximate the reality in nature. Photograph: Robert Powell

implies). Some insight into the first aspect was provided by the petition to the International Commission on Zoological Nomenclature in Part II of this series. The second aspect is more difficult, in practice if not in principle.

Willi Hennig, a German systematist, proposed in 1950 a major reform of existing animal classification schemes, a new approach that has become known as "phylogenetic systematics." Until its implementation and widespread (though not universal) acceptance by practicing taxonomists, the recognition that our understanding of animal genealogies is woefully incomplete resulted in a general willingness to use criteria that rely heavily (or solely) on similarities to define categories. In other words, "relationships" reflected in taxonomy might be relationships of similarity or relationships of genealogical descent or even some mixture of the two. Hennig suggested that "relationships," in a rigorous evolutionary sense, must include only considerations of descent, defined as the relationship between an ancestral species and its descendants. No longer could the placement of a taxon into a particular category be justified by arguments based on similarities. Thus, the association of crocodilians with lizards, because they are superficially



Adult male *Cyclura ricordii* from Parque Nacional Isla Cabritos, Dominican Republic. The generic name ("ring-tail") is based on the whorls around the tail, which are very evident in this specimen. The trivial name is a possessive patronym (indicated by the *-ii* ending), which honors Alexandre Ricord, who collected the type specimen. Photograph: Robert Powell

similar, was no longer acceptable (genealogically, crocodilians share a much closer common ancestry with birds and dinosaurs than with lizards and other squamates). Although sound in principle, the new paradigm was difficult to implement in many instances — mainly because we still lack the evidence necessary to understand many animal genealogies and, to a lesser degree, because we often are unwilling to reject familiar categories based on similarities or flawed interpretations of evolutionary relationships.

Another refinement of classification emerged from Hennig's work. Systematists previously had recognized two kinds of groups. "Monophyletic" groups were composed of the descendants of a single common ancestor and "polyphyletic" groups contained organisms that did not share a common ancestor. For example, Mammalia is monophyletic, but Homeothermia (a group composed of mammals and birds based on their ability to physiologically maintain elevated body temperatures) is polyphyletic because the two constituent groups have different "reptilian" ancestors. Hennig noted that many recognized "monophyletic" groups were not really monophyletic at all, and recognized a third type of group. Because these assemblages did not contain all of the descendants of a common ancestor, he called them "paraphyletic." Phylogenetic systematists asserted that paraphyletic groups were as unnatural as polyphyletic groups.

The most easily understood example is the Class Reptilia, as traditionally defined. Reptilia constitutes a paraphyletic group because some descendants (mammals and birds) are left out. Another example is the Family Pongidae, which consists of the great apes but excludes humans (who are placed in their own family, Hominidae). Because paraphyletic groups are logically inconsistent with the phylogenies that classification should reflect, the idea that we should abandon traditional schemes that include paraphyletic groups is growing in acceptance (although almost every textbook in print presents classifications that include paraphyletic groups).

How would a revised, purely phylogenetic classification of an iguana look? Actually, the answer is less than obvious, because the criteria that define the higher categories in particular are often vague and frequently subject to revision. However, one scheme (modified from a phylogeny presented in Pough et al. 1998. *Herpetology*. Prentice-Hall, Inc., Upper Saddle River, New Jersey) might look a lot like this:

- Chordata (animals with notocords, pharyngeal gill slits, and dorsal, hollow nerve cords)
- ..Vertebrata (chordates with at least rudimentary braincases and vertebral columns)
- ...Sarcopterygii (lobe-finned fishes and their descendants)
-Tetrapoda (amphibians and their descendants)
-Amniota (those tetrapods that reproduce via cleidoic eggs; excludes amphibians)
-Reptilia (excludes the common ancestor of mammals and all of its descendants)
-Diapsida (excludes "reptiles" with anapsid, synapsid, and euryapsid skull structures)
-Lepidosauria (the common ancestor of squamates and rhynchocephalians and all of its descendants)
-Squamata (lizards and snakes)
-Iguania (non-scleroglossine lizards; includes acrodonts as well as iguanids in the broad sense)
-Iguanidae (the oldest common ancestor of all species in the genera *Amblyrhynchus*, *Brachylophus*, *Conolophus*, *Ctenosaura*, *Cyclura*, *Dipsosaurus*, *Iguana*, and *Sauromalus* and all of its descendants)
-*Iguana* (the oldest common ancestor of *I. iguana* and *I. delicatissima* as currently defined and all of its descendants)
-*Iguana delicatissima* (the binomen, indicating a group consisting of the oldest common ancestor of all populations now assigned to *I. delicatissima* and all of its descendants)

An examination of this example quickly points to a problem inherent in a phylogenetic classification, namely that the number of groups can easily exceed the number of Linnaean categories. Some systematists have proposed alternatives that include using numerical prefixes instead of categorical names or even a “rank-less” system in which the hierarchy is indicated merely by indenting (as above). Unfortunately, these alternatives are not without problems of their own. Numerical systems can be applied only to one phylogeny without becoming confusing (does a particular number have the same meaning in each context?), and rank-less systems quickly become so cumbersome that determining who is related to whom is impossible (note that the example includes only one alternative at each level; if all chordate groups were included, the classification easily would fill many large volumes).

IV. What Classification Can — and Cannot — Do

Modern classification should demonstrate the relationship between phylogeny and taxonomy by identifying and naming hierarchical groups that define genealogies. That recognition acknowledges the underlying hypotheses that a classification seeks to examine, namely that groups reflect genealogical relationships. If a classification compares favorably with a phylogenetic tree, the hypothesis is supported. Unfortunately, the lack of available evidence for relationships of many groups often results in classifications based on similarities or even the intuition of the systematist. These often are merely efforts to organize diversity until a group can be adequately studied. Obviously, newly acquired evidence renders many of these tentative schemes unacceptable, and this is at the very root of many taxonomic changes. The distinction between classifications based on great quantities of pertinent evidence and those that reflect mere “guesses” is impossible — unless the reader is very familiar with the group(s) being classified. However, in both instances, a reader should remember that any classification is based only on hypotheses addressing the group relationships that exist between the organisms being classified.

The rank of a group does not necessarily reflect the distinctiveness of that taxon. A system-

atist may raise the rank of a group to reflect her views of its distinctive nature, but rank in and of itself does not provide that information. For example, when Frost and Etheridge (1989. A phylogenetic analysis and taxonomy of iguanian lizards (Reptilia: Squamata). *Univ. Kansas Mus. Nat. Hist. Misc. Publ.* (81):iv + 65 pp.) elevated what had been considered “iguanines” or “Iguaninae” to full familial rank (“Iguanidae”), the intent was to better reflect historical events, not to suggest that the group was any more distinctive than had been previously recognized.

Emphasizing the fact that rank does not denote degrees of distinction is the reality that ranks cannot be and are not applied equitably to different groups. In other words, the ranks in any given classification represent genealogical relationships by subordinating descendent groups to those representing older (ancestral) taxa; thus, the number of ranks merely reflects the relationships in a particular group rather than being definitive arbitrators of a certain level of distinction. In other words, a family of insects is not comparable to a family of squamates (as a matter of fact, if equivalency were the goal, an insect family may equate with an order or even a class of vertebrates). Rather than being a defect of modern classification schemes, these inequalities testify to the system’s flexibility. The idea that unrelated (actually distantly related) groups of comparable rank are biologically equivalent dates to the antiquated perception that all types of organisms represented rungs on a “ladder of life” that represented a scale culminating in “perfection” (in these ancient schemes, humans invariably resided on the top rung; what a humble species we are...).

Finally, classification cannot remain stable and unchanged. All taxonomic decisions are, in fact, hypotheses subject to additional testing and potential rejection when new contradictory data are uncovered. Consequently, like science in general, classification must be dynamic — and this is a strength rather than a flaw of the system. If classification were stagnant, it could not be scientific. Although we all bemoan the need to constantly relearn new classifications, we should instead be toasting the changes that reflect new knowledge, scientific progress, and are probably closer to the truth represented in nature.

V. Do 'Species' Exist In Nature?

When I was an undergraduate, I was taught that the species was the only "real" taxonomic rank, based on the assumption that it could be subjected to testing by applying criteria applicable in nature. Of course, the concept of species to which reference was being made was the "biological species," defined as a group of similar, reproductively interacting (or potentially interacting) organisms reproductively isolated from all other such groups. The emphasis on reproduction certainly was appropriate. I often tell my students that the primary role of individual organisms in nature is to reproduce, and that all other functions are secondary. Also, the contention that reproductive isolation was testable appeared reasonable — but was it? I began to have doubts when discussions veered to the many exceptions. Obviously, the principal criterion was not applicable to asexually reproducing organisms or to parthenogenetic organisms (those all-female species in which offspring are produced by development of an unfertilized ovum), but could it even be applied adequately to sexually reproducing populations with non-overlapping distributions? If organisms are geographically isolated (allopatric), is any test of reproductive isolation appropriate? When I began to examine examples with which I was familiar (allopatric "subspecies" of North American amphibians and reptiles or insular populations of West Indian forms), I found that assumptions based on degrees of morphological similarity or simple guesswork invariably were substituted for empirical testing. This conclusion then led me into a review of the voluminous literature pertaining to species concepts.

The best summary of my search for answers came when I ran across several papers which emphasized that speciation was a process, and that "species," variously defined, could exist at any stage in that progression. The biological species concept applied accurately only to groups of sexually reproducing organisms that had essentially completed the process. At the other extreme were populations of common ancestry that had only recently become isolated (geographically or ecologically) and had barely begun to differentiate as a consequence of differing selective pressures, mutations, or random changes in genetic compo-

sition often associated with small population sizes. Some of these isolates will never diverge to an extent sufficient for recognition as a distinct species, others may do so eventually — even to the extent of becoming reproductively isolated. Many of the competing species concepts actually address such "works in progress." For example, the "evolutionary species concept" recognizes populations as species that have diverged enough to be diagnosable and which, due to geographic (or ecological) isolation, have unique evolutionary trajectories. Against the argument that such diverging populations would readily interbreed if they should come back into contact with one another, proponents of the "evolutionary species" rightly note that science cannot deal with events that have yet to occur.

So, where does that leave the biologist who is trying to assess the biodiversity of a region (typically expressed as the number of species present), establish a conservation plan for a particular taxon (generally, species-level taxa are provided greater consideration than subspecies or isolated populations when management plans are developed), develop a captive-breeding program with the potential for the eventual release of progeny into the wild (releasing hybrids into naturally occurring populations will merely dilute or pollute the existing gene pool), or even engage in research using as a model a particular species, the identity of which is crucial (if only to provide an accurate label for the model)? Actually, the answer is not that difficult once agreement can be reached on a common definition of "species." The best I have found is that a species is a natural entity that derives its existence from historical evolutionary (ancestral) relationships (a phylogenetic emphasis), interbreeding (the traditional biological species concept), or some combination of both. If we can accept that definition (recognizing as we do that speciation is a dynamic process), then the "general lineage concept" should be acceptable to all. This concept recognizes species as segments of population-level lineages — and all contemporary species definitions, in one way or another, consider species to be segments of population lineages. Consequently, all species concepts are components or variations of this main underlying concept, although they may variously emphasize different diagnostic criteria.

What does this mean in the “real world?” It means that species definitions will vary to some degree depending on the criteria applied by the researcher and her agenda (if interested in conservation, she might be more inclined to recognize a population as a full species than, for example, another researcher who merely wants a label for his model, and would prefer that which is most familiar to his colleagues). To avoid such varying standards, some systematists have suggested substituting the term “operational taxonomic unit” for species. This apparently unconventional approach might seem strange at first, but has the very distinct advantage of setting aside disagreements over which species-defining criteria to emphasize by focusing on the actual entity — the population(s) that exist in nature.

How does this apply to iguanas? Catherine Malone (2000. *Mol. Phylogen. Evol.* 17:269–279) presented data suggesting that green iguanas from different regions in the Western Hemisphere are genetically distinct. These distinctions may or may not lead to interpretations suggesting that *Iguana iguana*, as currently defined, is actually a complex of separate species. However, the conservationist and the breeder can no longer, in good conscience, treat all green iguanas as if they were interchangeable. Conservation of unique insular populations, regardless of taxonomic rank, should be a high priority when management plans are developed and implemented. Allowing animals from different areas to breed could result (and has undoubtedly in many instances resulted) in hybrids that are no more “natural” than the “designer snakes” bred by some hobbyists.



Adult *Cyclura stejnegeri* from Isla Mona. This population was originally described as a species distinct from populations of *C. cornuta* on Hispaniola. Recent evidence indicates, however, that Mona Island animals are not genetically distinct, suggesting a very recent (possibly even human-mediated?) colonization of the island by Hispaniolan stock. Photograph: Robert Powell

In that same paper, Malone demonstrated a very close relationship between populations of *Cyclura* on Hispaniola (*C. cornuta*) and Isla Mona (*C. stejnegeri*). I have recently advocated the species-level recognition of the Mona Island population based primarily on allopatry and differences in morphological and biological (reproductive) traits. If additional data indicate that these populations do not differ sufficiently to warrant full-species status (suggesting that the differences merely reflect local conditions and that the two entities have only recently become separated), the general lineage concept would still apply. Any conservation plans that emphasize the preservation of both sets of populations would not be any less valid, nor would efforts to separate any captive populations by their origin be any less important.

Do ‘species’ exist in nature? Sure, but their identity may or may not correspond to our efforts at defining them. Plus, the animals don’t read our textbooks and they certainly don’t care what we call them.



A Day at the Zoo

AJ Gutman
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“**Y**ou mustn’t speak to the animals or they won’t take you seriously. These people are scientists working with critically endangered species.” I was having this conversation with my dear friend and house guest at the time, John Bendon. John has been working with both the International Iguana Society and the West Indian Iguana Specialist Group for many years, and is well acquainted with the scientists working at the San Diego Zoo. My husband was attending a medical conference in San Diego and John had set up appointments for me to meet some important people and some important animals at the Zoo and the affiliated Centre for Reproduction of Endangered Species (CRES). Like many of our readers, I knew only about species such as *Iguana delicatissima*, *Cyclura pinguis*, and *Brachylophus fasciatus* from the pages

of *Iguana Times* and other reptile publications, and this was my best and probably only chance of ever seeing live specimens.

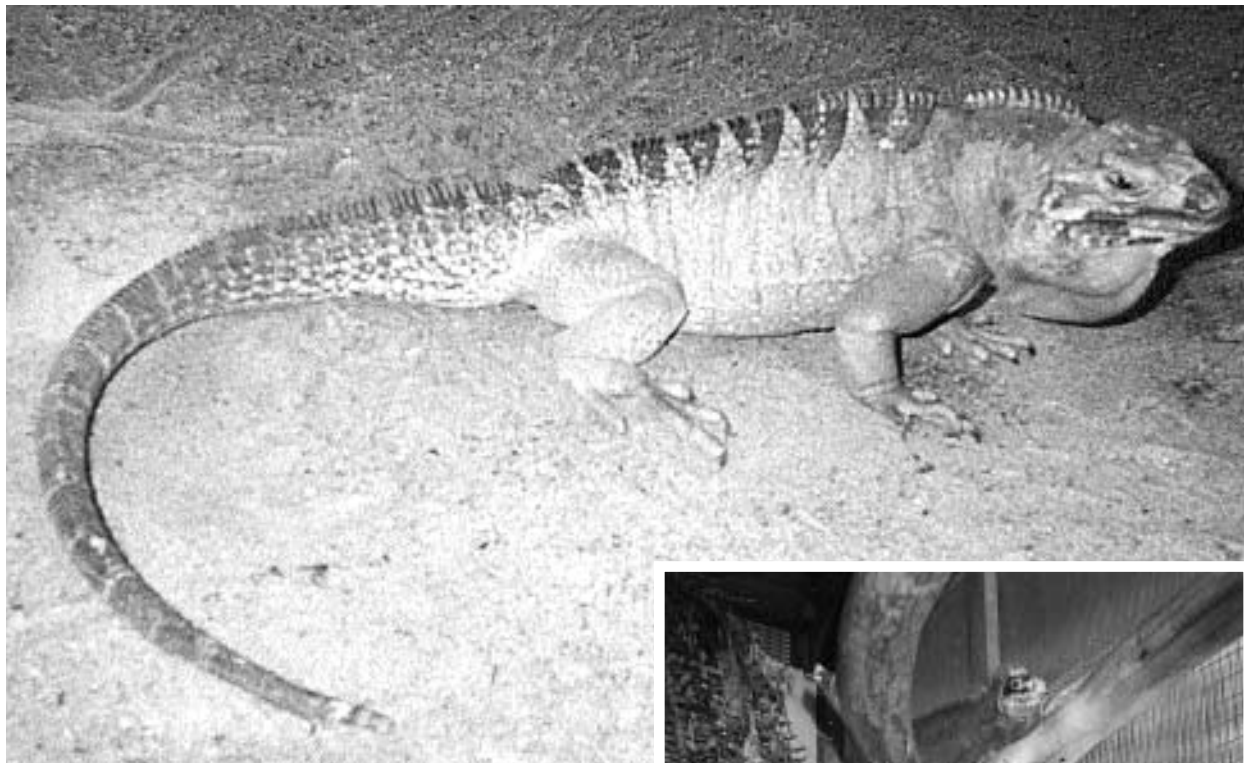
I was determined to appear as “serious” as possible, so I went rifling through back issues and unearthed articles on all of the above species. None of the material was unfamiliar to me because I’ve been teaching students, from preschoolers to university-level, about iguanas and conservation for years. Still, I was certain that I would somehow manage to embarrass myself.

Between the Zoo and the Wild Animal Park, I spent my first four days in San Diego admiring all kinds of remarkable animals, wonderful exhibits, and excellent presentations, and reading about the exciting work being done with the pandas, California condors, and other endangered species. As awe-inspiring as the whole experience was, I

was saddened to see people persistently misunderstanding animals that were different in any way. I recall the family (mother, father, and child) watching three magnificent condors that were perched together on a rock. They were picking at each other and the child thought they were fighting. The father started egging them on and the mother pulled her family away from the “disgusting” display. I had to stop myself from shouting at them. Couldn’t they see that this was a mother, father, and a juvenile that were grooming



Jeff Lemm of the San Diego Zoo holding a large Cuban iguana (*Cyclura nubila nubila*).
Photograph: Steve Steward



Above: A large Jamaican iguana (*Cyclura collei*).
 Right: Male and female *Iguana delicatissima*.
 Photographs: Jeff Lemm



each other and enjoying a lovely afternoon on their rock? How much more do people fail to identify with the plight of the reptiles?

By the day of my appointments most of the gloom had vanished, but I was still a little apprehensive about appearing sufficiently “serious.” At the CRES, I was met by Jeff Lemm, the Research Animal Coordinator. Jeff struck me immediately as someone who took great pride in his work and cared very deeply for the animals. I suspect he also has had plenty of experience entertaining goofy visitors, because he made me feel quite welcome as he introduced the animals and let me know which ones I could hug and which were being kept with as little human contact as possible in order to encourage breeding.

I was first introduced to three substantial white-throated monitors that are used in behavioral experiments. Then I had the pleasure of observing Ruby, a beautiful Komodo dragon, being fed her lunch of specially prepared “dragon meatballs.” Ruby was quite intent on her meal and didn’t seem the least bit troubled by anyone’s boots.

Subsequently, I got to meet the iguanas. Gitmo the Cuban iguana (*Cyclura nubila nubila*) has had his handsome face featured on *Reptiles* magazine. At 15 years of age and an impressive 17 pounds, he is a relaxed and charming spokesiguana originally from Guantanamo Bay. The Cuban iguanas of Guantanamo Bay were one of the first populations studied by CRES scientists to test conservation strategies such as headstarting and captive breeding. Information collected from this con-

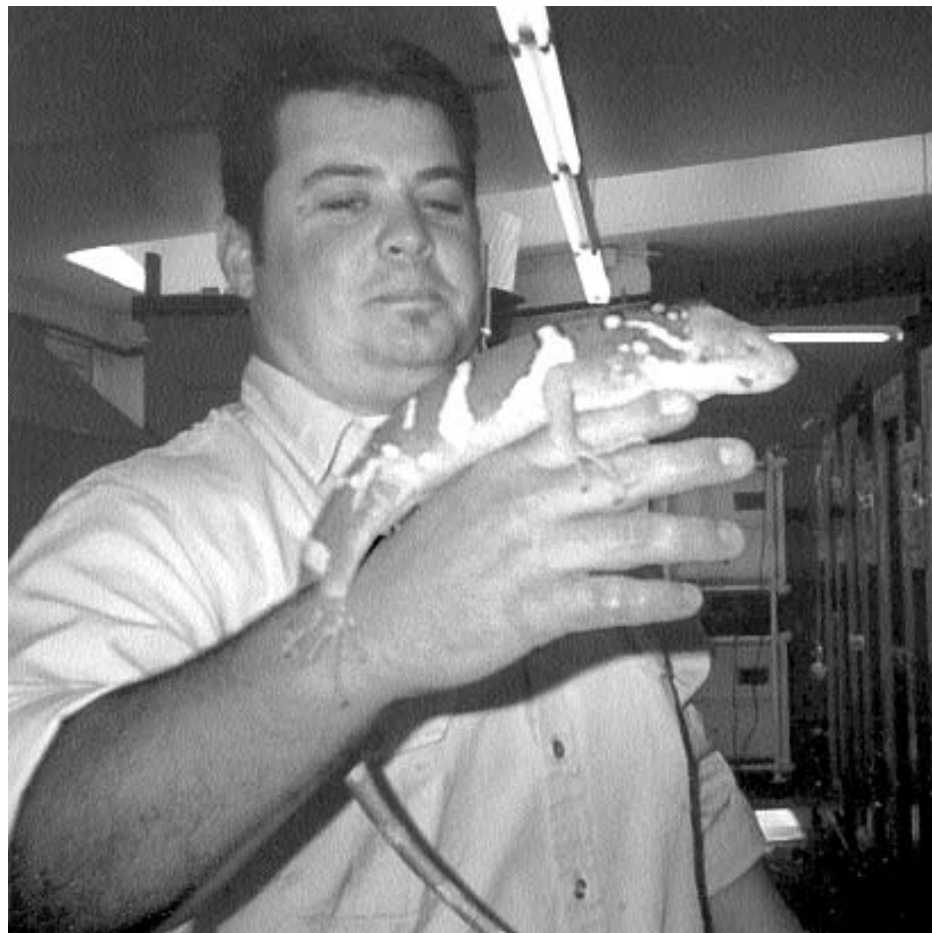
tinuing study has proven invaluable in assisting other endangered species of *Cyclura*.

The story of the Jamaican Iguana, *Cyclura collei*, has been well documented in the pages of *Iguana Times* since their rediscovery in 1990 after supposed extinction to the successful headstart program at the Hope Zoo in Kingston. Most recently, I recall an article about the neoprene vests produced by Nike to hold the radiotransmitters for tracking the headstarted iguanas. Even these high-tech vests have proven inadequate over time. A new strategy involving surgically implanting the transmitters has been tested and shown not to impair egg laying or mobility in captive-held Cuban iguanas. Three pairs of *C. collei* have been at CRES since 1992, including the youngest in any US zoo. One of the females nested successfully in this, her first lay year, although her nine eggs were infertile. Still, this was an important first step and definitely cause for optimism. Even though I know that the orange coloration typical of Jamaican iguanas photographed in the wild is caused by the high iron content in the soil of their native habitat, I thought it odd to see “clean” *C. collei* sporting the usual attractive *Cyclura* striping.

The Anegada or “Stout” iguana, *Cyclura pinguis*, has been a particular favorite of mine since reading an article by James Lazell in *Iguana Times* in 1997. This animal, Lazell writes, is described in local folklore as attaining “weights of more than 60 pounds and lengths over 6 feet.” The species varies in a number of ways from other members of the genus *Cyclura*. Most significantly, it lacks rings of enlarged cau-

dal scales, a defining featuring of “*Cyclura*,” which literally means, “ring tail.” Both the teeth and the skull bones also differ from those of other species, and the young *C. pinguis*, although displaying the usual striped patterning of young rock iguanas are various shades of green and become very dark, almost black as they mature. Some researchers have speculated that *C. pinguis* may be the stem population from which all the other species of *Cyclura* are descended.

At one point, fewer than 200 *C. pinguis* were thought to remain in the wild. Only isolated populations survived the hunting of previous centuries, and the remaining animals have had to contend with development and competition from feral livestock. Translocated populations on Guana and Neckar islands have experienced some success, but CRES has concentrated its efforts on a headstart program on Anegada, with already 50 animals being raised for eventual release.



John Kinkaid of the San Diego Zoo holds a Fijian banded iguana (*Brachylophus fasciatus*).
Photograph: AJ Gutman

CRES has housed three pairs of Stout Iguanas since the fall of 2000. These animals had been legally purchased and in the possession of a private breeder for ten years before coming to the zoo. I was impressed by their dark, glowering looks, but I suppose I was expecting them to be bigger than they were. Jeff was overwhelmingly skeptical about the 6 foot-60 pound iguana story, claiming the largest he had worked with was only a little over 1 m long and about 6–7 kg. Personally, I like the idea too much to abandon it just because the really big one has so far managed to elude everyone.


Iguana delicatissima is another remarkable species. It is the only other member of the genus *Iguana* beside the green iguana. It is somewhat smaller than its closest relative. Juveniles are bright green, but the adults become predominantly grey with the males acquiring pink highlights in the mating season. Wild populations of *I. delicatissima* face the usual obstacles caused by introduced predators, habitat destruction, and fragmentation of populations, but they also are faced with competition from and hybridization with green iguanas. *Iguana delicatissima* produces clutches that are intermediate in size between those of green iguanas and species of *Cyclura*. Eggs also are intermediate in size. Only seven animals are in captivity in only three institutions in the world. The pair at the Jersey Wildlife Trust have bred successfully (see report in *Iguana Times* 8(4)) but two eggs from a successful mating this year in San Diego failed to hatch.

I could have spent days at CRES, marveling at all the animals and asking a million questions, but I had only five minutes to run over to the zoo for my next appointment at the Reptile House. I was only a little sweaty and no more disheveled than usual by the time I arrived, struggling to regain my “serious” demeanor.

Again, I was in for a big treat. John Kinkaid, the Animal Care Manager, was clearly as enthusiastic about his animals as I was. “What have you seen so far? You can take out any of the Banded iguanas if you want to photograph them. Is there anything else you’d like to see?” John spent the next 2 ½ hours showing me all of his charges. I saw long-necked tree monitors and endless species of both rare and common snakes. I held young blue-tongued skinks that looked like fat sausages and was loath to disturb the young *Corucia* who

climbed on top of my head to nest in my hair. As a long-time dinosaur admirer, I had known about the remarkable tuatara long before I developed an interest in reptiles. The tuatara (genus *Sphenodon*) is a lizard-like creature that has been around since dinosaurs roamed the earth and it has no other surviving relatives. Few of them, however, exist today. The tuataras at the San Diego Zoo are members of the highly endangered Brothers Island population (*S. guentheri*) and are the only ones kept anywhere outside of New Zealand. We went outside to meet the Galápagos Tortoises; John knew them all by name and knew which individuals were grumpy and which would come galloping over to take the sweet potatoes we brought as treats.

My favorites, of course, were the Fijian Banded Iguanas, tiny, brilliantly colored creatures with alert eyes and calm temperaments. I particularly enjoyed holding the babies and a three-legged female who had lost a limb to infection. I was a little surprised to learn that her name was Ilene (I lean) and it left me wondering whether the *I. delicatissima* were named Hors d’oeuvre and Entrée (John has promised to let me name some of the next *Brachylophus* babies that hatch).

For days, even after returning home, I could still close my eyes and see so many beautiful faces, sense the weight of plump, healthy bodies, and feel wonderfully textured skin. Although much work remains to preserve all of the endangered animals of the world, we can only applaud the work being done on behalf of the reptiles by the dedicated staff at the San Diego Zoo. 

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Ed. Note: The *Cyclura pinguis* housed at CRES laid eggs in July 2001. After 90 days incubation at 30° C, four hatchlings emerged. This represents the first captive breeding of this species in a zoological facility.

Recent Literature Pertaining to West Indian Iguanas

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Calcium Metabolism in Iguanas

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Introduction

Calcium plays a key role in many biological processes, such as muscle contraction, egg shell production, blood clotting, enzyme activity, nervous system function, hormone release, and cell membrane permeability, in addition to being an essential component of bones. Calcium in the blood can be bound to other ions such as phosphate and citrate. It can also exist in the biologically active or free form. The blood concentration of calcium and its associated ions, as well as absorption and use by the body organs, is regulated by three major factors that interact independent of calcium intake. These factors are parathyroid hormone (PTH), calcitonin (CT, another hormone), and vitamin D. Parathyroid glands, which are located in the neck and which secrete PTH, and the thyroid gland, which secretes CT, are present in all air-breathing vertebrates.

Absorption

Vitamin D₃ (cholecalciferol) is converted by the liver and kidney to its biologically active form, 1, 25-dihydroxycholecalciferol (1,25 DHCC). This form is necessary for an iguana to properly absorb calcium from digested food in its intestine. Vitamin D₃ can be provided in the diet either as a preformed molecule or be converted from other molecules in the iguana's skin in the presence of ultraviolet stimulation. Dietary vitamin D can either be provided directly in specific food items or as part of a supplement added to the food prior to feeding. Iguanas utilize vitamin D₃ rather than ergocalciferol, vitamin D₂. Ergocalciferol is derived from plants and is less expensive to produce than cholecalciferol. Supplements listing vitamin D without a reference to the specific type usually contain ergocalciferol. Some food items such as commercial dog or cat food or monkey biscuits contain excessive amounts of vitamin D. When these items are fed to an iguana, hypervitaminosis D will occur. Likewise,

if the iguana is over-supplemented with vitamin D, the condition will also occur.

Vitamin D₃ can be synthesized in the skin of an iguana from precursor molecules. Ultraviolet light at wavelengths of 290–320 nm (UVB), shining on the iguana, is necessary for this reaction to take place. Following this reaction, the vitamin D₃ from the skin is transported in the blood to the liver and kidney where the conversion process into the biologically active form, 1,25-DHCC, is completed. Necessary wavelengths of ultraviolet radiation can be provided either from direct, unfiltered sunlight or a high quality, full-spectrum light source. This is the preferred manner for vitamin D₃ to be provided because an overdose is less likely to occur.

Unfortunately, glass or plastic will filter ultraviolet radiation out of sunlight, providing only heat and light. Likewise, poor quality or old ultraviolet lights will not provide adequate stimulation for proper vitamin D₃ conversion. Full-spectrum, ultraviolet strip lights will provide a better range of ultraviolet irradiation than incandescent or screw-in type bulbs. Currently, my favorite light is Zoo Med's Iguana Light 5.0 and Reptisun 5.0. These happen to be the same bulb with different packaging. Regardless of the brand you choose, the bulb should be replaced every 6–9 months. Although the bulb may still be producing light, the functional spectrum of ultraviolet irradiation will be insufficient for proper vitamin D₃ metabolism. Once the bulb develops a dark band near each end, the filament necessary to provide the ultraviolet spectrum has been burnt out. Remember, however, that no bulb can replace natural sunlight.

Storage

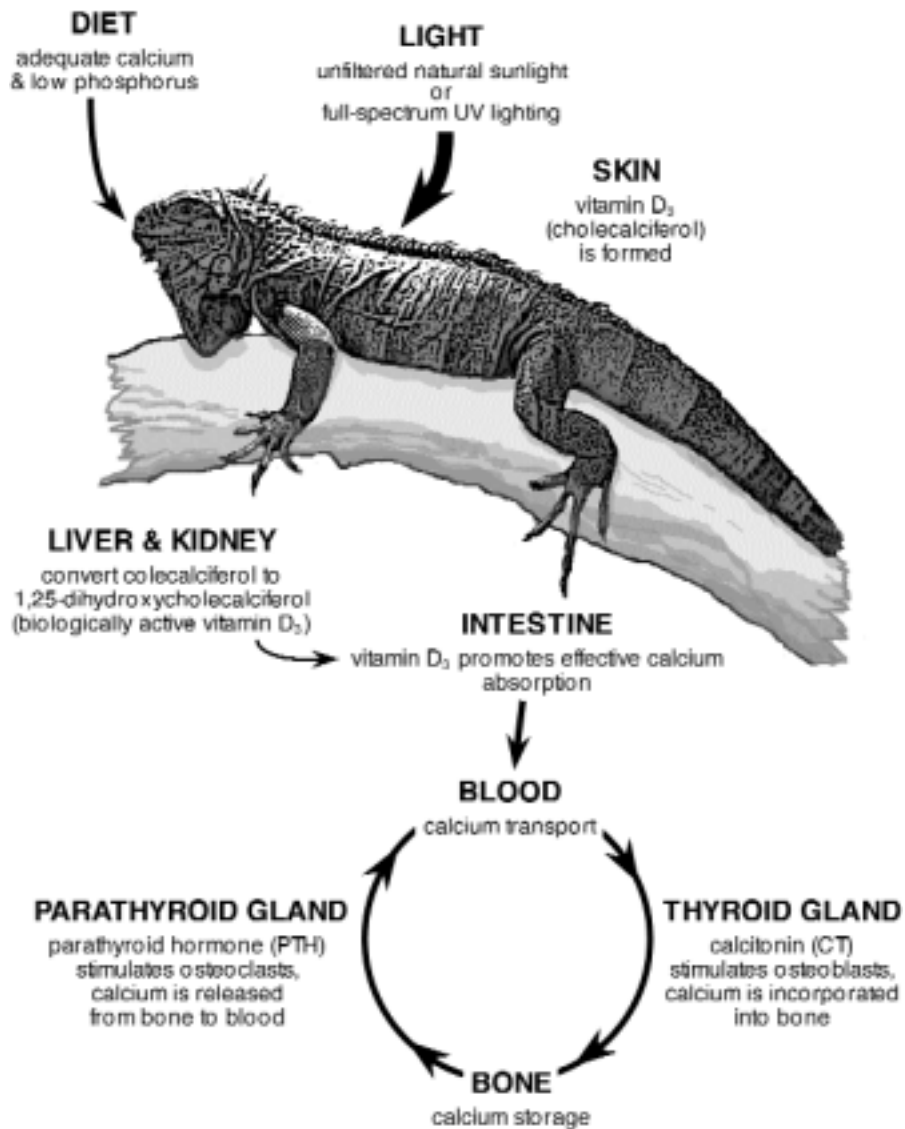
The main storage area for calcium in all vertebrates is in the bone matrix. The amount of calcium stored at any given time is a function of the action of two specific cell groups, the osteoblasts and the osteoclasts. Osteoblast cells are responsi-

ble for the resorption of calcium from blood and the production of bony matrix. Conversely, osteoclast cells are responsible for the demineralization of bone and a release of calcium into the blood.

When blood calcium levels decrease, the parathyroid gland secretes PTH. PTH stimulates osteoclast activity and inhibits osteoblast activity, which results in the release of stored calcium from the mineralized bone. PTH also causes an increase in phosphorus excretion by the kidneys. Lastly, PTH stimulates the final conversion of D₃ to metabolically useful 1,25 DHCC. The end result of all this activity is to increase the calcium absorption from digested food in the intestine. Once the blood calcium level returns to normal, the thyroid gland secretes CT. This hormone inhibits the release of stored calcium from bone by decreasing osteoclast activity. It also inhibits the excretion of phosphorus by the kidneys. Phosphorus is significant in that it can bind with free calcium and render it unavailable for use by the iguana's systems.

Cardiac Effect

Vertebrate cardiac function is also influenced by calcium ions within the myocardium (heart muscle). Calcium is rapidly exchanged within the myocardium. As calcium levels increase so does the animal's heart rate. Small elevations of calcium within the heart cells will result in increased con-



traction strength. However, as the concentration increases, the animal may develop a cardiac rhythm disturbance that may eventually lead to a cardiac arrest.

Reproductive Effect

Blood protein levels vary depending on the season, reproductive state, nutritional state, and temperature. The proteins in the blood that bind and transport calcium are highly influenced by the reproductive cycle. As a consequence of increased estrogen activity, blood calcium levels will increase in female iguanas as egg follicles are produced within the body. Thus the gravid iguana will not deplete its own calcium stores during reproduction.

Excretion

In a normal metabolic situation, a dietary excess of soluble calcium will not be absorbed by the intestine and will be excreted in fecal material. Additionally, a small amount of calcium is excreted with the urates. Likewise, only trace levels of calcium are present in the iguana's salt gland excretions.

Hypercalcemia

Excessive amounts of calcium in an iguana's diet will only cause a problem if it is accompanied by an excessive amount of vitamin D₃. This will happen when an owner is adding a vitamin-mineral supplement to an already high quality diet. In addition, the owner may be providing direct unfiltered, natural sunlight or full-spectrum, ultraviolet lighting. This can result in an excessively high amount of calcium being absorbed from digested food within the iguana's intestines. Ultimately, this will cause calcium salts to be deposited in various soft tissues. The most commonly affected sites include the aorta, heart muscle, pulmonary airways, gastrointestinal tract, and urinary system.


Hypocalcemia

Hypocalcemia (low blood calcium levels) can be caused by a number of different factors. Growing iguanas require a quality diet containing an adequate amount of calcium without an excess of phosphorus. Because calcium and phosphorus compete for the same binding sites in the blood, a diet high in phosphorus will result in low blood calcium levels. Sensing this decrease in circulating blood calcium, the parathyroid gland will secrete PTH. PTH stimulates the release of calcium stored in the iguana's bones. If the blood phosphorus level is still elevated at this time, the majority of freed calcium will be unable to find free binding sites. This results in the excretion of calcium within stool, leaching it away from bone and leaving the iguana with very soft bones. Some commonly fed items that are excessively high in phosphorus are lettuce, spinach, sprouts, tofu, peas, grapes, banana, mealworms, and crickets.

Oxalic acid in the diet should also be monitored as it will bind with calcium and prevent its absorption from the intestine. Foods containing oxalic acid such as spinach, rhubarb, cabbage, peas, potatoes, and beet greens should be fed in small amounts or avoided entirely.

Conclusion

Calcium metabolism in iguanas is a complex process with several variables. Specific wavelengths of ultraviolet stimulation from either direct, unfiltered sunlight or a high quality, full spectrum light source are necessary to convert vitamin D₃ within the iguana's skin. Vitamin D₃ must then be transferred first to the liver and then to the kidneys before it is finally converted into its biologically active form. Biologically active vitamin D is necessary to aid in the absorption of calcium from digested food in the iguana's intestine.

I try to make my clients visualize their iguana in the middle of a triangle with ultraviolet stimulation, optimum environmental temperature, and a high quality diet on the three corners. An optimal environmental temperature is necessary to activate intestinal microbes for proper digestion. A high quality diet, rich in calcium and low in phosphorus, should be provided. If all of these factors are provided, an iguana will have solid bones, a good growth rate, a strong cardiovascular system, and will be a fine specimen for breeding. 

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Calcium-related Pathologies in Green Iguanas

AJ Gutman
West Hartford, CT

Calcium-related pathology can be caused by several different factors and result in a number of different conditions, which are collectively known as Metabolic Bone Disease or MBD. Some of the most common causes of MBD are low dietary calcium levels, an excess of dietary phosphorus over calcium, excessive or deficient intake of vitamin D, and a lack of ultraviolet light in the proper wavelength for vitamin D conversion (UVB).

In the case of calcium/phosphorus ratio imbalance (i.e., an excess of dietary phosphorus over calcium), calcium stored in the bones is drawn out in order to maintain proper serum calcium levels. The early signs of this condition are the gradual swelling of limbs and uneven bone

growth, particularly in the jaw (Figure 1). A condition known as fibrous osteodystrophy produces what appear to be “chubby” limbs, which actually consist of fibrous tissue built up in order to stabilize the weakened bone (Figure 2).



Figure 1

Bunny is a ten year old male iguana, who is 4-1/2 ft long and weighs 14 lbs. He was given his name because he had been fed nothing but shaved carrots for two years before he was adopted and had an overwhelming case of hypervitaminosis A. He was fluorescent orange from head to tail. Urine, feces and shed skin were orange for weeks even after his diet improved. The one lingering sign of his early malnutrition is an overgrown lower jaw. When he is relaxed (most of the time), his tongue protrudes slightly, giving him a rather comical expression. *Photograph by Carole Saucier*

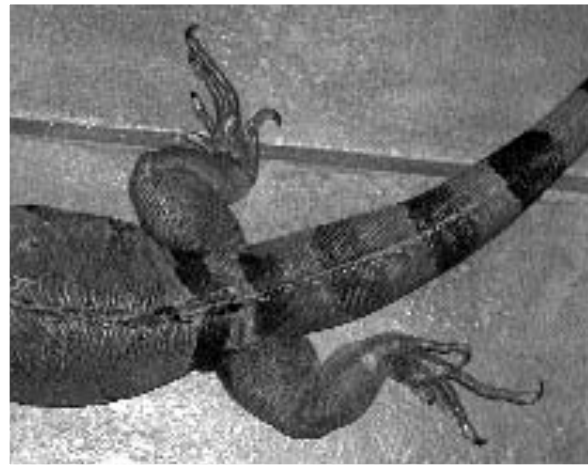


Figure 2

The muscular appearance of Dante's legs is caused by fibrous tissue built up in response to demineralization. *Photograph by Carole Saucier*



Figure 3


Dante is a female of unknown age who came to me with very little history. Her bones were so hopelessly demineralized that she could virtually be tied into a pretzel. She was unable to lift her body and could only move by wriggling across a flat surface. The most astonishing thing about Dante is that she has survived. After two years, she has shown considerable improvement in skin tone and color, muscle tone and mobility. Her front and back limbs remain bowed and her thighs are thickened by fibrous metaplasia. She is entirely mobile, even able to climb, despite considerable nerve damage to all of her digits. *Photograph by Carole Saucier*

Softening of the bone may also occur in the case of a vitamin D deficiency. If the diet contains insufficient vitamin D₃ or ultraviolet light exposure is insufficient for the vitamin to be synthesized under the skin, the result is identical: calcium will not be absorbed from the intestine, even if it is present. Calcium is instead leached from the bones to maintain serum levels. The joints can become swollen and the demineralized bone can be easily fractured. Another sign of MBD is an inability to lift the trunk (Figure 3), first with the back legs and then with the front, to the point where the animal is virtually unable to move its body even though the legs move vigorously. Spinal deformi-

ties may occur, and the spinal column can break, resulting in paralysis of the rear limbs. Another very obvious result is general failure to thrive, resulting in various degrees of stunting (Figure 4).

Hypocalcemia, or low blood calcium levels, will produce fine muscle tremors, which begin in the digits and progress to the limbs and the tail base. In severe cases, full seizures and tetany (locked limbs) can result. The animal will eventually become completely flaccid and die.

Hypercalcemia can occur as a consequence of excess dietary vitamin D as well as a supply of calcium and either direct sunlight and/or artificial UVB radiation. The excess calcium may be

deposited in the bone (Figure 5) as well as in the soft tissues of the body. If the heart muscle is affected, sudden death may occur. 

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All of the animals featured in this article are permanent residents of the CT Iguana Sanctuary. Special thanks to Dr. Larry Linnetz of the Chippen's Hill Veterinary Hospital for reviewing this article.

Figure 4

Hemingway was purchased from a pet shop for \$6.99, selected from a large group of virtually identical hatchlings because she had 23 toes. One rear foot has one extra toe and the other has two partially formed feet, one with three toes and one with four. Despite being raised with the same diet and lighting provided for other animals who have grown to full size, after 5-1/2 years, Hemingway is only 15 cm SVL and weighs a little over 1 kg. Last year she produced a clutch of 18 eggs which were about 1/3 the size of normal green iguana eggs. She has a healed vertebral fracture and both her front legs have been broken at various times. Her lower jaw is also slightly splayed but she has no other skeletal deformities. *Photograph by Carole Saucier*



Figure 5

Kahlo is an 8 year-old female green iguana who presented to a veterinary clinic at age 6 with a calcium deficiency (5.0 mg/dl, normal range is 7.5 – 10 mg/dl). Her owners were advised to give her crushed Tums as a calcium supplement. She was given Tums twice a day for two years and her vertebral column, from the neck to the base of the tail is fused. X-rays show substantial thickening of the bone throughout the trunk as well as in the long bones of the rear limbs. There is no apparent soft tissue involvement. *Photograph by Carole Saucier*

Green Iguana Invades West Hartford School

AJ Gutman

The pictures on the following pages are of Osiris, the green iguana adopted by the students of Ms. Joyce St. Germaine's Grade 7 Morning Meeting group at King Philip Middle School in West Hartford, Connecticut.

Osiris had spent the first eight or nine years of his life languishing, like all too many "Iggys," in a 55-gallon aquarium with a marginal diet and inadequate lighting. Both calls came in to the Connecticut Iguana Sanctuary at roughly the same time, one from Iggy's owners asking me to find a home for him and the other from Ms. St. Germaine about adopting an iguana for her classroom. Iggy was of "unknown sex" and allegedly fairly calm, although he hadn't been handled much. I thought he'd make a good candidate for the school, but I lost contact with his owners as the school year was coming to a close. Iggy had apparently left home to spend the summer outdoors in the natural sunlight. He was actually in pretty fair physical condition when he reappeared in the fall and his new placement was still available. Between a leftover cage from another adopted iguana, scavenged light fixtures, and proper ultraviolet lights donated by a local pet shop, he was well equipped to start school.

The habitat had all been set up and the students had diet and care sheets, iguana books, and back issues of the *Iguana Times* in hand before Iggy even arrived. The students were tremendously excited but listened intently when I came in to explain the basics of green iguana care with the iguana perched on my shoulder. Shyly at first, and then with increasing assurance, the students approached to touch him and ask their questions. Beyond providing proper care for their new "classmate," I asked that the kids give him a new name. The next day, when I returned with my Cuban iguana to give a talk about conservation, the board in the classroom was covered with potential names. We had a bit of a close call with "Fluffy," but "Osiris," after the Egyptian God of the Underworld, received the most votes.

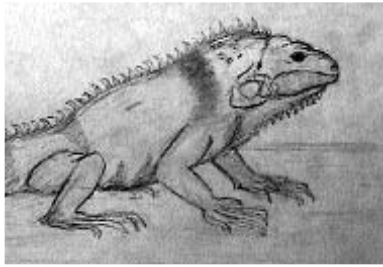
In the following weeks, I was pleased with the progress reports I received on Osiris. The students

would apparently come into the classroom in the morning, prepare Osiris' food and water and tidy his habitat even before the teacher arrived. He became quite the conversation piece, attracting students from all over the school, even if they weren't in any of Ms. St. Germaine's art classes! The special education students would come and sit by his habitat at lunchtime just to enjoy his company. A list had to be made up so that everyone would have the opportunity to take him home over weekends and holidays in his portable habitat. Ms. St. Germaine and Osiris brought out wonderful qualities in the students, who proved to be responsible and well-informed caregivers.

I was delighted with the artwork that Osiris had inspired and impressed with the physical details the students had depicted. I had talked about the differences between green iguanas and rock iguanas in the genus *Cyclura* — and all of the pictures display lovely dorsal spines and gular shields.

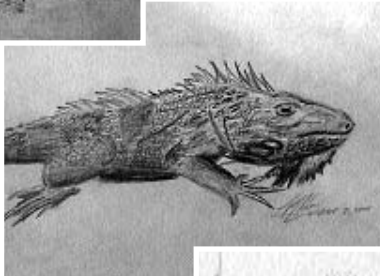
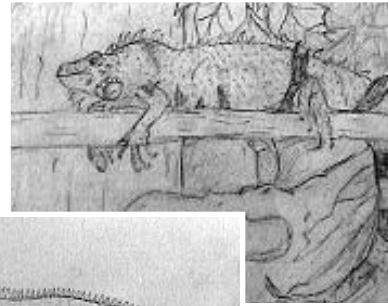
Sadly, the next chapter of Osiris' life was to be less happy, and provides a cautionary tale for all potential iguana owners. For the first time in his life, Osiris had a good diet and proper lighting; he had gained some weight and become quite comfortable with the school routine — and then came breeding season. Again, most likely for the first time in his life, Osiris was healthy enough to experience the hormonal surges of an adult male iguana. He became irritable, occasionally even mildly aggressive, and had a poor appetite. At one point, while the teacher was handling him, he jumped and bit her finger. Fortunately, she was not badly hurt, but she was justifiably concerned for the safety of her students. Together we decided to take the iguana out of the classroom before anyone else had a bad experience. So Osiris is back at the Iguana Sanctuary awaiting another placement, preferably with a male as his primary caregiver or with other iguanas with which he can socialize. Osiris' legacy remains, for the most part, positive from the months he shared with the students of King Philip Middle School.



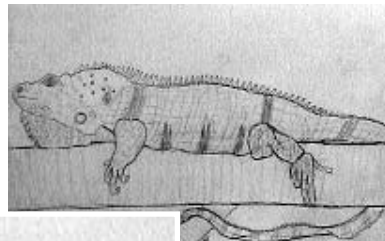


Jonah Small,
Age 13

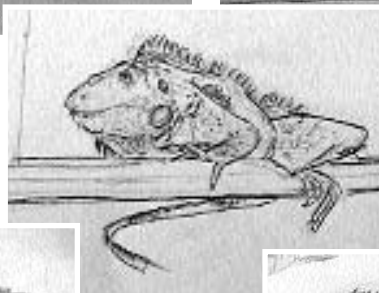
Victoria Skinner,
Age 12



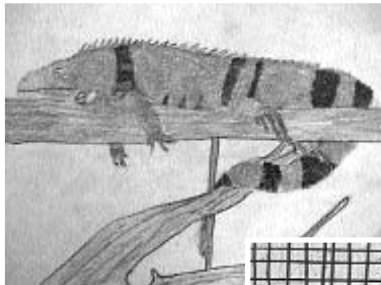
Josh Scheinblum,
Age 12



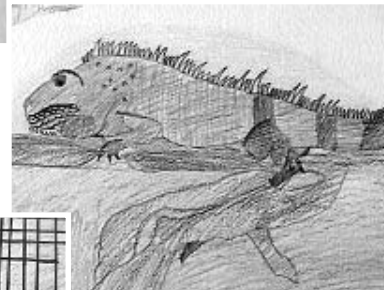
Daniel W.
Goldbaum-
Shortell, Age 13



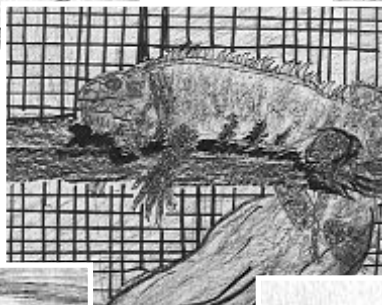
Spencer Glantz, Age 12



Ryan Reitz,
Age 12



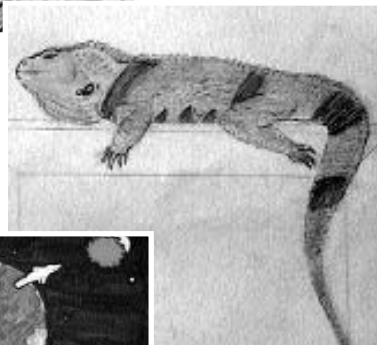
Gregory
Dassonville,
Age 12



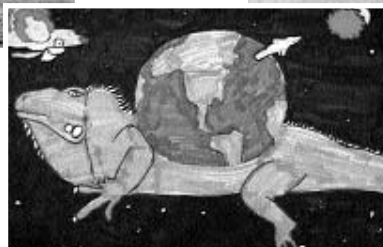
Allegra Levy, Age 11



Michelle Fechter,
Age 12



Michelle Fechter,
Age 12



Craig Wentworth, Age 12

Natural Hybridization between *Ctenosaura bakeri* and *Ctenosaura similis* on Utila, Honduras*

Gunther Köhler and Elke Blinn

Two species of spiny-tailed iguanas, *Ctenosaura bakeri* Stejneger, 1901 and *C. similis* (Gray, 1831) are native to the Caribbean island of Utila, which is situated off the coast of Honduras. These two species utilize different habitats and generally do not come into contact with one another. *Ctenosaura similis* occurs in open rocky areas and *C. bakeri*, which is endemic to the island, is largely restricted to mangrove swamps. Due to the limited distribution and the acute threat to the *C. bakeri* population from over-hunting by locals, the “Schutz- und Forschungsprojekt Utila-Leguan” (Conservation and Research Project Utila Iguana) was established in 1994. This project is sponsored jointly by the Zoologischen Gesellschaft Frankfurt (Frankfurt Zoological Society) and the Senckenbergischen Naturforschenden Gesellschaft (Senckenberg Biological Research Society) (Köhler 1998a). A captive breeding program for *C. bakeri* was established on Utila in April 1998 at the Iguana Research and Breeding Station.

On 11 May 1998, a freshly killed female *Ctenosaura bakeri* was brought to the Station by local people. The identity of the animal, which is presently part of the collection at the Forschungsinstitut and Naturmuseum Senckenberg (Senckenberg Research and Nature Museum) (SMF 78870), is unambiguous. Necropsy, which was performed immediately, revealed that she contained ten eggs. Eight of these were placed in moist vermiculite in a Jäger incubator at 28–32° C (temperature fluctuations due to power failure were limited). By 27 June, six eggs had spoiled, but the remaining two had increased in volume. On 12 and 14 August, two apparently healthy young animals hatched from these eggs (identity numbers 0510 and 0520). They measured 55 mm from snout to vent (SVL), 181 mm total length (TL), and weighed 4 g. Both had two claws removed for permanent identification.


When they were placed in natural sunlight in an outdoor enclosure, their coloration obviously differed from that of normal *Ctenosaura bakeri* hatchlings. The latter are a nearly patternless grey-brown (Köhler 1998b), whereas these two specimens had vivid markings with clear crossbands and ocelli and greenish coloration on the anterior dorsal half, as is typical for *C. similis* hatchlings. On 11 October, at the age of two months, the following coloration was noted using the “Naturalists Color Guide” by Smithe (1975–1981) as a color reference (code numbers of the colors in brackets):

Hatchling no. 0510 (217 mm TL; 70 mm SVL): dorsal surface of head and neck lime green (159); body sayal brown (223 C) with 5 dark (sepia 119) crossbands and light (cream color 59) ocelli; tail sayal brown (223 C) with dark (sepia 119) crossbands. Hatchling no. 0520 (199 mm TL; 65 mm SVL) varied only in the shade of green on the dorsal surface of the head and neck, which was registered as parrot green (160).

The scalation of the two hatchlings display a configuration that appears to be intermediate between those of *Ctenosaura bakeri* and *C. similis*. Hatchling no. 0510 has, without exception, two complete rows of enlarged spiked scales between the whorls (typical of *C. similis*) on the right side of the tail, whereas only one row is present in interspaces 9–12 on the left side (typical of *C. bakeri*). Consequently, the halves of the whorls do not correspond to one another along the median, a condition that does not occur in typical *C. similis* or *C. bakeri*. Hatchling no. 0520 has two complete rows of enlarged scales between the whorls; however, in interspaces 3–13, the foremost row is greatly reduced. Scales on the anterodorsal side of the upper thighs are enlarged but not spiky, therefore intermediate between *C. bakeri* (in which these scales are enlarged and spiky) and *C. similis* (in which these scales are not enlarged). Also, the number of dorsal spines, at 59 (no. 0510) and 64

(no. 1520), is intermediate between the values for *C. bakeri* (40–53, mean 44.6) and *C. similis* (61–96, mean 76.6) (data from Köhler 1995a, b).

An investigation of phylogenetic systematics based on morphological and genetic (RAPD fingerprinting) characters (Köhler 1995a) has shown that the thirteen species of the genus *Ctenosaura* can be divided into three monophyletic groups at

the subgeneric level. *Ctenosaura bakeri* and *C. similis* belong to different subgroups. *Ctenosaura bakeri* is more closely related to *C. melanosterna*, *C. oedirhina*, and *C. palearis*, whereas *C. similis* forms a tight cluster with *C. acanthura*, *C. hemilopha*, and *C. pectinata*. This is the first reported hybridization between two species in the subfamily Iguaninae. Although we have been performing field studies on Utila for many years, no further instances of hybridization between *C. bakeri* and *C. similis* are known to have occurred. From this, we assume that crosses between these species are rare, due primarily to their obvious ecological separation. Both hybrids will be raised at the Station in order to determine if they are fertile. 



Hybrid between *C. bakeri* and *C. similis* at two months of age.
Photograph by Gunther Köhler

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IGUANA NEWSBRIEFS

Wildlife Smugglers Arrested in Grand Cayman

German nationals Joachim Schmidt, Harald Endig, and Jürgen Geisler were detained by Customs officials after checking in at Grand Cayman's international airport on 30th January 2001. They were attempting to depart for Berlin via Miami with luggage packed with live reptiles, plants, and other wildlife from the Bahamas and Grand Cayman. Schmidt presented a local export permit, which was apparently forged, to an official.

The three came under suspicion when the National Trust for the Cayman Islands was alerted to Schmidt's presence on the island by a local resident who remembered concern over collecting by the same individual in the mid 1990's. After inquiries and further reports, the Trust learned that the three men were posing as academic researchers while collecting live reptiles in considerable numbers, but had made no recent contact with local officials and had not been issued with export permits.

As the Trust, the Departments of Environment and Agriculture, and local enforcement agencies began to assess the situation, a local security firm, Intelsec, agreed to donate services and placed the men under continuous surveillance. Evidence rapidly mounted that this was an illegal animal smuggling operation. This assessment was reinforced by information provided to the Trust by Traffic International on Schmidt's record of international trading in endangered species.

In a closely coordinated operation involving Intelsec, the Trust,

Department of Agriculture, Customs, Immigration, Department of Environment, and Civil Aviation, all possible routes for illegal export were monitored and the men were followed until they checked in at the airport. Bags seized by Customs after they were checked for international transfer contained 930 endemic Grand Cayman anole lizards, 140 Curly-tailed lizards from the Bahamas, and 112 Curly-tailed lizards from Grand Cayman. In smaller numbers were other reptiles and amphibians, marine life, terrestrial invertebrates, and a collection of bromeliads, cacti, and ferns. CITES restricted material included four endemic Ground Boas, and 13 endemic Banana Orchids, all from Grand Cayman.

Communication with the Bahamas Government revealed that no export permit had been issued for the reptiles collected in the Bahamas, nor had any corresponding import permit for these animals been issued in Grand Cayman.

On 2nd February in Summary Court, Schmidt, Endig, and Geisler were remanded in police custody on a series of smuggling charges. The three were returned to court on 7th February, when Schmidt also was charged with forgery: several charges under environmental legislation may soon be added. A trial date is expected to be set shortly.

Once photographed by police as legal evidence, the wildlife was identified and documented by the Trust working with the Departments of Environment and Agriculture. Zoology professor Sandy Echter-nacht from the University of Tennessee was flown

down by the Cayman Islands government to assist in identification of the reptiles from the Bahamas. By the evening of 3rd February, all the Grand Cayman wildlife had been released back to the wild.

For the full list of seized wildlife, and photographs including the suspects preparing lizard nooses while in Grand Cayman, visit the Trust's web site at www.caymannationaltrust.org

National Trust for the
Cayman Islands
17 Courts Road,
P.O. Box 31116 SMB,
Grand Cayman
Cayman Islands, West Indies
8th February, 2001

Cyclura cornuta and C. ricordii in the Dominican Republic

The Parque Zoológico Nacional of the Dominican Republic, The Toledo Zoological Gardens, and the Indianapolis Zoo are collaboratively coordinating a conservation project designed to collect baseline values for blood chemistry and vitamin D levels in wild populations of *Cyclura ricordii*'s iguanas, *Cyclura ricordii*, and Rhinoceros iguanas, *Cyclura cornuta*. Blood samples were collected from the populations of both species at Parque Nacional Isla Cabritos, an island in Lago Enriquillo near the Haitian border. A comparable study is being done by the Departamento de Recursos Naturales y Ambientales of Puerto Rico and the Toledo Zoological Gardens on Isla Mona, Puerto Rico, for the Mona Island iguana, *Cyclura stejnegeri*.

Both *Cyclura cornuta* and *C. ricordii* occupy the approximately 24 km² Isla Cabritos, which sits in the middle of the hypersaline Lago Enriquillo. The

habitat is typical of subtropical dry Antillean forest, with several species of cacti and trees such as *Bursera*, *Consolea*, *Guaiaecum*, and *Prosopis*.

Cyclura cornuta are far easier to snare than the wary *C. ricordii*, which bolt for their burrows at the first sight of a human. Fifteen *C. cornuta* and nine *C. ricordii* were processed during a recent trip. Animals were sexed, weighed, and measured. In addition to a general health examination, fecal samples were taken to determine bacterial species inhabiting the lower gastrointestinal tract.

Ed. Note: Please see The *Cyclura* of Parque Nacional in *Iguana Times* 8(2).

Source: *ISG Newsletter* 4(1), Spring 2001

International Iguana Foundation Established

First introduced at the Iguana Specialist Group's annual meeting in 2000, the International Iguana Foundation has now been incorporated as a Texas not-for-profit corporation. The Board of Directors and several guests from zoological societies and wildlife conservation organizations across the U.S. held their inaugural meeting at the Fort Worth Zoo in August 2001.

The IIF will effectively replace the iguana conservation funds administered through the Fort Worth Zoo that have helped operate the recovery programs in both Jamaica and Anegada (British Virgin Islands). The Foundation will provide a peer review process to evaluate funding requests from a greater array of iguana projects. With \$42,000 in commitments from 13 organizations, the Foundation will

IGUANA NEWSBRIEFS

be in a position to encourage long-term planning. Additional corporations and zoos in Europe, Australia, and North America have been identified as possible contributing members.

The IIF will take its funding priorities from those identified by the IUCN/SSC Iguana Specialist Group. The mission of the IIF is to promote the conservation of all species of iguanas.

Source: *ISG Newsletter* 4(2)
Fall 2001

Morris Animal Foundation Grant Awarded

In July 2001, the Fort Worth Zoo received a \$46,440 grant from the Morris Animal Foundation entitled "Health Assessment of Free-Ranging and Headstarted West Indian Iguanas."

This grant will provide funds to:

- Establish baseline health parameters for five species of free-ranging iguanas.
- Perform health screening on headstarted iguanas prior to release into the wild.
- Provide training and technology for local veterinarians and biologists to carry on this work.

The proposal is a collaborative effort involving the Fort Worth Zoo, the Wildlife Conservation Society, the San Diego Zoo, the Indianapolis Zoo, and the Toledo Zoo. The goal of the project is to compile and publish a comparative physiological database for use by researchers on various species of *Cyclura*.

Rick Hudson
Fort Worth Zoo

Source: *ISG Newsletter* 4(2)
Fall 2001

The Impact of Hurricane Floyd on the Bahamian rock iguana, *Cyclura rileyi rileyi*

Less than 700 endemic *Cyclura rileyi rileyi* remain in a small number of locations on and near San Salvador Island. The iguana population continues to decline due to predation of eggs and young by feral rats, competition with a cactus-eating moth, and smuggling. In September 1999, Hurricane Floyd lashed San Salvador with 155 mph winds and a substantial storm surge. Adult iguana populations were generally unaffected, but much of the nesting habitat on offshore cays was swept away and most of the 1999 hatchlings were destroyed. Some of the cay populations may have been extirpated by the storm. Long-term damage to vegetation due to soil loss should be monitored and immediate nesting habitat restoration needs to be considered.

R.L. Carter & W.K. Hayes
Department of Natural Sciences
Loma Linda University

Source: *ISG Newsletter* 4(2)
Fall 2001

Iguana *delicatissima* Martinique

Iguana delicatissima populations on the various islands of Martinique remain healthy. Measures have been taken to expand some of the nesting sites where late-arriving females had previously been observed excavating the eggs of other females. Populations of introduced *Iguana iguana* are being controlled to prevent problems with competition and hybridization.

Petite Terre (Guadeloupe)

A particularly intense dry season in the area has had an adverse effect on the *Iguana delicatissima* population. In one area, only two iguanas were seen alive where thirty adults are usually found. In another area of one hectare that was historically inhabited by twenty or more iguanas, no live animals were seen — but 25 carcasses were found. The mortality may be due to starvation or overheating as all the animals found dead were mummified. The trees were leafless. In two and a half hours, 321 dead adult iguanas were counted in various vegetation types. An estimated 2500 adults may have died during this dry spell. This does not include animals that could have died at the beginning of the drought and were eaten by hermit crabs. This estimate also does not include those individuals expected to die because they are unable to walk and feed. Such animals were found hanging in the trees, barely alive. The adult loss may therefore be as high as 4000 animals. With surviving adults weakened and unable to lay normal clutches, the impact on effective population size may be substantial.

Unfortunately, no collecting permits were issued for the dead individuals so that studies might be performed.

Saint-Barthélemy

A small remnant population of *Iguana delicatissima* survives. The dry season was responsible for the death of several goats that competed with iguanas for food.

Michel Breuil
Paris Museum of Natural History

Source: *ISG Newsletter* 4(2)
Fall 2001

Booby Cay Update

The first trip to Booby Cay in two years was planned for November 2001, to allow Joe Wasilewski, John Bendon, and two other investigators to continue research on the endemic *Cyclura carinata bartschi*. Unfortunately, due to a hurricane, the mail boat didn't arrive on Mayaguana and no gasoline was available to power the small boat needed to get to the cay. John Bendon stayed on Mayaguana until the gas arrived and took a day-trip to Booby Cay to assess damage from the wind and storm surge. All appeared to be well and several previously marked iguanas were sighted.

Since the previous trip in 1999, a letter has been written by Mr. James Knowles of the Ministry of Agriculture in Nassau to the police on Mayaguana asking them to remove the remaining goats from the cay. The letter was delivered and funds should be available to assist the police. A return trip by the Booby Cay team is planned for March 2002 and the researchers hope to find the island free of goats. Annual trips are proposed in order to continue the iguana census and ensure that the cay remains free of the goats that compete with iguanas for the limited vegetation. An application for a grant to cover the cost of investigations for three years is being made to the newly formed IIF (International Iguana Foundation). In addition, further funds should have accrued from the sale of T-shirts and artwork (by J. Bendon) to facilitate future research.

John Bendon

Iguana Times



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Volume 2, Number 1 (January 1993): Fiji Banded Iguanas; Roatán Island Spiny-Tailed Iguana; Salmonellosis in Reptiles; The Captive Husbandry and Propagation of the Cuban Rock Iguana, *Cyclura nubila*: Part 4. Breeding; Iguana Rescue Group Update; Lizard Letters; Iguana Newsbriefs; News of the Society. **Not available at the present time. May be reprinted in the future.**



Volume 2, Number 2 (May 1993): The Mating Behavior of *Iguana iguana* (Part 1); A Visit with Mao; News of the Society; Albert Schwartz; Iguana Newsbriefs



Volume 2, Number 3 (August 1993): The Mating Behavior of *Iguana iguana* (Part 2); The Captive Husbandry and Propagation of the Cuban rock iguana, *Cyclura nubila*: Part 5. Raising Hatchlings; Iguana Rescue Group Update; First Breeding of Rhinoceros Iguana, *Cyclura cornuta*, at the National Zoo; Iguana Newsbriefs



Volume 2, Number 4 (December 1993): Evolution of Nesting Patterns in Iguanine Lizards; Iguanas as Pets?; News of the Society; Iguana Newsbriefs



Volume 3, Number 1 (March 1994): Herpetoculture and Conservation; Smuggling... Bahamian Iguanas; Cesarean Section in a *Cyclura*; Full Spectrum Lighting; Respiratory Diseases in iguanas; Lizard Letters; Iguana Newsbriefs; Treasurer's Report; First full-color cover!



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Volume 3, Number 3 (October 1994): Adaptations to Herbivory in Iguanine Lizards; Herpetoculture Today: One Person's Thoughts; Ecology, Status, and Conservation of the Utila Spiny-tailed Iguana, *Ctenosaura bakeri*; Book Review: Iguanas: A Guide to Their Biology and Captive Care; Treasurer's Report; Iguana Newsbriefs



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Volume 4, Number 4 (December 1995): A Study of the Mona Rock Iguana, *Cyclura cornuta stejnegeri*, Nesting Sites on Mona Island, Puerto Rico; IIS Conference in San Salvador: Review and Report; Lizard Letters; Iguana Newsbriefs



Volume 5, Number 1 (March 1996): Psychosocialization of the Green Iguana: How to Better Handle Your Pet; Green Iguanas are Social Beings; International Sweep Targets Reptile Smugglers; Illegal Trade in Reptiles: Traffic Protected by Legal Void; Abstracts of Scientific Presentations from the 3rd Annual IIS Conference in San Salvador; Iguana: Survival of the Tastiest; Book Reviews; Lizard Letters; Iguana Newsbriefs



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 Progress for *Cyclura rileyi cristata*; Booby Cay Update; Iguana Rescue: Spot, Socks, Stanley and E.T.; Meet the Board (I.I.S.); Obituary: Captain Ron Harrod; Iguanas on the Web; Lizard Letters; Iguana Newsbriefs



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 The *Cyclura* of Parque Nacional: Isla Cabritos; *Cyclura* Behavior During a Hurricane; Jamaican Iguana Recovery Program; A Nature Sanctuary on Utila; Iguana Newsbriefs



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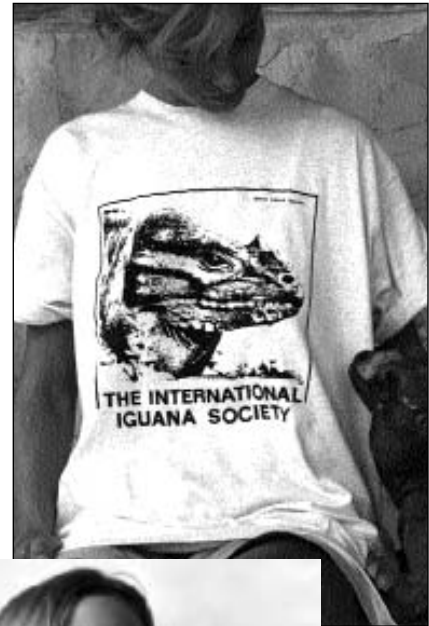
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Adult male *Ctenosaura nolasensis* from Isla San Pedro Nolasco on a rock overlooking the Gulf of California.
Photograph: L. Lee Grismer

