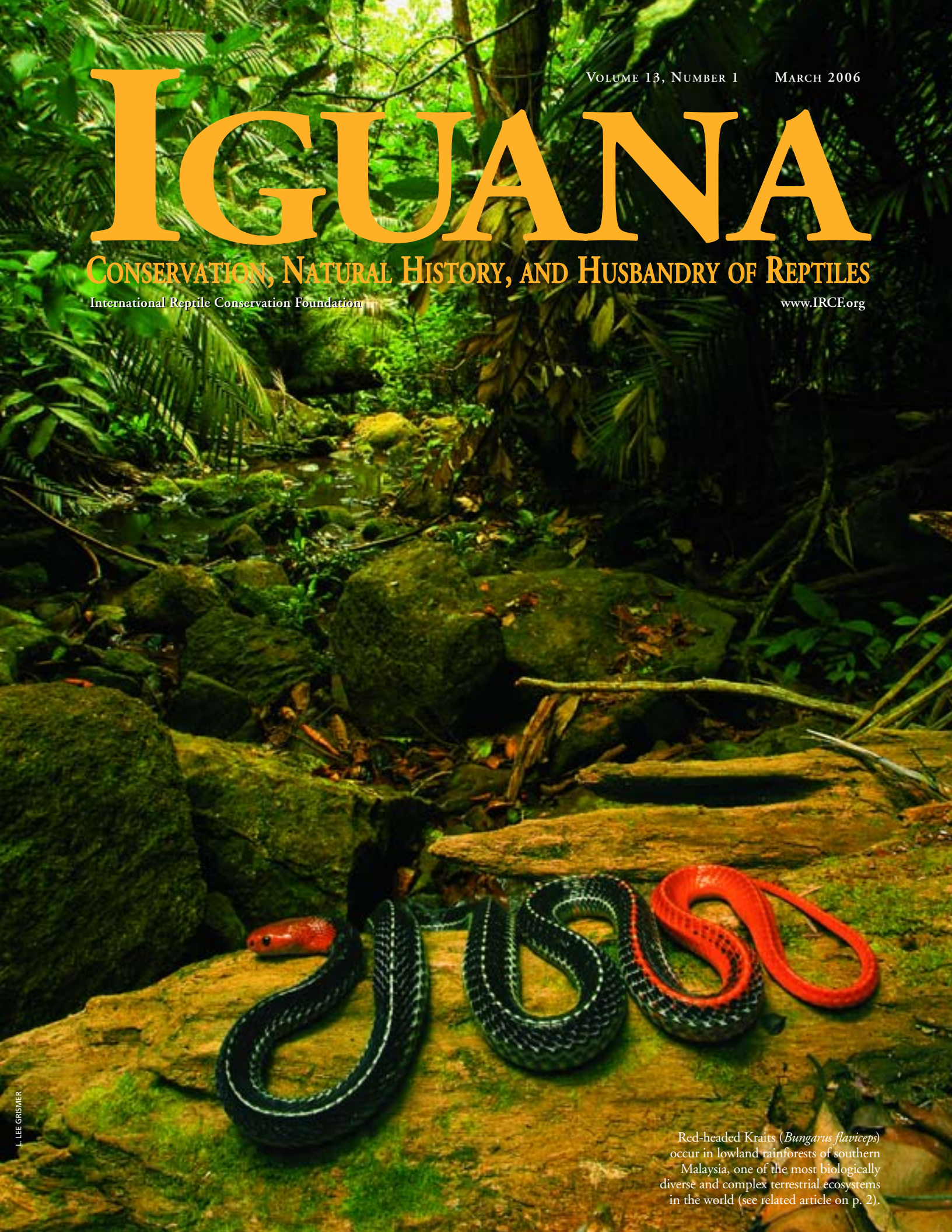
Volume 13, Number 1 March 2006

IGUANA

Conservation, Natural History, and Husbandry of Reptiles

International Reptile Conservation Foundation www.IRCF.org



L. LEE GRISMER

Red-headed Kraits (*Bungarus flaviceps*) occur in lowland rainforests of southern Malaysia, one of the most biologically diverse and complex terrestrial ecosystems in the world (see related article on p. 2).

KENNETH L. KRYSKO

Brown Basilisks (*Basiliscus vittatus*) are well-established in southern Florida and are expanding their range (see article on p. 24).

ALEJANDRO SANCHEZ

The Puerto Rican Dwarf Gecko, *Sphaerodactylus klauberi*, is found only in mesic, montane habitats (see article on p. 16).

JOSEPH BURGESS

Cuban Iguanas (*Cyclura nubila*) are but one of several Cuban reptiles that use the U.S. Naval Base at Guantanamo Bay as a wildlife refuge (see article on p. 8).

ROBERT POWELL

Male anoles are fiercely territorial. Here two male *Anolis cristatellus* on Guana, British Virgin Island, battle over a territory centered on a small palm tree (see article on p. 22).

JOSEPH M. POLANCO

Adult male Emerald Tree Boa (*Corallus caninus*) with head elevated in response to stimuli indicating the presence of a possible meal. Long thought to be a difficult captive, the key to successful husbandry is careful preparation (see article on p. 37).

L. LEE GRISMER

The Cat Gecko (*Aeluroscalabotes felinus*) is a slow moving, almost catatonic species with a range that extends from southern Thailand south through peninsular Malaysia and Singapore to Borneo (see article on p. 2).

JOSEPH BURGESS

"El Lagarto Azul," the Blue Anole (*Anolis gorgonae*) of Isla Gorgona, Colombia (see travelogue on p. 47).

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Cat Geckos (*Aeluroscalabotes felinus*) are most commonly found in shrubs and low trees in the vicinity of streams. Although this is the most ancient of all living gecko lineages, these lizards bear a number of highly specialized features to accommodate their arboreal lifestyle.

Slender Toes in Southern Malaysia

L. Lee Grismer

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Geckos are one of the largest and most distinctive groups of lizards in the world and, in some regions, are among the most conspicuous elements of the ecosystem. Well over 800 currently recognized species of geckos are distributed worldwide, with the highest concentration occurring in tropical and subtropical regions. Most geckos are nocturnal, thin-skinned, large-headed with bulging, lidless eyes boasting extravagantly sculpted pupilary margins, and adept climbers. In fact, this latter characteristic, accompanied by its myriad of digital specializations, is the iconic trademark of geckos and a key feature of their overall success and diversity. The vast majority of geckos have varying degrees of digital specializations involving the modification of the scales beneath their toes. These enhance their ability to gain purchase on a wide range of substrates, be they vertical or inverted, rough or smooth. The most common specialization comes in the form of "toe pads." The scales on the underside of the digits (subdigital lamellae) have become transversely expanded to increase their overall surface area and are adorned with microscopic structures that enhance adhesion to almost any substrate. Toe pads may occur along the entire length of the digit, as in the majority of species, including the familiar Tokay Gecko (*Gekko gecko*) and the Common House Gecko (*Hemidactylus frenatus*), or they may involve only the terminal scales at the tips of the digits as in the many species of New World Leaf-toed Geckos (*Phyllodactylus* spp.). Still others have digits on which expanded scales occur only at the base and the remainder of the digit is slender and unmodified. In all of these digits, the claw may or may not be present.

In the ancient, tropical lowlands of southern peninsular Malaysia and the associated islands of the Seribuat Archipelago, which is cradled along its eastern shore, geckos are not only the most diverse group of lizards, but among the most conspicuous

Many of the Bent-toed Geckos (*Cyrtodactylus* spp.) have only recently been discovered and named; the article formally describing *C. aurensis*, which is endemic to Aur Island, was published in 2005.

Another Bent-toed Gecko (*Cyrtodactylus quadrivirgatus*) is common and ranges widely across southeastern Asia.

Smaller (65–75 mm SVL) species of Bent-toed Geckos (*Cyrtodactylus* spp.), such as *C. sworderi*, are most frequently encountered when precariously perched at the end of a small twig or on the surface of a leaf.

nocturnal elements in these rainforest ecosystems. Although a number of the species have "typical" gekkonid fingers and toes, on which the toe pads extend along the length of the entire digit, the most speciose groups have a different type of digit — one where the digits are kinked or bent along their length, and the subdigital scales for the most part remain unmodified or are only slightly expanded at the base of the digit. This bend or inflection, which can occur in geckos with toe pads as well, results from modifications in the shapes of the phalanges (the bones in the digits) and the way they articulate with one another, resulting in yet another adaptation for climbing. The padless geckos with bent fingers and toes in this part of the world are the Cat Gecko (*Aeluroscalabotes felinus*), the Bent-toed Geckos (*Cyrtodactylus* ssp.), and the Rock Geckos (*Cnemaspis* spp.).

Aeluroscalabotes felinus is a slow moving, catatonic species most commonly found in shrubs and low trees in the vicinity of streams. The species' distribution extends from southern Thailand south through peninsular Malaysia and Singapore to Borneo. Although this is the most ancient of all living gecko lineages (Grismer, 1988), it bears a number of highly specialized features to accommodate its arboreal lifestyle. These include more forwardly directed eyes, a prehensile tail, and, of course, bent, padless digits. Additionally, digits one and two are nearly parallel in arrangement and they oppose digits four and five, which also are parallel to one another, thus providing *A. felinus* with a chameleon-like grasp of the substrates on which it climbs.

The Bent-toed Geckos, genus *Cyrtodactylus*, comprise one of the largest groups of geckos in the world. This genus contains at least 90 species and ranges across all of Asia and into the South Pacific. It also is one of the fastest growing groups, with over 15 new species being discovered and described within the last five years. One-third of those came from southern peninsular Malaysia and the Seribuat Archipelago: *C. aurensis*, endemic to Aur Island (Grismer 2005); *C. semenanjungensis*, endemic to southern peninsular Malaysia (Grismer and Leong 2005); *C. seribuatensis*, endemic to seven islands in the Seribuat Archipelago (Youmans and Grismer 2005); *C. sworderi*, endemic to southern peninsular Malaysia and just recently rediscovered and redescribed (Grismer et al. 2006); and *C. tiomanensis*, endemic to Tioman Island (Das and Lim 2001). In addition to these species, the more common and widely distributed *C. consobrinus* and *C. quadrivirgatus* also occur in the region.

The Bent-toed Geckos are notorious for their climbing abilities, and each species seems content to spend the majority of its time in one type of microhabitat. For the smaller (65–75 mm SVL) *Cyrtodactylus quadrivirgatus*, *C. semenanjungensis*, and *C. sworderi*, this microhabitat usually consists of branches and leaves of the small trees in which they forage, and these species are most frequently encountered while they are precariously perched at the end of some small twig or on the surface of a leaf. The larger species (120–135 mm SVL), such as *C. consobrinus*, *C. tiomanensis*, and, to some extent, *C. aurensis*, spend most of their time on tree trunks and boulders. The former two species are commonly seen as high as 15 m above the forest floor on the sides of trees, whereas *C. aurensis* is a bit more discriminating in that it is almost exclusively found on relatively small boulders that are partially concealed by overhanging vegetation.

The most specialized species of all the Bent-toed Geckos in southern Malaysia is the newly discovered and described *Cyrtodactylus seribuatensis* of the Seribuat Archipelago. This remarkable endemic is restricted to the periphery of seven tiny islands, where it makes its living in the harsh, ever-changing interface between land and sea known as the intertidal zone. This is one of the most extreme environments in which a terrestrial vertebrate may choose to live and, not surprisingly, few species successfully exploit this microhabitat. Making a living here means an individual must gauge its activities around a daily cycle of advancing and receding tides, which is further complicated by the fact that each episode dramatically alters the habitat. Additionally, food can be scare and what is available is usually hypersaline because of its marine origin. The handful of lizards known to live in intertidal areas and feed exclusively (or nearly so) from such a salty menu have evolved some extraordinary anatomical and physiological adaptations for eliminating the excess salt they ingest (e.g., Dunson 1976, Grismer 1994, Hazard et al. 1998). Although our studies of *C. seribuatensis* have just begun, stomach content analyses and field observations confirm it is eating intertidal invertebrates — but we do not yet know how it deals with the excess salt load. During the day, these lizards remain hidden beneath surface debris such as coconut husks, palm fronds, and pieces of driftwood that accumulate on the beach. At night, they emerge to search for food,

and lizards can be seen moving about, hopping from rock to rock, and foraging in the cobble at the water's edge.

The Rock Geckos (*Cnemaspis* spp.) of southern Malaysia are a curious, somewhat cartoonish looking group of lizards that, as their common name would suggest, spend the vast majority of their time on rocks — in this case, boulders. This is a relatively large group of nearly 50 species dispersed to areas as distant as eastern Africa and India, although their highest diversity is in Indochina and southeastern Asia. The digits of Rock Geckos lack all traces of toe pads and, for the most part, appear completely unmodified — save for that same old bend, which, as in *Cyrtodactylus*, is an adaptation to its bouldering lifestyle. This, however, is not the only specialization in this group. The digits are also very long, which is functionally complementary to their very long limbs and tails and flattened heads and bodies. All of this serves to bring the lizard's center of gravity close to the substrate, which any good rock-climber will tell you, is essential to keep from falling. So, the flattened body with the long, splayed, limbs and elongate digits is the perfect morphology for moving about on vertical and inverted flat surfaces. Attendant with this lifestyle and microhabitat preference, however, is the fact that many potential predators will be coming from "above." As such, these lizards have evolved flattened heads with widened snouts, making them somewhat duck-like in appearance, and their eyes have moved inward toward the center of the head and have rotated slightly upward, enabling them to see "up" without having to raise their heads too far off the substrate. *Cnemaspis* steps even further out of the typical gecko mold in that it does not have the weird looking eyes and elaborate pupils of most species, but instead has simple, round pupils, which, surprisingly, is in line with its other gecko-mold-breaking characteristic — it is diurnal.

Four species of *Cnemaspis* occur in southern Malaysia, three of which are some of the largest members of the group (90–100 mm SVL) and endemic to their own island in the Seribuat Archipelago: *C. baueri*, an endemic of Aur Island (Das and Grismer 2003), *C. lim*, an endemic of Tioman and Tulai islands (Das and Grismer 2003), and *C. pemanggilensis*, which is endemic to Pemanggil Island (Grismer and Das 2005). A fourth and somewhat smaller species (*C. kendallii*) is widespread throughout Malaysia. During the day, *C. baueri, C. limi*, and *C. pemanggilensis* can be observed moving about in their boulder microhabitat — but only in dark, shady areas where one boulder leans against another or in the deep recesses of large cracks. This would lead one to think that these species are nocturnal. However, at night they are hard to find unless you go deep into the cave-like boulder piles looking for them. *Cnemaspis kendallii*, on the other hand, is commonly seen foraging on rocks and the trunks of large trees, darting to and fro in the green filtered sunlight beneath the canopy. In fact, this species is so obvious at times, it has evolved an anti-predator defensive display during which it curls its tail high above its back, showing off the bright-yellow underside while wagging it slowly back and forth. At night, *C. kendallii* turns a ghostly white and can be found sleeping on rocks and the trunks of trees, or even clinging to the undersides of leaves as much as 20 m above the forest floor.

Unfortunately, some of these bent-toed denizens of Malaysia are in danger of losing major tracts of their habitat. Much of the lowland forest of southern peninsular Malaysia, to which *Cyrtodactylus sworderi* and *C. semenanjungensis* are endemic, is being converted into oil palm plantations (think of this the next time you order popcorn at the movies, the yellow coloration of which comes from palm oil). Although our data

Larger species (120–135 mm SVL) of Bent-toed Geckos (*Cyrtodactylus* spp.), such as *C. tiomanensis*, spend most of their time on tree trunks and are commonly seen as high as 15 m above the forest floor.

Cyrtodactylus seribuatensis of the Seribuat Archipelago is the most specialized of all Bent-toed Geckos. This newly discovered species makes its living in harsh, ever-changing intertidal zones.

The Rock Geckos, such as *Cnemaspis lim*, are a curious, somewhat cartoonish looking group of lizards that, as their common name would suggest, spend the vast majority of their time on boulders.

Because many potential predators come from "above," Rock Geckos, such as *Cnemaspis baueri*, have evolved flattened heads with widened snouts, making them somewhat duck-like in appearance, and eyes that are rotated slightly upward, enabling them to see "up" without having to raise their heads too far.

At night, *Cnemaspis kendallii* turns a ghostly white and can be found clinging to the undersides of leaves as much as 20 m above the forest floor.

on the natural history of these two species comes only from anecdotal observations made during the collection of the type series, these geckos are clearly lowland rainforest specialists. In nearby mountainous regions, where we have been conducting field research, we have not yet found these species and believe the habitat there is inappropriate. Nor is this habitat appropriate for the oil palm industry, which is rapidly replacing the extremely diverse flora and fauna of the lowland rainforests with a single species of palm. This will not only affect the species of *Cyrtodactylus*, but every other species in the region. Currently, these isolated mountain ranges amid a sea of oil palms are all that is left of the native rainforest in some areas. If not for the existence of the Endau-Rompin National Forest in this general area, which thus far has resisted habitat conversion and has been host to a number of scientific expeditions (see Wood et al. 2006 for summary), our knowledge of the natural history of this portion of southern peninsular Malaysia would be all but lost.

Equally bleak is the future of the islands on which endemic *Cnemaspis baueri*, *C. limi*, and *C. pemanggilensis* enjoy the safety of their shaded, rocky retreats. These are rapidly becoming popular tourist get-aways, with all the accoutrements of a growing tourism infrastructure — and they are beginning to make inroads into the forest. In fact, the villagers on Tioman Island and many of Malaysia's leading scientists and naturalist are struggling right now to halt the construction of a marina and a large airport along a portion of virgin, unspoiled coastline (Grismer 2005). Currently, none the species are listed on the IUCN Red List, although the endemic, insular species would clearly qualify (see http://www.redlist.org/info/categories_criteria.html).

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The Herpetological Community

The geckos of southern Malaysia occur in one of the most biologically diverse and complex terrestrial ecosystems in the world. Lowland rainforests are renowned for their diversity, but, in southern Malaysia, and especially on Tioman Island where 13 species of geckos make their home, the diversity is even more astounding. Tioman is the largest island in the Seribuat Archipelago and is characterized by steep-sided mountainous terrain reaching 1038 m. It supports lowland rainforest on its alluvial foothills and hill forest above 300 m. The coastline and low-lying periphery are dominated by mangrove and coastal forests. Exposed granitic outcroppings consisting of large boulders define much of the island's rugged topography, and its hillsides are cut by a number of boulder-strewn, fast-flowing streams in both open and closed canopy forest. This environmental diversity supports nearly 100 species of amphibians and reptiles on this small island. These range from tree-hole nesting and stream-dwelling frogs such as the White-spotted Treefrog (*Nyctixalus pictus*) and the Spotted Stream Frog (*Rana picturata*), respectively, to strange looking lizards such as the Chameleon Anglehead Lizard (*Gonocephalus chamaeleontinus*). At least 44 species of snakes live on Tioman Island, with adaptive types ranging from tiny blind snakes in the family Typhlopidae to King Cobras (*Ophiophagus hannah*), Red-headed Kraits (*Bungarus flaviceps*), and Reticulate Pythons (*Python reticulatus*). Geckos are an intricate part of this diverse ecosystem and function as both predators and prey for many species.

Chameleon Anglehead Lizard (*Gonocephalus chamaeleontinus*).

White-spotted Treefrog (*Nyctixalus pictus*).

King Cobra (*Ophiophagus hannah*).

Spotted Stream Frog (*Rana picturata*).

Reticulate Python (*Python reticulatus*).

JOSEPH BURGESS

Adult Cuban Iguana, *Cyclura nubila*, and an example of the very dry habitats at Guantánamo Bay.

Conserving the Remarkable Reptiles of Guantánamo Bay[1]

Allison C. Alberts

Photographs by the author except where indicated.

When looking for a suitable place to study some of the world's rarest reptiles, a relatively isolated military base might at first seem like a surprising choice. However, the United States Naval Base at Guantánamo Bay, Cuba, like many military installations worldwide, supports large areas of undisturbed natural habitat and is home to an impressive abundance of wildlife. Guantánamo Bay lies in Oriente Province in the southeastern corner of Cuba. It is the oldest overseas United States military base, originally acquired as a coaling station in 1903, but reaffirmed by treaty in 1934 after the American fleet aided Cuba during the Spanish-American war. Because only 11% of the 20-square-mile base is actively used by the military, large areas of near-pristine cactus and thorn scrub, buttonwood and *Phyllostylon* forest, and mangrove tidal thickets remain.

Guantánamo lies in the rain shadow of the looming Sierra Maestra. Consequently, this starkly beautiful region is very dry, receiving only 40–75 cm of rain each year. With air temperatures averaging 28–30 °C throughout the year, it's no wonder that as many as 30 terrestrial species of amphibians and reptiles, 21 of which live nowhere outside of Cuba, make Guantánamo their home. Among these, the Cuban Iguana (*Cyclura nubila*) is one of the largest, undoubtedly the most visible, and certainly the most charismatic. No one completes a tour of duty at "Gitmo" without getting to know these inquisitive, prehistoric-looking giants.

Endemic Cuban Todies (*Todus multicolor*) take advantage of large areas of near-pristine habitats at the United States Naval Base, Guantánamo Bay, Cuba.

Giant Iguanas

Remarkably, these robust lizards have somehow managed to survive millennia of hurricanes and hunting by native peoples. Unfortunately, outside the fenceline, iguana populations are now declining because their habitat is being eliminated by develop-

Typical undisturbed coastal habitat at the United States Naval Base, Guantánamo Bay, Cuba.

[1] Reprinted with permission from: A. C. Alberts. 2003. Conserving the remarkable reptiles of Guantánamo Bay, pp. 67–73. *In* R. W. Henderson and R. Powell (eds.), *Islands and the Sea: Essays on Herpetological Exploration in the West Indies*. Contributions to Herpetology, Volume 20. Society for the Study of Amphibians and Reptiles, Ithaca, New York.

ment or degraded by invasive species. A host of exotics, including mongooses, dogs, feral cats, and black rats, prey heavily on juvenile iguanas, and, in many areas, domestic ungulates are consuming the native vegetation on which iguanas critically depend. Since the early 1990s, my colleagues and I at the San Diego Zoo have had the privilege of visiting Guantánamo Bay many times, working to design conservation strategies for Cuban Iguanas and other threatened reptiles.

Getting to Guantánamo is no easy undertaking, but thanks to the United States Navy, we're able to fly in style aboard the base commander's C-12 aircraft, with a pleasant layover in Jamaica that allows us to spend time with friends and colleagues at the tiny yet fascinating Hope Zoo in Kingston. Since the rediscovery of the Jamaican Iguana (thought to be extinct since 1940) in a rugged limestone-floored forest outside Kingston, aptly named the Hellshire Hills, the Hope Zoo has been working to establish a headstarting program for young iguanas. A dedicated facility was built on zoo grounds, which currently houses 100 baby iguanas — all being raised in a safe environment until they are old enough to survive on their own in the wild. To date, 26 iguanas sporting radiotransmitters have been returned to Hellshire, all have established stable home ranges, and at least some released females appear to be nesting successfully. Education is a major part of the mission of the Hope Zoo, and they have recently completed a new learning center on zoo grounds that attracts thousands of school children each year. The brightly painted sign at the zoo's iguana exhibit sends a simple message that says it all: "Nuff Respect Due."

After a short plane flight out of Kingston, Cuba's rugged coastline comes into view, and one can begin to appreciate the strategic and economic importance of the many deep and sheltered harbors afforded by Guantánamo Bay. With the hazy mountains and bustling Guantánamo City in the distance, we board a military ferry to cross the bay, a journey that begins in calm waters favored by West Indian manatees, but becomes increasingly choppy as the crossing progresses. After about 45 minutes, we arrive on the windward side of the naval base, piled high with gear, and ready to begin our research.

Lizards and Howitzers

We initially began our field studies of Cuban Iguanas in 1993 along a windswept section of rocky coast called Firing Point, with the hope of gaining an understanding of the basic biology of these lizards, as well as developing practical strategies for their recovery. We quickly came to appreciate the origin of the site's name when we first experienced the thunderous testing of nearby howitzers, an event to which the local iguanas appear amazingly and blithely oblivious. Although frustrating trial and error characterized our early attempts to capture these often feisty five-foot-long lizards, the process was ultimately made easier by our fortuitous discovery that red grapes, like red flowers, were a favored food item and could easily be used to lure unsuspecting iguanas into hand nets. Over the course of a year, we captured each adult iguana at Firing Point once a month, and recorded its body length, weight, head size, and the diameter of the femoral scent glands lining the thighs, all of which seem to be important for successful defense of territories. After placing the animals in canvas bags to quiet them, we also collected a blood sample from the tail for hormone analysis.

For the iguanas, the daily routine varies little, consisting of a vigorous burst of social activity after morning emergence, followed by relatively peaceful migration to nearby areas of vegeta-

JOSEPH BURGESS

Adult Cuban Iguana, *Cyclura nubila*, at Guantánamo Bay.

JOE BURGESS

The most unfortunate iguana/human encounters, which iguanas invariably lose, involve motor vehicles.

tion for midday feeding, and ending with a second bout of social interaction late in the afternoon prior to entering nighttime refuges. Most adult males regularly engage in aggressive interactions with other males. These usually consist of a lumbering chase, but occasionally prolonged pushing, hissing, and biting matches ensue. Almost without exception, the most dominant males have the highest testosterone levels, are larger in body and head size, and possess more active scent glands than lower-ranking males. These despots defend small but superior territories that each overlap the ranges of several females. Lower-ranking males do not defend territories, instead moving between the territories of dominant males, from which they are continually evicted. Headbobbing, chases, and mouth-gaping, the typical weaponry of iguana territoriality, are used almost exclusively by dominant males. These males also spend more time close to females during the breeding season, courting them with gentle nudges and headnods. Although dominant males appear to have better access to mates than subordinate males, they comprised no more than a third of all adult males at Firing Point.

Study site at Firing Point, Guantánamo Bay, prior to 1995. About 60 adult iguanas inhabited the area shown here.

The following year, we conducted an experiment to determine if temporary relocation of dominant males would increase the chances that sexually mature but genetically underrepresented subordinate male iguanas would have the opportunity to mate. This strategy represented a unique approach to lizard conservation, and has the potential to serve as an important management tool for critically small populations. For the duration of the breeding season, we moved the five most dominant males from Firing Point to a large outdoor holding enclosure at the base Army Veterinary Clinic. Within a few days, the five largest previously subordinate males began defending territories that were nearly spatially identical to those vacated by the relocated individuals. In the absence of the dominant males, subordinate males courted females vigorously and their testosterone levels rose dramatically. At the close of the breeding season, the previously dominant males regained their previous territories within two days, although the battles required were among the longest and most intense that we had ever observed. Temporary removal of dominant males may represent a valuable management tool for small or otherwise genetically compromised populations by potentially increasing the number of males contributing to the gene pool.

Giant Anoles (*Anolis smallwoodi*) are relatively common at the Guantánamo Bay Naval Base.

The World Intrudes

When you work at the same site year after year, you begin to take for granted that it will never change. Such had been the case for Firing Point and its enviably observable iguanas until the fateful Spring of 1995, when over 50,000 Cuban and Haitian migrants arrived unexpectedly at Guantánamo Bay, aboard literally anything that could float. In response to the crisis, extensive areas of forested habitat were graded along the coastline in order to construct temporary tented housing. Although military officials did an admirable job of keeping people and wildlife at a safe distance, Operation Sea Signal nevertheless resulted in a noticeable reduction in the local iguana population. At the height of the refugee crisis, the dry tropical forest surrounding Firing Point was reduced to less than 5% of its former extent, and we could only find a single forlorn adult male iguana inhabiting the area.

Our deep dismay at seeing the destruction of Firing Point's ancient cactus forest was slightly tempered by the realization that we now had the unique opportunity to study if and how rapidly iguanas would recolonize the area. Our aim was to document the extent to which this dry tropical forest ecosystem was sufficiently resilient to recover from severe disturbance, and to study the ecological role that iguanas might play in this process. By mid-1999, we were heartened to find that over 25 adult iguanas had resettled the area, and all appeared to be growing well and in good health. For both males and females, the relationship between body mass and body length had improved to the point where it was comparable to that of healthy undisturbed iguanas, indicating that despite the loss of significant habitat, iguanas were able to forage effectively following disturbance. At the same time, vegetation at the site showed definite signs of regeneration and a number of new seedlings emerged.

Given that iguanas relish the fruits and flowers of many plants, we believed that they might play an important role in the recovery of native vegetation. Past research by us and others has shown that seeds that have passed through the digestive tracts of iguanas tend to sprout sooner and produce seedlings that grow faster than seeds that have not. In addition, repetitive cropping by iguanas, evidenced by an abundance of oddly-shaped flat-topped bushes along Guantánamo's limestone coastline, is likely to stimulate the development of new foliage. By aiding germination, providing nutrients to developing seedlings, promoting plant growth, and dispersing seeds into new areas, iguanas play a key role in keeping forest ecosystems healthy. As so often happens with scientific endeavors, one study leads to a host of new avenues for research. Seeing the recovery process first hand at Firing Point, a site that was so intimately familiar to us, led to a new line of inquiry into the relationship between local iguana populations throughout the base and the vegetation on which they depend. As unglamorous as it may seem, surveying different habitats to determine the density of local iguana populations is an important first step in assessing their ecological relationship with local plant communities.

After identifying eight key habitat types on the base, we returned to Guantánamo in 2000 to carry out a series of morning and afternoon walking surveys using a technique called distance sampling. This involved a team of three slogging through varying densities of thorn scrub (one must stay on an absolute straight-line course to meet the strict assumptions of this survey methodology — meaning that, as much as we wanted to, we

United States Marine with Cuban Boa, *Epicrates angulifer*, at Cuzco Beach nature area, Guantánamo Bay.

could never cheat and go around those nasty-looking cactus patches), for a half-mile or so per transect. Whenever an iguana was sighted, we paused our sweaty march to cheer, note the size and sex of the animal, and measure its perpendicular distance from the transect line. We used a Global Positioning System (GPS), which communicates with a series of navigational satellites orbiting the earth, to record the latitude and longitude of the start and finish of each transect line. The morning breeze, which blessedly and predictably picked up around 1100 each day, was a welcome break from the stifling heat. Additional delights included the occasional delicate pink orchid suspended in midair amid impenetrable thorn scrub, or the bright green, yellow, and azure hues of a sleeping giant anole, or "chipojo," in a *Capparis* tree.

Despite hazardously steep terrain, we successfully completed 24 transect lines, and determined that iguanas are approximately four times as abundant along the coastline as inland. Most likely, this is due to the many holes and crevices in the crumbling limestone that characterize the shoreline. These provide a host of hiding places and refuges from the heat, particularly for young iguanas. Not surprisingly, iguanas are three to ten times as abundant in natural areas as in those that have been impacted by people. Perhaps because suitable refuges are fewer and farther between, habitat disturbance in the form of construction and replacement of native vegetation by introduced grasses appears to have twice the negative impact on inland iguana populations as on those along the coast. During one of our transects, we did come across an unusual and unexpected sight — an adult male iguana with the telltale remains of a diminutive yellow juvenile Cuban Grassquit (a small passerine bird) in his mouth, testament to the fact that iguanas are not always vegetarian in their food choices.

Snakes, Turtles, and Banana Rats

With financial support from the United States Department of Defense, we have recently been able to expand our work to include population surveys not only for iguanas, but also for two other ecologically important reptiles on the base, boas and sea turtles. Taking on this additional task meant no rest for the weary — to make the most of our limited time on the base, each full day of iguana surveys was followed by an evening of searching for Cuban Boas and monitoring sea turtle nesting beaches.

The most efficient way to search for Cuban Boas (*Epicrates angulifer*) — a truly impressive snake, with rainbow iridescence on its scales and a body length of up to nearly four meters — is

ROBERT POWELL

Populations of large rodents called Cuban Hutias (*Capromys pilorides*) or "Banana Rats" appear to be burgeoning on the base, and their exploding population is causing significant problems by destroying vegetation and damaging equipment. Cuban Boas (*Epicrates angulifer*) probably play a key role in naturally regulating hutia populations.

Eight of ten beaches at the United States Naval Base, Guantánamo Bay, Cuba, are used for nesting by endangered Hawksbill Turtles (*Eretmochelys imbricata*).

to slowly drive roads just after sundown. Nevertheless, one of our most intriguing boa encounters occurred when we were on foot. Researcher Glenn Gerber's practiced eye spotted a Lignumvitae "Tree of Life" which had been hollowed out by lightening — the perfect hiding place for a young male boa. We marked the snake with a microchip just under the skin for permanent identification, and collected a small blood sample for genetic analysis. On future trips, our goal is to use surgically implanted radiotransmitters to track the movements of these elusive and little-known snakes in order to better understand their home range dynamics and habitat requirements. We are especially interested in documenting the effects of an ongoing relocation program, in which boas are removed from urban areas by base personnel and released into more natural surroundings.

In recent years, populations of large rodents appear to be burgeoning on the base. These animals are known to science as hutias, but to most base residents as "banana rats," owing to the distinctive curvature of their scat. Although one can't help but smile at the ubiquitous hutias, which traipse around the base in ungainly family groups that communicate constantly with chirps and whistles, their exploding population is causing significant problems by destroying vegetation, chewing through radiator hoses, and perpetrating other undesirable antics. Cuban Boas probably play a key role in naturally regulating hutia populations, so we are keen to further investigate the ecological relationship between these two species.

After about 2100 hours, when nightly boa catching became significantly less likely, we headed out to investigate a series of beaches on the base that are potentially used by sea turtles for nesting. Because they are relatively undisturbed and protected from hunting, Guantánamo's scenic beaches are of regional importance for sea turtle conservation. Fortunately, it's fairly easy to distinguish which species of turtles are using these beaches simply by examining their tracks. The nesting crawl of all sea turtles generally resembles the path of a miniature bulldozer, with Hawksbill tracks showing an alternating flipper pattern and Green Turtles a more symmetrical, opposite pattern. Because Leatherbacks are one of the largest living reptiles, surpassed in size only by some crocodilians, their tracks are impossible to miss.

To date, we have mapped ten beaches on the base using GPS and surveyed them for evidence of sea turtle nesting activity. Eight of the ten beaches are used by Hawksbill Turtles, one by Green Turtles, and one by Leatherback Turtles, information that will help guide the Navy in successfully managing these beaches for both people and turtles. Two of the beaches have evidence of more than 100 nesting pits each, and appear to be especially important for Hawksbills. Given that Hawksbill populations are under intense hunting pressure throughout much of the Caribbean, it is crucial that these beaches be carefully managed to minimize human impacts. Together with natural resources personnel on the base, we are committed to evaluating alternative management strategies and raising public awareness about sea turtles and their nesting habits.

Without a doubt, the highlight of our sea turtle work at Guantánamo Bay was a particularly warm and humid night at Pebble Beach in June. This is a small, rocky beach, but one favored by turtles nonetheless. We hadn't dared hope that we would actually encounter a living turtle, but to our delight, as we approached the beach we heard the rasping sound of a female Hawksbill's plastron scraping over the rocks as she lurched onto land. With a special flashlight that emitted only a dim red beam, we were able to scrunch forward on our bellies close enough to observe the nesting process. She selected a site under an aged Sea Grape Tree that, judging from soil erosion that revealed old eggshells encrusted many layers deep, has probably been used for this purpose for decades. Oblivious to the eggs of previous

Iguana crossing signs installed at key locations throughout the naval base have helped reduce road casualties.

Annual iguana demonstrations are held for military and civilian personnel and their families.

nesters, which she dug up and flipped out of the nest cavity with impunity, this particular female took about an hour to dig her nest. With remarkable dexterity, she used her rear flippers to reach down, scoop out flipperfulls of sand, and carefully deposit them nearby. When the nest cavity was deep enough to suit her, she proceeded to lay over a hundred glistening spherical eggs, and then gently backfilled the nest cavity. Her task complete, she never paused to rest, instead making a direct line to the water and disappearing into the moonlit waves.

Reptile Outreach

Public education is key to the success of any conservation program. Over the years, we have attempted to educate both military servicemen and civilians through open lectures at our field sites, classroom presentations to elementary and secondary students, endangered species pamphlets, and newspaper and radio interviews. In response to a rash of unfortunate incidents in the mid-1990s, we designed a set of "Iguana Crossing" signs for high traffic areas where collisions had occurred. We have been thrilled to see that over 20 of these signs have been erected at critical locations, and to learn from our local collaborators that iguana road casualties are now a rare occurrence. In fact, the only "problem" with the signs has been their unanticipated popularity as impromptu souvenirs — an issue subsequently addressed by offering scaled-down versions for sale in a local giftshop.

With the help of the base TV station, which advertises regularly for us on the event scroller, we have had excellent turnouts for our semi-annual iguana demonstrations. These presentations are held in the evenings at Iguana House, a relatively remote building near the coast that always seems to have an iguana or two hanging around. Usually about 80 or so people attend, some of them getting their first-ever close up view of an iguana, with a chance to touch one if they wish. While we try to spread the message that iguanas should be neither harassed nor fed (an ever-present problem), we also spend a significant amount of time answering questions. These range from why iguanas bob their heads to how the large population of feral cats on the base is impacting them. Interest and curiosity among base residents about iguanas and other native reptiles continues to be intense, and past interviews and surveys have shown that most people's feelings about them are positive, boding well for the continuing successful co-existence of humans and wildlife on the base.

Public interest in Guantánamo's extraordinary wildlife continues to be high, as evidenced by the more than 75 dedicated volunteers who have helped us with our work over the years. Part of the message we hope to send is that protecting wildlife need not conflict with the military mission. In fact, healthy natural systems are often those best suited to supporting the security and training functions central to military operations. For such a small piece of land, Guantánamo Bay has experienced an unusually tumultuous history. Despite its drastic transformation from the early days of open commerce to its more recent role as a safe haven for Cuban and Haitian refugees, the extraordinary biodiversity of Guantánamo has managed to survive intact. Whatever the future may hold, we can only hope that with awareness and dedicated stewardship, the distinctive reptiles, other native wildlife, and the natural habitats of Guantánamo Bay will continue to flourish.

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Adult male Puerto Rican Dwarf Gecko, *Sphaerodactylus macrolepis guarionex*: Like other very small lizards, Dwarf Geckos struggle with heat and water loss, avoidance of which requires sophisticated exploitation of available structural, thermal, and temporal microhabitats.

Size Does Matter

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"We are prisoners of the perceptions of our size, and rarely recognize how different the world must appear to small animals."

Steven Jay Gould
Natural History, January 1974

Size of an animal is in many ways its most important biological trait. According to J.B.S. Haldane's principle, "sheer size very often defines what bodily equipment an animal must have." Lizards are a diverse group of animals with extremely diverse morphologies and biologies. Lizards vary greatly in size from the largest living lizard, the Komodo Dragon (*Varanus komodoensis*), which measures up to 3 m from head to tail, to the smallest living lizard, the Jaragua Dwarf Gecko (*Sphaerodactylus ariasae*), which measures only to 28 mm from head to tail. Many exhibit amazing adaptations relative to their sizes. However, extremes in body size can incur considerable consequences. Particularly, as size decreases, physiological functions such as water balance and heat regulation can become exigent on small lizards' biologies. Herein I discuss the physiological challenges facing Dwarf Geckos (genus *Sphaerodactylus*) and describe how these remarkable lizards not only cope, but also thrive in suitable environments.

The genus *Sphaerodactylus* is comprised of over 90 species that are widely distributed throughout the West Indies, occurring on every major island in the Caribbean, as well as in northern South America through Central America into parts of México as well as southern Florida. Species of *Sphaerodactylus* occupy a wide variety of ecosystems that range from montane rainforests and hilly scrub woods to coastal, desert-like habitats. Species range in size from 16 mm snout-vent length (SVL) to 40 mm SVL. A few species reach the lower limits of amniote body size and are considered to be the smallest terrestrial verte-

S. BLAIR HEDGES

Sphaerodactylus ariasae, discovered in 2001 on Isla Beata, a small Hispaniolan satellite island, is the smallest known amniote (a group that includes all reptiles, birds, and mammals). Extremely small body size imposes severe challenges in regard to thermo- and osmoregulation.

ALEJANDRO SÁNCHEZ

Adult male *Sphaerodactylus macrolepis macrolepis* from St. Croix, U.S. Virgin Islands: *S. macrolepis* is a polytypic species with nine currently recognized subspecies, all endemic to the Puerto Rico Bank. *Sphaerodactylus macrolepis* is the most abundant and widely distributed Dwarf Gecko in Puerto Rico. Populations in different areas exhibit great variation in morphology, microhabitat use, and osmoregulation.

brates discovered to date. Adults of the smallest species, *Sphaerodactylus ariasae*, from Isla Beata, off the southern coast of Hispaniola, can curl up on a dime! Furthermore, population densities can be phenomenally high. One species (*Sphaerodactylus macrolepis*), which is endemic to the Puerto Rico Bank, is known to reach densities to 67,000 lizards per hectare, quite possibly the highest population density for any lizard in the world!

For such tiny lizards, Dwarf Geckos exhibit considerable diversity in morphology, ecology, behavior, and general natural history — including the fact that many violate a general rule of gecko biology. Unlike most geckos, which are nocturnal, species of *Sphaerodactylus*, with only a few exceptions, are diurnal or crepuscular. Another departure from general gecko habits is that most species are ground-dwellers, with very few known to be primarily arboreal or saxicolous. The paucity of arboreal forms may be attributable to the fact that Dwarf Geckos lack the typical large flattened "toe pads" used by most other geckos for climbing. These toe pads sport tiny rows of plate-like projections called lamellae, each of which is equipped with thousands or even millions of microscopic hook-like hairs called setae. These make it possible for most geckos to climb on nearly any surface, even ceilings or vertical panes of glass. However, as the name implies, *Sphaerodactylus* (*sphaero* = round and *dactylus* = digit) feet bear round lamellae that are restricted to the tips of their toes.

These tiny lizards inhabit a variety of microhabitats in just about every type of terrestrial environment in the West Indies. They are commonly found in dense leaf litter, inside termitaria, or under dead palm fronds, agaves, fallen trees, large rock spills, and human debris, such as wooden boards and galvanized steel sheets. A few species (e.g., Jamaican *S. semasiops* and *S. oxyrhinus*) are known to occur only in the complex microhabitats of arboreal bromeliads.

The Surface Area-to-Volume Ratio

A major physiological challenge that affects all small animals is a high surface area-to-volume ratio (SA/V), which, in turn, affects basic physiological processes like osmoregulation and thermoregulation. As a lizard's body size decreases, the relative surface area increases. This increase occurs because surface area decreases as length squared, whereas volume decreases as length cubed. Consequently, volume decreases more rapidly than surface area, resulting in a high ratio. For tiny sphaerodactyls, the high SA/V has profound effects on how they live their lives and function in the environment.

Problem 1: Evaporative Water Loss

One vital challenge associated with a high SA/V is controlling water loss to the environment through evaporation. Evaporative water loss (EWL) plays an important role in the patterns of behavior and activity for lizards of all sizes, but most especially the smaller species. The rate of EWL depends primarily on three factors: Size of an animal, rate of oxygen consumed, and physical properties of the skin. Due to their incredibly high SA/V, small lizards inevitably experience very high rates of cutaneous evaporative water loss. This is particularly true of Dwarf Geckos.

Adult male *Sphaerodactylus macrolepis mimetes* from Puerto Rico: Note the toe tips with round lamellae for which the genus is named.


ALEJANDRO SÁNCHEZ

Adult *Sphaerodactylus klauberi* from a montane rainforest in southeastern Puerto Rico: *S. klauberi* is endemic to Puerto Rico and is one of the larger species of Dwarf Gecko, reaching sizes to 39 mm SVL. This species is found only in mesic, montane habitats.

In the few EWL studies on *Sphaerodactylus*, researchers found that these lizards exhibit incredibly high rates of EWL. In fact, some of the rates reported for *Sphaerodactylus* are among the highest recorded for any lizard. These studies suggest that, in comparison to other lizards inhabiting similar or identical environments, Dwarf Geckos have modest physiological adaptations capable of compensating for high EWL. Additionally, EWL rates are generally higher for reptiles inhabiting humid habitats than species inhabiting arid habitats. In terms of humidity, species of *Sphaerodactylus* occupy all types of environments. Some, like *S. klauberi*, which is endemic to Puerto Rico, are found only in very mesic (moist) montane ecosystems, whereas others, such as *S. parkeri*, from Jamaica, occupy xeric (dry) coastal environments that have all of the characteristics of deserts. Although all species demonstrate high EWL rates, one study found that eggs of *S. cinereus*, a Hispaniolan form, might have the lowest EWL rate of any reptilian egg. More research on EWL of eggs is needed to further explore this adaptation.

Problem 2: Thermoregulation

Thermoregulation is also difficult when faced with a high SA/V. Dwarf Geckos are poikilothermic, meaning that they have no internal metabolic mechanism for regulating body temperatures, which consequently vary with the environment. As in any small-bodied animal, heat is gained and dissipated relatively rapidly, negating any ability to effectively regulate body temperatures using behavioral mechanisms, such as those used with amazing efficiency by many larger reptiles. Large surface areas result in greater exposure, and the relatively small body volume retains heat ineffectively. Thus, sphaerodactyls are extremely vulnerable to heat stress. On the other hand, unlike larger lizards, Dwarf Geckos absorb heat rapidly, and, unlike most larger forms, do not need to bask in order to raise their temperatures. The net effect, however, is that these diminutive species cannot effectively deal with variations in environmental temperatures.

The Solution: Microhabitat Selection

So, what defenses do Dwarf Geckos have against dehydration or heat stress imposed by their diminutive sizes? Although evidence shows that their bodies are not adapted physiologically to min-


ROBERT POWELL

Sphaerodactylus parvus, from Anguilla: This species can attain huge population densities in suitable habitats.


ALEJANDRO SÁNCHEZ

A Cosmopolitan House Gecko (*Hemidactylus mabouia*) from Tortola, British Virgin Islands. This gecko is widely distributed in the West Indies. Although much larger, House Geckos may share communal nests with Dwarf Geckos and often are found cohabitating under large rocks, fallen trees, and logs.


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Adult *Sphaerodactylus nicholsi* from the Bosque Seco, an extremely arid region in southwestern Puerto Rico: This species is the smallest Dwarf Gecko endemic to Puerto Rico and lives in sympatry with the much larger *S. roosevelti*.

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Adult female *Sphaerodactylus roosevelti* from the Bosque Seco in Puerto Rico: This species reaches sizes to 39 mm and is active predominantly at night. Like many, but not all Dwarf Geckos, *S. roosevelti* is sexually dimorphic. Note the prominent dorsal stripes, a characteristic seen only in females of this species.

imize water loss and maintain suitable body temperatures, sphaerodactyls can overcome these limitations by behaviorally exploiting microhabitats often unavailable to larger species. Microhabitat selection is undoubtedly the best defense against dehydration and overheating. Most of the terrestrial habitats occupied by these lizards are relatively heterogeneous regarding humidity, and individuals of most species occur under a variety of complex substrates that appear to preserve high humidity levels. Several studies on Dwarf Gecko ecology have shown that the two most important factors in microhabitat selection are relative humidity and structural complexity. For example, *S. parvus*, endemic to the Anguilla Bank, demonstrates a clear preferential use of microhabitats, such as large rocks shaded by dense forest canopies that provide effective insulation from overheating. Additionally, leaf litter on the forest floor, for example, can be relatively deep and dense, sometimes greater than a meter in depth. This type of substrate provides an ideal microclimate in which relative humidity levels are substantially higher than ambient humidity. Microhabitat selection extends also to aspects of reproduction in Dwarf Gecko ecology. Nest sites are invariably established in humid, sun-sheltered microhabitats (e.g., under large, fallen trees, logs, or large rocks). Moreover, Dwarf Gecko eggs are commonly found in communal nests (one nest site where multiple females lay eggs), often with eggs of other species and genera (e.g., *Hemidactylus* spp.). Even in arid environments, Dwarf Geckos typically are found in the most humid and appropriate microhabitats, usually under trees or cover — access to which is possible only because of their small sizes. For example, in Puerto Rico's "Bosque Seco" (dry forest), which is in essence a desert, *S. nicholsi* and *S. roosevelti*, are typically found in the leaf litter underneath Sea Grape trees, which is substantially more humid than the ambient climate. By actively selecting microhabitats that preserve humidity, these lizards can endure and even thrive in very arid environments. Additionally, many species restrict activity to twilight hours, times of day when ambient temperatures are less severe. Although not common among species of *Sphaerodactylus*, presumably because most forms can effectively exploit the "right" microhabitats, some species, like *S. roosevelti* from Puerto Rico, *S. parkeri* from Jamaica, and *S. sputator* from the Anguilla and St. Christopher banks, have opted for nocturnal lifestyles, reducing even more their exposure to daytime heat and the consequent danger of dehydration.

Conclusion

> "For every type of animal there is a most convenient size, and a large change in size inevitably carries with it a change of form."
>
> J.B.S. Haldane, 1928

Despite physiological challenges imposed by diminutive size, geckos in the genus *Sphaerodactylus*, like many other small animals, must rely on behavioral and ecological strategies to survive. Dwarf Geckos overcome the challenges of desiccation and heat stress by actively selecting the least dehydrating microclimates available in their macroenvironments. So, the small size that is

ALEJANDRO SÁNCHEZ

Adult male *Sphaerodactylus roosevelti* from the Bosque Seco in Puerto Rico: Note the reduced prominence of dorsal stripes, which is characteristic of males.

disadvantageous in the context of physiological responses to the environment is the very thing that facilitates the exploitation of microhabitats, enabling these tiny lizards to survive and successfully radiate across the West Indies. Consequently, I can add to Haldane's principle that size "defines what bodily equipment an animal must have" the caveat that size also defines what behavioral responses an animals must use.

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Lizard Warfare

Robert Powell

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Male anoles (genus *Anolis*) are fiercely territorial. Although ritual behaviors involving posture, orientation, and head-bobs with dewlap extensions often dissuade an interloper from seriously challenging a resident male, battles sometimes ensue — and they can become violent, often leaving wounds that frequently become infected. Large abscesses on the jaws of males are a common sight.

In this instance, a male Crested Anole (*Anolis cristatellus*, the darker, slightly smaller individual with the notch in his tail crest) had established a domain dominated by a small palm tree on the grounds of the resort on Guana Island (British Virgin Islands) — only to find himself confronted one morning in October 2005 by a serious rival.

Each quickly assumed a threatening posture involving lateral presentation, erection of the nuchal (nape) crest, an inflated body, elevated tail, and gaping jaws (facing page) in an effort to convince his counterpart that further efforts were futile. Each possessed an advantage, the resident was defending an established territory with which he was intimately familiar, but the interloper was slightly larger. Circling each other in an attempt to establish and hold the high ground (top left), all caution was thrown to the wind and jaws locked in an attempt to throw the other to the ground (top center and right). The interloper succeeded on three occasions, with the resident quickly reengaging in what had now become open warfare.

Eventually, larger size prevailed, and the former resident was banished to the outer reaches of the fronds from which he soon disappeared from view. Within minutes, the proud victor claimed the spoils of battle (right) and life went on in the sometimes violent world of lizards.

MARKUS HENNIG

Neonate Brown Basilisk (*Basiliscus vittatus*) along water's edge at Vanderbilt Beach County Park, Collier County.

The Introduced Brown Basilisk (*Basiliscus vittatus*) in Florida

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Abstract,—The Brown Basilisk (*Basiliscus vittatus* Wiegmann 1828) is the only established representative of the family Corytophanidae in Florida. Until recently, the only reported populations of *B. vittatus* in the United States were in the southeastern Florida peninsula from northern Miami-Dade County and adjacent Broward County to the north. Herein, we document likely modes of introduction of this species in Florida and illustrate range expansion as far south as Homestead in Miami-Dade County, as far north as St. Lucie County, and as far west as Collier County.

Key Words: Corytophanidae, Exotic, Iguania, Lizard, Non-native

The Florida herpetofauna presently contains 50 recognized species of lizards, with an overwhelming 34 (68%) of these being non-native and primarily of tropical origin (Krysko and Enge 2005). Fifteen (44%) of these non-native lizards are in the superfamily Iguania (*sensu* Frost et al. 2001), and eight are anoles in the family Polychrotidae. The Brown Basilisk (*Basiliscus vittatus* Wiegmann 1828) is the only established representative of the family Corytophanidae in Florida, although a few adult Green Basilisks (*Basiliscus plumifrons* Cope 1876), a larger and more arboreal species than *B. vittatus*, have occasionally been observed (Bartlett and Bartlett 1999, Meshaka et al. 2004, R. Goushaw, pers. comm.). Because no voucher specimens or photographs of *B. plumifrons* from Florida are available, we view these sightings as escaped or released pets that do not presently represent established populations. Until recently, *B. vittatus* had only been documented from northern Miami-Dade County and adjacent Broward County in the southeastern peninsula. Herein, we document likely modes of introduction of this species in Florida and illustrate range expansion to the south, north, and west.

Materials and Methods

To determine the present geographic distribution of *Basiliscus vittatus* in Florida, we made field collections of this species from July 2000 through June 2005. Specimens were collected by hand, with nooses (Strong et al. 1993), blowguns shooting tapered corks, and fishing rods using invertebrates for bait (Krysko 2000). *Basiliscus vittatus* can be extremely wary and difficult to approach closely, but we were extremely successful at collecting this species using domestic crickets or crabs on a fishing hook for bait. When a lizard was observed, we used a fishing rod to cast a food item to within about 3 m of the lizard. Lizards would typically jump off their perches or out from dense vegetation and eat the bait, and were then easily reeled in and collected. Specimens were deposited in the Florida Museum of Natural History (FLMNH), University of Florida (UF collection). We also obtained locality records from the literature and systematic collections throughout the United States. Source acronyms for collections follow Leviton et al. (1985), with the addition of Everglades National Park (EVER), from which the entire collection is currently being accessioned into UF. All records with locality data were plotted using ArcView v3.2 (ESRI).

Results and Discussion

Native Distribution and Natural History.—Basiliscus vittatus is found in lowland habitats from coastal regions of central México south through Central America and northern South America to Ecuador (Savage 2002, Köhler 2003). *Basiliscus vittatus* inhabits tropical and subtropical forests in both disturbed and undisturbed habitats, where it can be found on the ground, in bushes, or on the lower branches of trees, particularly near bodies of water (Campbell 1998). Juveniles are more closely associated with the water's edge than adults (Maturana 1962, Hirth 1963, Laerm 1974).

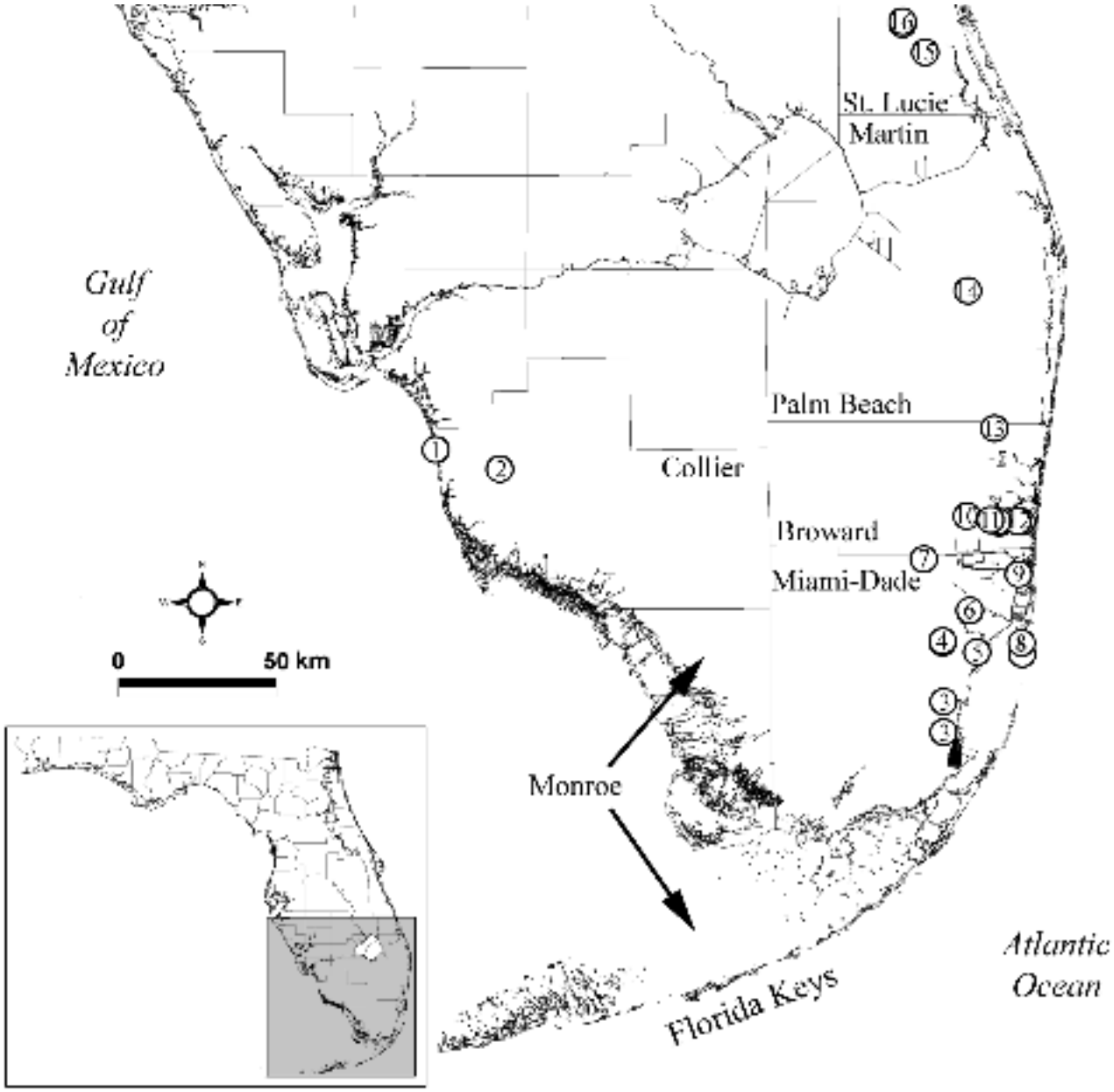
This diurnally active species is most frequently observed in August and September, but is active year-round (Hirth 1963). Peak activity occurs in the early morning and late afternoon during sunny days, but lizards may be active sporadically throughout the day during overcast weather (Hirth 1963). *Basiliscus vittatus* has a small home range of about 7.9–19.8 m^2 in Costa Rica (Fitch 1973a). At night, *B. vittatus* retreats to elevated (0.3–2.7 m or more) perches (i.e., in palm fronds, on twigs or branches overhanging rivers, under bridges), where it sleeps until daybreak (Conant 1951, Neill and Allen 1959, Alvarez del Toro 1960, Hirth 1963).

Neonates, which measure 35–40 mm snout-vent length (SVL) and weigh 1.5 g, grow an average of 15 mm during their

first month of life (Hirth 1963). Maturity is reached at about six months of age; adults typically measure around 115 mm (females) to 134 mm SVL (males), but males may grow as large as 170 mm SVL and > 90 g (Fitch 1973a, b, Savage 2000). *Basiliscus vittatus* is reported to live about three years in the wild, but most survive less than one year (Hirth 1963, Fitch 1973a). A female usually deposits between two and four clutches of 2–6 eggs annually (maximum of 12 eggs; Alvarez del Toro 1960), primarily during a nine-month nesting season beginning in mid-February (Fitch 1973a).

Neonates are reported to eat a variety of invertebrates — tenebrionid beetles, ants, grasshoppers, amphipods, lycosid spiders, and lepidopteran larvae — whereas adults feed on both invertebrates and plant matter such as grasses, seeds, stems, and berries (Hirth 1963, Lee 2000). Predators include snakes, birds, other lizards, and Atlantic Ghost Crabs (*Ocypode quadratus*). Basilisk eggs oviposited on beaches may sometimes be unearthed by nesting sea turtles (Hirth 1963, Campbell 1998). Basilisks may run up to 30 m towards water or vegetation to escape predation (Fitch 1973a), often in a bipedal stance with only their hind feet touching the ground. Basilisks are popularly referred to as "Jesus Christ lizards," because of their ability to run across the surface of water for short distances.

Distribution in Florida.—We compiled 307 records of *Basiliscus vittatus* from Florida. Sixty-eight of these are preserved speci-



Records (n = 307) of the Brown Basilisk (*Basiliscus vittatus*) in Florida. Localities include: (1) Vanderbilt Beach Park, (2) Golden Gate, (3) Homestead, (4) Snapper Creek Canal, (5) Red Road, (6) Miami International Airport, (7) Krome Avenue and US 27, (8) Key Biscayne, (9) Elaine Gordon Park, (10) Cooper City, (11) Davie, (12) Hollywood, (13) Parkland, (14) Loxahatchee, (15) Fort Pierce, and (16) Header Canal and Glades Cutoff Roads.

mens collected between 1979 and 2005 (Appendix), 55 of which were collected during our surveys. The remaining 239 records are our observations of individuals in the wild. *Basiliscus vittatus* was found in five Florida counties, including Broward, Collier, Miami-Dade, Palm Beach, and St. Lucie.

Wilson and Porras (1983) first recorded *Basiliscus vittatus* in Florida from three localities in Miami-Dade and Broward counties, and these had been the only reported populations in the United States until recently (see Conant and Collins 1998, Crother 2000[2001]). In 1976, *B. vittatus* was found in two areas of Miami, Miami-Dade County: near a sparsely vegetated canal near the northwestern corner of Miami International Airport (MIA), and around an animal dealer's compound near NW 70th Street and 70th Avenue (Wilson and Porras 1983). In 1981, the latter site was demolished, but lizards were subsequently seen on a nearby canal bank. Wilson and Porras (1983) predicted that the merging of these two nearby populations was likely because of the species' ability to adapt to modified habitats and that its dispersal was not limited by city growth. Meshaka et al. (2000) speculated that *B. vittatus* would be the next non-native species to enter Everglades National Park.

In Miami-Dade County, we recorded *Basiliscus vittatus* in parking lots and along canals, shores of lakes, and borrow pits from SW 120th Avenue and 72nd Street east to the Snapper Creek Canal and Red Road, near the junction of Krome Avenue and US 27, in Enchanted Forest Elaine Gordon Park, in Bill Baggs Cape Florida State Park and Crandon Park on Key Biscayne, and as far south as SW 117th Avenue and E Palm Drive in Homestead near the Turkey Point Power Plant. For example, at MIA we observed 20 juvenile *B. vittatus* in one hour hiding in grass about 60 cm tall along a single canal. At this site, we also recorded Cane Toads (*Bufo marinus*), Green Anoles (*Anolis carolinensis/porcatus*), Bark Anoles (*A. distichus*), Brown Anoles (*A. sagrei*), Green Iguanas (*Iguana iguana*), Tropical House Geckos (*Hemidactylus mabouia*), and Brahminy Blind Snakes (*Ramphotyphlops braminus*). We recorded five *B. vittatus* on sidewalks, in parking lots, and in grass on SW 117 Avenue from Snapper Creek to just south of Sunset Drive. At this site, we also recorded Greenhouse Frogs (*Eleutherodactylus planirostris*), Giant Whiptails (*Aspidoscelis motaguae*), and *Anolis sagrei*. On two occasions, while fishing for *Aspidoscelis motaguae*, we blind casted a live cricket on the sidewalk in front of vehicular traffic and had a *B. vittatus* run out from shrubs onto the sidewalk to grab and eat the insect. We recorded more than 50 *B. vittatus* along Snapper Creek on Red Road between SW 88 and 100 streets. There, *B. vittatus* is frequently observed on trees, grass, or cement walls. At this site, we also recorded Red-eared Sliders (*Trachemys scripta elegans*), *Anolis distichus*, *A. carolinensis/porcatus*, *A. sagrei*, Puerto Rican Crested Anoles (*A. cristatellus*), Knight Anoles (*A. equestris*), and *Iguana iguana*. Around 25 *B. vittatus* were collected using flashlights at night as they slept in vegetation along a canal near the junction of Krome Avenue and US 27 (B. Love, pers. comm.). Along with at least 43 other non-marine amphibian and reptilian species, we recorded more than 125 *B. vittatus* from Crandon Park and Bill Baggs Cape Florida State Park on Key Biscayne (Krysko et al., in prep.). We recorded seven *B. vittatus* in vegetation along canals near the Turkey Point Power Plant. At these sites, we also recorded Two-toed Amphiuma (*Amphiuma means*), *Bufo marinus*, *Eleutherodactylus planirostris*, Green Treefrogs (*Hyla cinerea*), Cuban Treefrogs (*Osteopilus septentrionalis*), *Anolis carolinensis/porcatus*, *A. sagrei*, *Hemidactylus mabouia*, Corn (*Elaphe guttata*) and Yellow Rat (*E. obsoleta*) snakes, Southern (*Nerodia fasciata*) and Florida Green (*N. floridana*) watersnakes,


KEVIN M. ENGE

Juvenile Brown Basilisk (*Basiliscus vittatus*) on vegetation along Snapper Creek on Red Road between SW 88 and 100 streets, Miami-Dade County.


KEVIN M. ENGE

Adult female Brown Basilisk (*Basiliscus vittatus*) on a tree along Snapper Creek on Red Road between SW 88 and 100 streets, Miami-Dade County.


KEVIN M. ENGE

Adult male Brown Basilisk (*Basiliscus vittatus*) on a Fig (*Ficus* sp.) along Snapper Creek on Red Road between SW 88 and 100 streets, Miami-Dade County.


KENNETH L. KRYSKO

Juvenile Brown Basilisk (*Basiliscus vittatus*) on a palm at Crandon Park, Key Biscayne, Miami-Dade County.


KENNETH L. KRYSKO

Adult male Brown Basilisk (*Basiliscus vittatus*) along a driveway on curb at Crandon Park, Key Biscayne, Miami-Dade County.

Ramphotyphlops braminus, Ribbon Snakes (*Thamnophis sauritus*), Florida Soft-shelled Turtles (*Apalone ferox*), Common Snappers (*Chelydra serpentina*), Striped Mud Turtles (*Kinosternon baurii*), Peninsula Cooters (*Pseudemys peninsularis*), American Alligators (*Alligator mississippiensis*), and American Crocodiles (*Crocodylus acutus*).

Wilson and Porras (1983) reported a third well-established population of *Basiliscus vittatus*, of unknown origin, along a canal on NW 70th Street between Stirling and Griffin roads in Davie, Broward County. In Broward County, we found *B. vittatus* along many canals and lakes, and in parking lots at localities such as Wolf Lake Park and Stirling Road just west of NW 66th Avenue in Davie, Stirling Road about 0.8 km west of I-95 in Hollywood, Stirling Road about 1.6 km east of I-95 and just east of NW 65th Avenue in Hollywood, C-11 Canal in Cooper City, and in Parkland. We recorded 16 *B. vittatus* along lake margins at Wolf Lake Park, along with *Anolis distichus*, *A. sagrei*, *Iguana iguana*, Ringneck Snakes (*Diadophis punctatus*), *Elaphe guttata*, *Ramphotyphlops braminus*, and Florida Brown Snakes (*Storeria victa*). We recorded four *B. vittatus* in the parking lot of a reptile dealer on Stirling Road just east of NW 65th Avenue in Hollywood, along with African Rainbow Lizards (*Agama agama*), *Anolis equestris*, *A. sagrei*, Common House Geckos (*Hemidactylus frenatus*), Red-sided Curly-tailed Lizards (*Leiocephalus schreibersii*), a Chinese Water Dragon (*Physignathus cocincinus*), and Smooth-backed Gliding Geckos (*Ptychozoon lionotum*). We recorded five *B. vittatus* in the vicinity of NW 81 Terrace in Parkland, along with Hispaniolan Green Anoles (*Anolis chlorocyanus*), Large-headed Anoles (*A. cybotes*), *A. sagrei*, and *Iguana iguana*.


KENNETH L. KRYSKO

Adult male Brown Basilisk (*Basiliscus vittatus*) on a tree at Wolf Lake Park, Broward County.

ANTHONY T. REPPAS

Senior author holding an adult male Brown Basilisk (*Basiliscus vittatus*) at Wolf Lake Park, Broward County.

Krysko et al. (2005) first reported *Basiliscus vittatus* from Palm Beach County in Loxahatchee, where an adult male and female were observed in a backyard. However, in 1992, a reptile dealer reported buying 100–150 *B. vittatus* per week from children who collected them in the West Palm Beach area, and a commercial collector caught about 300 *B. vittatus* in three nights along canals in West Palm Beach in 2003 (G. Ward, pers. comm.).

Krysko et al. (2005) first reported *Basiliscus vittatus* farther north in St. Lucie County at the northern end of CR 609 (Header Canal Road), as well as east of Carlton Road ca. 1.6 km north of Glades Cutoff Road, where an adult male and female and two juveniles were spotlighted and observed in dense vegetation along canals at night. An adult female was collected while sleeping on a branch at night in an abandoned citrus grove along Eleven Mile Road ca. 1 km north of CR 712 (Midway Road). A disjunct population has been established since about 1990 in White City, south of Fort Pierce (G. Ward, pers. comm.).

Krysko et al. (2005) first reported *Basiliscus vittatus* from southwestern Florida at Vanderbilt Beach County Park in Naples, and near the junction of 17th Street SW and 16th Avenue in Golden Gate, Collier County. *Basiliscus vittatus* was first observed at Vanderbilt Beach County Park in 2000, where a locally abundant population inhabits an urbanized coastal wetland of predominantly Red Mangroves (*Rhizophora mangle*) and Brazilian Pepper (*Schinus terebinthifolius*). This small wetland is positioned around the perimeter of a public parking lot adjacent to a Gulf of Mexico beach. All size classes have been observed at this locality, mostly along the edges of water and the adjacent parking lot, sidewalks, and roads, where lizards are frequently observed basking and foraging. *Basiliscus vittatus* has also been observed since January 2004 along a canal in adjacent Golden Gate.

Natural History in Florida.—In Florida, *Basiliscus vittatus* is commonly found along the edges of vegetated canals and lakes, especially those bordered by Australian Pine (*Casuarina equisetifolia*), Brazilian Pepper, willow (*Salix* spp.), Buttonwood (*Conocarpus erectus*), and mangrove trees. This species is diurnal and is frequently observed on hot, sunny days; on overcast or cool days, it often basks on vegetation overhanging water or near the water's edge.

In Miami-Dade County, *Basiliscus vittatus* is known to feed on beetles (including the Eyed Elator, *Alaus oculatus*), roaches, ants, hemipterans, and *Ficus* fruits (Meshaka et al. 2004). At Vanderbilt Beach County Park in Naples, Collier County, one of us (JCS) observed *B. vittatus* pursuing and eating large insects and arachnids 2.4–3.0 m away, as well as two *B. vittatus* fighting over a captured *Anolis sagrei*. At this site, we have used domestic crickets, as well as locally collected Wood (*Sesarma cinereum*) or Fiddler (*Uca pugilator*) crabs as bait on fishing rods to collect *B. vittatus*.

KEVIN M. ENGE

Adult male Brown Basilisk (*Basiliscus vittatus*) in vegetation east of Carlton Road, St. Lucie County.

THOMAS M. CRAVENS

Adult male Brown Basilisk (*Basiliscus vittatus*) on a Brazilian Pepper (*Schinus terebinthifolius*) stump within Red Mangroves (*Rhizophora mangle*) at Vanderbilt Beach County Park, Collier County.

MARKUS HENNIG

Juvenile Brown Basilisk (*Basiliscus vittatus*) on a Brazilian Pepper (*Schinus terebinthifolius*) stump at Vanderbilt Beach County Park, Collier County.

Gravid female *Basiliscus vittatus* have been found from March through July in Florida, and a gravid female collected in June oviposited a second clutch in October (Meshaka et al. 2004). *Elaphe guttata*, Black Racers (*Coluber constrictor*), and Eastern Indigo Snakes (*Drymarchon couperi*) are reported to have been observed eating juvenile *B. vittatus* (see Meshaka et al. 2004).

Since the introduction of *Basiliscus vittatus* in 1976 (Wilson and Porras 1983), this species had slowly spread throughout many parts of Miami-Dade and Broward counties. Its current presence in Palm Beach County is likely due to natural range expansion. However, the occurrence of this species in Collier and St. Lucie counties is likely due to subsequent illegal introductions, because large gaps in distribution occur between these localities. Nonetheless, its preference for riparian habitats and the presence of an extensive and interconnected system of drainage canals will continue to allow *B. vittatus* to expand its range naturally into almost every area in southern Florida.

Acknowledgments

We thank Anthony T. Reppas, A. Nichole Hooper, Ellen M. Donlan, Elizabeth A. Golden, Todd S. Campbell, Julian C. Lee, Andy P. Borgia, Rick Rego, Steve A. Johnson, Kurt W. Larson, Esther M. Langan, Larry D. Wilson, Sean B. Thompson, Debbie T. Townsend, Steve H. Townsend, Bill Love, F. Wayne King, Chris S. Samuelson, Brooke L. Talley, Kristen L. Bell, Brian J. Camposano, Lorraine P. Ketzler, Ronald St. Pierre, George J. Ward, and Mark A. Flowers for assistance in the field; Thomas M. Cravens and Markus Hennig for providing photographs; Bill Love, Stan Chrzanowski, Raymond Goushaw, and J.H. Altman for information on basilisk populations in Florida; and Jenny Seitz for support to JCS.

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Appendix. Specimens examined from Florida counties. Note that Everglades National Park (EVER) specimens are in the process of being accessioned into UF.

Broward: UF 120962, 121430–35, 121798–99, 122501–02, 124584, 142920; *Collier*: UF 137034–36, 141603; *Miami-Dade*: EVER 302935–37, 302960, 304113, 306530, 308399–401; KU 220259, 222395; UF 61444, 121460, 122500, 122581, 130654–56, 130773, 131490–91, 131505, 131519, 133835–37, 134228–30, 134821, 134904–05, 134911–15, 137075, 140835, 142694, 144157–61, 144248; *Palm Beach*: UF 137179–80; *St. Lucie*: UF 137407, 137447.

Timber Rattlesnake (*Crotalus horridus*) Biology and Conservation in the Upper Mississippi River Valley[1]

Saint Mary's University of Minnesota

Winona, Minnesota
24 September 2005

Photographs by Barney Oldfield, www.lizardsandlandscapes.com

Excerpts from Abstracts.[2]

Why a Symposium About Timber Rattlesnakes?

Why the concern about a venomous species of snake that shares home-space with humans in states along the Upper Mississippi River? … [S]tudies reveal and confirm that the species is losing its foothold along the Upper Mississippi and its collateral river-bluffland corridors.

Timber Rattlesnakes once ranged from southern Maine to Florida and westward to Minnesota and Oklahoma, down to Texas.…

Timber Rattlesnakes were probably the first venomous snake encountered by early settlers during their forays into the forests and mountains of eastern North America. One of the earliest explorers to our region, Father Louis Hennepin, noted rattlesnakes as "*serpens sonnettes*" in his travel log during his Upper Mississippi voyage in 1680. Shortly thereafter, in 1700, Leseur mentioned the potential "danger" of rattlesnakes in the caves around Lake Pepin. Two centuries later, the impact of increased human settlement along the Mississippi on Timber Rattlesnakes could be read about in local newspapers. One such article reported the killing of hundreds of "rattlers" in a single day at Minnesota's Cedar Creek Bluffs (*The Winona Daily Republican-Herald*; August 16, 1913). Similar events occurred at other sites along the Upper Mississippi Valley, and human fear regarding this abundance of dangerous rattlesnakes led to the implementation of a bounty system that served as an economic incentive for the killing of Timber Rattlesnakes. The bounty system provided a viable source of income for some individuals during years of hard economic times, and thousands of Timber Rattlesnakes were killed. Their heads and rattles were turned in for a fee. Bounty systems were eventually repealed in Wisconsin and Minnesota, but not until 1975 and 1989, respectively.

Amazingly, for three centuries following the arrival of settlers, the Timber Rattlesnake has managed to persevere despite the continuous loss of its habitat to agriculture, the dissecting of its habitat with roads, encroaching housing developments in recent decades, and depredation by man. One cannot deny that

[1] Limited quantities of the complete program with extensive "abstracts" and color photographs are available from Zoo Book Sales (zoobooks@acegroup.cc) or visit their website: www.zoobooksales.com.

[2] Daniel Keyler's introduction is presented verbatim, with excluded sections indicated by "…" Abstracts are summarized and occasionally paraphrased for brevity.

An old adult male Timber Rattlesnake (*Crotalus horridus*) from Houston County, Minnesota.

An adult male Timber Rattlesnake (*Crotalus horridus*) from Houston County, Minnesota, showing classic sulphur coloring, black chevrons, velvet black tail, and tan rattle.

the Mississippi's bluffs and valleys, which have been the Timber Rattlesnake's home for thousands of years, represent some of the most beautiful landscapes in the country. However, the constantly increasing interface between Timber Rattlesnake habitat and humans has gradually taken its toll on the rattlesnakes over time, and loss of Timber Rattlesnake habitat is accelerating.

Mutual coexistence between humans and rattlesnakes is complex, but is essential if the Timber Rattlesnake is to retain its place in the Upper Mississippi River Valley ecosystem…. If true conservation of this species is not achieved in the near future, the Timber Rattlesnake will fade from the Upper Mississippi River Valley, becoming a legend of the past.

Daniel E. Keyler

Some Notes on Phenology, Reproduction, and Winter Biology of Timber Rattlesnakes in Wisconsin

Since 1999, Timber Rattlesnakes at several Wisconsin den sites have been monitored with radio transmitters [see *Iguana* 12:90–97]. Three records of snakes emerging in early April may have involved animals that were ill. The latest recorded den ingress was 19 October.

Snakes moved within winter dens, reaching their deepest penetrations during December and January. Lowest body temperatures occurred from late March to early April. Movement toward the den entrance began at about that same time.

Seven females monitored over five years produced 15 clutches. Mean interval between clutches was 3.14 years (range 2–5 years). The earliest recorded birth was 30 August, the latest occurred in early October.

Craig Berg

Reproduction at a Northwestern Illinois Timber Rattlesnake Rookery

Since 1991, monitoring a Timber Rattlesnake rookery in northwestern Illinois has generated the following data: (1) Gravid females arrived between 29 April and 21 July. (2) Postpartum female departure ranged from 22 August to 30 September. (3) Earliest neonate appearance ranged from 19 August to 15 September. (4) Latest dates for neonate emergence ranged from 28 August to 12 October. (5) Litter sizes ranged from 5–11 (total of 106 births observed to date). (6) Of 18 reproductive cycles, 13 (72.2%) were 2 years and 5 (27.8%) were 3 years (mean = 2.28 years). Two females had both 2-year and 3-year cycles. (7) For 22 females, 10 (46%) gave single births during the monitoring period, 8 (36%) gave birth twice, 2 (9%) gave birth 3 times, and 2 (9%) 4 times. (8) Many gravid females depart from the rookery prior to parturition and give birth at undetermined locations. One such location was about 30 m upslope from the rookery den. Additional observations included: One mating event on 22 August 2001 in the vicinity of the rookery; interactions between neonates and mothers, including cloacal posturing with scent ejection; interactions between gravid females, non-gravid females, and males; rain-drinking by gravid females; and molting.

Habitat modification by burning and cutting around the rookery resulted in the creation of an additional rookery that was utilized by females from the original rookery. Such practices might be used to restore historical basking/gestating/birthing sites in blufflands that have become overgrown and shaded and are no longer used.

Brian Bielema

Long-term Field Studies of the Timber Rattlesnake: What Has Been Learned?

A series of dens in the southeastern Adirondack Mountains of New York have been under continuous study since 1978. Resultant data and on-going conservation efforts allow this system to serve as a microcosm of approaches taken to protect and manage Timber Rattlesnakes anywhere in their range.

Den populations vary from 42–558 new individuals captured over a 25-year period. Although not population size esti-

mates, the data suggest a wide variation in numbers of snakes using dens. Shifts between dens are rare. Estimated survival rate in field-born snakes was about 65% in the first year, whereas adults (5+ years old) survived at about 90% per year. Recapture intervals of 22 and 23 years for snakes released initially as adults (at least 10 years old when marked) suggest a natural lifespan that approaches 35 years.

Five major range segments correspond to ecoregions. These divisions may deserve targeted conservation attention based on particular biological features associated with each region and its subdivisions. Varying parameters of snake biology can guide efforts within a management unit. For example, in the New England Upland management unit (where the current study is taking place), the snake is characterized by high adult survival rates, low rates of reproductive performance brought on the decadal span necessary for female maturity, and exceptional longevity in some individuals. In contrast, snakes in the Southeast Atlantic-Gulf Coastal Plains management unit would require different strategies because adult survival rates may be lower, reproductive performance higher or shifted to younger age classes, and shorter longevity. Some management plans should therefore stress steps to enhance survival, others to enhance reproduction. Enhancing longevity might be achieved by legal protection coupled with vigilance. To reflect such regional variations, a national Timber Rattlesnake Conservation Action Plan (TRCAP) was developed ten years ago. The chief goal of the plan has been to produce a major synopsis of the historical and current distribution, threats, and management options authored at the state level by recognized authorities. Those involved in TRCAP are hopeful that this plan will become an exemplary model of a comprehensive conservation strategy for the Timber Rattlesnake. Certainly, it is one of the first for any reptile in North America.

William S. Brown

A History of Timber Rattlesnakes in Winona County, Minnesota

Detailed petroglyphs of rattlesnakes were traced by Theodore Lewis in the 1880s from a cave in La Moille and artifacts from a nearby rock shelter were attributed to the Woodland Tradition (~2500–1000 years before present). Unfortunately, the petroglyphs are no longer extant. Tales from the 1800s tend to emphasize the size of individual snakes and the sheer number of snakes that were destroyed at certain localities. The most celebrated characters in the history of human interactions with rattlesnakes were the bounty hunters of the 1900s. "Black Bill" Venzol of Elba would bring rattlesnakes to the old schoolhouse for the children to see, Raymond Carter of Pickwick caught 86 rattlesnakes from one spot in a single afternoon during the Great Depression, and, across the border in Fillmore County, Arnold Rank killed over 2000 rattlers during his long career. Fortunately, times have changed. The bounty has been eliminated, and bounty hunters have been replaced by rattlesnake responders who remove nuisance snakes from yards and relocate them to more natural habitats within their home ranges.

Philip A. Cochran

A Timber Rattlesnake raising its head in response to the approach of the photographer (Winona County, Minnesota).

An adult female Timber Rattlesnake in a rock cranny with neonates, which will stay with her up to two weeks. Note the opaque eyes of the neonates prior to their first shed (Houston County, Minnesota).

Timber Rattlesnake Work with Private Landowners in Minnesota

Triggered by increased frequencies of human-rattlesnake encounters, the Minnesota Department of Natural Resources (MN DNR) has been working with private landowners in southeastern Minnesota on bluff prairie management and Timber Rattlesnake management. The main reasons for increased encounter rates are degrading habitat, habitat fragmentation, and encroaching land development.

The Timber Rattlesnake was listed as a threatened species in Minnesota in 1996. Its range once covered all of the bluff counties along the Mississippi River. Today, the active range is reduced to remnant populations in Goodhue, Olmsted, Wabasha, and Winona counties, with larger populations in Fillmore and Houston counties — with most on private lands. Many once active den sites are extirpated, and many currently active dens are in jeopardy of extirpation.

Restoration of habitats involved clearing cedar-infested bluff prairies in critical snake habitats. Initially, efforts were successful, but slow, affecting only a few acres at a time. A new federal program created by Congress in 2002, the Landowner Incentive

Program (LIP), administered by the U.S. Fish & Wildlife Service, allocates funds to assist states in working with private landowners on "at risk species." LIP funds help landowners implement management practices that maintain, enhance, or restore habitats that benefit bluff prairie "at risk" species. Practices include cedar removal, invasive species control, and prescribed burning.

Jaime Edwards and Dave Spiering

Status of Timber Rattlesnakes in Wisconsin

Wisconsin Timber Rattlesnake populations appear to be significantly reduced from historic levels. Human persecution, including a county-administered bounty system, has been a major contributing factor. Records indicate that hunters targeted gravid females, accelerating the population declines by restricting recruitment. Other factors include den destruction and habitat loss to agriculture. In recent years, natural succession has resulted in overgrowth of prairies, specifically contributing to degradation or loss of overwintering or rookery sites.

The state has outlined a four-tiered approach to conservation that will be implemented as funding allows. One element is an educational program for rural landowners called "Rare Snake Workshops." These help promote conservation of four prairie- or bluffland-dwelling snakes, including the Timber Rattlesnake. As of summer 2005, 58 workshops have been conducted. Each addresses how to safely handle and move venomous snakes, why habitat management is necessary, and the Department of Natural Resource's nuisance control program.

Additional conservation efforts include surveys to identify and protect hibernation sites and support of research to better understand this snake in Wisconsin.

Robert Hay

Timber Rattlesnake Bites in the Upper Mississippi River Valley

Two species of rattlesnakes, the Timber Rattlesnake (*Crotalus horridus*) and Massassauga (*Sistrurus catenatus*) are native to the Upper Mississippi Valley. Bites, albeit rare, do occur. Prior to 1880, 70 cases of venomous snakebite were reported in Wisconsin. Twelve were fatal, five victims were men, four were children, and three were women. Literature records indicate that 15 bites occurred in Wisconsin from 1958–59, but only four in Minnesota.

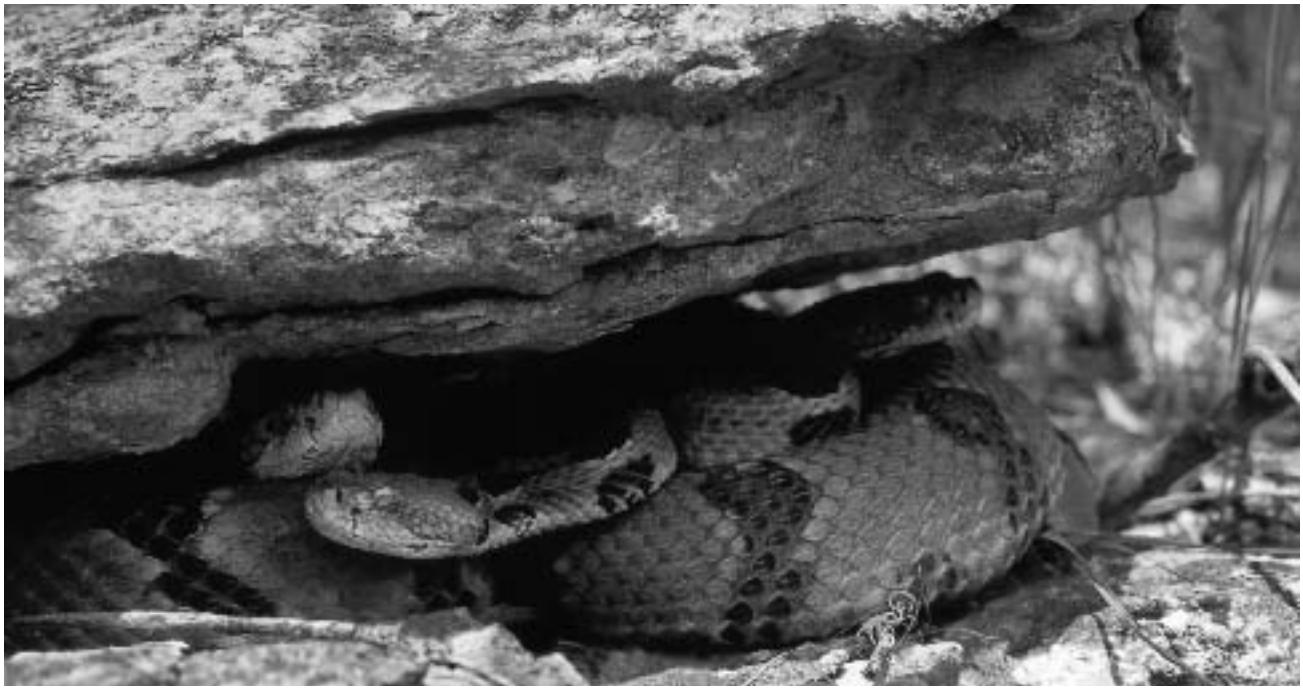
More recent records show 36 cases of rattlesnake bite, involving eight different species, in Minnesota, western Wisconsin, and northeastern Iowa from 1982–2002 (1–2 bites per year). Timber Rattlesnakes were responsible for 27 bites, with 15 in Minnesota, seven in Wisconsin, and five in Iowa. All bites occurred between April and October. Fewer than half (44%) were naturally occurring bites; the rest resulted from deliberate human manipulation of snakes. Most victims were males (81%) and the average age was 33 ± 12 years. All victims were evaluated in a medical facility, only 12 were hospitalized. Fang punctures were evident in all patients, but symptoms of envenomation were absent or minimal in 52% of victims. One instance of intravenous envenomation was fatal. Venom-induced effects were profound and occurred rapidly. Antivenin was administered to 11 patients, two had surgery, and average hospital stay was 3.5 days.

Daniel E. Keyler

Timber Rattlesnakes in Northeastern Iowa

Timber Rattlesnakes occur in northeastern, southeastern, and small areas of central Iowa. Little information exists in the liter-

A very large adult male Timber Rattlesnake with a complete (tan) rattle and a black basal segment (Fillmore County, Minnesota).



A trio of male Timber Rattlesnakes at spring emergence. This site was destroyed by snake hunters later in the same season. Den rocks were dislodged from the bluff, and several crushed Ringneck Snakes (*Diadophis punctatus*) were all that remained. The den has not been used since (Pierce County, Wisconsin).

ature regarding the species in the state and unpublished surveys provide insubstantial baseline data. Consequently, trends are difficult to quantify.

Variations in morphology encompass the full range of what is expected in the Upper Mississippi Valley. Ground color ranges from golden yellow to tan or brown. A rust-red middorsal stripe is almost always present, but may vary in intensity, especially posteriorly. "Bow-tie" markings are common and often become full bands toward the tail. Entirely gray specimens are known, but are uncommon.

Emergence begins in late April to early May. Autumn staging is initiated in late September; ingress occurs by mid-October. Individuals have been observed basking in mid-April, but those animals usually show signs of dermatitis. Most adult males and non-gravid females appear to migrate to summer feeding sites 7–15 days after first emergence. Gravid females select den sites, rock crevices with significant depth or large loose rocks, as rookeries. Neonates to two-year olds seem to prefer loose rock in small forest patches in or at the edge of prairies.

Reproductive data are scant. Nothing is known of courtship or mating. Females produce litters at least biennially or triennially. Parturition usually occurs in late August or early September, peaking during the first week in September. Litter sizes range from 5–12, average of 8. Neonates range from 257–348 mm in total length; average is 344 mm.

Bounty records from 1925–1952 show an obvious decline in numbers, and conversations with bounty hunters indicate a decline in snakes rather than a reduction in efforts to catch them. Timber Rattlesnakes were unprotected in Iowa until 2001 (the only other reptile unprotected in the state was the Garter Snake. Recent revisions of rules now protect Timber Rattlesnakes in 12 counties of eastern and southern Iowa.

Jeff LeClere

Velvet Tails of the Blufflands: Field Observations and Anecdotal Information

Over 22 years, I have searched and searched, found timbers, not found timbers, photographed more than several, molested many gathering biological information, answered a few intriguing questions, and pondered numerous riddles of Timber Rattlesnake biology. Den areas are found in limestone and dolomite outcrops, rookery sites in limestone and sandstone, and summer pastures in hardwood forests and bluff prairies. With others, I have documented egress and ingress dates, average and maximum sizes of males and females, color variation, reproductive dynamics, maturity, longevity, frequency of shedding, and behavior. Also during this time, the battle to remove the Minnesota bounty was won, and the Timber Rattlesnake was subsequently given legal protection in both Wisconsin and Minnesota. However, in Minnesota, with this revived emphasis, poaching and anti-rattlesnake sentiment have grown.

Seldom are rattlesnake bites to large animals such as cattle and horses likely to be fatal, although facial and throat swelling that restrict airways may be a concern. Dogs and rarely cats may be bitten, most frequently in the head or front legs. Venomous snakebite that produces rapid swelling and pain should be considered serious, and the animal should be taken immediately to a veterinarian. The use of antivenin may be limited due to cost factors, but aggressive medical therapy including antibiotics, analgesics, and supportive therapy may be indicated.

A rust-colored middorsal stripe characterizes many Timber Rattlesnakes from the Upper Mississippi River Valley (Pierce County, Wisconsin).

The ultimate survival of "Velvet Tails" in the Upper Mississippi River Valley must be about habitat protection, public education, and a strictly enforced protective policy. Since reestablishing dens is not a reliable option, attention should be focused on known viable populations by providing relatively large expanses of minimally managed habitat.

Barney Oldfield

The Ecology and Conservation of the Timber Rattlesnake in the Agricultural Landscape of Central Iowa

Since 2002, we have focused attention on a den site in Madison County that appears to be healthy despite being adjacent to a busy highway. Data are based on over 100 snakes plus litters born in captivity from wild-caught females.

Monitoring about nine snakes implanted with radio transmitters per year, we found that, in 2001, 42% of snake locations were in edge/scrub habitats, 24% in woodland habitats, and 34% in grassy/open habitats. Average canopy cover was 60%. Madison County animals tended to have smaller home ranges and move shorter distances than rattlesnakes in eastern populations.

An effort to document time spent in agricultural fields and in natural versus disturbed habitats indicated that efforts aimed only at protecting rock outcrops used as hibernacula are doomed to failure if the entire range of the animals is not considered. One individual, for example, spent nearly an entire season in a field or along a fence line bordering a cow pasture. Much of the remaining habitat in Iowa is extremely fragmented and degraded, calling for conservation efforts on a landscape scale.

Jeffrey R. Parmelee and Paul W. Frese

Minnesota State Parks: Protecting Timber Rattlesnakes within an Ecosystem Management Framework

The Minnesota Department of Natural Resource's Division of Parks and Recreation is legislatively mandated to preserve presettlement natural features and communities as well as other natural, scenic, scientific, and historic features of significance. Given this mandate, the Division has the responsibility to preserve and perpetuate populations of Timber Rattlesnakes along with other rare species.

The historic range of the Timber Rattlesnake in Minnesota included eight southeastern counties that encompassed ten state parks. The current range has decreased to six counties with seven state parks. At least 37 historic den sites are known from those seven parks. Assuming a minimum viable population size of 25–45 snakes per den suggests that these parks once supported populations totaling about 1000–1600 individuals.

The bounty system in effect from 1909–1989 resulted in these parks being heavily hunted. The impact of wanton killing combined with vandalism of den sites and habitat degradation due to disturbances have caused significant declines in populations (>90% in one park). Rattlesnakes have been extirpated in three of the seven parks and populations in the other four have declined dramatically. Only about one-third of historically active den sites remain extant.

The Division's objectives for these parks are: (1) To restore or maintain native plant communities, and (2) to preserve or restore animal populations so that all native species for which reintroductions and maintenance are possible are present. Specifically, for Timber Rattlesnakes, the objectives are: (1) To restore sustainable populations to the three parks where the species has been extirpated, and (2) To restore and maintain existing populations at levels that are sustainable.

Since 2001, increased efforts to protect the species have been funded through the State Wildlife Grant program, with current work grouped into four main categories: Surveys and monitoring, protection, habitat management, and education.

Ed Quinn and Shawn Fritcher

Habitat Selection and Home Ranges of Wisconsin Timber Rattlesnakes in the Mississippi River Valley

Data collected from nine radiolocated Timber Rattlesnakes (4 males, 3 females, 2 juveniles) and 353 subsequent observations (132 male, 129 female, 92 juvenile) reveal that all three groups were found in secondary woodland more than expected by chance (19% female, 24% male, and 39% juvenile versus 13% expected). The greatest disparity was for use of prairie habitat (28% female, 2% male, 15% juvenile versus <2% expected). Sumac/dogwood/blackberry shrub also was over-utilized (13% female, 5% male, 11% juvenile versus <2% expected). Males were found most frequently in mature oak woods (39%), but less frequently than expected (43%). Males also utilized swamp woodlands (24%) at about the expected rate (25%). Marsh (3% female, 4% male, 0% juvenile versus 13% expected) and agricultural habitats (0% female, 1% male, 0% juvenile versus 13% expected) were under-utilized.

Richard A. Sajdak

HUSBANDRY

Emerald Gems (*Corallus caninus*): Captive Husbandry and Propagation Part I: Introduction and Habitats

Joseph M. Polanco

Photographs by the author except where indicated.

Ranging widely across northern and central South America, with the largest known range of any currently recognized species of boid on earth, the Emerald Tree Boa (*Corallus caninus*) is among the most recognizable species in herpetoculture. Although broadly distributed, the species is nowhere common and, given the absence of empirical data to the contrary, we can only assume that population numbers are equivalent to those of the past.

Corallus caninus has long been a barometer species for biologists concerned with the ecological conditions in its natural environment. Today, the species also can be seen as an indicator of how improvements in the basic understanding of the species and the development of specific tactical skills have led to dramatic advances in herpetoculture.

Secretive, totally arboreal, nocturnal, sometimes irascible, and armed with a formidable array of weaponry, Emeralds were long considered a hands-off species fit only for professional zoologists. For decades, the species remained widely misunderstood. As eye-catching disposable acquisitions, they were used in the pet trade largely as an attention-getting loss leader, a fact that led to the premature death of many thousands of imported specimens. Today, *C. caninus* is considered one of the pinnacles of modern herpetoculture. The same refinements in husbandry practices that have led to similar successes with other challenging species provide a bright and optimistic future for the Emerald Tree Boa in captivity.

With this two-part article, I present methods honed by years of observation and practical experience. These should give anyone considering the acquisition of this fascinating species a sound basis on which to build his or her own practical strategy for success. This first installment will provide a conceptual preparation and housing considerations. Part two will present sound acquisition strategies along with the more technical aspects of husbandry and propagation, as well as a glimpse at some of the empirical data from which the suggested strategies were formulated.

INTRODUCTION

Once the decision to keep Emeralds has been made, the best chances for success hinge on solid preparations. These preparations are designed to minimize the stress for keeper and the kept in order to assure a smooth and pleasurable transition for both.

In nature, Emeralds are exclusively arboreal primary rainforest dwellers that thrive within a relatively narrow range of conditions. Until recently, this combination was quite challenging to recreate within a captive environment. Maintaining moderate ambient heat, high relative humidity (RH), and continuous air circulation was difficult enough, but attempting to balance these elements to within the specifications of a Neotropical rainforest habitat have traditionally proven all but impossible for the average herpetoculturist. As a result, even today, appropriate captive habitats are still relatively uncommon. Interestingly, however, long before the advent of hi-tech gadgetry, horticulturists had

The extent, continuity, and pattern of white markings in *Corallus caninus* vary considerably in different parts of the species' natural range (see also *Iguana* 12:2–7).

TONY NICOLI

Facility for housing Emerald Tree Boas showing vented enclosures, external lights, and pullout trays for easy maintenance.

Facility for housing Emerald Tree Boas showing tall cages with large openings that allow ready access for maintenance. Note the humidifier in the foreground; controlling the environment of an entire room precludes the duplication of control mechanisms for each enclosure.

refined techniques for the maintenance of precise atmospheric conditions in greenhouses, and these same strategies can be successfully applied to housing *C. caninus.*

HABITAT: ACQUISITION AND PREPARATION

Setting up an environment that reliably mimics conditions in the wild will minimize the stress involved in adapting your acquisition to a new habitat. The key ingredients — temperature, humidity, and air circulation — need to be brought into balance and proven to be continuously sustainable (around-the-clock and throughout the year) prior to the introduction of any inhabitant.

Habitat selection is largely a matter of personal taste and practical affordability. Although many types of caging exist, some materials are better suited to housing this species than others.

Plastics, such as acrylic and PVC, are ideal caging media in which to house tropical species. Aside from being impervious to the ravages of moisture, these materials also are able to withstand the stresses of expansion and contraction resulting from constantly changing temperatures. Additionally, many plastics are lightweight, and most forms are quite durable and easily customized. The latter quality is invaluable when making adjustments to fine-tune a newly acquired habitat. Some plastic habitats offer exceptional visibility. Others are virtually indestructible, but still manage to remain feather light. All in all, given the myriad forms and practical applications, plastics are the material best suited to the task both aesthetically and in terms of cost and availability.

Glass enclosures have long been an industry standard, providing keepers with the advantages of high visibility and invulnerability to moisture. These too are available commercially in a variety of styles and budget categories. However, glass has the disadvantages of being relatively heavy, less durable than plastics, and more difficult to maintain and to customize.

Wooden and melamine enclosures, while both popular in general herpetoculture, are less practical for use with tropical species. Extensive moisture proofing of all unsealed interior surfaces, including joints, access ports, and vents is a necessity for those wishing to utilize these materials. Wood, being inherently hygroscopic (readily absorbing moisture), attracts and absorbs moisture much like a sponge. Even when covered in melamine, moisture will seep into joints, finding any chink in a unit's waterproofing. Once absorbed by the unprotected wood, moisture causes damage via swelling, and deformity, and ultimately rots the unit. Additionally, the relatively high weights of these materials combined with their extreme vulnerability to the fluctuations in temperature and humidity required by tropical species are serious disadvantages that offset the benefits of low initial cost and high customizability.

Practical considerations useful in assessing the desirability of a particular unit are its overall dimensions, visibility, accessibility, and ventilation and thermal properties.

- **Dimensions:** *Corallus caninus* requires little actual space in which to reside. Vertical space should be the primary consideration when evaluating possible caging. Large adult specimens rarely exceed 2 m in length, and even these rare giants can be comfortably housed in units with as little as 30% of their body length in height. However, any enclosure should be of sufficient volume to allow for perching at different levels, as this metabolically slow species requires nightly exercise in order to optimize its digestive processes. An average 1.8 m-long adult will be completely comfortable in a unit measuring 45 x 45 x 65 cm (approximately 18 x 18 x 25 in, with the greatest dimension in height).
- **Visibility:** The day/night cycle within the Neotropical range of *C. caninus* varies little, and a year-round 12/12 formula will fulfill the species' physiological needs. Enclosures constructed of opaque materials may require in-cage lighting if ambient illumination is inadequate. Some cage designs provide screened openings for above-cage lighting and heating, but such openings sacrifice some degree of heat and moisture retention. Such units generally require modification in order

to keep temperature and humidity levels within acceptable limits.

- **Accessibility:** Cleanliness is of utmost importance when dealing with tropical habitats. Fortunately, *C. caninus* is a very low-maintenance form when compared to many other commonly kept species. Nevertheless, ease of maintenance should be evaluated seriously, especially for those planning on housing larger numbers of animals. Ideal units will have large openings that provide unobstructed access to any part of the interior. Fixtures such as perches and substrates should be easily accessible, and preferably removable. Slide-out substrate trays provide for easy removal of water bowls and other cage furnishings with a minimum of disturbance to the unit's inhabitant.
- **Ventilation:** Proper air circulation is crucial to maintaining a balanced tropical habitat. Too little exchange results in condensation, mold, and bacterial growth, whereas too high a rate may prevent adequate humidification and lead to respiratory issues and dysecdysis (shedding problems). The ability to easily modify a selected unit becomes most apparent in this context; the ventilation rule-of-thumb is that "the greater the inherent difficulty of modifying a unit, the greater the initial need for more than ample ventilation." Restricting airflow is always easier than creating it; therefore, glass units may need a vent as large as an entire exterior surface plane in order to assure proper airflow. Units with the best design actively utilize thermodynamics to provide a proper balance. Some units achieve this by virtue of their physical design, whereas others employ a system of fans, vents, and dampers. While both methods are effective, the latter is generally more versatile and better suited to a wider range of applications.
- **Thermal Properties:** The thermodynamic properties (relationship between heat and other forms of energy, in this case, air circulation) of a unit are largely determined by the placement of ventilation ports. Thermal gradients are essential in creating dynamic airflow as well as assuring a comfort zone for a unit's inhabitant. Because heated air rises, most units are provided with top or high-level exhaust vents. However, equally important is the supply vent through which fresh, cooler air will find its way into a unit. These "supply vents" should be located at lower levels of the unit. Ideally, both the supply and exhaust ports will be equipped with a damper.

Once a unit has been selected, the next step is to consider the basic elements that will become a permanent part of the environment. Appropriate hardware elements will be functional and durable. Environmental controllers, fans, humidifiers, heat sources, lights, water bowls, perches, and even substrate materials and cover vegetation should all be given the same degree of earnest consideration previously focused on unit selection.

Whereas aesthetic considerations will influence the selection of cage furnishings to some degree, the most ergonomically efficient minimalist designs require less of virtually everything. Focusing on the inhabitant as the primary attraction and minimizing the number of decorative items will minimize maintenance time and allow for greater budget flexibility, especially when considering larger colonies.

Adult male *Corallus caninus* showing the slit pupils associated with nocturnal activity, the heat-sensitive pits that locate prey and direct strikes even in the absence of light, and the characteristic posture assumed by Emerald Tree Boas.

By contrast, naturalistic enclosures mimicking the natural environment of the occupants provide stunning visual displays that enhance interest and promote an appreciation for the beauty and symbiotic nature of the species and its natural habitat. However, each additional layer of complexity in design adds to the level of maintenance required for both the inhabitant and the habitat to remain in optimal health.

Depending on the nature of the facility, minimalist habitats within environmentally controlled rooms may consist of as little as two perches and a water source. Although such setups have proven ideal and are commonly parts of larger collections, the majority of herpetoculturists employ environmentally independent self-contained habitats. Such units require additional hardware to achieve and sustain the continuous levels of temperature and humidity necessary to maintain Neotropical

Adult male *Corallus caninus* demonstrating the color and "personality" that causes these snakes to be so prized by hobbyists.

FRANK FUSARO

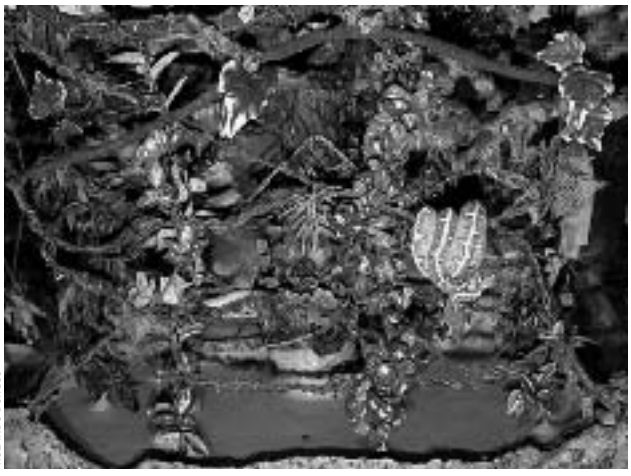
A naturalistic enclosure for housing an Emerald Tree Boa; note the low air intake, high vent, and large water bowl.

ROLANDO BURGOS

Naturalistic enclosures can provide a sense of the interactions that occur between a tropical snake and its natural environment.

ROLANDO BURGOS

Naturalistic enclosures can be striking, but the inhabitant is often less evident than in minimalist enclosures.



ROLANDO BURGOS

Complex naturalistic enclosures require considerably more maintenance than minimalist habitats; prospective snake owners should consider the extra time and effort required before committing to such an endeavor.

species. The use of either interior heating devices, such as radiant heat panels, or external heat sources, such as ceramic heaters, bulbs, or under-cage heating pads, are common. Of necessity, this type of equipment must be regulated. Thermostats, hygrostats, or the simple regulation of voltages via analog rheostats are all in common use, and all are known to be effective, although the latter is a far less reliable option.

Initial acquisition of only the most basic essentials is a cost-effective and flexible position from which to begin testing the environmental properties of a chosen habitat. Limiting initial purchases to just these items allows for options to be considered as specific need arises, as opposed to committing oneself to as yet unproven combinations.

For example, one might begin with the acquisition of an enclosure, a radiant heat panel, and a proportional thermostat. After setting up the unit including any proposed cage furnishings, one can begin to stabilize the environment to within the tolerances recommended for the species. A target range of 29 ± 1 °C at 65 ± 5% RH (the maintenance section in part II of this article will provide a full breakdown of the seasonal climatic cycles) stably maintained on a round-the-clock basis under both lighted and unlighted conditions is optimal. If temperatures within a unit are adequate but humidity levels are too low (the most commonly encountered situation), one can consider options for augmenting the RH according to the nature of the habitat. The addition of an under-cage heating unit (*Flexwatt*, heat tape, heating pads) will help raise RH levels in any configuration in which water or a water container comes into contact with the cage floor or substrate. An ideal balance occurs when the under-cage heater is controlled by the same controller used to regulate the radiant heat panel, although this is not always possible. Air stones, foggers, waterfalls, and even full-blown automated misting systems are all proven options for raising RH levels. Various alternatives in all of these categories are commercially available and limited by the usual constraints of aesthetics and budget.

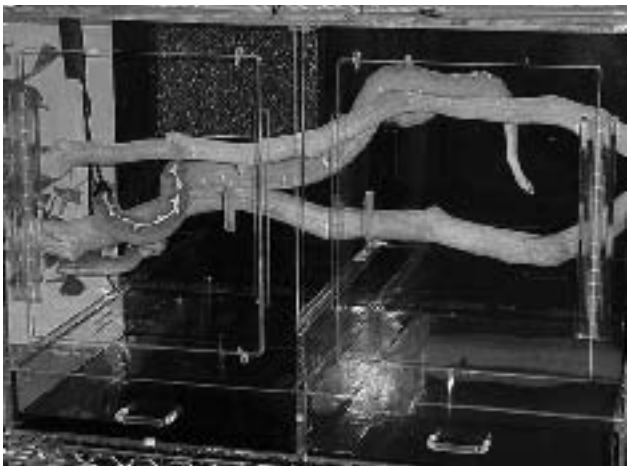
Another common scenario involves the formation of excessive levels of visible condensation when temperatures and humidity are sustained within the optimal range. In order to solve this problem, a basic understanding of why condensation forms is necessary. Warmer air is able to hold a greater amount of moisture than cooler air. When warm, moist, slow-moving air inside an enclosure comes into contact with a relatively cool surface (such as the walls of the enclosure), it begins to cool. Once that air cools below its capacity to hold its current moisture load, it "gives up the excess" in the form of condensation that subsequently forms on the cooler surfaces. Since reducing the overall RH below Neotropical standards is not an acceptable option, in order to prevent condensation, air circulation must be increased. Augmenting the movement/exchange rate of air within the enclosure decreases the amount of time that any particular air mass is in contact with the afore-mentioned cooler surfaces. This reduced contact translates into a reduction in cooling and an increase in the evaporation rate within the enclosure, thereby decreasing the formation of condensation.

Air circulation within a habitat can be enhanced in many ways. These options, once again, are limited by considerations of aesthetics and affordability. The use of external ventilators, such as reciprocating fans or individual unit-specific exhaust fans (computer case fans are a commonly employed solution), is an extremely efficient and cost-effective strategy. Habitat modifications that enhance the thermodynamic properties of a unit, such as the introduction of additional venting or the augmentation of existing vents with dampers, is likewise effective. In some cases, simply modifying or adjusting the balance or manner in which internal/external heat is applied (because warmer air rises, a reduction in heat at the upper levels of a cage will cause the warmed air at the bottom of an enclosure to rise and seek to escape, resulting in increased circulation) can be a very effective form of thermodynamic modification.

Once construction and setup have been completed and a habitat has been fully stabilized, the most time-consuming and nearly all of the most demanding work has been done. Successfully accomplishing this goal prior to the acquisition of an actual animal will give you the best possible chance of keeping your prized acquisition in peak condition. In the next installment, I discuss how to acquire a healthy specimen and specifically how to go about giving it exactly what it requires throughout its life to thrive and even reproduce. I think you'll be pleasantly surprised at just how little actual work is required — once you've completed the tasks that we covered in this installment.

Acknowledgements

My thanks go out to John Benz, Rolando Burgos, Stan Chiras, Craig and Karen Clark, Frank Fusaro, Robert Henderson, John Martin, Al Montejo, Tony Nicoli, and the entire online *Corallus* community of readers and participants at http://www.thetreeboaforum.com for supplying and sharing their pictures, empirical data, anecdotal accounts, and tremendous passion for this species.



Minimalist enclosures work well and are easily maintained.

Easily modified, lightweight plastic enclosures with perches at several heights facilitate maintenance of proper temperature and humidity.

Minimalist enclosures appropriately emphasize the inhabitant.

Stan Rand recording Túngara Frogs (*Physalaemus pustulosus*) on Barro Colorado Island, Panamá, in the 1960s.

PROFILE

A. Stanley Rand (1932–2005)[1]

Michael J. Ryan

University of Texas at Austin

There is a hole in my chest where my heart used to be, and a chasm in tropical biology the size of the Panama Canal. Stan Rand died on 14 November 2005, and we are all the worse off for it, personally and professionally.

Dr. Austin Stanley Rand, Stan to all who knew him, was born on 29 September 1932. Perhaps destiny dealt him no choice but greatness in biology, as his father Austin was already a famous ornithologist at Stan's birth. Stan was never far from field biology or museums when he grew up — he published his first paper when he was 12!

Stan began his graduate studies with Dr. Ernest Williams at Harvard, where he became an early member of that awesome lineage of students of *Anolis* biology under Williams's tutelage. He received his Ph.D. in 1961, and remained at Harvard on a postdoc for a year. That year included an intensive period of study of Jamaican anoles at the University of the West Indies. He and his wife Pat then relocated in São Paulo, Brazil, for two years while Stan was a postdoc with Dr. Paulo Vanzolini. Initially, Stan was paid from royalties from a song that "Vanzo" wrote. That tune must have been quite a hit in Brazil — or maybe Stan just lived modestly (money was never a big issue to him). Regardless, the Rand's first child, Hugh, was born there and it appears he didn't starve.

In 1964, Stan received an invitation from Dr. Martin Moynihan to join a new cadre of impressive young scientists that Moynihan was assembling at the Smithsonian Tropical Research Institute in Panama. Stan joined the staff. He, Pat, and Hugh moved to Panama, where their two daughters, Margaret and Katherine, were born. They lived on STRI's Barro Colorado Island (BCI), where the forest was inhabited by anoles and iguanas during the day and the Rands were serenaded by choruses of Túngara Frogs at night.

Stan published early and often — over 100 scientific papers in 60 years of publishing. Note that he is not yet done; Túngara Frog papers with his data will continue to bear his name for some time, and I predict that one will appear in 2014 to mark Stan's 70th year in the scientific literature. Many of Stan's scientific contributions can be partitioned into studies of *Anolis* lizards, iguanas, and crocodiles, and, as a grand finale, his study of Túngara Frogs. Stan explored many fascinating tidbits of nature in addition to those projects, but I will briefly review only these contributions.

Stan published a series of studies on *Anolis* biology in the 1960s that had an immediate and lasting impact on tropical biology, ecology, and behavioral ecology. Prominent among those contributions was his notion of the "ecomorph." The genesis of this concept originated when his data showed that on each island of the Greater Antilles, different *Anolis* species had diversified and adapted to nearly identical niches on separate islands. During that time, Stan also investigated dominance interactions among lizards, showing that, if the size difference between males was sufficient, the larger male won, but, if the size difference was minimal, the resident won. He demonstrated the "residency effect" in 1967, well before this became an important issue in behavioral ecology. Stan also integrated physiological ecology into his studies. Critical to the ecomorph concept was the climatic, not just the structural, habitat the lizards occupied. At the behavioral level, he showed that lizards' responses to predators were strongly influenced by their body temperatures. All of this foreshadowed Stan's continuing emphasis on the organism's entire biology and the necessity of viewing it in its natural context.

KATHRIN P. LAMPERT

Stan and Pat Rand in front of their house in Gamboa, Panama, in 2003.

[1] *Iguana* has not and does not plan to use obituaries as "profiles" again in the future. However, Stan Rand's contributions to herpetology were so monumental that we felt that we could not, in good conscience, let his death preclude the opportunity to feature him and his impact on our discipline. — The Editors

Stan made at least two other major contributions during his work with anoles. One was a paper with Williams in 1970 on signal redundancy in communication systems. They used information theory to estimate the quantity of information about species identity that potentially could be communicated in a lizard community. They calculated that the total amount far exceeded what was necessary. This study was a wonderful demonstration of how animals use multiple aspects of their displays to reinforce the same message, and it was one of the first applications of information theory to animal communication in the wild. Stan also considered the relationship between ecological space and predator-prey interactions in the context of "aspect diversity," arguing that variation among species could result from predator-driven selection that causes species to diverge in the "escape space" available to them. This concept greatly augmented studies of apostatic selection and anticipated much of the work we see today in sensory ecology.

Another stage in Stan's work dealt with social behavior in and between Green Iguanas and crocodiles. Much of this work was with Gordon Burghardt and his students, centered on the small island of Slothia, a mere stone's throw from Barro Colorado Island. Female iguanas swim to Slothia from BCI and nest communally. Stan and his brother Will wrote an insightful paper on conflict resolution. It analyzed the competition between female iguanas over the burrows they dug for nesting. The analysis combined stochastic processes and energetic constraints and showed that females took into consideration the amount of energy they had expended in building the burrow.

XIMENA E. BERNAL

Stan Rand wearing his "Túngara team" hat during the field season in 2004.

PAT RAND

Embarking for a 1990 field trip to the mountains of western Panamá (from left: Debbie Greene, Walt Wilczynski, Stan Rand, Mike Ryan, Kyra Mills, Ulysses [uncertain of last name], and Frederico Bolanos).

This study later led to some consternation among theoreticians interested in honest signals who were convinced that the "Concorde Effect" (adding more investment only because past investments have been made) should be maladaptive. I remember one night on BCI when, over some rather mediocre Panamanian rum, John Maynard Smith (who to me was always the "Stan of theoretical biology") asked Stan just how this could be. Although Stan knew the theory about games, the data reigned supreme — this is what they do, he replied.

Some interesting interactions between crocs and female iguanas had been witnessed by few besides Stan. A female croc had earlier nested at the same site where the fecund iguanas sought shelter for their eggs. The female croc, Natasha, as the several-meter-long crocodile was affectionately known, rushed a nesting iguana, and grabbed the expectant mother in her mouth. Instead of devouring her, or at least dismembering her, as any protective maternal archosaur should do, Natasha delicately carried the iguana back to the water and released her. Crocodiles carry their newly hatched young to the water, so Stan thought that having a small squirming baby reptile in her mouth released Natasha's maternal instincts. Some of this crocodile work is published, and much more is oral history on BCI. When great scientists such as Stan pass, we marvel at the accumulation of knowledge they left us, and we lament the untapped knowledge that went with them.

Stan began to study acoustic communication in frogs in the forest of Boracéia in Brazil while conducting his postdoctoral research with Vanzolini. That interest continued when he moved to Panama. He immediately set out to document the vocal diversity of these gnomes of the Panamanian nights, but he also turned his considerable nocturnal skills towards one species, the Túngara Frog (*Physalaemus pustulosus*, which at the time had the more melodious generic moniker of *Engystomops*).

I went to BCI to begin my studies of sexual selection and communication in Red-eyed Treefrogs (*Agalychnis callidryas*) in 1978. These frogs proved intractable for the study I had planned, and I quickly switched my attention to Túngara Frogs. At this point, Stan had published one paper on their foam-nesting behavior, although nothing on their communication.

However, he gave me a manuscript that had been written in the late 1960s or early 1970s that described the complex calling of these frogs: a simple call, or "whine", that could be produced alone or could be followed by one-to-many secondary components, or "chucks." The manuscript was filled with incredibly interesting and detailed natural history as well as experimental studies of female phonotaxis. Among other things, Stan was interested in whether female frogs were more attracted to the complex call over the simple call. These experiments were conducted when the emphasis of mate recognition was focused at the species level and was concerned with how it contributed to speciation through behavioral isolation. In frogs, this work was being carried out in exemplary fashion by such luminaries as Murray Littlejohn and Carl Gerhardt, both of whom were inspired by the earlier studies of Frank Blair. So, at that time, Stan was working in the intellectual shadow of the Modern Synthesis and its emphasis on speciation, but instead he was addressing questions about female choice and sexual selection. This was some time before Robert Trivers (who also worked on *Anolis* and was advised by Williams during his Ph.D. studies) wrote his paper on parental investment and sexual selection in 1972. I added some to that early manuscript of Stan's and we published it in 1981. I finished my thesis in 1982 while Stan was still concentrating on reptiles.

Stan and I remained in touch during the next few years, although neither of us worked on Túngara Frogs. In 1985, we met in the halls of the Smithsonian's Natural History Museum in Washington, D.C. and I suggested we start up a joint project with those little beasts. In 1986, we began a now 20-year collaboration on what became known to some as the "Túngara Frog Project." Our initial interests were modest as we began testing female phonotaxis in a carport using a plywood and burlap testing chamber in Gamboa, Panama. Stan and family had just moved from Panama City to Gamboa, and STRI was planning on having some laboratory facilities there soon. The first question we addressed was what aspects of the mating call made it attractive to females, and the first studies we published in 1990 argued that, in this system, sexual selection was generated by sensory exploitation. That idea, convergent with and inspired by others such as MJ West Eberhard at STRI, has generated some interest. Our interests in sexual communication in these frogs continued to expand in concert with the lab facilities in Gamboa, which in turn accommodated a more sophisticated approach to our own research questions.

Stan was always interested in the entire biology of an animal, and our studies soon grew to embrace additional aspects of communication, comparative studies of populations and related species, and, through our collaboration with Dr. Walt Wilczysnki, the neural mechanisms that controlled mate choice. Memorable during those years was a 5000-km transect in which Stan and I sampled and collected Túngara Frog calls and tissues throughout the entire range of the species. Most of the data were collected when we departed from Austin, Texas after the meetings of the American Society of Ichthyologist and Herpetologist (ASIH) that was hosted there in 1993. We drove from Texas to Panama, collecting all the way. Those samples were supplemented by numerous trips to South America, where we studied other populations of Túngara Frogs and their relatives. The data from that transect have already provided the grist for at least four separate studies, and their uses are still not exhausted.

XIMENA E. BERNAL

Holding a microphone and a Marine Toad (*Bufo marinus*) in place of the crucifix and the dove, Stan Rand impersonates Saint Francis of Assisi. Stan was passionate about fieldwork and deeply appreciated the beauty of toads. The picture was digitally modified at Stan's request to create a monk's hairstyle.

In the year 2000, Stan, Walt Wilczynski, David Cannatella, and I were PI's on a multidisciplinary grant. This grant, which involved collaborations among more than a half dozen labs, addressed issues from phylogenetics to molecular neurobiology, all emanating from the basic biology of the Túngara Frog that Stan first glimpsed in 1964. As the grant ended in 2004, we were asked to organize a two-day symposium on "Sexual Communication in Túngara Frogs" at the Animal Behavior Society meetings in Oaxaca, México. To kick off that symposium, numerous attendees, many with little or no interest in frogs, sexual selection, or communication per se, packed the room to hear Stan Rand present what ended up being his last scientific presentation: "Natural History of the Túngara Frog." When Stan finished that talk, I detected in the sustained applause a tone of reverence and appreciation for someone special.

The work on Túngara Frogs will continue unabated, serving as a scientific legacy to Stan, but it also will be a continuing collaboration from the grave. Although no longer with us, we will never outlive Stan's inspiration or exhaust his insights.

Having now provided a most cursory summary of Stan's scientific career, I would like to end by saying more about Stan the person, which is the real reason why so many of us mourn his passing. Above all, Stan was a naturalist. His eyes, ears, and mind were focused on the organism in its environment. He was well schooled in theory, but not terribly impressed by it. He was

a great experimenter, but was always a bit cynical about how such results might apply in the wild. Once we were waiting out a drought in a small dusty town in the bush in Brazil. We went to see a movie, "Edward Scissorhands." An old woman narrates the story in which, as a youth, she befriends a boy who has scissors for hands. Afterwards, I asked Stan how he liked the movie. He said it was totally unrealistic, the chronology didn't match, and the old woman could not have been a youngster when she first met Edward. I said, "Stan, for chris-sakes, the boy had scissors for hands! How realistic is that? So what if the chronology was off." He wouldn't budge. The opening of the movie was built on a house of cards and he would contemplate no farther.

For most, Stan is intricately associated with STRI. The Smithsonian Tropical Research Institute is a great institution, and Barro Colorado Island is its crown jewel. We celebrated Stan's retirement from STRI with a symposium in his honor at the 1998 meetings of the ASIH in Guelph, Canada, the proceedings of which are published in *Anuran Communication* (Smithsonian Institution Press, Washington DC, 2001). All of the more than 20 authors I first invited to participate said yes; so much for a list of back-ups! When I introduced the symposium, I said that, but perhaps for BCI, Stan was STRI's most valuable resource. An institution's greatness is defined, of course, not just by its physical facilities but also by its humanity — and that is where Stan made by far his greatest contribution. Because of his immense knowledge of tropical biology, Stan was often called upon for advice, especially to initiate novices to this land of plenty. His generosity knew no bounds, and his humor, warmth, and enthusiasm were contagious. He readily extended this generosity into the personal realm. He and Pat formed the social hub of Gamboa for the last 20 years, and their house was a scientific salon. Pat's famous "frog dinners" for many of the visiting researchers in Gamboa (regardless of whether or not the scientists worked on frogs) were the social highlights of our summers. These dinners were also an incubator of scientific ideas. Stan was not a "science nerd," he was broadly informed and could entertainingly engage guests with a broad array of topics, but his insights and wit were always sharpened and ready to be applied to the next scientific question.

XIMENA E. BERNAL

When a student asked Stan about chemical defenses of Túngara Frogs (*Physalaemus pustulosus*), he volunteered to lick some to find out if he could detect any chemicals. Stan had a humorous disposition and enjoyed making people laugh in the lab.

XIMENA E. BERNAL

Stan getting ready to fly in an ultralight plane in 2003 over the area of Chilibre, Panamá. Stan was an adventurous man always looking forward to new experiences.

I remember once bemoaning that, because Stan was not at a university, numerous students missed out on all that he had to offer. Wrong, wrong, wrong! STRI offers a wide array of fellowships for researchers at all stages of their careers. They all need STRI sponsors. I have counted more than 50 students that Stan sponsored before 1990; surely I have missed many. In addition, since 1986, Stan acted as sponsor to more that 70 interns and associates who have worked with us on the Túngara Frog project. He visited my lab in Austin twice a year for a long time; those visits were so heavily booked that I had to sequester Stan at a local pub to have time with him — but even that hiding place was discovered all too quickly. Finally, literally hordes of students owe Stan deeply. Two now rather famous biologists, one studies monkeys and the other ants, told me long before they were famous that Stan was crucial to the early development of their research forays on BCI. When I informed by mass e-mail numerous colleagues of Stan's death, I received a plethora of responses in which the word "love" was used much more than one might associate with "macho" (and "macha") field biologists.

So, now we say good-bye, Stan. Thanks for all that you shared, the family, the friends, the tropics, and the frogs. You will not be forgotten. Next rum's on me.

Acknowledgements

I thank both Ray Huey and Jonathon Losos for their thoughts on Stan's *Anolis* work.

TRAVELOGUE

The Blue Anoles of Isla Gorgona

Joseph Burgess

Jacksonville, Florida

The idea for this trip began to form about six years ago. A group of *Anolis* enthusiasts (yes, believe it or not, such folks do exist) were corresponding on our website when someone posted a photograph of a pure blue anole with the label "*Anolis gorgonae*." At that time, none of us had ever heard of it. Considering that over 350 species of *Anolis* have been described, this was not too unusual. I was familiar with all of the West Indian species (at least by name), and, based on the looks of the animal in the photograph, I suspected that it was a continental form in a group of species frequently assigned to the genus *Norops*[1]. However, I was skeptical that this was even a real lizard. It was a pure blue, from head to tail, and the picture just looked like it had been doctored. Not only did I suspect that the color was enhanced, but a name like *gorgonae* (after a mythical creature) suggested that this, too, was a mythical creature and that someone was playing a prank on the group.

Colombia sits at the junction of Central and South America, features a vast array of varying habitats, and is a hot-spot of biodiversity.

Blue lizards do exist. Species such as *Cyclura lewisi* and *Chamaeleo* (*Furcifer*) *pardalis* are blue, and several anoles and some Day Geckos (genus *Phelsuma*) are at least partially blue. So, why was this animal so hard for me to take seriously? This lizard was just too blue to believe. It looked as if it had been painted blue; it had no pattern and no stripes or spots. What purpose could being solid blue serve any creature in a natural environment (and, in nature, logical reasons almost always exist for certain colors or characters)?

A day or two later, a group member from Germany confirmed that *Anolis* (*Norops*) *gorgonae* was a real species, and was even able to identify the geographic origin — Isla Gorgona off the Pacific coast of Colombia. I searched in earnest to find more information, but met with very little success. I did determine that Isla Gorgona was a real place, but… was the lizard really blue? I couldn't find any natural history information or any descriptions that verified the color. Some subsequent exchanges on the website discussed the possibility of going to Isla Gorgona to find out for ourselves, but, at that time, the western coast of Colombia could be a dangerous place, with paramilitary guerillas and government insurgents in control of some areas. Some problems remain, but, as time passed, the image of the blue anole of Gorgona haunted me. Every so often, I would do an internet search in an effort to find more information or photographs of the species. Discussions (mostly less than serious) about getting to Isla Gorgona persisted — but too many obstacles appeared to preclude a casual trip to the island. I had checked, and getting there was certainly not like traveling to one of the easy-to-visit islands in the West Indies with which I was quite familiar. Isla Gorgona is a Colombian national park (and a prison?), and you need permission to visit. In addition, the logistics of getting to the island are daunting. The park service does not provide transportation. So, how could an *Anolis* fanatic get there?

One day, as luck would have it, Nathan, the very same person who posted the picture of the anole, met and married Ingrid, a Colombian woman. Could this finally be an in? It was! Still, it didn't happen overnight. Over the next year, I continued to search for information. I even enlisted the help of Sandy Echternacht (University of Tennessee), who had spent considerable time in the Neotropics, and he managed to find a publication about the herpetofauna of Gorgona. It was from the early 1970s and in Spanish, but it was far more than I had been able to find. I also came across another picture of a blue lizard that

[1] See the footnote in the article by Alexander Gutsche (*Iguana* 12:240–243) about the status of the genus *Norops*.

was linked to Dr. Kirsten Nicholson's website. I contacted her and found out that she had been to Isla Gorgona just a few months earlier — now, I was making some real progress. We corresponded via email, and she helped clarify the status of some of the other anoles that occurred on the island and which the publication (in Spanish) had misidentified.

Getting to Isla Gorgona

Traveling to any country is always an adventure, but, when you are able to dive into the culture with one of its citizens, you really get a different perspective. I had been to Colombia before, but, after the first day, I could tell I was going to see a lot more than I had previously.

The trip began in the beautiful old city of Cartagena, where I attended Nathan and Ingrid's wedding. From there, we spent some time in Bogotá and Cali before setting out for Gorgona. We would be joined on the trip by one of Nathan's friend, Dominic. While herpetology is not his interest, he would prove to be a good sport and supportive of our efforts. Getting to the island is no easy task, and definitely not something for the casual traveler. From the U.S., you would have to take several flights on progressively smaller planes and then a boat ride from two optional points of departure. We chose the town of Guapi, since the boat ride from there was about eight hours shorter; however, the boat was much smaller than I'd prefer for a voyage into the Pacific.

As soon as we landed in Guapi, the plane was surrounded by Colombian marines with automatic weapons. They established a perimeter for the safe debarking of passengers. The entire town had a strong military presence, a constant reminder of how dangerous this area of Colombia could be.

The old city of San Diego, Cartagena, Colombia.

The river town of Guapi.

Lush Isla Gorgona.

Guapi is an interesting little river town. No roads pass in or out of the city, which has only the small airstrip and the river for transporting people and goods. Although roads exist within the town, vehicular traffic, excepting only an occasional minibus or truck, is absent. Being there was like stepping back in time. We watched dugout canoes bringing fruits and vegetables to the riverside town square. The river was truly the main street; all of the action was there. After about a half-hour wait spent taking in the local flavor, our boat captain, "Highpitch," arrived and we were on our way.

After a short stretch of the Rio Guapi, we emerged into the Pacific Ocean. About 20 miles of ocean now stood between us and our destination. The day was overcast and hazy, but the island started to take shape on the horizon after about 10 miles. It didn't look much different than many of the mountainous islands I'd visited before, but it was a stark contrast compared to the mainland we had just left behind. This portion of Colombia's western coast is a flat estuarine coastal landscape. So, having this island rise from the sea before us was immensely impressive. As we got closer, we began to make out some of the island's features, a beautiful rainforest that probably hasn't changed much in thousands of years. I could see the few small buildings of the park facilities as we approached the shore, but no dock. I wasn't dressed for a beach landing, but Highpitch was an experienced captain and got us right onto the beach; I didn't even get my shoes wet.

Upon arrival, we were greeted by park staff and given an indoctrination to the park, its rules, and a brief history (in Spanish). In 1526, Francisco Pizarro discovered the island on his way to Perú. When he visited the island, he was amazed by the number of snakes he saw, and consequently named it "Gorgona," in reference to Medusa, the mythical Gorgon with a proliferation of serpents upon her head. The island is still known for its plentiful snakes, but it also has an otherwise rich fauna, flora, and marine environment (coral reefs). For these reasons, the government declared the island a national park in 1984. Prior to that, it contained the most feared penitentiary in the country. The ruins of the prison remain, but are quickly being reclaimed by the forest. The park facility buildings are actually part of the old prison's administrative and staff structures.

The park includes 61,688 hectares, of which approximately 97% correspond to marine area and 1,660 hectares are terrestrial. The main island is 9 km long and 2.5 km wide, with a highest elevation of 330 m. It and the smaller island of Gorgonilla are covered by lush tropical forest that descends from the top of the mountain to the edge of the ocean. The known fauna includes 19 lizards (4 of which are endemic), 15 snakes, 8 amphibians, over 175 birds (including sea and migratory), 12 bats, monkeys, a sloth, sea turtles, whales, and sea lions that come to visit from the relatively nearby Galápagos Islands. The park receives only about 7,000 visitors a year, most of which are students or scuba divers.

Isla Gorgona

We collected our bags and were on our way to our cabin when we came across the first reptile, a Red-headed Basilisk (*Basiliscus*

A large mural depicts the park namesake, Medusa, The Gorgon.

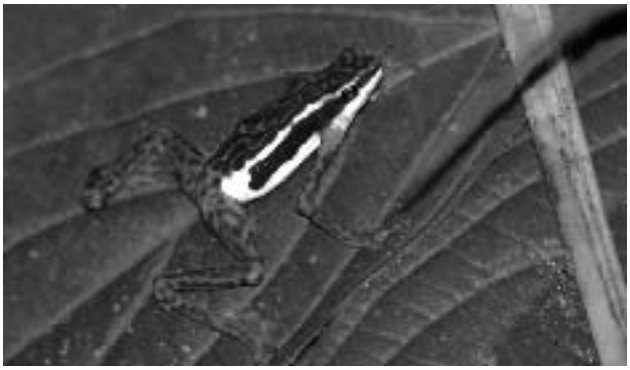
galeritus), quickly followed by our first amphibian, a dart frog (*Epipedobates boulengeri*). These were the most commonly encountered species during our visit. The dart frogs were present almost in plague proportions, a testament to the efficiency of their toxic skin secretions to deter predation. When walking, we had to be careful not to step on them.

We were eager to get into the forest and begin our search for the blue lizards. From the very beginning, I was concerned about even finding one. Anoles on the southern continent often are far less abundant than what you encounter in the West Indies or even some parts of North America. My previous visits to South America had yielded only a few individuals, and I often missed many targeted species. We discussed our desire with a member of the park staff, who took us to a trail along which he had seen them — but he told us that they are very rare. We traversed the trail and found many other interesting species,

Dart Frogs (*Epipedobates boulengeri*) were ubiquitous and obvious, exploiting the protection provided by extremely toxic skin secretions.

A handsome male Red-Headed Basilisk (*Basiliscus galeritus*), one of the most commonly encountered reptiles on Isla Gorgona.

Anolis princeps is a true giant, reaching total lengths to 64 cm.



Harlequin Toads (*Atelopus elegans*) often lie exposed to view, even during daylight hours, relying on bright warning coloration to deter predators.

Harlequin Toads (*Atelopus elegans*), Wood Lizards (*Enyaliodes heterolepis*), Bridge's Ground Lizards (*Ameiva bridgesii*), and a Large-scaled Black Treesnake (*Chironius grandisquamis*), but we were almost to the end of the trail and had not seen a single anole. We decided to take a side trail into an overgrown fruit orchard, which turned out to be a very good decision. We almost immediately found two species, and after some initial confusion, identified them as *Anolis* (*Norops*) *medemi* (an endemic) and a juvenile *A.* (*N.*) *princeps*. We returned to the main trail and, with only about 50 meters left, our guide pointed out an enormous *A.* (*N.*) *princeps*. I had no idea they could get that big. With my eyes locked on this giant anole, I walked right past the object of the trip. From behind me, I heard Dominic say: "It's the blue one" (remember that he is not a "herper" and is unfamiliar with scientific names). As I turned to see what he was describing, I saw it: A glowing neon blue lizard that looked very out-of-place in this shadowy forest. It was more fantastic than I imagined it could be, and we all stared in amazement. All doubt was gone, and the fabled blue anole not only existed, it lived up to all the anticipation. After a lot of talk and a short photo session, we headed back. Although exciting, we still had some work to do. Virtually no literature addresses *A.* (*N.*) *gorgonae*, so I wanted to find out as much about it as I could. We had to find more.

As we adjusted to a steady diet of fish (or sometimes chicken), rice, and plantains provided by the park, we made several additional excursions into the forest, but with limited success. We were finding only about one blue anole per day. Only a few trails were accessible and the park required visitors to have a guide. The staff was very protective of the park, which was a welcome surprise. They also had an obligation to protect the everyday tourist from the serpents and had strict rules for venturing out at night. Our guide, Orlando, was always a little nervous about our "off the trail wanderings" and the fact that Nathan and I were not wearing "snake protection boots." Concerns centered mostly on venomous snakes, like the Fer-de-Lance (*Bothrops* sp.), especially at night, although we saw none. Snakes of other kinds were certainly not in short supply. We encountered several in the area immediately around our cabin. In fact, one afternoon, we found a large Boa Constrictor (*Boa constrictor*) consuming one of the large rodents (*Proechimys semispinosa*) that graced our cabin porch each night. However, after wrangling several large boas and several other snakes, we earned Orlando's respect and confidence. We also in a way became his guide, teaching him specifics about the amphibians and reptiles that we encountered along the trails. After a while, we were permitted to make several hikes alone, which is normally not allowed, and we were grateful.

Although this was considered the dry season, it rained often and was extremely humid. After one good downpour, Nathan and I hit the trails to see what the rain had brought out of hiding. One interesting observation was that the multitudes of dart frog were now carrying tadpoles on their backs. This is a common strategy among some dart frogs. They lay their eggs in a moist and protected crevice or a convenient crab-opened

Ingrid watches a large Boa Constrictor finish its meal.

One of the many Brown Vine Snakes (*Oxybelis aeneus*) encountered during the trip. These exceedingly slender snakes feed primarily on lizards.

"Lagarto Azul," the Blue Anole (*Anolis gorgonae*) of Isla Gorgona.

coconut. Upon hatching, they ferry the tadpoles to a permanent source of water in which to complete their development.

One fortunate day, we were on the beach trail and conditions must have been perfect, because we found five *A.* (*N.*) *gorgonae*. In the following days, we found additional animals in this area. So far, all were in closed canopy forest with little to no undergrowth. Also, 90% of what we had seen so far was on small diameter (single stalk) trees and lizards were perching low (< 1 m) on the trunks. We also were finding a high female-to-male ratio, with females being a deeper blue than any of the males we observed. Our observations contrasted with what Kirsten Nicholson had seen during the wet season, when she found no females and only three males, all of which were found on large-diameter trees at heights >3 m. The paucity of arboreal lizards was easy to explain. The density of saurophagus snakes (*Oxybelis*, *Leptophis*) was very high.

We saw only two species of tiny geckos in the genus *Lepidoblepharis*, this is *L. peraccae*.

Yellow-headed Geckos (*Gonatodes albogularis*) have an extensive distribution throughout Central America and northern South America. Like many lizards in the genus *Gonatodes*, this species is sexually dimorphic; females lack the yellow head of males for which the species is named.

Although not reported in any of the literature, House Geckos (*Hemidactylus* sp., probably *H. frenatus* or *H. leightoni*) were present in small numbers. These most likely represented a recent introduction from the mainland. Already, however, these apparently new arrivals appeared to be excluding a smaller introduced gecko (*Lepidodactylus lugubris*) from several of the facility's buildings.

One frustrating situation during this trip was our failure to find two species of anoles I had hoped to see, *A.* (*N.*) *biporcatus* and *A.* (*N.*) *chocorum*. While I am familiar with *A.* (*N.*) *biporcatus*, having encountered them during visits to Central America, I was completely unfamiliar with *A.* (*N.*) *chocorum*. Fortunately, the park had a small lab with preserved specimens, which were immensely helpful in clarifying the inevitable identification problems initially encountered with new faunas. Those specimens also gave me the opportunity to view any species we had not observed in the field. The park also had an informative library (mostly in Spanish), with references to the island's ecology as well as that of Colombia and South America.

Every day on Isla Gorgona brought new discoveries and interesting creatures we had never seen. Our time on the island came to an end all too quickly — but it and the Lagarto Azul will be long remembered. The island is a great opportunity for any student or professional herpetologist. Very few non-Colombian scientists visit the island, and its abundant biotic riches lay largely untapped.

Acknowledgement

I thank Ingrid Sorza, for planning and coordinating the trip and for her tireless translation and patience.

HISTORICAL PERSPECTIVE

Preliminary Study of the Thermal Requirements of Desert Reptiles[1]

Raymond Bridgman Cowles and Charles Mitchill Bogert

Preface

Cowles and Bogert's "Preliminary Study of the Thermal Requirements of Desert Reptiles" is something of an anomaly in biology. It is a paper that introduced new concepts concerning an entire vertebrate class and presented a rigorous framework for experimental studies which has survived with remarkably little change for three decades. A major field of herpetological research can be traced directly to the appearance of this work, and for more than a quarter of a century nearly every paper dealing with the thermal relations of reptiles has referred to "Cowles and Bogert 1944."

Cowles had long been interested in the ecology of the reptiles of the deserts of southern California and in 1938 he took advantage of sabbatical leave to set up a field station in the Coachella Valley. His initial interest was the winter activities of reptiles and he gathered information by following a bulldozer that was excavating clumps of mesquite and creosote bush in preparation for irrigation. It was this interest in cold reptiles that first brought him into the desert with a thermometer in his hand. The resistance of reptiles to low temperatures and their ability to resume activity when they were warmed suggested to him that perhaps it was increasing temperatures at the end of the Mesozoic that led to the extinction of dinosaurs via heat-induced sterility. On this basis he suggested that fur and feathers first evolved to keep heat out, not in. From this hypothesis it was a natural step to studying the reactions of living reptiles to high temperatures. The prevailing view at the time held, with impeccable logic, that if a lizard sits on a burning hot rock, the lizard must be as hot as the rock. Biologists marveled at the heat tolerance of reptiles, although there were some hints that reptiles really preferred to be cooler.

The continuing value of the "Preliminary Study" rests on its two major characteristics: it was an entirely new way of looking at the biology of reptiles, and the methods and their application were extraordinarily rigorous. Cowles and Bogert discarded 80% of their body temperature measurements because of uncertainty about the activity of the animal before a measurement was made or because they felt the temperature might have changed during the process of

Continued on page 54

Introduction: At the present time there is little available information on the influence that desert climates exert on ectotherm activities. The small amount of data which are available has been gathered chiefly as matter incidental to other problems in the biology of reptiles. Even with this meager information, the potential significance of these data requires more elaborate studies than those now available. It appears probable that temperature as a factor of the environment has a profound influence on reptilian distribution and ecology. Undoubtedly it has been fully as important in the evolution and dispersal of reptiles.

Editor's Note.—Early herpetological literature tended to be of interest to a very limited audience — other herpetologists. Much of the work was focused on listing the species found in particular areas and describing their basic natural history, and an evolutionary perspective, beyond the taxonomic focus, was rare. Perhaps the first herpetological work to break into the awareness of biologists at large was the 1944 publication of "A Preliminary Study of the Thermal Requirements of Desert Reptiles" by Cowles and Bogert, an eco-physiological study with an evolutionary view. The importance of the work stems from the demonstration that "cold-blooded" organisms did not passively take on the temperature of their environment, as previously thought. Instead, Cowles and Bogert were the first to document what we now take for granted: Reptiles have sophisticated behavioral mechanisms that allow them to precisely regulate their body temperatures within a fairly wide range of ambient conditions. This was not the last collaboration between the two nor the final study of reptilian physiology. However, whereas most of the work published that long ago is rarely referenced, the paper excerpted here is still frequently cited, showing its enduring value — sixty years later, this work is still a major milepost.

The original paper is too long to fully include here, as is the Preface by Harvey Pough, added in the SSAR 1974 reprint. I have selected excerpts from both the original work and Pough's preface in order to give readers a sense of the scope of the work, selecting paragraphs that illustrate both substance and style of the work. In the interest of brevity, the bibliography has been omitted, although references were retained in the text (but not in the preface). For those interested in reading more, the SSAR reprint is still available for sale, along with some other historically important herpetological publications. All can be found at www.nbb.cornell.edu/neurobio/department/faculty/adler/not%20using/ssar.html.

Gad Perry, Editor
Texas Tech University

[1] *Bulletin of the American Museum of Natural History* 83:261–296 (1944, reprinted in 1974 by the Society for the Study of Amphibians and Reptiles, Miscellaneous Publications, Facsimile Reprints in Herpetology).

Preface continued from page 53

measuring. The importance of that caution cannot be overstressed. Inanimate objects (in this instance beer cans) distributed through the environment show a distribution of "body" temperatures which resembles the body temperature distribution measured from live lizards. In other words, the observation of a negatively skewed temperature distribution centered about a clearly-defined mean that is higher than air temperature does not demonstrate thermoregulation. It is essential to combine measurements of temperatures with observations of the animals' activities.

The scope of the field opened to investigation by the view of reptiles as animals capable of a considerable degree of homeothermy has not yet been fully realized. In the first place it has made the classic division of animals into homeotherms (warm-blooded) and poikilotherms (cold-blooded) meaningless. During the course of the study Cowles coined the words endotherm and ectotherm to emphasize the source of the energy that warms the body. The realization that reptiles can and do control their body temperature has had ramifications in many areas of herpetology. Ecologists have found that niches are defined in part by thermal relationships, ethologists have discovered that reptiles behave differently at different body temperatures, and zoogeographers must consider the radiant energy regimes available on postulated routes of migration. It is scarcely possible to ask a question about the biology of reptiles in which their thermoregulatory capacities are not directly or indirectly involved. In particular, the very active research in reptilian environmental physiology is built to a great extent around thermal relations and thus stems from the "Preliminary Study."

There has been remarkably little modification of the views embodied in the original paper during more than a quarter century of extensive work. One of the first changes was a de-emphasis of the concept of the "ecological optimum" represented by the mean value of the body temperatures measured during activity. Bogert found that the same genera of lizards maintained very similar body temperatures in different habitats while different genera maintained different temperatures in the same habitat, indicating an hereditary preference for a particular body temperature level. The hereditary preference could be affected by environmental conditions. For example, in Florida, which was frequently cloudy, *Cnemidophorus* body temperatures were skewed toward the lower end of the activity range while they were skewed to the upper end in sunny Arizona. In other words, the activity temperature should be viewed as a range of temperature which is acceptable to a lizard species and allows it to carry on the activities necessary for life. Indeed, a lizard that is kept continuously at the average temperature it selects in a temperature gradient loses weight and may even die. Regal has shown that lizards voluntarily select low body temperatures at night. Apparently different aspects of a lizard's internal economy function best at different temperatures and some temperature variation is essential.

F. Harvey Pough
(excerpted from the 1974 SSAR edition)

L. LEE GRISMER

This view from Santa Rosa Mountain illustrates several "typical" components of the Coloradan subdivision of the Lower Sonoran life zone.

The great advantage inherent in studies of desert reptiles lies in the extraordinarily high maximum temperatures, as well as the greatly exaggerated temperature changes, so characteristic of desert climates. Such environmental conditions may amplify subtle details of thermal relationships that would otherwise escape notice. The resulting accentuation of temperature responses throws into relief temperature relations which in the equable climate of the tropics might otherwise remain as imperceptible, or at least unperceived, nuances in thermal adaptations.

Methods: The region wherein most of these experiments were conducted presents typical aspects of the Coloradan subdivision of the Lower Sonoran life zone. Cages and other equipment were installed in the field, as described hereinafter, at a locality near Indian Wells, Riverside County, California. This locality lies on the floor of the Coachella Valley a few feet above sea level, with drainage to the southeast into the sink of the Salton Sea. The surface of this body of water is below sea level.

Experimental results (representative species, chosen for diversity and availability of pictures): *Coleonyx variegatus*, Banded Gecko. The thermal responses of this nocturnal lizard closely approximate those of the nocturnal snakes. It is able to crawl at temperatures as low as 11° C., but in actual practice the animals do

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The thermal responses of nocturnal Banded Geckos (*Coleonyx variegatus*) closely approximate those of nocturnal snakes.

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Normal activity of Desert Iguanas (*Dipsosaurus doralis dorsalis*) occurs at temperatures ranging from 34–41 °C.

not ordinarily expose themselves to temperatures below 16° C. As a matter of fact, they are rarely found in the open below air temperatures of 18° C., except when the ground is warm. Whereas this gecko appears to be somewhat more resistant to cold than the snakes, it is also capable of enduring somewhat higher temperatures than these animals. For the snakes as well as for this lizard, the activity range lies in the vicinity of 30° C. This is well below that of the diurnal lizards. The small number of available specimens has prevented a satisfactory determination of the critical maximum, but this point is reached at a body temperature somewhat below 41° C. Under extreme conditions of heat and with relative humidity at 11 per cent, respiratory cooling of about 2.5° C. has been noted.

Dipsosaurus dorsalis dorsalis, Desert Iguana or Northern Crested Lizard. After one night of exposure to temperatures slightly below 8° C., a common night temperature in early spring, these lizards are torpid and often so sluggish that they are unable to move. As their body temperatures rise with increasing warmth, they remain helpless up to 14° C. At 18° C. they are unable to coordinate rapid movements, and they resort to clumsy intimidation displays. A temperature of 21° C. permits slow locomotion, and at 24° C. torpidity is still evident but the animal can walk with well-coordinated movements. The temperature of 27° C. constitutes a well- defined minimum voluntary tolerance. It is notable that at low temperatures this species of lizard is more seriously discommoded than are some others that have wider territorial ranges. Normal activity extends from 34°–41° C., and the mean for all records (38 observations) is 37.4° C. Retreat from high temperatures observed in 20 caged animals over a period of two months indicates that they avoid exposure to body temperatures of more than 41° C. Nevertheless, lizards under apparently ideal conditions were recorded with temperatures of 42° C. immediately after they were shot, and on six occasions lizards captured alive had temperatures of 43° C. Although the lizards that were shot did not give any evidence of prolonged exposure resulting from fear of the collector, the noosed lizards assumed the usual state of tonic immobility attendant on the presence of danger. However, it did not appear probable that there had been time for any abnormal heat absorption. Until additional observations are possible, it seems advisable to consider 41° C. the maximum normal temperature tolerance. Desert iguanas taken near Indian Wells on the Colorado Desert reach the critical maximum at 47.5° C. (6 trials; min., 47° C.; max., 48° C.). A like number from Saltdale, a locality at a higher elevation on the Mojave Desert, under experimental conditions reached the critical maximum at 47° C. Three of the animals were again subjected to the same test and at the end of 30 minutes collapsed and died at 47° C. Only two tests for the so-called lethal temperature have been made, one based on an individual from the Mojave Desert and another from the Colorado Desert. The one from the cooler Mojave died at 50° C., the other at 50.5° C. The difference is doubtfully significant and probably not the result of climatic adaptation.

Crotaphytus wislizenii, Leopard Lizard. Only one individual was available for study. After repeated observations over a period of two weeks it became evident that this animal invari-

BRADFORD D. HOLLINGSWORTH

Chuckwallas (*Sauromalus ater*, formerly *S. obesus*) do not expose themselves to view until their body temperatures have risen sufficiently to insure an ability to escape a predator.

ably retreated to cover when lowering temperatures approached 23°C. Other observations did not yield conclusive data.

Sauromalus obesus, Chuckawalla. At 14° C. these animals are scarcely able to right themselves from a supine to normal position. At 21 ° C. slow but effectual locomotion is possible, while at 24° C. the fear response seems to be dulled, a distinct contrast to the condition in *Dipsosaurus* where fear and alertness seem to reach the normal pitch at this temperature. Fifteen observations were made on wild individuals obtained on the Mojave Desert in the course of a single cloudy day. Throughout the period, air temperature remained at 24° C., while the temperature in the crevices occupied by the animals was 25.5° C. Although all the individuals were discovered in rock crevices, none of the animals was more than halfway to the bottom of its retreat. Reluctance to appear in the open at what seem to be entirely tolerable conditions apparently endows these animals with an excellent safeguard against capture by predators; apparently chuckawallas do not expose themselves to view until their body temperatures have risen to the point where celerity of responses insures their ability to escape.

It was instructive to find that the lighter colored, but somewhat smaller individuals from the Colorado Desert absorbed heat more slowly than the black-and-dark-red color phases more characteristic of the cooler Mojave Desert. At maximum temperatures attainable under moderate thermal conditions, a large black and red individual reached a temperature 2° C. higher than that of smaller, lighter colored individuals. In spite of its darker color and more effective heat absorption, the larger lizard required a longer time to reach its ultimate thermal level. This is consonant with the change in surface area relative to the changed mass of an organism. The influence of color on rate of absorption can be determined to an exact degree only by the use of two series of lizards of different color but having identical surface areas and mass.

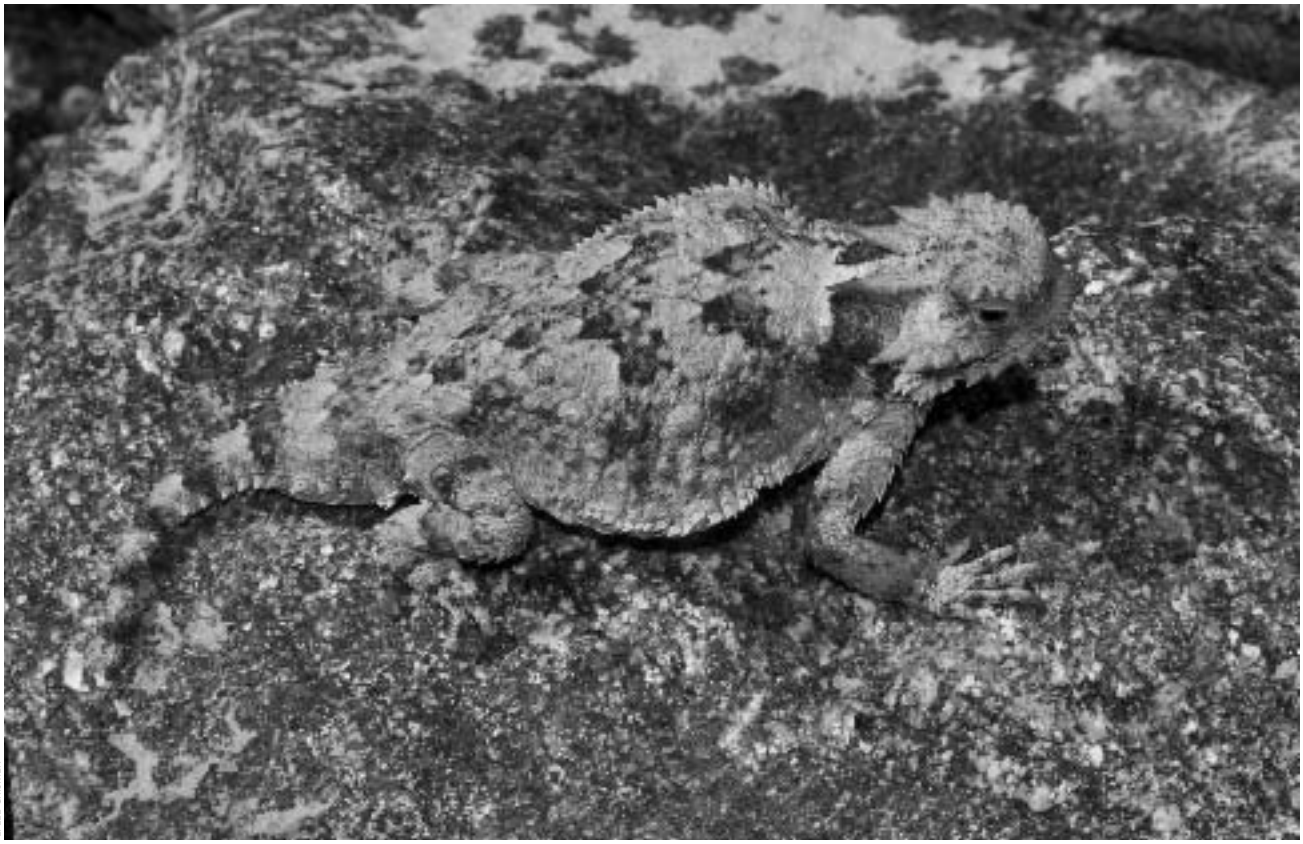
Chuckawallas should furnish an excellent source of information on the importance of color as a physiological adaptation versus its value as a means of concealment. The color variability (but not metachromatism) that is found within any one species of the horned lizard (*Phrynosoma*), fringe-footed lizard (*Uma*), and many snakes seems to be a device of primary importance in concealment. The same may be found true in the chuckawalla which displays a high degree of color variability in different localities, particularly in the Colorado Desert.

The darker coloration of the Mojave Desert form may reflect a need for greater heat absorption consonant with its larger size and the cooler climate of this higher desert. The various pattern phases represented in the warmer Colorado Desert are lighter colored on the body, although the head is nearly completely black. It is pure speculation, but it seems possible that such a pattern enables these Colorado Desert lizards to absorb heat rather rapidly when only the head is protruding from a crevice. On the other hand, the yellow coloration of the trunk would not absorb heat so rapidly as would the red and black body of the Mojave Desert form when these lizards venture forth into direct sunlight. Such a black and yellow pattern, therefore, may represent an evolutionary compromise. On the other hand, such a pattern can be interpreted as disruptive coloration. Klauber (1939) has pointed out that black rock or the dark areas resulting from shadows in a paler rock habitat may make it difficult to distinguish the body outline of these dusky colored lizards. Hence their coloration may be of protective value. It is noteworthy, however, that large diurnal lizards in all parts of the world tend to be dark colored. This is particularly true of the crocodilians, the larger monitors (*Varanus*), and of the larger iguanids (*Ctenosaura* and *Amblyrhynchus* for examples). It is not impossible that the heat-absorbing properties of dark skins are required to insure the intake of sufficient heat to permit these large poikilotherms to attain temperatures within the normal activity range.

To return to *Sauromalus obesus*, the average range for activity is 37.7° C. This figure was obtained from 25 observations which were made as the animals retreated to shade, and 24 as they retreated underground when shade temperatures became too high. The two series agree to within 0.2° C. The highest temperature recorded for voluntary tolerance was 42° C. The critical maximum appeared at 44.5° C. in one individual, at 49° C. in another, and in a third (under laboratory conditions) at 43.3° C. The reasons for the wide variations are not known. The putative lethal was found to be 50°-51° C. with only four trials, one of them conducted in the laboratory.

Phrynosoma sps., the Horned Lizards. Little difference in thermal preferences can be detected between the three southern California horned lizards, although, to judge by their preferred habitats, strong differences would be expected. One species, *Phrynosoma b. blainvillii*, is confined to the coastal areas and the higher semi-desert districts of the mountains. Another, *Phrynosoma p. platyrhinos*, has a wide geographic range that includes considerable temperature differences, and the third, *Phrynosoma m'callii*, is restricted to the warmer areas of the Colorado Desert. *P. p. platyrhinos* is found at elevations of 3000 feet, but it is also encountered in the Coachella Valley at sea level or slightly below, where, as at the mouth of the Box Canyon in Riverside County near Mecca, its range overlaps that of *P. m'callii*.

In view of the slight differences in heat economy and the considerable difference in temperature conditions in these habitats, it seems probable that the necessary accommodation to diverse climates is accomplished by means of habits. Coloration and neurological adjustments may also be involved, and it is



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Desert Horned Lizards (*Phrynosoma platyrhinos*) have a broad geographic range that includes varying temperature regimes.

noteworthy that both of the desert dwelling species are paler in coloration than the coastal form. A comparison of the averages of temperature adjustment at the most significant levels is shown below.

From these data it appears probable that a difference of thermal adjustment amounting to only 2° C. distinguishes the coastal species from *P. m'callii*, an inhabitant of the hottest desert areas. This thermal similarity was further emphasized by the observation that sand temperatures of 41° C. or more seemed equally effective in restraining the sand-burrowing impulse. When forced to submerge themselves, however, they all endured short exposures to temperatures as high as 43° C.

As temperatures became unbearable all three species submerged in the sand of their cages, and as the surface layers became hotter they pushed downward until a hard-pan at a depth of 75 to 80 mm. prevented them from penetrating deeper. Under these conditions, usually by 2 to 3 P.M., they would rush to the surface and retreat to the nearest shade, where by that time temperatures had moderated sufficiently to be endurable.

Phrynosoma m'callii displayed a greater tendency to crepuscular activity than either of the other species, sometimes remaining above ground for an hour or more after the others had retreated and temperatures in the late dusk had dropped to 29° C. Retreat below ground appeared to be due as much to the light conditions as to the compulsion exerted by a falling temperature.

One of the difficulties involved in obtaining thoroughly reliable thermal records for any given reaction is revealed by the inconsistent behavior of a single example selected at random from among a large number of similar instances. While attempting to obtain data on the minimum temperature at which *Phrynosoma m'callii* leaves the sand on first emergence in the morning, it was noted on one occasion that two individuals resting side by side under apparently identical conditions ultimately emerged at body temperatures respectively 22° and 36° C. Thus there was manifest a difference of 14° C. for a single, apparently spontaneous reaction. It should be emphasized that the lower temperature is well below the level usually tolerated, while the higher figure lies well within the range for normal activity and not far below the limit of voluntary tolerance to high temperature.

Arizona elegans occidentalis, Western Glossy Snake. Burrowing snakes are difficult creatures with which to work, and consequently there is little available information on the activities of this digging species. Although it is one of the commoner snakes collected while driving at night, in captivity it was secre-

	Retreat from cold	Activity range	Maximum voluntary tolerance	Number of observations
P. b. blainvillii	28.0° C	34.9° C	39.0° C	26
P. p. platyrhinos	29.0°	36.8°	39.0°	10
P. m'callii	29.3°	36.9°	41.0°	10

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Glossy Snakes (*Arizona elegans*) are burrowers; any surplus heat acquired during periods when active on the surface is rapidly lost by direct conduction when these animals burrow.

tive and seldom appeared above ground except for intervals of relatively short duration. Like any true burrowing snake, it seems capable of flowing into and out of the loose desert soil with very little locomotory difficulty. Surplus heat acquired during active periods on the surface is rapidly lost by direct conduction when these animals burrow.

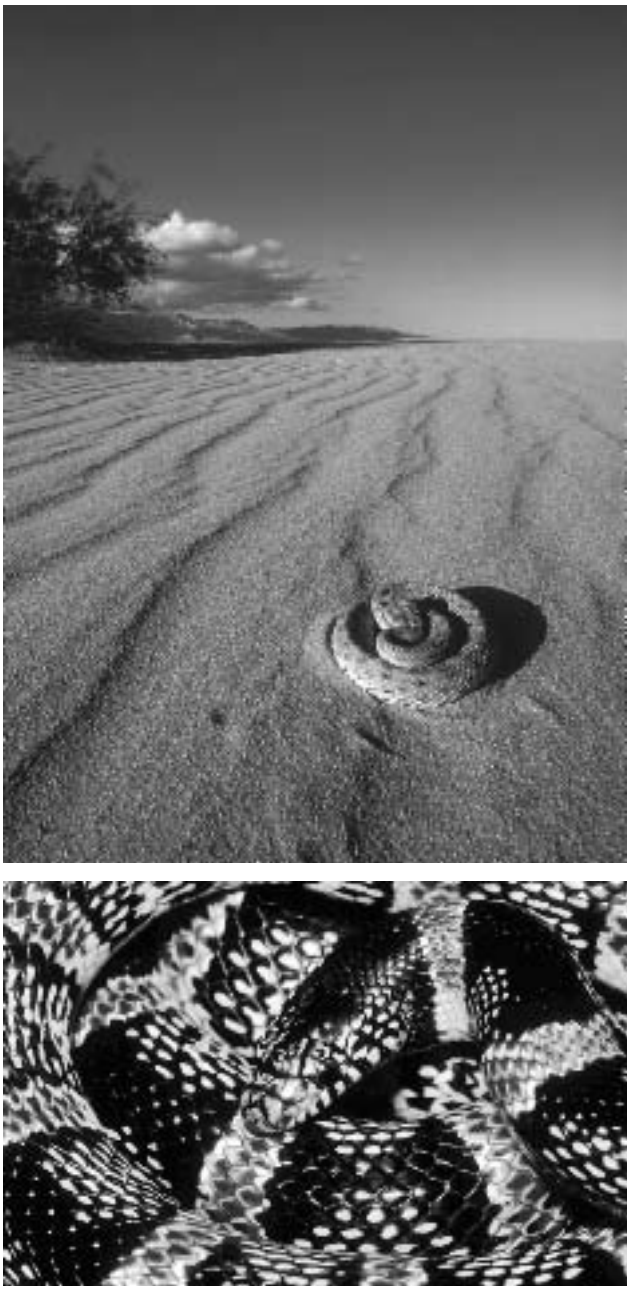
The lowest temperatures at which this species was observed above ground were 14° and 18° C. These appearances were exceptional, and surface activity was of very short duration, probably not much in excess of a few seconds. At 19°-20° C., appearances become more frequent, and it is probable that this constitutes a normal lower limit for voluntary surface activity. As stated previously, strong stimuli such as fright or those involved in sexual activities frequently result in modifications of other normal responses.

When glossy snakes were confined in the same cage with *Crotalus cerastes* and *Rhinocheilus lecontei* there were no marked differences in their responses to temperature. With respect to light, however, *C. cerastes* was more tolerant than the other two species. Apparently these three snakes are all relatively cold-tolerant reptiles. Klauber (1939) lists *C. cerastes* and *Rhinocheilus* as the snakes having the appearance of greatest tolerance to low temperatures, and we would include *Arizona* in the same category upon the basis of our observations.

One of the difficulties besetting the acquisition of exact thermal data is the ability of the burrowing snakes to glide into the soil with no preliminary warning of the approach of a change in behavior. On one occasion, as temperatures fell rapidly, eight of the burrowing snakes were moving about the cage shortly after dusk. As their disappearance was anticipated at air temperatures of 19°–20° C., and body temperatures were desired, the observer was ready to grasp the snakes as they started to descend into the soil. As frequently happened, there was almost simultaneous retreat, and before the snakes could be extricated some seconds' delay had occurred. Because they had already been immersed in what at the time were the warmer, deeper layers of the soil, and would be expected to yield erroneous data, the attempt was abandoned. However, a *C. cerastes* in the same cage, which retreated at the same time and was halfway down the mouth of its open burrow, was seized and the temperature recorded as 20° C. It is probable that the somewhat higher temperature represents heat absorption from the substratum, and that the other snakes would have shown the same temperature at the time of their departure.

Under laboratory conditions these snakes reached their critical maximum at 42, 42, 41, 41, 42, 43° C., mean 41.8° C. Putative lethal temperatures were 43°–44° C. (six observations).

Despite the normal avoidance of both light and high temperatures, these snakes occasionally bask on the surface of the ground in winter, and in summer a large gravid female was captured in Coachella Valley, July 7, 1940, at 8 A.M. in full sun. The day was cloudless and hot, probably well over 38° C. in the shade. To judge by the tracks in the sand, the snake had been



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Sidewinders (*Crotalus cerastes*) and Long-nosed Snakes (*Rhinocheilus lecontei*) are both relatively cold-tolerant, but the former is more tolerant of light than other nocturnally active snakes.

very active, presumably during the night and early morning, boring in and out of the ground near a large hummock of earth. It was probably seeking a suitable spot for oviposition. She deposited 23 eggs the following day, and these hatched after 68 days of incubation at room temperature, which fluctuated between 25° and 32° C. At eight days of age, the young were tested for the critical maximum and responded at 38°–39° C. All recovered but showed varying degrees of partial caudal paralysis. Thus the young appear to suffer from temperatures 3°–5° C. lower than those which would be fatal to the adults.

Crotalus atrox (*C. cinereous* auct.), Western Diamond Rattlesnake. Freshly captured individuals have been observed moving about at 14° C. but this was presumably the result of abnormal stimuli; activity at this low temperature may be ascribed to the presence of abnormal environmental factors. Even at 18° C. there is some activity, but it is limited in frequency, and it is not until temperatures of 27°–30° C. are encountered that the snakes are persistently active. A temperature of 39° C. was observed in the only test for the critical maximum, and this is probably somewhat lower than should be expected.

Discussion: As suggested earlier, one of the seemingly important requirements of reptiles is an effective extension of both their daily and seasonal hours of activity. This necessity constitutes a problem which is greatly accentuated in desert regions of the temperate zone….

The acquisition and maintenance of necessary body temperatures are the *sine qua non* of existence for terrestrial vertebrate ectotherms. All other activities requisite for survival of reptilian species seem ultimately to depend upon the maintenance of necessary body temperatures which makes this element one of basic importance. Successful predation by carnivorous reptiles is based on 'alertness and agility' and these attributes reach maximum efficiency at or near optimum temperatures. Even for the herbivorous types, the attainment of suitable temperatures is imperative, for they must also maintain high body temperatures if they are to function at maximum efficiency during the crucial moments when they must escape their enemies. "Survival of the fittest" among terrestrial reptiles would appear to be the survival of the warmest in those instances where other factors are equal. In other words, the most successful reptiles probably are those which, by means of their habits, are able to approach a state comparable to that attained by homiothermic animals….

Presumably the less adaptable reptiles have failed to survive in desert regions because of the rigorous climatic conditions. Conversely, relicts are more often found on islands and peninsulas owing to the relatively slight temperature fluctuations characteristic of maritime climates. Schmidt (1943) has recently discussed peninsular life and "paleopeninsulae," pointing out that, "The common faunal characteristic of the major peninsulas is their accumulation of peculiar forms of life, frequently primitive." It has often been hypothecated that insular and peninsular relicts survive because they are relieved of "competition with modern elements," or because "biotic pressures are reduced." On the other hand other authors have spoken of the "extraordinary congestion in species" on peninsulas. Can an abundance of species lead to diminution of competition?...

Many modem distributions possibly can be interpreted in terms of thermal and moisture requirements when these are better understood. It must be borne in mind that the principal climatic areas of today probably were in existence prior to the Pliocene. During the late Quaternary seasonal changes presumably approximated those of today. As the summer advances, the temperatures of the surface soils rise above the optimum during daylight hours, and most species included in the sand fauna, both invertebrates as well as vertebrates, burrow increasingly deeper. By so doing they follow the vertical drift of favorable temperatures. The resultant concentration or stratification of fauna in favorable thermal zones may be an important factor in the lives of burrowing reptiles, since it results in a concentration of the available food supply in a comparatively narrow thermal zone.

Summary and Conclusions: Twelve diurnal and seven nocturnal species of reptiles indigenous to the Southwest have been studied. Data derived from field observations, from animals in cages set up in the desert, and from supplementary laboratory investigations provide the basis for the following statements:

1. The reptiles under observation were voluntarily active only between the temperature extremes of 16° and 42° C. (cloacal temperatures). Thus the maximum voluntary thermal tolerances of reptiles are somewhat less than those reported for birds. Actually the ecological optimum or the mean for the "normal activity range," as defined herein, is somewhat lower than the normal temperature of many mammals. Consequently even the reptiles inhabiting one of the hottest regions in the world cannot be considered notably thermophilic.

2. Contrary to previous reports, nocturnal reptiles not only tolerate but prefer temperatures somewhat lower than those of diurnal reptiles. Provisionally the difference between mean critical thermal levels for diurnal arid nocturnal reptiles may be said to approximate 6° or 7° C.

3. Under captive conditions approximating those in their normal habitats the reptiles studied were able to avoid extensive temperature fluctuations. Particularly noteworthy in this respect was the ability of the sidewinder (*Crotalus cerastes*), while in a relatively inactive or quiescent state, to maintain its body temperature within the narrow limits of 31° and 32° C. The acuity of temperature discrimination in this species under such conditions is astonishing, more especially because the sidewinder proved to be one of the least stenothermic reptiles investigated. Individuals in an active state were noted with temperatures varying from 16° to 34.5° C.

4. Observations recorded for one lizard (*Sceloporus m. magister*) indicate that defecation is most frequent at body temperatures of 37° to 38° C. It is suggested that such temperatures are necessary before peristalsis is possible, although this same lizard commonly fed with the body temperature closer to 30° C. If such precise requirements are widespread among reptiles, it may account for the high mortality rate among captive reptiles in many zoological gardens where animals are maintained under conditions which prevent them from selecting preferred temperatures.

5. One of the notable facts is the close approximation of the maximum temperatures tolerated voluntarily and the critical maximum which immobilizes the animals. A difference of somewhat less than 6° C. between these levels is indicative of the tem-

perature hazards under which some of these animals would exist, were it not for concomitant adaptations, particularly in habits. The utter impossibility of prolonged activity in the full summer sunshine of the desert is clearly indicated by the black-bulb temperature of 87° C. observed as early as May.

6. It is suggested that reptilian relicts tend to survive on islands or peninsulas owing to the relatively slight temperature fluctuations characteristic of maritime climates. For similar reasons such relicts would tend to survive in tropical regions rather than in continental climates of temperate zones where a higher degree of adaptability to temperature fluctuations would be a prerequisite.

7. A notable characteristic of desert reptiles is the rapidity with which these animals absorb heat. Changes are so rapid as to exceed those of the thermometer in the case of small lizards (*Uta stansburiana*). The rapid changes in reptilian temperatures seem to be due primarily to: (1) their lack of effective surface insulation; (2) their lack of hypodermal adipose tissue; (3) their pigmentation, particularly the melanin; and (4) in the smaller species, to the relatively small volume in proportion to the large heat-conducting surface.

8. Since an important factor in the thermal adjustment of desert reptiles is the surface-mass ratio of the body, it follows that smaller lizards are capable of utilizing very short intervals of favorable exposures (assuming other factors to be approximately equal). In contrast, larger lizards, under favorable conditions of heat, will require more time in which to reach the optimum, but their activities at higher temperatures will be less restricted than those of smaller individuals or species.

9. Although large lizards exposed to solar radiation or to the warm substratum attain temperatures of maximum toleration more slowly (and also dissipate heat more slowly) than small lizards, there is no apparent correlation between body size and the maximum temperature voluntarily tolerated. Even though the largest diurnal lizard used in these experiments (*Sauromalus obesus*) withstood a body temperature of 42° C. of its own volition, this maximum was closely approached by a much smaller diurnal lizard (*Phrynosoma m'callii*) that voluntarily tolerated 41° C. The data for nocturnal reptiles are not so extensive, but preliminary investigations demonstrate a lower voluntary tolerance.

10. It is apparent that for diurnal lizards the effect of color change (that is, the tint or shade rather than the hue) operates to provide an extension of time at marginal thermal levels, but the data assembled in these preliminary investigations throw little light on the relative merits of protective coloration versus physiological adaptation. However, a consideration of the size, pattern, and coloration of *Sauromalus obesus* in various regions suggests that some patterns may be interpreted in terms of habits, and that an evolutionary compromise may exist when antagonistic forces are involved.

11. Thermotaxis through behavior is one of the outstanding characteristics of desert reptiles. Body temperatures within the normal activity range are attained principally (1) by selecting positions in or on soil, or rock, where heat through direct conduction can be absorbed, or (2) by basking, with all or only part of the body exposed, to sources of solar heat. Conversely temperatures above the critical maximum are avoided (1) by retreating to cooler depths, in the ground (by burrowing or in preempted burrows), in rock crevices, or beneath insulating material, (2) or by respiratory cooling under extreme conditions.

12. Because the activities necessary for the survival of both the species and the individual are dependent upon the acquisition and maintenance of suitable body temperatures, thermoregulation by means of behavior may be considered an element of basic importance in the existence and evolution of reptiles in continental climates.

L. LEE GRISMER

Rapid changes in reptilian body temperatures, especially in smaller species like the Side-blotched Lizard (*Uta stansburiana*) are attributable, at least in large part, to the relatively small volume in proportion to the large heat-conducting surface.

Artwork by David M. Dennis from the cover of the 1974 reprint of this classic study.

BIOGRAPHICAL SKETCH

Raymond Bridgman Cowles (1896–1975) was born in South Africa, but educated in the United States, receiving a doctorate from Cornell in 1928. He spent most of his professional life at UCLA, where he started out as an instructor in 1929 and became a full professor in 1947. Important work, besides the paper covered here, includes a 1952 paper in *Science* on infrared receptors of pit vipers and two books, *Zulu Journal: Field Notes of a Naturalist in South Africa* (1959) and *Desert Journal: A Naturalist Reflects on Arid California* (1977). He retired in 1963 and died in 1975.[1]

Raymond Cowles noosing a lizard. Photograph courtesy of Kraig Adler.

Charles Mitchill Bogert (1908–1992) was born in Colorado and studied with Raymond Cowles at UCLA, receiving his Master's degree in 1936. He then joined the American Museum of Natural History, where he eventually became the curator and chairman of the herpetology department. His collecting work took him to many parts of the world, and Mexico was a particular favorite. In 1946, he became the first president of the Herpetologists' League, one of many posts he held for the major American herpetological societies. Besides the thermoregulation studies for which he is most famous, Bogert also published a 1956 monograph with Rafael Martín del Campo, *The Gila Monster and Its Allies*, which was reprinted by SSAR in 1993, and *Sounds of North American Frogs*, released by Folkways Records in 1958. He died in 1992.[2]

Charles Bogert photographing a Gila Monster (*Heloderma suspectum*). Photograph courtesy of Kraig Adler.

[1] For more information, see http://www.wku.edu/~smithch/chronob/COWL1896.htm or *Copeia* 1977:611–612.

[2] For more information, see http://www.wku.edu/~smithch/chronob/BOGE1908.htm or *Copeia* 1993:264–266.

COMMENTARIES

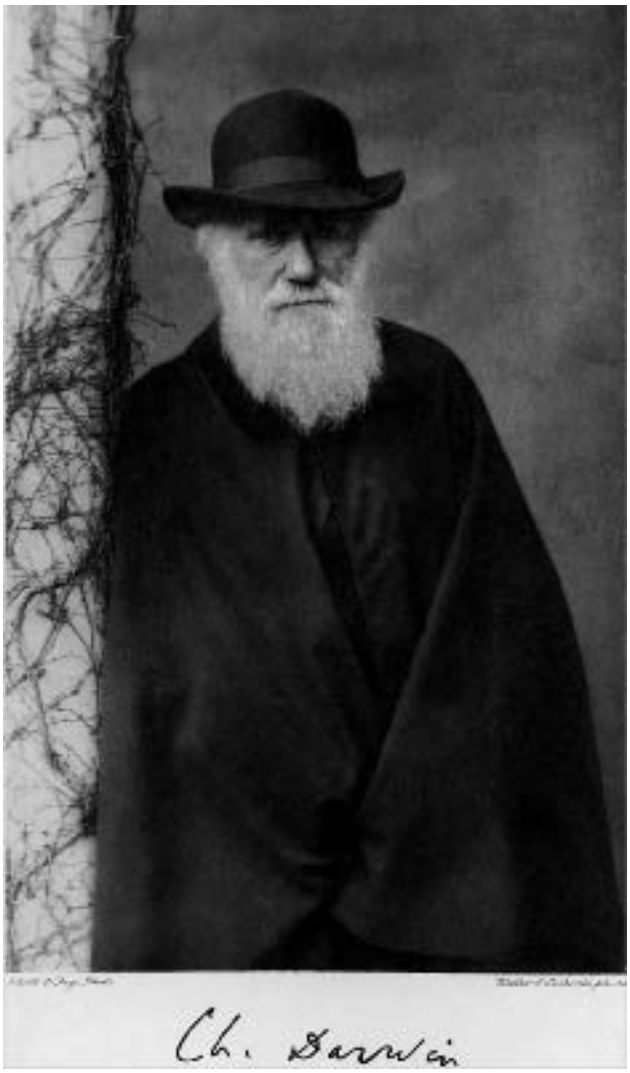
Intelligent Design?

Gad Perry

Department of Range, Wildlife and Fisheries Management
Texas Tech University, Lubbock, Texas

Charles Darwin was not looking for trouble when he set off on the Beagle in 1831. He most definitely could not have imagined that, more than 150 years later and a third of the globe away, judges in one of the world's most advanced nations would still be handing down rulings on his findings. Yet here we are, and, as I write this in late December 2005, a federal judge once again has had to inform the American public that the theory of evolution is the only scientific explanation we have for how life arose on this planet. The case in point involved the school board of Dover, Pennsylvania, which in late 2004 adopted a policy requiring students in science classes to be told about "intelligent design" (ID) as "an explanation of the origin of life" (the text of the statement can be found at http://www.cnn.com/2005/LAW/12/20/intelligent.design.ap/). In striking down this requirement, U.S. District Judge John E. Jones III, a Republican appointed by President Bush, said that the school board's decision was not just unconstitutional but also dishonest: "We find that the secular purposes claimed by the Board amount to a pretext for the Board's real purpose, which was to promote religion in the public school classroom." He also had some strong words for the members of the school board who created the policy, all eight of whom subsequently lost their positions in recent elections and were replaced by board members who promised to eliminate the policy. He called the effort to force ID on the students a "breathtaking inanity" and pointed out that "It is ironic that several of these individuals, who so staunchly and proudly touted their religious convictions in public, would time and again lie to cover their tracks and disguise the real purpose behind the ID policy" (the text of the decision can be found at http://www.pamd.uscourts.gov/kitzmiller/kitzmiller_342.pdf).

Alas, that is not likely to be the end of the ongoing battle to remove the teaching of evolution from the nation's science curricula, preferably to be replaced by material perceived to be more compatible with Christian views of a particular flavor. Proponents of ID correctly point out that evolutionary theory does not explain everything. The struck-down Dover statement, for example, says: "Gaps in the theory exist for which there is no evidence." In as much as our knowledge of anything is incomplete, they are absolutely correct. However, the underlying problem appears to be that many religious people in the U.S. believe that accepting evolution somehow requires them to give up their faith. The theory of evolution does make statements about how life evolved once it appeared on Earth, and these statements now have extensive support from biology, geology, and other fields of science. They are not consistent with a literal interpretation of the biblical creation story, but neither are parts of physics, astronomy, geology, and other sciences. Nonetheless, science has nothing to say about whether or not any particular deity exists, and evolutionary theory does not make claims about the ultimate source of life. As stated by the recently-deceased Pope John Paul II, one can be a Christian and accept evolution: No inherent contradiction exists between the two. In fact, many believers see no problem accepting evolution, and many scientists are religious.



Charles Darwin is often villified by those claiming evolution cannot be true, and his theories are often disparaged by critics who pejoratively call them "Darwinism," suggesting that an acceptance of evolution is comparable to a personality cult.

"As a Christian, a trained engineer and scientist, and a professor at Emory University, I am embarrassed by … [attempts] to censor and distort the education of Georgia's students," said former President Jimmy Carter, a Baptist and Nobel prize winner, in 2004 in response to suggestions that the word "evolution" should be banned from the state's curriculum. Additional information can be found at the White House web site (http://www.whitehouse.gov/history/presidents/jc39.html).

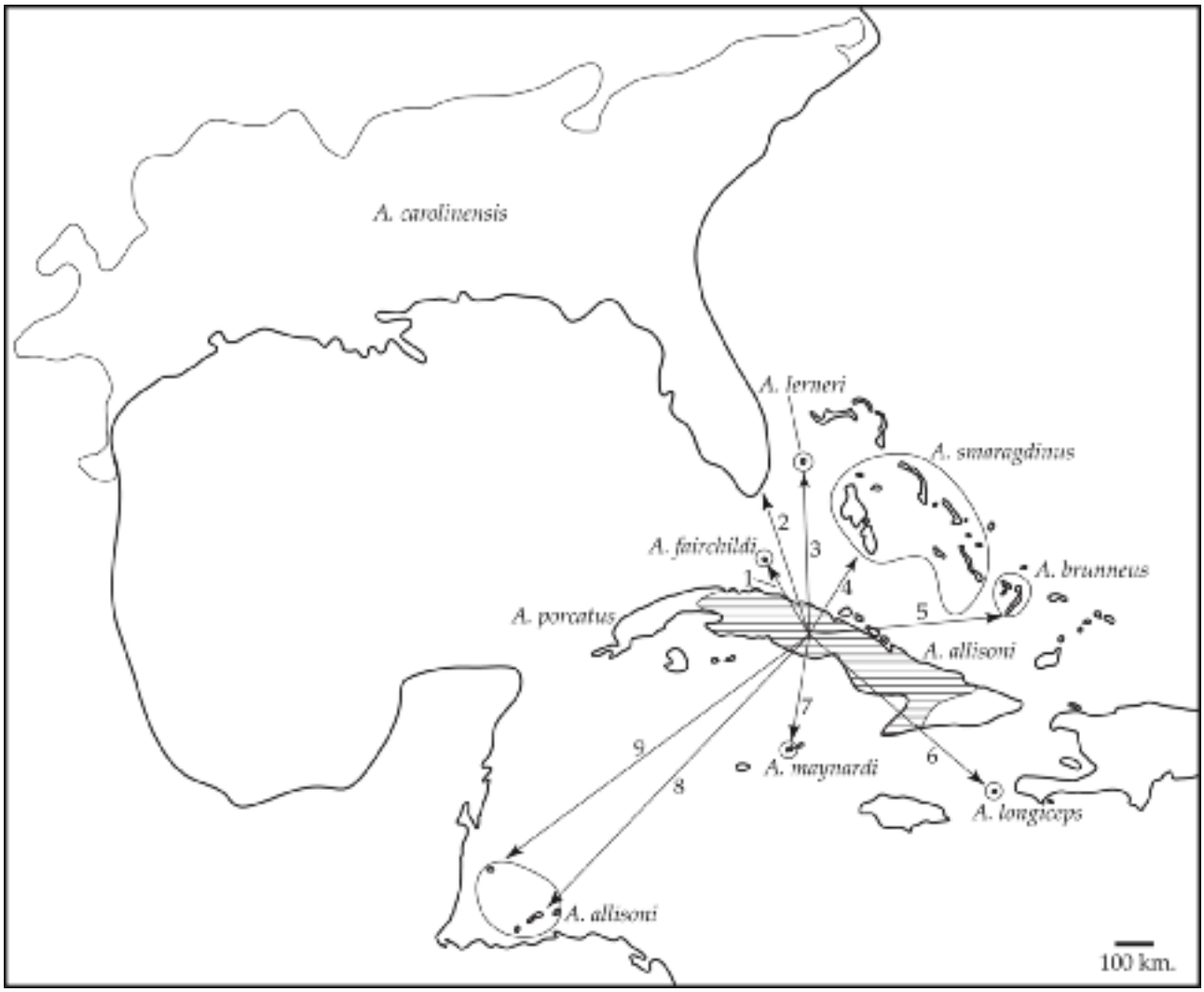
Michelangelo's Sistine Chapel illustrates the negative consequences of curiosity. The church in Michelangelo's time, like many authoritarian regimes, very actively stifled any free-thinking, believing that curiosity would foster doubts and lead to inquiries, all of which are threatening to the status-quo.

What is ID? At heart, it claims that biological complexity — proponents often cite processes such as blood clotting, which rely on multiple biochemical pathways — shows that life could not have evolved, but must rather have been formed by an unnamed intelligent designer. In Pennsylvania, Judge Jones complained about the "striking ignorance" of the education board regarding the underpinnings of ID, but that does not necessarily discredit the concept. However, Judge Jones also had some clear words about the underlying scientific merit. ID is "not science," and "the fact that a scientific theory cannot yet render an explanation on every point should not be used as a pretext to thrust an untestable alternative hypothesis grounded in religion into the science classroom or to misrepresent well-established scientific propositions." In fact, he ruled that ID is "creationism relabeled." ID cannot be science primarily because it does not provide any means for scientists to test it. The few scientists who advocate ID have been unable to provide scientifically valid ways to evaluate their idea, and have consequently yet to receive external support for such work or publish anything in the peer-reviewed scientific literature. Moreover, let's assume for a moment that ID proponents are correct and evolutionary theory is too weak to hold water. The scientific method would require us to seek an alternative, but the Judge pointed out that the argument made by ID proponents is "at bottom premised upon a false dichotomy, namely, that to the extent evolutionary theory is discredited, ID is confirmed."

OK, ID is not science. Why have scientists throughout the world long accepted evolution as the cornerstone of all biological sciences? To appeal to scientists, an explanation has to have predictive value. One must be able to make statements such as: "*If* I am correct about the nature of gravity *then* this pen will drop as soon as I let go of it." Only a single case in which the pen drifts up to the ceiling disproves our hypothesis, but no matter how many times it falls, the possibility always remains that *next* time, it will do something different. That is why scientists should never claim to have proven anything. Still, we have now dropped enough items and watched them crash to the floor that no sane person will step off the roof with the hope of floating up. Gravity has so much predictive power that we now call it a theory and take it for granted, even though physicists still do not understand *why* it works.

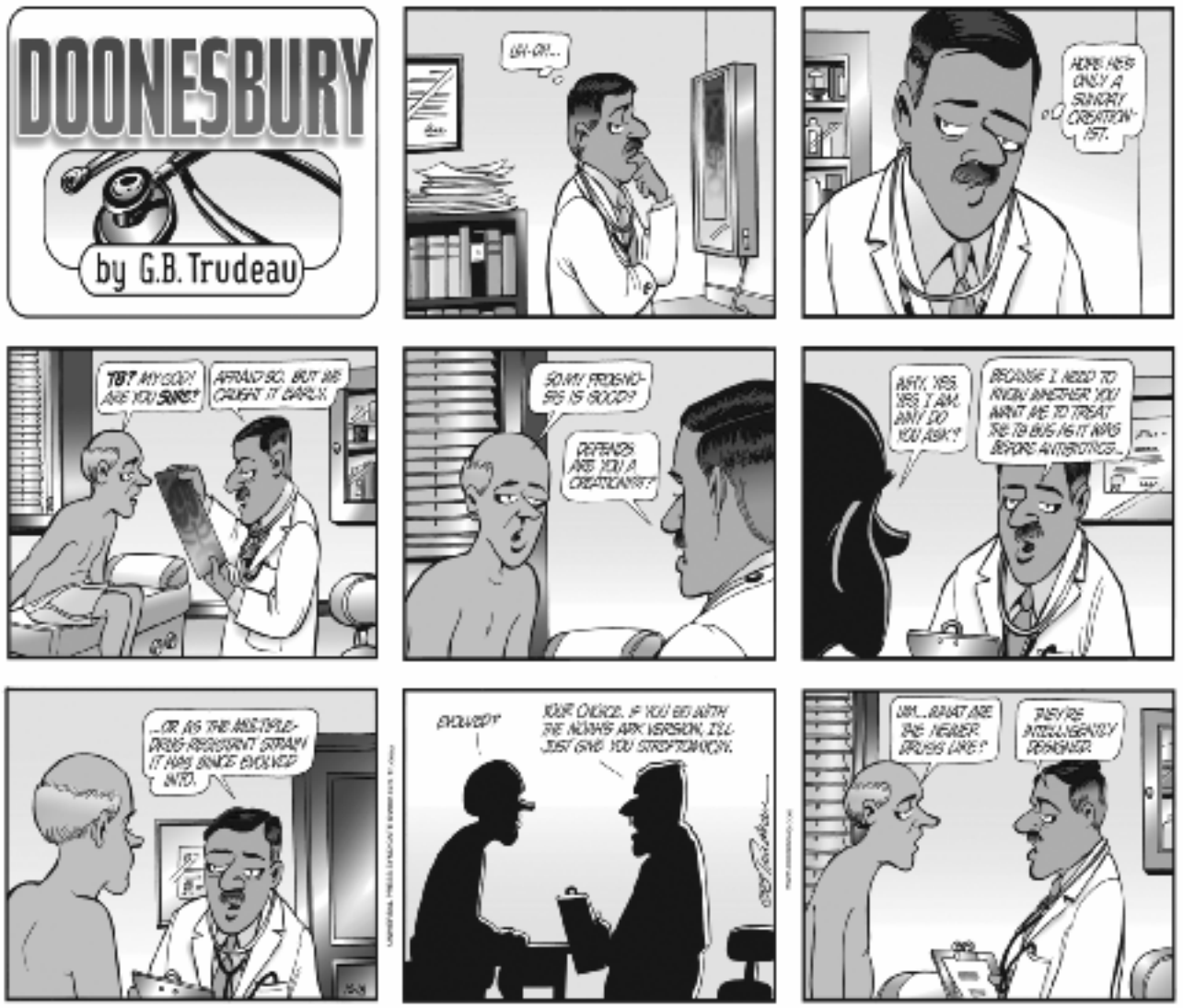
Our understanding of evolution also allows us to make testable predictions about the world around us. For example, a single solid case in which a fossil of a mammal is found in a layer preceding the evolution of fish would refute our understanding of the process, because fish are thought to be ancestral to mam-

This series of "family trees" shows how natural selection has affected anoles on the islands of the Greater Antilles. **A.** When only physical characteristics are considered, species cluster according to ecomorph class (a descriptive suite of characters that reflects an animal's lifestyle or niche) regardless of geographic affinities. Letters indicate the islands on which a species is found (C = Cuba; H = Hispaniola; J = Jamaica; P = Puerto Rico). **B.** In sharp contrast with A., this tree, which was generated using molecular data (DNA sequences), indicates frequent transitions among ecomorph classes and a much stronger correlation between close relationships and geographic affinities. In other words, species found on the same island are much more likely to be closely related than species on different islands that might share very similar appearances as a consequence of being in the same ecomorph class. This example of how evolutionary methods can shed insights on ecological relationships was adapted from Losos et al. (1998. *Science* 279: 2115–2118).



Evolutionary studies have confirmed Cuba as the origin of all species in the *Anolis carolinensis* group (top); adapted from Glor et al. (2005. *Molecular Ecology* 14: 2419–2432). Most dispersal routes follow prevailing winds and currents; a notable exception is *A. longiceps* on Navassa Island (left; no. 6 on the map), which is to the southeast of Cuba. Over-water dispersal of the ancestors of *A. longiceps* was presumably facilitated by the counter-clockwise winds associated with hurricanes (Powell. 1999. *Caribbean Journal of Science* 35: 1–13).

mals. In fact, evolutionary biologists predicted the evolution of drug-resistant germs and pesticide-resistant insects. Both are large and well-publicized problems now, especially with the prevalence of drug-resistant diseases such as tuberculosis being on the rise. Evolutionary biologists also were the first to point out that a disease such as avian flu, that currently attacks birds in Asia, could easily evolve into a pandemic killing many millions of people all over the world — a contingency many countries, including the U.S., are investing billions of dollars to address. Evolutionary biologists made predictions about the mechanisms by which evolution proceeds long before the tools for studying evolutionary developmental biology were available to test them. Cutting-edge research from recent years has shown how different-looking morphological structures could evolve from similar underlying genetic building blocks. Scientists used to think that eyes had evolved many times, giving rise to the different structures shown by insects and mammals, for example. Recent discoveries have identified a single gene, called Pax-6, which is involved in the formation of eyes in creatures as diverse as fruit flies, squid, and humans. Apparently, all modern eyes, no matter how different-looking, have evolved from a primitive



Understanding evolution can have important practical applications. Doonesbury © 2005 G.B. Trudeau. Reprinted with permission of Universal Press Syndicate. All rights reserved.

organ found in a shared ancestor. As one final demonstration of its utility, an understanding of evolutionary processes allows us to use DNA to determine paternity, identify bodies, and assign blame in criminal cases.

For those of us engaged in conservation, an understanding of evolution is especially important. "Everybody knows" small populations are at risk, but evolutionary biology explains why, and further predicts how fast they might decline. We all recognize that habitat fragmentation is undesirable, but only because evolutionary theory allows us to analyze the potential genetic consequences. Without the concept of coevolution, how would we understand the strong dependence some plants have on particular pollinators, or why closely related species of parasites often infect closely related hosts? Evolutionary theory also tells us that invasive species are going to adapt to their novel environments and become even more problematic, something managers have to know when designing responses to that problem. Finally, evolution is responsible for the many species of iguanas and other insular species in the Caribbean, and an understanding of DNA and the varying rates at which different kinds of DNA evolve allows us to identify unique populations deserving of extra protection.

The now-defeated Dover board defined a theory as "a well-tested explanation that unifies a broad range of observations." By every measure available to us, evolution is not "just a theory" — as one so often hears it disparagingly called — but is instead an extremely robust and successful theory whose predictive value has repeatedly been demonstrated. Of course, there are many things we do not yet know. As a leading proponent of ID pointed out after the Pennsylvania ruling, "A thousand opinions by a court that a particular scientific theory is invalid will not make that scientific theory invalid … It is going to be up to the scientists who are going to continue to do research in their labs that will ultimately determine that." Some details of evolutionary theory will doubtlessly need to be reformulated as more information comes in — for that's how science works. The time has come for religious zealots to leave their beliefs outside the science classroom, which is properly devoted to studying natural explanations of the phenomena that rule our lives. Evolutionary theory is unlikely to be replaced any time soon.

We need a National Reptile and National Amphibian[1]

J. Whitfield Gibbons

Savannah River Ecology Lab, Aiken, South Carolina

We need two new symbols in America — a national reptile and a national amphibian. For the reptile, I nominate the garter snake. For the amphibian, I propose the leopard frog. Together they would symbolically represent America's commitment to our natural heritage of native animals, including the reptiles and amphibians, the herpetofauna. Herpetofauna for the most part are not game species and are unfamiliar to most people. Also a few can be dangerous when they defend themselves. But they are part of our natural environments and deserve our respect and protection. Designating representatives that everyone in America can be as familiar with as the bald eagle would go a long way toward shifting attitudes positively toward our native, nongame wildlife.

A mechanism for choosing a national reptile and amphibian has already been set up through Partners in Amphibian and Reptile Conservation (PARC). The national steering committee could readily set up a discussion of the selection process on their listserve. Membership to PARC is free and access to the PARC Web site (www.parcplace.org) is open to anyone. The final choice of the national reptile and amphibian could be done by a Web site vote, as was done recently in Illinois. In that election, the eastern tiger salamander was chosen as the state amphibian and the painted turtle became the state reptile. For the national reptile and amphibian, after the PARC Web site election, the national steering committee would begin the political process of getting approval through Congress, a final step to make it official.

Every state has an officially recognized bird, flower, and tree. Thirty-five have a state mammal. More than half have a state insect. All are animals or plants that are special in some way to the state. An official state organism presumably represents the natural or cultural heritage of the state (but keep reading for some puzzling exceptions). We should celebrate our native wildlife on a national scale. This includes reptiles and amphibians.

The environmental sentiment of the country has developed to the point that we recognize that birds, mammals, trees, and flowers are not the only important natural resources in a region, state, or nation. Every state should have an official reptile, such as a turtle, snake, or lizard, and an amphibian, a frog or salamander. So should the nation.

Why should nongame, noncommercial animals get this kind of attention? Because when people feel something belongs to them, their concern for its welfare increases. Officially recog-

[1] Reprinted with permission by the author and Partners in Amphibian & Reptile Conservation (http://www.parcplace.org/).

BRIAN EDMOND

A Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) from Holt County, Missouri. Some type of garter snake occurs in every one of the 48 continguous states.

nized national species would enhance awareness of the natural heritage of our country and in the case of herpetofauna bring attention to a beleaguered group of animals.

Selecting a national reptile and amphibian may stir debate among herpetologists, members of PARC, and others. Although some states have shown a creative and progressive spirit in promoting native animals as symbols of their natural heritage, many state plants and animals surprisingly are not native species. Choosing an introduced species to represent one's state does not support our natural heritage. Nonetheless, 11 states have selected the European honeybee as their official insect.

Picking nonnative species does not stop with honeybees. South Dakota's bird is the Chinese ring-necked pheasant. For state mammals Missouri has a mule and five states have the horse, neither of which is native to the United States. Alabama may hold the record for the most perplexing change in a state species, changing its state flower from the native and gorgeous goldenrod (which contrary to conventional wisdom does not cause hay fever) to the camellia, an East Asian import.

But garter snakes and leopard frogs are as native as you can get, occurring in every one of the 48 contiguous states. It's true that no single species of reptile or amphibian is found in all of the states; so quibblers may point out that the species of garter snakes and leopard frogs found in Alabama are not the same ones as those found in Arizona. Nonetheless, each represents a group of closely related, recognizable species. The fact that no species of garter snake or leopard frog occurs naturally in Hawaii should not be a concern in the debate about how to select a national animal, because neither does the bald eagle.

SUZANNE L. COLLINS, CNAH

Southern Leopard Frogs (*Rana sphenocephala*) are one in a complex of related species found throughout the continental United State.

BOOK REVIEW

Ecology and Evolution in the Tropics

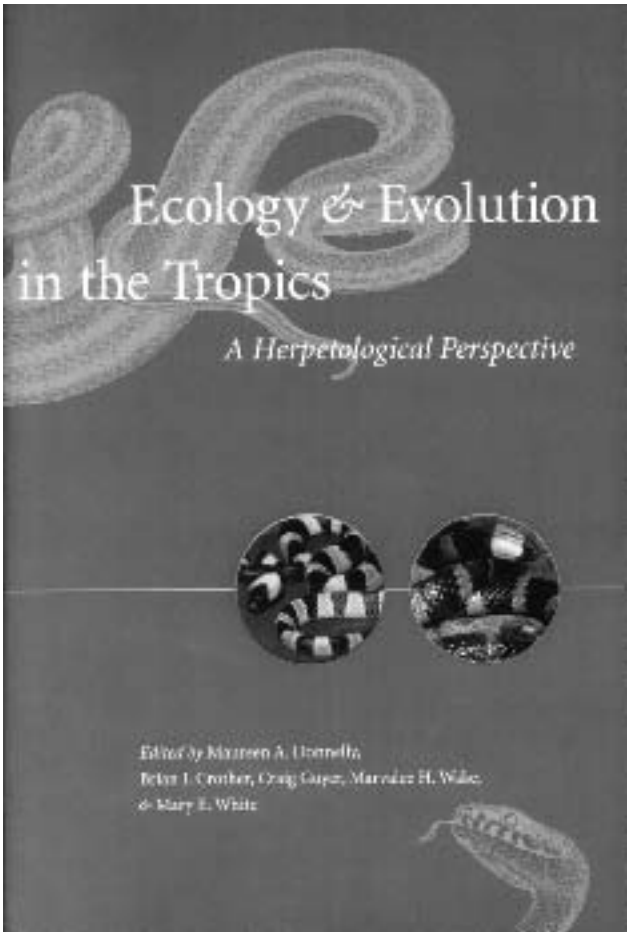
Donnelly, M. A., B. I. Crother, C. Guyer, M. H. Wake, and M. E. White (eds.). 2005. *Ecology & Evolution in the Tropics: A Herpetological Perspective*. The University of Chicago Press, Chicago, Illinois. 675 pp. Softcover. ISBN 0-226-15658-3. $45.00 (hardcover also available for $95.00).[1]

This edited volume contains a short foreword by Luis D. Gómez dedicating this compendium to Jay M. Savage (author of the monumental 2002 book: *The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas*), a brief preface acknowledging a host of contributors and reviewers, 18 separately authored chapters organized into two sections ("Part I: Evolution and Biogeography" and "Part II: Ecology, Biogeography, and Faunal Studies"), followed by a 65-page listing of references, affiliations of contributing authors, and extensive indices to subjects and taxa.

Although typically organized around a central theme, collections of contributed papers often suffer from deficiencies in focus that might be inevitable in many instances. In this instance, the individual chapters often provide extensive, useful, and timely information, but an almost total lack of cohesion and continuity leaves the reader feeling that they might as well have appeared separately in scientific journals. Only the connection of many of the contributors to Jay Savage (whose publications and interests were as diverse as this collection) and a general tropical theme unite them.

However, even the "tropical" theme so prominently featured in the title is misleading (might this have been imposed by the publisher in order to entice a more diverse readership?). Only a few systematic chapters address taxa found north of Costa Rica, only one (on taxonomic theory) is widely applicable, only one (on evolution of anoles assigned to the genus *Norops*) touches on the West Indies, and only three (on higher-level snake phylogeny, elapid relationships, and long-term frog monitoring by local people in Papua New Guinea) focus largely on areas outside the Neotropics. The title promised a much broader overview.

Consequently, the value of this volume must be evaluated on the basis of its individual parts. These vary from the theoretical to practical and highly technical to readable and entertaining. All are professionally written and edited, and adequately illustrated (although the volume cries out for more illustrations of especially the more unfamiliar taxa discussed in many chapters). However, many are so narrow in scope that few readers will find more than a couple of chapters applicable to their own interests.



Part I begins with Arnold Kluge proposing a new system of classification, which he illustrates by using eublepharid geckos. His rankless hierarchy of names effectively reflects phylogenetic relationships and is undoubtedly superior to traditional Linnaean nomenclature in doing so. Whether its utility in this context will lead to wide acceptance remains to be seen. Chapter 2, by Marvalee Wake, Gabriela Parra-Olea, and Judy Sheen, examines phylogenetic relationships in Central American caecilians. Although data generated by using various techniques have yet to establish an unambiguous phylogeny for these poorly known fossorial amphibians, current data have shed new light on evolutionary patterns of reproductive modes. David Wake, in Chapter 3, uses phylogenetic and distributional information to infer how Costa Rican salamanders radiated to fill their current niches. Wake concludes his chapter with a very timely discussion of amphibian declines in Costa Rica. Chapter 4, by Ronald Heyer, Rafael de Sá, and Sarah Muller, addresses conflicting hypotheses seeking to explain the distribution of *Leptodactylus silvanimbus*, a

[1] This review is being published simultaneously in the *Bulletin of the Chicago Herpetological Society*.

frog found only in the cloud forests of Honduras. The authors conclude that the species is a relict and has no close relationships with any other Middle American forms. Shyh-Hwang Chen, in Chapter 5, uses chromosomal data to elucidate historical relationships in two groups of *Eleutherodactylus* frogs from Central America. In Chapter 6, Sharon Emerson examines the physiological basis of sexual dimorphism in frogs. The next two chapters deal with snake phylogeny. Chapter 7, by Mary White, Maria Kelly-Smith, and Brian Crother, examines the origins of snakes, whereas Chapter 8, by the late Joseph Slowinski and Robin Lawson, takes a narrower view by using molecular data to elucidate relationships among elapids. The last chapter in this section, by Harry Greene and Roy McDiarmid, honors Alfred Russel Wallace and Jay Savage for their contributions to our understanding of venomous snake mimicry. For both its historical value and well-written evaluations of mimicry systems, this may be the most broadly appealing and even entertaining contribution in the entire volume. The content entices even non-snake biologists with its potentially wider applications, and the very subject is so innately fascinating that any biologist, professional or amateur, will be entranced.

Part II begins with Karen Lips using a detailed examination of a single breeding season of the recently described, leaf-breeding frog, *Hyla calypsa*, to evaluate reproductive modes in tropical anurans. In Chapters 11 and 12, Craig Guyer and Maureen Donnelly explore interspecific competition among co-occurring hylid frogs at a reproductive site in Costa Rica and Norman Scott and Luz Aquino describe foraging strategies of frogs in the Gran Chaco of Paraguay. I love the title of the latter, "It's a Frog-Eat-Frog World in the Paraguayan Chaco," and I very much appreciate the color plates that illustrated a few of the species mentioned (as indicated previously, many of the other chapters would have benefited from doing the same). David Bickford, in Chapter 13, uses a study in Papua New Guinea to describe how an integrated conservation and development project can be used to answer scientific questions about frog diversity and conservation. Although narrowly focused, this contribution has broad applicability for similar projects that might be designed and implemented in developing tropical nations throughout the world. In Chapter 14, Kirsten Nicholson focuses on mainland taxa to explore the origins and radiation of anoles placed in the genus *Norops*. Similarly, in Chapter 15, Steven Werman used phylogenies for Neotropical pitvipers to infer a most likely historical scenario. Chapters 16 and 17 present faunal inventories by Roy

JOSEPH BURGESS

The Knight Anole (*Anolis equestris*), mistakenly attributed to South America, was used as an outgroup in the analysis of relationships among anoles assigned to the genus *Norops*.

JAMES R. MCCRANIE

Leptodactylus silvanimbus, found only in the cloud forests of Honduras, is the subject of one of the very few chapters addressing Neotropical species found north of Costa Rica.

McDiarmid and Jay Savage (of the Osa Peninsula in Costa Rica) and by Maureen Donnelly, Megan Chen, and Graham Watkins (of the Iwokrama Forest in Guyana). The volume's final chapter presents an overview of the presumably ancient herpetofaunal diversity of Guyanan tepuis, odd, elevated geological formations that form habitat islands within a broad region.

Because of Jay Savage's vast body of work and the fact that contributors are linked to him by academic genealogy or collaboration, a few common ideological threads are apparent. Both detailed phylogenetic studies and examinations of natural history traits are of tremendous value in expanding our understanding of amphibians and reptiles. Combining them is less common, of even greater value, and some of the chapters in this volume are testament to Savage's example for integrated studies using various methods once thought to be independent or even mutually exclusive of one another. On the other hand, formal recognition of the genus *Norops*, for example, although advocated by many scientists who study mainland anoles, is less enthusiastically received by others who work primarily in the West Indies. Similarly, historical biogeographies that emphasize vicariance versus over-water dispersal for the origins of many West Indian species are less than universally accepted. Presenting these without discussion of alternative hypotheses does the uninformed reader a disservice by implying a concordance that doesn't exist.

So, who should buy (or at least read) this book? Professional herpetologists will certainly find at least a few chapters of interest, conservation biologists should definitely read the chapter by David Bickford on using local resources when implementing conservation projects, and everyone should read Harry Greene and Roy McDiarmid's chapter on mimicry. Although relatively inexpensive by modern standards, I doubt that very many non-professionals will find enough of interest to justify purchasing the volume. Instead, they should prevail on friends who make the plunge or on the nearest university library to read the selections applicable to their own interests.

Robert Powell
Avila University
Kansas City, Missouri

CONSERVATION RESEARCH REPORTS

Erosion Netting a Threat to Snakes and Lizards

Erosion netting consists of woven mats of seed-implanted straw or jute layered between two sheets of netting. The most commonly used size of netting is 20 x 20 mm. Although supposedly photodegradable, netting may remain intact after as many as eight years. WALLEY ET AL. (2005. *Journal of Kansas Herpetology* (16): 26–28) documented the threat of this netting to lizards and snakes, which become entrapped in it. Entangled animals may perish from heat exposure or starvation or suffer injuries that might prove fatal due to constriction of vital organs or infection.

GARY CASPER

Butler's Gartersnake (*Thamnophis butleri*) from Ozaukee County, Wisconsin showing injuries from erosion netting.

CITES-listed Lizards in the French Pet Trade

During the 1990s, over 100,000 CITES-listed lizards were imported by the French pet trade, with the numbers per year increasing dramatically during the last half of the decade. Reporting results of a study funded by WWF-France, AFFRE ET AL. (2005. *Herpetological Review* 36:133–137) examined the data pertaining to imports of CITES-listed lizard into France, which is a growing distribution center for reptilian pets in Europe. The top five species imported during the 1990s were *Iguana iguana* (over 40,000 individuals, mostly from the United States), *Phelsuma madagascariensis* (almost 6000 individuals, almost all from Madagascar), *Uromastyx acanthinura* (over 5000 individuals, mostly from Mali), *Chamaeleo senegalensis* (over 5000 individuals, nearly all from Senegal), and *Varanus exanthematicus* (nearly 4000 individuals, largely from Togo). Data indicated that increasing numbers of imported CITES-listed lizards were captive-bred, reflecting the farming of Green Iguanas (*I. iguana*) in Central and northern South America. These data, however, are misleading in regard to other listed species, which are almost always wild-caught, as are many non-listed species for which data are lacking and about the status of which we know essentially nothing.

JOHN BINNS

During the 1990s, nearly 4000 Savannah Monitors (*Varanus exanthematicus*) were imported by the French pet trade, mostly from Togo.

Habitat Quality and Australia's Most Endangered Snake

Fire suppression over the past two centuries has produced increases in vegetation density and canopy cover in many Australian landscapes, potentially affecting small populations of nocturnal reptiles that use exposed shelters for diurnal thermoregulation. WEBB ET AL. (2005. *Copeia* 2005: 894–900) tested the effect of removing overhanging vegetation from shaded rocks on use by Australia's endangered Broad-headed Snake, *Hoplocephalus bungaroides*. One year after clearing vegetation, basking rocks were hotter and were used more frequently by three reptilian species, including Broad-headed Snakes and an important prey species (Velvet Geckos, *Oedura lesueurii*). The authors suggest that, until effective fire management measures are in place, sapling removal from overgrown rock outcrops could help to protect small populations of endangered reptiles.

PAVEL GERMAN/WILDLIFE IMAGES

Australia's endangered Broad-headed Snake (*Hoplocephalus bungaroides*) may benefit from clearing vegetation that has overgrown basking sites after two centuries of fire suppression.

Island Boas of Belize

Boa Constrictors (*Boa constrictor*) inhabiting islands off the coast of Belize have been heavily collected for the pet trade, which describes these as a "dwarfed" race. BOBACK (2005. *Copeia* 2005: 880–885) determined that, compared to mainland boas, island boas have significantly smaller litters of smaller neonates and have extraordinarily small population sizes that range from 8–88. Evidence of declining population sizes and application of IUCN criteria indicate that island populations of Belizean boas warrant immediate conservation priority due to their low reproductive output, small population sizes, and continued demand in the pet trade.

SCOTT M. BOBACK

This adult male Crawl Cay Boa (*Boa constrictor*; 116 cm SVL) was one of only about eight free-ranging individuals on an island that has been heavily impacted by collection. After completion of the initial study, the author returned to the cay in 2003 to find that more land had been cleared and that a new structure was being built. In only a very short amount of time, the author and his colleagues found no boas.

Non-native Reptiles in Florida

Forty-one exotic species of amphibians and reptiles are known to occur in Florida, and more are being discovered on a regular basis. A hospitable climate, disrupted natural ecosystems, a mobile and growing human population, and service as the major transportation center for the U.S. pet trade all contribute to the increasing numbers of invasive species.

Enge and Krysko (2004. *Florida Scientist* 67:226–230) documented an established population of the Asian agamid lizard commonly called the Bloodsucker (*Calotes versicolor*) in St. Lucie County, Florida. This population was apparently introduced in 1978, and approximately 100 specimens have been captured by two commercial collectors in the past 10 years. All specimens were captured from nocturnal roosts 1–9 m high in weeds, vines, bushes, and trees. The known population boundaries extend approximately 10 km east-west and north-south, and they encompass citrus groves, Brazilian pepper (*Schinus terebinthifolius*) thickets, mesic flatwoods, and canals. The authors did not attempt to assess the possible ecological impact of this species on native wildlife, but it has been known to feed on small vertebrates in Asia.

KENNETH L. KRYSKO

Gravid female and neonate Bloodsuckers (*Calotes versicolor*) from St. Lucie Co., Florida.

Krysko et al. (2004. *Florida Scientist* 67:249–253) documented an established population of the Veiled or Yemen Chameleon (*Chamaeleo calyptratus*) in Fort Myers, Lee County, Florida. The authors recorded at least 70 individuals, including both genders and all size classes in consecutive years, indicating a reproducing population. *Chamaeleo calyptratus* also has been reported from areas near Lehigh Acres and Alva, Lee County, and Naples, Collier County, suggesting independent introductions of this popular exotic lizard. Monitoring of this population should continue, and eradication should be attempted if adverse ecological impact on native species is observed.

KENNETH L. KRYSKO

Adult and juvenile (*Chamaeleo calyptratus*) from Lee Co, Florida.

Enge et al. (2004. *Florida Scientist* 67:303–310) documented populations of the introduced African Rainbow Lizard (*Agama agama africana*) in Homestead, Miami-Dade County; Hollywood, Broward County; Palm City, Martin County; Punta Gorda, Charlotte County; and Sanford, Seminole County. The Homestead and Punta Gorda populations have been established for over 10 years and have expanded at least 0.5 km from the point of introduction. The Palm City population has been established since 1999 and the Sanford population since 2000. All lizards were in urban or suburban situations. Maximum clutch size and maximum snout-vent length (SVL) of male and female *A. a. africana* in Florida exceeded those in native Nigerian populations. All adult females (> 94 mm SVL) collected May–August contained 5–18 vitellogenic follicles or oviductal eggs, but a female collected on 19 September was not gravid. Monitoring should be conducted to determine whether the species could invade natural habitats and exert a negative impact on native wildlife.

KENNETH L. KRYSKO

African Rainbow Lizard (*Agama agama africana*) from Miami-Dade Co., Florida (UF 134222).

The Nile Monitor (*Varanus niloticus*), the longest lizard in Africa, was first observed in southwestern peninsular Florida in the Cape Coral area of Lee County in about 1990. From April 2001 through July 2003, **Enge et al.** (2004. *Southeastern Naturalist* 3:571–582) compiled data from 146 sightings or captures of this species. Numerous individuals of all size classes were observed or collected, suggesting the occurrence of a reproducing population. Although records are mostly confined to Cape Coral, the data indicate that *V. niloticus* has recently expanded its range northwards and to nearby islands. Because this large lizard has the potential to disperse into nearby ecologically sensi-

TODD CAMPBELL

This 5-foot, 15-pound Nile Monitor (*Varanus niloticus*) was captured at a residence in Cape Coral.

tive areas and preserves where it could pose a serious threat to waterbirds, Burrowing Owls (*Athene cunicularia*), sea turtles, and other native wildlife, population monitoring and eradication are warranted.

KRYSKO AND ENGE (2005. *Florida Scientist* 68:247–249) confirmed the existence of the Butterfly Lizard (*Leiolepis belliana*) in Miami, Miami-Dade County, Florida. The authors found *L. belliana* active during the daytime in an area encompassing six square city blocks, where it was observed basking and foraging on open grassy lawns and inhabiting burrows. The population of *L. belliana* originated from a tropical fish dealer and has been established since at least 1992. If eradication of the Miami population is desired, it should be attempted while the population remains localized.

KENNETH L. KRYSKO

Butterfly Lizard (*Leiolepis belliana*) from Miami-Dade Co., Florida.

Green Iguanas (*Iguana iguana*) are firmly established in southern Florida, including a large population on Key Biscayne. In its native range, *I. iguana* is known to be almost strictly herbivorous. Juveniles are often reported to be somewhat omnivorous, but prey items are rarely identified. The tree snail *Drymaeus multilineatus* is common in southern Florida, where it is found on stems and leaves and in edificarian habitats. TOWNSEND ET AL. (2005. *Southeastern Naturalist* 4:361–364) examined *I. iguana* stomachs from Bill Baggs Cape Florida State Park, Key Biscayne, and discovered *D. multilineatus* in two lizards, including 12 snails in one juvenile *I. iguana*. The large and rapidly growing *I. iguana* populations in southern Florida may have the potential to devastate some highly localized native species of tree snails.

KENNETH L. KRYSKO

The tree snail *Drymaeus multilineatus* is common in southern Florida, where it is known to be eaten by introduced Green Iguanas (*Iguana iguana*). Such observations suggest that the large and rapidly growing *I. iguana* populations in southern Florida may have the potential to devastate some highly localized native species of tree snails.

MESHAKA ET AL. (2005. *Southeastern Naturalist* 4:521–526) searched for introduced Northern Curlytails (*Leiocephalus carinatus armouri*) along Florida's southeastern coast from Port Salerno, Martin County, north to the Indian River/Brevard County line to determine the extent to which this species has expanded its range since its introduction to Palm Beach County almost 50 years ago. They found the distribution of these lizards to be almost uninterrupted in heavily modified coastal habitats from northern Broward County through Palm Beach County. Despite urban heat islands, the authors suggested that frost isotherms would prevent stable populations from becoming established north of Fort Pierce on the eastern coast and just below Sarasota along the state's western coast.

Recent studies of geographic patterns of nonindigenous species richness suggest that a few key biogeographic and anthropogenic factors explain much of the variation in the richness of established species. However, the factors identified in these studies may be taxon- and scale-specific or general rules might apply broadly across taxa and spatial scales. To address this issue, SMITH (2006. *Biological Conservation* 127:327–335) identified factors that contributed significantly to variation in nonindigenous herpetofaunal richness at a relatively small spatial scale, the county level, in Florida. The author also used the Jaccard similarity index to determine if nonindigenous species affect the biotic similarity of the herpetofaunas of Floridian counties. County latitude strongly and negatively affected nonindigenous herpetofaunal richness, explaining approximately two-thirds of the variation in this variable. To a smaller degree, human population and university presence both related positively with nonindigenous herpetofaunal richness. Several other variables, including county land area, were not significantly related to nonindigenous herpetofaunal richness. The consistent importance of human population to nonindigenous species richness in this and past studies suggests that the influence of anthropogenic factors may be universal and are as or more important than the natural biogeographic factors that generally relate with native species richness. The author found no evidence of overall homogenization, but a significant relationship between homogenization scores and distance between counties suggested that the effect of nonindigenous herpetofaunal richness on the similarity of county biotas is scale-dependent, such that adjacent counties tend to experience homogenization. The results of this and similar studies may be useful in predicting the introduction and spread of nonindigenous species and in evaluating the effects of such introductions on native biodiversity.

KEVIN M. ENGE

KENNETH L. KRYSKO

Northern Curlytail (*Leiocephalus carinatus*) from Palm Beach Co., Florida.

NEWSBRIEFS

Wake Up, Floridians, to this Cold-blooded Killing

As if the results of the sixth day of Creation, when God made "every thing that creepeth upon the earth," were being canceled out, hordes of new people are putting some of Florida's humblest residents to flight, wiping them out in hundreds of thousands. *Amphibians and Reptiles: Status and Conservation in Florida*, a just-published scientific survey edited by Walter E. Meshaka, Jr. and Kimberly J. Babbitt, paints a gloomy picture of what is happening to the state's herpetofauna.

Crushed beneath car wheels, buried by bulldozers, poisoned by insecticides and fertilizers, chased from back yards and patios as obnoxious pests, eaten alive by exotic red ants, over-collected by egotistical pet owners, Florida's snakes, turtles, frogs, lizards, and salamanders face a future that is getting grimmer and narrower year by year.

"Florida has a greater biodiversity of reptiles than any place on the North American continent, just a wonderful diversity of creatures," said Bruce Means, executive director of the Coastal Plains Institute and one of the contributors to the book. "Unfortunately, they are under assault from wildly burgeoning human masses. I've been doing this for 44 years, and I've seen species like the Southern Dusky Salamander just disappear. I am not optimistic about the future at all."

A collection of articles by scientists who are experts in their field, the book speaks openly of "persecution" and "extirpation" of some reptiles, particularly Box Turtles, Gopher Tortoises, and Common Kingsnakes. Scientific abbreviations like "DOR" stand for "Dead on Road," and mean the myriad squashings of frogs, lizards, turtles, and snakes beneath the wheels of ever more abundant vehicles. Some roads, like U.S. 441 across Payne's Prairie in Alachua County, and the Tamiami Trail that runs across Florida from Miami to Tampa, are virtual abattoirs, greased with the gory little bodies of "anurans." "On Aug. 5, 1991, I stopped counting after 10,000," biologist Jim Weimer said in a 1996 interview, describing a single night on U.S. 441 across Payne's Prairie. "This was just one night. On May 2, 1991, there were over 5,000 Southern Leopard Frogs killed."

KENNETH L. KRYSKO

Kingsnakes (*Lampropeltis getula*) are declining precipitously in Florida. Those spared by collectors ae being killed by non-native fire ants.

Florida is growing by leaps and bounds. The population is already above 15.3 million and expected to reach 25 million over the next quarter-century. Every hour, 28 new people come to live in Florida. Billions of dollars are to be made in development. "But at what price?" Meshaka and Babbitt ask in their introduction. "Drives to work are unbearable, and one must drive farther and farther to see nature . . . as space runs out, agriculture is now giving way to human development, the borders of which stand cheek to jowl with every major wetland, upland, and estuarine system in the state."

The condition of Florida's herpetofauna has become "drastically unrecognizable" from what it was 50 years ago. In short, these little frogs, snakes, lizards, salamanders, and turtles are behaving like croaking, slithering, wriggling, plodding-footed, extremely stressed little canaries in a sunny coal mine. Their deaths are hastening the day when Florida, the richest habitat in America for mammals, birds, reptiles, turtles, crocodilians, and amphibians, will be little more than a sterile monoculture.

Interestingly, enormous Palm Beach County is not the most biodiverse county in Florida when it comes to herpetofauna. That honor goes to little Franklin County, southwest of Tallahassee in the Big Bend, with 99 native amphibian, turtle, crocodilian, and squamate reptile species. Nearby Liberty County is second, with 98, and Santa Rosa County has 97. Palm Beach County, by contrast, has only 69, Martin 44, and St. Lucie 46 species. The least biodiverse place in Florida, when it comes to these creatures, is DeSoto County, just east of Charlotte County near Florida's lower west coast.

If you want to grasp the dizzying reach of these creatures' antiquity, consider the lowly Eastern Box Turtle (*Terrapene carolina*). It has been in Florida since the Pliocene Era, which began five million years ago. At least three subspecies occur in the state, and one island, Egmont Key, off Tampa Bay, used to have so many of them that early 18th Century French explorers in the Gulf referred to all of America as "L'île aux Tortues," the Isle of Turtles [see *Iguana* 12: 152–159]. Egmont Key became a National Wildlife Refuge in 1974, but it is being eroded and lacks the funds to afford more than a single caretaker. The Box Turtle is generally thought of as "common" in Florida but this report suggests it may not be nearly as common as supposed.

The fate of the Gopher Tortoise (*Gopherus polyphemus*) is even more dire. This slow-moving creature lives in burrows on sandy uplands, the very sort of land most prized by developers. Bulldozers often entomb the hapless tortoises alive. Thanks to their slow metabolism, they may linger for months underground before dying of thirst and hunger. As many as 68,000 Gopher Tortoises have been killed in Florida over the past 12 years, according to Florida Fish and Wildlife Conservation Commission figures, in order to make room for roads, houses, malls, and golf courses. "Current Gopher Tortoise regulations and conservation measures appear to be inadequate to sustain the species in

SUZANNE L. COLLINS, CNAH

As many as 68,000 Gopher Tortoises (*Gopherus polyphemus*) have been killed in Florida over the past 12 years in order to make room for roads, houses, malls, and golf courses.

Florida through the next century," writes Ray E. Ashton Jr. in the new report.

The grimmest article of all in the new book is "The Decline and Extirpation of the Kingsnake in Florida," by Kenneth L. Krysko and Daniel J. Smith. The Common Kingsnake (*Lampropeltis getula*) is a magnificent creature, coming in several colors, harmless, beautiful and sweet-tempered, and therefore much sought-after by collectors, who pay up to $300 for one. Traffic and drainage along the infamous U.S. 441 across Payne's Prairie practically wiped out the snake in the 1960s. By 1977, not a single Common Kingsnake could be found there. Collectors captured practically all the Common Kingsnakes along the Tamiami Trail west of Miami by 1995. Franklin County used to abound with them. A survey in 2000 found a single specimen, mortally wounded on a highway. At present, the only large population of Common Kingsnakes lies around and to the west of Lake Okeechobee. Non-native fire ants are busily killing off these refugees.

More than 77,590 American Alligators (*Alligator mississippiensis*) have been killed as "nuisances," because they invaded Florida back yards since 1977; the state Fish and Wildlife Conservation Commission now fields about 5,000 calls each year from alarmed homeowners. The state lets private trappers dispose of them, and their meat and hides were worth nearly $3 million in 1999.

The pet industry is thriving at the expense of wildlife. One Florida collector caught 4,194 Southern Cricket Frogs (*Acris gryllus*) and sold them over a two-year period. Turtles are captured and sold at the rate of up to 5,663 a year. Rattlesnakes are sought-after for their skins, meat, and gallbladders, which are used in Chinese traditional medicine. About 20,000 snakes of all species are removed from the wild annually to be sold as pets.

The legendary Ross Allen of Silver Springs was one of the biggest entrepreneurs. Jolly old Ross Allen was a hero to countless children and Boy Scouts in the 1950s and 1960s. They loved watching him handle snakes fearlessly, and were thrilled to hear how many times he had been bitten by rattlers and survived. They didn't know Allen was in the snake trade up to his neck. Over a five-year period, Allen bought and sold 6,858 Eastern Rat Snakes (*Elaphe obsoleta*; now assigned by some authorities to *Pantherophis alleghaniensis*) alone, the new report says. Allen regarded the woods of central Florida as a kind of infinite piggybank of valuable snakes.

SUZANNE L. COLLINS, CNAH

Over one five-year period, Ross Allen, famous Florida snake-handler, bought and sold 6,858 Eastern Rat Snakes (*Elaphe obsoleta*; now assigned by some authorities to *Pantherophis alleghaniensis*).

The figures in the new book are devastating. From 1990 to 1994, collectors captured and sold 5,683 salamanders, 88,096 frogs and toads, 17,627 turtles, 189,712 lizards, and 85,311 snakes of all species. Eighty percent of the lizards, 76 percent of the snakes, 50 percent of the turtles, and 27 percent of the lizards came from Lake Okeechobee south. This is just the legal, reported trade.

A few bright spots appear in the report. American Alligators are thriving, even getting larger. The average "nuisance" Alligator hide now measures 7.3 feet in length. Also, 1.26 million acres of state-protected land remains in Florida, off-limits to development.

Still, Meshaka and Babbitt declare: "Rather than just waving our arms to attempt to slow the rate of human growth and habitat alteration, we should anticipate the worst and develop plans that have the potential to maintain current levels of biodiversity."

Michael Browning
Palm Beach Post
15 September 2005

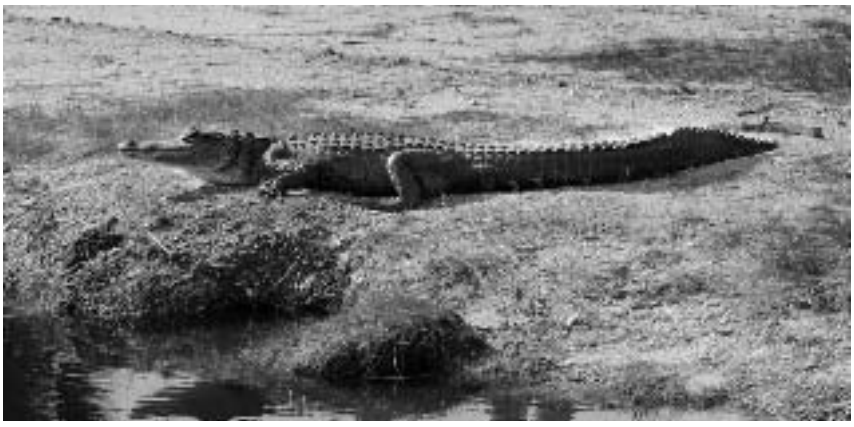
American Alligators Killed

Any Florida alligator longer than 4 feet that makes residents or visitors feel unsafe, and that is reported to the state's Gator Hotline, is subject to a practice called "harvesting." The animal is taken away by a trapper and ultimately killed. Linda Collins, a spokeswoman for Florida's Statewide Nuisance Alligator Program (SNAP) reports that a total of 7,991 were harvested in 2005.

For years, the city of Sanibel only had aggressive gators removed from the island. However, following an incident in July 2004, in which a woman was killed by a 12-foot American Alligator, Sanibel joined the statewide program for removing them.

Since the change on Sanibel, more than 100 American Alligators have been harvested there, including 23 in 2005. No fatalities and no subsequent reports of pets or human attacks have been reported since the policy was instituted.

News-Press (Fort Myers, Florida)



SUZANNE L. COLLINS, CNAH

Nearly 80,000 American Alligators (*Alligator mississippiensis*) have been killed as "nuisances" since 1977.

SUZANNE L. COLLINS, CNAH

American Alligators (*Alligator mississippiensis*) that frighten or threaten Florida residents may be "harvested" (taken by a hunter and killed).

Mexican Garter Snake One Step Closer to Protection as an Endangered Species

Responding to a petition and lawsuit from the Center for Biological Diversity, the U.S. Fish and Wildlife Service (USFWS) announced today that the Mexican Garter Snake (*Thamnophis eques*) may warrant protection as an endangered species under the Endangered Species Act (ESA) and announced that they will begin a status review to be completed by September 2006. The species is an aquatic Garter Snake with a distribution in Arizona, southwestern New Mexico, and México. It is one of hundreds of native riparian species that are threatened by the destruction and degradation of rivers, streams, and springs in the Southwest. The Center petitioned for protection of the snake 15 December 2003.

Populations of the Mexican Garter Snake are severely fragmented and isolated due to loss and destruction of suitable habitat, which consists of riparian areas with permanent water, streamside vegetation for cover, and native prey species. "The decline of the Mexican Garter Snake is symptomatic of an extremely widespread decline in the aquatic fauna of the Southwest," stated Dr. Phil Rosen, herpetologist with the University of Arizona.

The Mexican Garter Snake has been extirpated from most of its U.S. range, including the Colorado, Gila, and much of the Santa Cruz and San Pedro rivers. The decline of the Mexican Garter Snake is closely linked to the deteriorating quality of streamside habitats, the disappearance of native frogs and fishes, and the rampant introduction and spread of nonnative species, such as the Bullfrog, Sunfish, and Bass.

"Widespread degradation of southwest rivers and introduction of dozens of exotic species necessitates protection of the Mexican Garter Snake," stated Noah Greenwald, conservation biologist for the Center for Biological Diversity. "The Endangered Species Act is an important safety net for the nation's wildlife and could help save the Mexican Garter Snake."

TOM BRENNAN

Mexican Garter Snakes (*Thamnophis eques*) are one step closer to protection as an endangered species.

Center for Biological Diversity
5 January 2006

Second Eastern Box Turtle Conservation Workshop

The North Carolina Zoological Park and the Humane Society of the United States are pleased to announce that the Second Eastern Box Turtle Conservation Workshop will be held at the North Carolina Zoological Park in Asheboro, North Carolina on 24–25 March 2006.

This workshop will pick up the work started at the first workshop held in Laurel, Maryland in 2004. Several presentations will be scheduled in the morning, but the focus of the meeting will be to develop working groups for the issues identified under Research, Repatriation, and Rehabilitation of Box Turtles and Box Turtle Conservation Education.

SUZANNE L. COLLINS, CNAH

Eastern Box Turtles (*Terrapene carolina carolina*) are the focus of a second conservation workshop this month in North Carolina.

U.S. Turtle Species Added to CITES Appendix III

The Alligator Snapping Turtle (*Macroclemys temminckii*) and all species of Map Turtles (*Graptemys* spp.), which are native to the United States, are being given international protection by their inclusion in Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The listing, which will allow the U.S. Fish and Wildlife Service to work with states to regulate exports, marked the first time the U.S. has used Appendix III to protect native species.

The Alligator Snapping Turtle, the largest freshwater turtle in the world, is a species of concern due to several factors that include loss of habitat and collection from the wild for human consumption and export as pets.

Twelve species of North American Map Turtles are currently recognized. Two of these are on the Federal list of threatened species and a third is a candidate species for Federal listing. Map Turtles are vulnerable for many reasons; some currently known threats to the species include loss of habitat, exposure to contaminants, and collection for the pet trade.

SUZANNE L. COLLINS, CNAH

Alligator Snapping Turtles (*Macroclemys temminckii*) and all species of Map Turtles, such as this Barbour's Map Turtle (*Graptemys barbouri*) are now included in CITES Appendix III.

Surprising Killer Of Southeastern Salt Marshes: Common Sea Snails Conserving Diamondback Terrapins May Help Preserve Coastal Habitats

Periwinkles (*Littorina* sp.), the spiral-shelled snails commonly found along rocky U.S. shorelines, play a primary role in the unprecedented disappearance of salt marsh in the southeastern states, according to new research published in *Science*. Based on extensive field studies, the work challenges six decades of salt marsh science. Ecologists have long thought that stressed soil – too much salt, not enough oxygen – was the main killer of this critical marine habitat. Brian Silliman, a Brown University research fellow and a

University of Florida assistant professor, said drought-stressed soils pave the way for predatory periwinkles that spread fungal disease as they graze on cordgrass.

"Snails can transform healthy marsh to mudflats in a matter of months," said Silliman, lead author of the *Science* paper. "This finding represents a huge shift in the way we see salt marsh ecology. For years, scientists thought marsh die-off was simply a 'bottom-up' problem related solely to soil conditions. We found that the trouble also comes from the top down. Drought makes the marsh vulnerable, then the snails move in."

Thousands of acres of salt marsh have disappeared from South Carolina to Texas since 2000, according to several scientific studies. In Louisiana alone, more than 100,000 acres of marsh were severely damaged between June 2000 and September 2001. This drastic decline poses a serious threat to the ecology and economy of the southeastern seaboard and the Gulf Coast. Salt marshes serve as nursery grounds that support commercial fisheries, protect coastline from storm-induced floods, and filter fresh water before it flows out to sea.

Mark Bertness, chair of the Department of Ecology and Evolutionary Biology at Brown and a co-author of the paper, said a better understanding of the causes of salt marsh loss would point to better ways to protect them. "Loss of blue crabs and turtles, which prey on periwinkles, allows the snails to flourish," Bertness said. "Protect the crabs and turtles [such as Diamondback Terrapins, *Malaclemys terrapin*] and you can help save the marshes."

Silliman came up with the periwinkle premise as a graduate student conducting field research in Virginia.

Periwinkles (*Littorina* sp.) are spiral-shelled snails commonly found along rocky U.S. shorelines. They apparently play a primary role in the unprecedented disappearance of salt marsh habitats in southeastern states.

SUZANNE L. COLLINS, CNAH

Diamondback Terrapins (*Malaclemys terrapin*) are known predators of small mollusks like periwinkles. Impacted by the declining quality of coastal habitats and heavily exploited by humans for food, terrapin populations in many areas have declined dramatically in historical times. Actively managing the species may not only help conserve these turtles, but may help preserve salt marsh habitats in the southeastern United States.

Silliman found that removing snails from cordgrass, the dominant plant species in salt marshes, bumped up grass growth as much as 50 percent. Silliman earned his Ph.D. at Brown and worked in the Bertness lab along with Johan van de Koppel, a former postdoctoral research associate now at the Netherlands Institute of Ecology. For more than two years, the trio tested Silliman's top-down hypothesis of marsh ecology along the Georgia, South Carolina, and Louisiana coasts in conjunction with Louisiana State University researchers Lee Stanton and Irving Mendelssohn.

In 12 randomly selected die-off sites, the team surveyed periwinkle populations. They found the largest concentration of snails – as many as 2,000 per square meter – along dead-zone borders. To test the idea that the snails contribute to cordgrass death, they created dozens of deterrents – wire mesh enclosures measuring about one meter square. Enclosures were placed ahead of fronts of grass-grazing snails and monitored for more than a year.

Inside the enclosures, snail-free cordgrass thrived. In fact, plant biomass increased more than threefold. Outside the cages, in 11 of the 12 sites, snail overgrazing converted healthy marsh to exposed mudflats in as little as three months. When snail density was high, destruction was more extensive.

Researchers also wanted to test the notion that increased soil salinity, brought on by drought, acts in concert with snails to kill marshland. So, in one healthy site in Georgia, the team elevated soil salt concentrations in areas with and without snails. Sites were monitored for eight months. In the experimental plots, increased salinity reduced grass growth by 45 percent, while high salt levels, in combination with the presence of snails, reduced grass growth by 84 percent.

How do periwinkles contribute to marsh destruction? Silliman has shown that they kill the grass by slicing the stems during grazing, leaving plants vulnerable to harmful fungi. In a process called "fungal farming," snails then consume the fungi living off injured grass. "We've found a synergism between climate change and grazers," Silliman explained. "Severe drought triggers formation of traveling fronts of grazing snails. Then there is runaway consumption, which leads to waves of marsh destruction. Given predicted increases in climate change-induced drought, these results highlight the potential for marsh die-off to be even more intense and extensive in the future."

The findings, the authors argue, underscore the interplay of climate and consumers in the worldwide collapse of coastal systems. While an overabundance of snails may fuel southeastern salt marsh destruction, they point to other examples of habitat destruction that may be caused, in part, by a plethora of grazers: Sea urchins wiping out California kelp beds, sea stars devastating Australian coral reefs, snow geese decimating marshes along the Artic Sea, bark beetles killing off Arizona pine forests.

Georgia Sea Grant, Louisiana Sea Grant, The Nature Conservancy, the National Science Foundation and the Schure-Beijerinck-Popping Fund supported the work.

Science Daily, 20 December 2005
Source: Brown University
(http://www.sciencedaily.com/releases/2005/12/051219091308.htm)

Florida May Require Permit for Large Reptiles

You can't keep them from eating alligators in the Everglades. You can't bust people for letting them loose — unless you happen to catch them in the act — but you can, at least, make people think twice before buying a Burmese Python or a Nile monitor or any of a handful of large, nonnative reptiles that have formed wild colonies from Flamingo to DeLand.

That's the rationale behind a new state bill that would require a $100 annual

permit to keep certain large reptile species, and provide for "pet amnesty days," during which 16-foot pythons and the like can be turned in, no questions asked.

While the exact list of species has yet to be figured out, and the state's plan for the unwanted animals is fuzzy at best, the bill "is a great start," said Florida Rep. Ralph Poppell, R-Vero Beach, who is co-sponsoring the legislation along with Sen. Bill Posey, R-Rockledge. It would put large reptiles in the same tightly controlled category as venomous snakes — which Florida residents also need a $100 permit to keep.

"Before, you could just buy little Johnny one, no big deal," Poppell said. Now little Johnny could be forking over $2,500 during the course of the snake's life, and have to answer to the state if it ever gets loose. The bill would, its supporters hope, slow the tide of unwanted reptile pets and reduce impulse purchases, since buyers would need a permit in hand first. Biologists don't expect the bill, if it passes, will make Burmese Pythons vanish from the Everglades, or even slow their progress beyond South Florida. "There's thousands of them out there," said Kevin Enge, a biologist with the Florida Fish and Wildlife Conservation Commission. "Burmese Pythons could potentially survive up to Orlando or on the coast even farther north."

Strangely, the recent abundance of pythons seems to have only encouraged more python-dumping. "The park biologists are finding clean ones lately, without scratches or marks," Enge said, indicating they've been raised in captivity.

The bill would give unhappy owners a way to dispose of their erstwhile captives. The state's first "pet amnesty" event is being planned for Orlando. What will happen to the dropped-off creatures, however, is unclear. "That's something we'll have to work out," Enge said. "A lot of these animals I don't think there's a real market for. Realistically, they are probably gonna be euthanized. How we're gonna explain that to the public I don't know."

JOSEPH BURGESS

Spiny-tailed or Black Iguanas, such as this *Ctenosaura similis*, a Middle American native, are locally abundant in several regions of southern Florida where they often inflict considerable damage on decorative landscaping, most of which is composed of non-native vegetation.

Dave Soltz, manager of Mr. Petman in South Daytona, said he felt the $100 permit requirement would dissuade retail buyers of large reptiles. Soltz said he tries to be as clear as possible about the growth and requirements of pets like Burmese pythons, but it doesn't always take. "We give them as much information as they're willing to listen to," he said. Commercial reptile breeders, of which Florida has dozens, have lent support to the permitting measure — because the alternative could be to shut down the trade in all exotics. "That would be the next step," Poppell said. "But we really don't want to put people out of business."

Enge thinks dealers may have been responsible for the first releases of Nile Monitors and Burmese Pythons, because it takes quantities of animals to establish a breeding colony. Eugene Bessette, an Alachua County snake breeder who supports the restrictions and helped the state craft them, said he thought individual pet owners were to blame for most of the releases. "People throw away cats; they throw away dogs; they throw away children," Bessette said. "We live in a disposable society." Whatever the cause, the fact is that colonies of Spiny-tailed Iguanas, Nile Monitors, Burmese Pythons, African Rock Pythons, and Boa Constrictors are established in pockets of Florida, and have been for years. Eradication efforts are likely to intensify soon, Enge said. "They're gearing up for the Burmese Pythons. There will probably be federal money to try and eradicate them."

It's not merely because 16-foot snakes freak people out, said Enge, but because their prey items could include threatened and endangered species. "So far what we've found in their stomachs are limpkins, house wrens, one had a feral cat," Enge said. "We worry that they could get into Wood Stork colonies."

The bill, if it passes, may serve to keep the next big, unwelcome, predatory species out of the state. Anacondas are being considered for the list. At least two have been discovered in the Everglades, probably released by their owners and not reproducing. No one expects that the giant South American snakes would survive and breed here, but then, no one expected Burmese Pythons to, either. "Ten years ago, I'd have said Burmese Pythons could never become established in Florida," Enge said.

LORI OBERHOFER, EVERGLADES NATIONAL PARK

ROY WOOD, EVERGLADES NATIONAL PARK

This young Burmese Python (*Python molurus bivittatus*; top), caught in Everglades National Park, is testament to the reality that wild snakes are thriving and breeding in southern Florida. The larger adult (bottom) is more typical of snakes being seen and reported; many obviously are former pets released by owners when they become too large to easily accommodate in captivity.

Virginia Smith
Daytona Beach News Journal
19 February 2006

State to Consider Reptile Ban in Schools[1]

For students who have pet snakes, salamanders, or other reptiles in their classrooms, an order to remove the coveted creatures would probably seem cold-blooded.

State officials aren't ready to lay down that law in public schools yet, but they recently did so at licensed child care centers across North Carolina. The reason is *Salmonella* – a bacterium found in the digestive tracts of all reptiles that can cause diarrhea, fever, headaches, and severe vomiting in humans.

A newly formed panel with the N.C. Commission for Health Services

[1] Editors' note: The IRCF strongly endorses the educational use of reptiles in properly supervised situations in which necessary precautions and hygiene are enforced.

will meet for the first time this month to discuss school sanitation rules, which haven't been revised in 15 years, and it could be a scaly outcome for the use of reptiles in education. "The sanitation requirements now (at schools) are not nearly as restrictive as they are for toddlers and infants at child care facilities," said Ed Norman, an environmental epidemiologist with the children's health branch of the N.C. Department of Environment, Health, and Natural Resources. "This committee has formed to look at those rules." Norman said the rules governing child care centers were reviewed in August and went into effect January 1. Public health officials suggested the reptile ban as a way of preventing *Salmonella* outbreaks among preschoolers who can be forgetful about handwashing. Since *Salmonella* is carried in the intestinal tracts of reptiles, they intermittently or continuously shed the bacteria in their feces. The disease can be fatal for young children or anyone with a weakened immune system, Norman said. "Younger kids are at greater risk, but really, any child could be," he said.

Robert Hunt, environmental supervisor for the Nash County Health Department, said he knows of no child-care centers here that were affected by the new rule. In line with the state standard, his office performs health inspections only once a year at public schools in the county, but Hunt said he would recommend that children not be allowed to handle a reptile – especially iguanas – in a classroom. "Ensuring proper handling and handwashing afterward is very important," Hunt said.

Reptiles can't be found at every school around the Twin Counties, but they're not exactly uncommon. Science kits furnished as part of the N.C. Standard Course of Study provide many classrooms with critters such as hermit crabs, earthworms, and mice. At D.S. Johnson Elementary School, that's also how fourth-grade teacher Edith Berry obtained eight anoles – tiny lizards that resemble chameleons. Berry said the benefits have been innumerable. Her students learn about the lizard's ecosystem, its ability to change color according to its surroundings and its dietary affection for crickets. "It's been absolutely wonderful," Berry said. "It's one of the reasons my students have grown to love science." Berry requires her students to wear disposable gloves while handling the anoles.

SUZANNE L. COLLINS, CNAH

A Red-bellied Water Snake (*Nerodia erythrogaster*) in a classroom at Williford Elementary School (North Carolina) greatly enriched the learning experience for students.

COURTESY OF TODD CAMPBELL

Todd Campbell, Assistant Professor of Biology at the University of Tampa, holding a Nile Monitor (*Varanus niloticus*). Building on work by Kraig Hankins (City of Cape Coral), Kenneth Krysko (Florida Museum of Natural History), and Kevin Enge (Florida Fish and Wildlife Conservation Commission), whose collective efforts generated a public awareness of this issue, Dr. Campbell has been actively working on the monitor problem since 2003.

At Williford Elementary School, third-grade teacher Suzanne Lindsey doesn't feel that's necessary. Lindsey said she has had a snake in her classroom aquarium every spring for about the last 20 years – usually from April through the end of the school year. She's also occasionally had other reptiles. "It would be a terrible thing to have something that neat and not be able to touch it," Lindsey said. "But my kids are only allowed to hold it under supervision. "They understand the risk of *Salmonella*, and we talk about the importance of handwashing when we're finished." Lindsey's students are not allowed to feed the reptiles or help with cleaning the aquarium, and she said having an animal in the classroom is more enriching than simply looking at a picture. Last year, their Red-bellied Water Snake (*Nerodia erythrogaster*) turned out to be pregnant and gave birth to 63 babies that were each smaller than a pencil. "Every class came by and saw them, and it was so memorable," Lindsey said. If the law changes, she said, so be it. "If we're told they're no longer allowed, I'll respect that," Lindsey said. "Unfortunately, these laws come and go."

Michael Barrett
Rocky Mount Telegram
6 February 2006

Lose the Lizards in Lee County

The City of Cape Coral has a population of the Nile Monitor Lizard (*Varanus niloticus*) perhaps numbering in the thousands. The City has been logging sightings and attempting to eradicate the monitor lizard since 2001. The trapping effort has included city employees, grant-funded individuals, college interns, and volunteers. So far, we have captured 120 monitors.

In recent months, monitors have been sighted on Sanibel Island, Fort Myers, and in the Charlotte Harbor Aquatic Buffer Preserve. They are probably established on Pine Island. The fears that these exotic lizards would spread to the barrier islands are most likely founded. With the realization that the City's current efforts are not adequate to reduce the population of monitors, we are enlisting the aid of the U.S. Department of Agriculture, Wildlife Services. They have been the lead agency dealing with Brown Tree Snakes, African Pouch Rats, and feral hogs, among others. They are familiar with the monitor lizard problem and are interested in assessing what is needed to control the population. They are attempting to gauge the amount of local support for an eradication/management effort. They are also interested in meeting with anyone concerned about the spread of the Nile Monitor in southwestern Florida.

We are asking you for support in eradicating the monitors of Lee County, Florida. The USDA needs to hear from concerned individuals now. The amount of federal funding for this will depend on the amount of public support for its necessity. Please pass this information along to anyone that is concerned with the spread of monitor lizards in southwestern Florida. A letter or email to your congressional representatives or the USDA stating your support for eradicating the Florida populations of monitors would be helpful.

Thank you for your efforts to preserve Florida's and the nation's natural resources.

Bernice Constantin
Florida and Puerto Rico Wildlife Services
2820 East University Avenue
Gainesville, Florida 32641
bernice.u.constantin@aphis.usda.gov

Kraig Hankins
Environmental Biologist, City of Cape Coral
khankins@capecoral.net

Grant To Fund Bog Turtle Conservation

A program aimed at restoring and conserving Tennessee's smallest, most endangered turtle got a $11,350 boost from the American Zoological Association's Conservation Endowment Fund. The grant to the Knoxville Zoo and Bern W. Tyron, the zoo's director of animal collections/herpetology, will be used in 2006 to increase resources and staff for the Tennessee Bog Turtle Program. The program began in 1986 when the first animal was found in Johnson County. Funding comes from the Nature Conservancy of Tennessee, Tennessee Wildlife Resources Agency, and the zoo.

Bog Turtles (*Glyptemys muhlenbergii*) live in wetlands with shallow, slowly flowing water. Bog Turtles are characterized by a large bright orange, red, or yellow blotch on each side of the head. These animals have been found in 12 states, from New York to Maryland, and, after a 250-mile gap, south from southwestern Virginia to northern Georgia.

Fewer than 100 live turtles have been discovered in Tennessee since the first was found almost 20 years ago. Tyron estimated 93 wild turtles now live in the remnants of a wetland bog in eastern Tennessee. The mud-loving turtles aren't always easily seen. Two of the Johnson County sites were found as recently as 2002 and 2003.

One of North America's smallest turtle species, the average Bog Turtle is 3½" long. The largest known Southern Bog Turtle, found in Johnson County, is only 4½" long.

Helping wild turtles reproduce is the key to helping the species survive. Researchers haven't seen young turtles in recent years, but have found destroyed nests. "The eggs just disappear," Tyron said. Data suggest that only half of the females lay eggs in any given year; typically each only lays three eggs. Some of the grant money will pay for an outdoor egg incubation station to safeguard the wild turtles' eggs. Tyron and field coordinator, Lynn Eastin, will remove eggs from the nests they find to the center. After they hatch, baby turtles will be returned to their nest spots.

While the program's priority is restoring and managing animals found in the wild, it also places captive-born turtles into the field. Born and reared for a time at the zoo, 113 of the captive-born turtles have been put on undisclosed Carter County property in the last 15 years. Even after 15 years, Tyron said the release of the zoo-born turtles remains an experiment that cannot replace efforts to save those born in the wild. He estimates more than 50 percent of the captive-bred turtles have survived in Carter County. Add those to the 93 known wild animals and still fewer than 200 Bog Turtles live in the Tennessee countryside.

Other CEF grant money will hire a second field coordinator for the program and pay for 23 tiny radio transmitters. Secured to turtle shells by epoxy, the 5.2-g transmitters have allowed researchers to monitor 39 wild turtles since 2001 and nine captive-born released turtles since 2002. The grant-funded transmitters are in addition to 30 paid for by the Nature Conservancy. Tyron plans to put a transmitter on every adult wild female turtle that is found. The transmitters will help researchers know which turtles reproduce and then find the eggs for the incubation center.

Bog Turtles may be small, but they can move. From April until fall hibernation, a turtle may crawl ½–¾ of a mile. The signal from one turtle's transmitter led researchers to the Johnson County habitat found in 2002. One turtle traveled almost 2½ mi, moving out of its home valley and over a mountain. Researchers will never know exactly where the animal was going; its transmitter was found by the side of a road.

SUZANNE L. COLLINS, CNAH

Researchers studying Tennessee Bog Turtles (*Glyptemys muhlenbergii*) received a grant from the American Zoological Association's Conservation Endowment Fund.

Amy McRary (amymcrary@comcast.net)
12 December 2005

Memorandum of Understanding between ISG, IIF, and ICRF

In October 2005, a memorandum of understanding between ISG, IIF, and ICRF was established in order to facilitate cooperation in the development and implementation of conservation action on behalf of iguanas and their habitats.

The IUCN/SSC Iguana Specialist Group (ISG) prioritizes and facilitates conservation, science, and awareness programs that help ensure the survival of wild iguanas and their habitats. The ISG currently consists of 86 biologists, conservation managers, and government officials from 25 countries. ISG membership is by invitation from elected co-chairs on behalf of the chair of the IUCN Species Survival Commission.

The International Iguana Foundation (IIF), chartered in part to support the conservation action plans of the ISG, supports conservation, awareness, and scientific programs that enhance the survival of wild iguanas and their habitats. IIF Membership is restricted to approved board members (14 currently serve).

The International Reptile Conservation Foundation (IRCF) works to conserve reptiles and the natural habitats and ecosystems that support them, with a strong emphasis on iguanas. An advisory council and editorial board advise the president and other officers. Public membership is international with payment of annual dues, and members receive quarterly copies of the journal *Iguana*.

Both IIF and IRCF are registered 501 c (3) nonprofit foundations and engage in fund-raising activities to support iguana conservation. IRCF focuses primarily on web-based marketing campaigns and direct merchandising to fund programs, whereas IIF relies strongly on a zoo base of support and extramural grants. Both IRCF and IIF fund projects in accordance with ISG conservation priorities, with priority given to those projects that: (1) Are components of approved Species Recovery Plans, (2) Are ISG endorsed, (3) Directly contribute to the survival of endangered iguanas and their habitats, and (4) Are part of an established conservation program. For

projects not involving iguanas, IRCF seeks recommendations from other IUCN specialist groups as appropriate.

Mutual benefits include: (1) Enhanced ability to develop coordinated strategies to meet ongoing project needs, particularly those of an emergency nature requiring a rapid response and the use of volunteers. (2) Enhanced ability to reach the general public with conservation messages through a variety of media, including a strong internet presence, the journal *Iguana*, joint public relations campaigns, and public venues such as trade shows. (3) Enhanced information-sharing channels with the American Zoo and Aquarium Association (AZA), scientific community, and public sector to raise both monetary and in-kind services to support iguana conservation projects. (4) Enhanced communication to facilitate prioritization of worthy projects, provide insight into critical project needs, and foster public support for program priorities.

IIF, IRCF, and ISG are committed to using their collective resources to promote the cause of iguana conservation. IIF, IRCF, and ISG pledge to work together to identify and outline funding priorities and projects that complement each other. In general, IIF will seek to provide long-term core project support, including baseline funding for salaries and project costs, including travel, equipment, and supplies, whereas IRCF will focus on immediate, discrete, critical program needs, and gaps in funding and staff. Both IRCF and IIF will continue to prioritize their iguana conservation efforts based on the guidance of the ISG. All three organizations will strive to maintain open communication channels to maximize information flow and coordination of efforts.

ISG
Iguana specialist group

IRCF

Durrell Wildlife Finds Montserrat Galliwasp Lizard Thought to be Extinct

During recent herpetological surveys, Durrell Wildlife's herpetologist on the ground in Montserrat, Agnieszka Ogrodowczyk, found a critically endangered Giant Montserrat Galliwasp (*Diploglossus montisserrati*). The significance of this find is that the Montserrat Galliwasp had been considered possibly extinct, because only two other individuals had been found in the last ten years, both from just one small area in the Centre Hills. This discovery provides optimism for believing that the giant galliwasp of Montserrat is in a better state than was previously thought. However, the species must still be regarded as highly threatened due to the active volcano, which has already reduced the forest, on which the species appears to depend, by one third of its original range. The animal caught by Agnes was 41 cm in length and weighed 170 g.

DURRELL WILDLIFE CONSERVATION TRUST

Durrell herpetologist, Agnieszka Ogrodowczyk, holds the newly rediscovered Montserrat Galliwasp.

Giant Galliwasps are large (20 cm or more in head-body length), secretive, ground-dwelling lizards found only in the Neotropics. Four species are known from the West Indian islands of Hispaniola and Jamaica, but the Montserrat species is the only one found in the Eastern Caribbean. All Galliwasps are threatened with extinction, and one Jamaican species is known from only one museum specimen, and may in fact be extinct.

The next step is for the Montserrat Forestry Department and Durrell Wildlife Conservation Trust to develop and carry out a full field survey of all the remaining moist forest areas in order to develop a conservation strategy for this unique island lizard. The herpetology staff at Durrell Wildlife also is working on and studying a closely related species in an effort to better understand these animals' behavior and breeding ecology in hopes of generating valuable information that can be transferred to field scientists in Montserrat to conserve the species in the wild.

DURRELL WILDLIFE CONSERVATION TRUST

The Montserrat Galliwasp in its habitat.

The Montserrat Reporter Online
27 January 2006

OBITUARIES

John L. Behler (1943–2006)[1]

I had the good fortune of spending a day with him just a week before his death as we put the finishing touches on a manuscript on which we were working. At the end of the day, we made plans to meet in late winter at Bog Brook, where we had been surveying turtles together for nearly a quarter of a century. His death has been a great shock to me and everyone who knew him.

Alvin Breisch
New York State Department of
Environmental Conservation

John Luther Behler was born in Allentown, Pennsylvania. He received his undergraduate degree from the University of Miami and his master's degree in biological sciences from East Stroudsburg University. After teaching biology at Hobart and William Smith Colleges, he joined the Wildlife Conservation Society, which operates the Bronx Zoo, as a New York State Council on the Arts curatorial trainee in 1970. In 1976, he became Curator of the Herpetology Department. Since 1996, he also served as program coordinator for the Wildlife Conservation Society's Wildlife Survival Center on St. Catherines Island, Georgia.

Behler assumed leadership positions in the development of captive breeding programs for endangered and threatened crocodilians, tortoises, and freshwater turtles. Through his efforts, Batagur Turtles (*Batagur baska* and *Callagur borneoensis*) and False Gharials (*Tomistoma schlegelii*) successfully bred in captivity for the first time at the Bronx Zoo. He received the American Zoo and Aquarium Association's (AZA) Edward H. Bean Award in 1980 for most significant reptilian birth for his work with Chinese Alligators (*Alligator sinensis*). Behler's interests also focused on the ecology and behavior of reptiles and reptilian diseases. He also conducted extensive field studies of tortoises in Madagascar and of Spotted and Bog turtles (*Clemmys guttata* and *Glyptemys muhlenbergii*, respectively) in North America.

WILDLIFE CONSERVATION SOCIETY

John Behler with a Spotted Turtle (*Clemmys guttata*) equipped with a tracking device. John conducted extensive field studies on this species, which is becoming increasingly rare throughout much of its range.

Among his many conservation affiliations, Behler chaired the World Conservation Union's Tortoise and Freshwater Turtle Specialist Group and was a member of the Convention on International Trade in Endangered Species (CITES) Turtle Trade Working Group. He was a former coordinator of the AZA's Crocodilian Advisory Group and was a member of the AZA's Chelonian and Lizard Taxon Advisory Groups. Behler worked closely with the New York State Department of Environmental Conservation's Endangered Species Unit and the U.S. National Park Service. He served on his community's Conservation Board and on the Westchester County Environmental Management Council.

In the early 1990s, he warned about an increasing trade of wild Asian turtles in China, where they are prized as food and in preparing traditional medicines. At the time, the Chinese had been importing turtles from Thailand, Indonesia, and even the United States. Behler argued against the practice and pushed for the opening of turtle farms in China to supply the growing commercial market.

He authored more than 40 popular and scientific articles and five guidebooks highlighting reptiles and amphibians, the best known of which was the 1979 reference book that remains in wide use, the *National Audubon Society Field Guide to North American Reptiles and Amphibians*, coauthored with F. Wayne King.

[1] The bulk of this obituary was provided by Alvin Breisch, much of it based on data provided by Linda Corcoran, Wildlife Conservation Society; a small amount of additional information came from the obituary published in the *New York Times* on 5 February 2006.

Raymond Walker

JOHN BINNS

Raymond Walker and Nancy Woodfield, BVI National Parks Trust, during a *Cyclura pinguis* Species Recovery Plan workshop held in Tortola, BVI, July 2001.

Raymond Walker died on Saturday, 21 January 2006, from complications following surgery to remove a brain tumor. For the past six-plus years, Raymond worked for the British Virgin Islands National Parks Trust, where he oversaw the Anegada Iguana Headstart and Recovery Programme. That program experienced many changes and improvements under Raymond's oversight, growing from a basic headstart operation to one that has repatriated 72 iguanas back to the wild since 2003. Those of us who worked in the BVI on the iguana project with Raymond knew him to be a decent, genuine, and hard-working individual, one who took great pleasure in contributing to the progress of the program. He was always helpful and upbeat, with a contagious smile that made working with him a pleasure. Some members of the Iguana Specialist Group met Raymond when he attended the ISG meetings in Puerto Rico (1999) and Grand Cayman (2001).

Personnel at the BVI National Parks Trust office are deeply saddened by this tragic turn of events. He will be missed by all of us who worked with him over the years.

Please join me as we extend our sincere condolences to his family, including his wife and two very young children, and co-workers.

Rick Hudson
ISG Co-chair

IRCF ON THE MOVE

Dart Foundation Grant for Blue Iguanas

IRCF's 501(c)3 status came into play late last year, when the Blue Iguana Recovery Program was looking to apply to the Dart Foundation for project funding. For institutional reasons, an application was most likely to be successful if submitted by a 501(c)3 Foundation or equivalent.

Responding to the Blue Iguana Recovery Program's request, IRCF submitted a formal bid to the Dart Foundation for US $36,400 to cover the costs of a range of urgently needed improvements to the captive breeding and head-starting facility for Blue Iguanas at the QE II Botanic Park on Grand Cayman. At the same time, IRCF launched a web appeal on www.BlueIguana.ky to raise additional funds for a security fence for the facility.

In mid-December, good news came in from the Dart Foundation, and, by mid-January, IRCF had transferred the funds to Grand Cayman and the captive facility is now a hive of activity. The security and tour control fences are going up, a large hurricane-damaged breeding pen is being restored, landscaped, and subdivided, and plans are underway to trench for electrical and water supplies. The Dart Foundation and the individuals who have contributed to the fence appeal will all be recognized on a panel to be mounted in the main tour area.

DART FOUNDATION

FRED BURTON

Dart Foundation-funded improvements to the captive breeding and head-starting facility for Blue Iguanas on Grand Cayman.

Andros Footballers Adopt Iguana Mascot

The Central Andros Football Club adopted the Andros Iguana (*Cyclura cychlura cychlura*) as its mascot and was rewarded with t-shirts provided by the Shedd Aquarium and the IRCF. The team logo (below) features the artwork of Joel Friesch (IRCF).

CENTRAL ANDROS IGUANAS FOOTBALL CLUB

Anyone interested in helping to support the Andros footballers and their efforts to promote iguana conservation, please contact John Binns (JFB@IRCF.org).

Shedd
The World's Aquarium

IRCF

IRCF

International Reptile Conservation Foundation

Editor's Remarks

Since expanding the journal's coverage from iguanas to all reptiles in 2005, we extended the scope of our "Newsbriefs" to include newsworthy items affecting reptiles from all over the world and we introduced "Conservation Research Reports," summaries of articles published elsewhere about the conservation of reptiles. Simply put, the purpose of both sections is to increase the awareness of events and new research that supplement the other features of *Iguana* and vastly extend the journal's breadth of coverage. To entice readers to explore these sections, we try very hard to illustrate each entry with at least one photograph, especially when the focal species is likely to be unfamiliar to many readers. In order to accomplish this, we have exploited friends, colleagues, and strangers by asking permission to use their photographs — and, mostly because they, too, have an interest in the conservation of reptiles, permission is readily and quickly forthcoming. Although singling out any contributors generates the risk of omitting others who are equally deserving, two individuals stand out, primarily because we have asked for their help again and again — and, each time, they cheerfully supply the necessary images. Suzanne L. Collins, of the Center for North American Herpetology (CNAH), almost invariably has and lets us use her exquisite images of North American species, and Kenneth L. Krysko, of the Florida Museum of Natural History, graciously allows us to supplement newsbriefs or summaries with his photos of species native to and introduced into Florida. We thank them and all of the other generous contributors who, we like to think, dramatically enhance the written word with their art.

The Editors

Statement of Purpose

The International Reptile Conservation Foundation works to conserve reptiles and the natural habitats and ecosystems that support them.

The International Reptile Conservation Foundation, Inc. is a non-profit 501 c(3) California corporation.

Membership Information

IGUANA, the Journal of The International Reptile Conservation Foundation, is distributed quarterly.

Annual Rates:

Individual U.S. or Canadian Membership	$25.00
Individual Membership, Digital (Adobe PDF)*	$25.00
International Membership	$50.00
U.S. Institutional Subscription,	$30.00
International Institutional Subscription	$55.00

Additional copies are available upon request at $6.00 each plus postage.

*The Adobe PDF is optimized for web publishing and does not provide the quality and resolution of the archival printed version, especially noticeable in photographs and complex graphics.

www.IRCF.org

Join Online at: www.IRCF.org/iguana

Membership Questions?

Email: info@IRCF.org, or contact AJ at 860-236-8203, or write to: IRCF, 3010 Magnum Drive, San Jose, CA 95135

Solicitations

The IRCF encourages contribution of articles, letters to the Editor, news items, and announcements for publication in IGUANA. General articles can deal with any aspect of reptilian biology, including conservation, behavior, ecology, physiology, systematics, or husbandry. Submission of photographs to accompany articles is encouraged. Manuscripts may be submitted via e-mail (send to AJ@IRCF.org). Authors of one page or more of print will receive a free copy of the journal in which their contribution appears, and will receive a PDF file of their article for distribution.

Donations

For any donations, please include your name, address, phone number, and e-mail address.

Advertising Policy

We advertise only non-living products (except feeder insects). For advertising rates and options contact Sandy Binns, Advertising Director, at SB@IRCF.org or 3010 Magnum Drive, San Jose, CA 95135.

FOCUS ON CONSERVATION

Grenada Bank Treeboa
Corallus grenadensis

ROBERT POWELL

Status and Conservation of Treeboas on the Grenada Bank

The Grenada Bank Treeboa (*Corallus grenadensis*) exhibits one of the most variable color patterns in any species of snake, and that variation has been shown to be correlated with elevation and associated meteorological conditions (temperature, rainfall, amount of possible sunshine). The species is known to occur on ten islands on the Grenada Bank. The largest island on the bank is Grenada, with an area of 311 km^2. The other nine islands are part of the Grenadines (with political affiliations to St. Vincent or Grenada), have areas ranging from 0.7 km^2 (Petit Martinique) to 32 km^2 (Carriacou), an average size of 8.5 km^2, and a total area of 77 km^2. The total *potential* range of *Corallus grenadensis* is under 400 km^2. Over the past 200–300 years, however, deforestation has reduced that area by at least 50%.

Over the past 500+ years, treeboas on Grenada have had to adapt to new prey species (introduced rodents), large-scale elimination of native trees and the introduction of orchard trees (nutmeg, mango, breadfruit, citrus, cacao), and the introduction of alien predators (opossums, mongooses, monkeys).

Since 1989, projects focused on treeboa biology (primarily on Grenada) have monitored numbers of snakes at several localities in disparate habitats and weather regimes across the island. In the late 1990s, researchers from the Milwaukee Public Museum (MPM) began to witness declines in treeboa encounter rates. Those declines have continued to the present — and are of grave concern.

Of equal concern is a lack of information about what may be happening on those Grenadines that harbor treeboas. These small, picturesque islands are rapidly being developed for a burgeoning tourist industry, and several have been sold to private entities. MPM would like to initiate population assessments of treeboas on several of the smaller Grenadines, and anyone interested in contributing to the treeboa assessment program is encouraged to send tax-deductible contributions to:

Milwaukee Public Museum
Attn: Bob Henderson
800 W. Wells Street
Milwaukee, WI 53233-1478

BARNEY OLDFIELD, WWW.LIZARDSANDLANDSCAPES.COM

This close-up of a Timber Rattlesnake (*Crotalus horridus*) reveals the elliptical pupil characteristic of nocturnally active pit-vipers and the infrared-sensitive pit from which this family of snakes gets its name and which is used to direct strikes. This individual was from Pierce County, Wisconsin (see article on p. 31).

JOESEPH BURGESS

"El Lagarto Azul," the Blue Anole (*Anolis gorgonae*) of Isla Gorgona, Colombia (see travelogue on p. 47).