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IGUANA

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Central Netted Dragons (*Ctenophorus nuchalis*) from Australia are popular in captivity due to their striking appearance and great temperament. See article on p. 226.



KRISTA MOUGEY

Newly hatched Texas Horned Lizard (*Phrynosoma cornutum*) on the face of a watch. See article on p. 204.



KENNETH L. KRYSKO

Invasive Knight Anoles (*Anolis equestris*) should be removed when encountered in the wild. See article on p. 212.



MARK DE SILVA

Grenada Treeboas (*Corallus grenadensis*) remain abundant on many of the Grenadine Islands despite the fact that virtually all forested portions of the islands were cleared for agriculture during colonial times. This individual is from Mayreau. See article on p. 198.



JOSHUA M. KAPFER

Of the snakes that occur in the upper midwestern United States, Bullsnakes (*Pituophis catenifer sayi*) are arguably the most impressive in stature and may be rewarding subjects of research. See article on p. 190.



WIKIPEDIA.ORG

Populations of the Caspian Seal (*Pusa caspica*) have declined by 90% in the last 100 years due to unsustainable hunting and habitat degradation. See "Conservation Alert" on p. 220.



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JOHN BINNS

The Grand Cayman Blue-fanned Anole (*Anolis conspersus*) has been forced to assume higher perches due to competitive interactions with introduced Brown Anoles (*A. sagrei*).



Bullsnakes (*Pituophis catenifer sayi*) are arguably the most impressive snakes in the upper midwestern United States.

Chasing Bullsnares (*Pituophis catenifer sayi*) in Wisconsin: On the Road to Understanding the Ecology and Conservation of the Midwest's Giant Serpent

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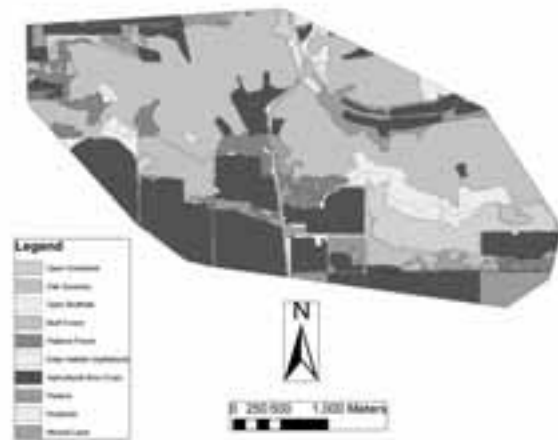
Photographs by the author except the facing page and where indicated.

When herpetologists weigh their options for new study locales, the upper midwestern United States (UMUS) does not leap to mind. This is particularly true of Wisconsin, which might evoke visions of Holstein cattle and knee-high snow for six months out of the year. To those who were born in warm climates, the “Badger State” might as well be the North Pole — certainly not a destination for herpetofaunal research. Also for this reason, graduate students in herpetology searching for tiny bits of space or funding to eke out an academic existence do not first cast their eyes northward. In addition to the cold, they perceive a lack of herpetofaunal diversity, which is true when compared to the tropics. However, the UMUS has a *nice* number of native species (I like to say a “manageable” number¹), about many of which surprisingly little is known. Couple this with the fact that, for many of these species, the UMUS represents the periphery of their geographic distributions and an intersection of various habitat communities, interesting research questions start coming to mind. Therefore, conducting herpetological research in the UMUS (or, specifically, Wisconsin) can be a rewarding endeavor for those who pursue it.

Snakes are the most speciose group in this region, with slightly over 20 native species occurring here. Of these, the sub-family Colubrinae is largest, represented by six species: Smooth Greensnakes (*Opheodrys vernalis*), Racers (*Coluber constrictor*), Eastern Milksnakes (*Lampropeltis triangulum triangulum*), Western Foxsnakes (*Pantherophis vulpinus*), Gray Ratsnakes (*Pantherophis spiloides*), and Bullsnares (*Pituophis catenifer sayi*). Among the true constrictors in this sub-family, Bullsnares are arguably the most impressive in stature, often exceeding 5 ft (~150 cm) in snout-to-vent length (but I've received unconfirmed reports of 8 ft, or 240+ cm, individuals in Wisconsin). While this may not sound impressive to those who are fortunate enough to study boas and pythons, in a region where people

mostly encounter gartersnakes that are less than a foot (~30 cm) in length, a five-foot plus snake is impressive.

The distribution of the Bullsnares in North America once was vast. In fact, members of the genus *Pituophis* have a historic range that covers much of the United States, from the eastern to western coasts, north into Canada, and south into Mexico. Bullsnares are the most widely distributed species within this group, and their range encompasses most of the Great Plains Region and a portion of the Midwest. The Great Plains Region once was dominated by prairies and grasslands, and this habitat has become synonymous with Bullsnares and Gophersnares. Much of this habitat has been converted to agriculture since the time of European settlement, and, because of this, Bullsnares now are most often associated with agriculture and the rural landscapes where they persist. In fact, the Bullsnares is often referred to as a “friend of the farmer” because of the voracity with which it consumes rodents. As early as 1926, Hisaw and



A map outlining habitat types available to radio-tagged Bullsnares within the author's southwestern Wisconsin (USA) study area from 2003 to 2005 (permission to use copyrighted material granted by the American Society of Ichthyologists and Herpetologists).

¹ Wisconsin has 22 species of snakes, 11 species of turtles, four species of lizards, and 19 species of frogs, toads, and salamanders.

Gloyd reported on this species' ability to control "injurious" rodents and, more recently, Rodríguez-Robles (2002) reported that mammals such as pocket gophers, mice, and ground squirrels make up 75% of the diet. Unfortunately, this association with agricultural habitats often leads to mortality, as Bullsnares spending an appreciable amount of time in agricultural fields often are killed inadvertently by farm equipment (see below and Kapfer et al. 2008a).

Despite their nearly pan-geographic distribution in North America, their importance in rodent control, and reported declines in several Midwestern states, relatively little research has been conducted on members of this genus. Although some studies have focused on habitat selection and movement patterns of Great Basin Gophersnakes in Utah, California, and British Columbia (Parker and Brown 1980, Shewchuk 1996, Rodríguez-Robles 2003) and the Northern Pinesnake in Tennessee and Florida (Gerald et al. 2006a, 2006b; Burger and Zappalorti 1998), the Bullsnares has received less attention. Until recently, the most thorough research on habitat associations and movements of this species had been conducted by Fitch (1999), who spent 50 years studying an entire snake assemblage in Kansas, and an unpublished report from Nebraska by Fox (1986), whose goal was to control snakes that were eating waterfowl eggs on a wildlife refuge. With the exception of Moriarty and Linck (1998), no studies of their ecology in the Midwest had been conducted. Although interesting, this study focused on the movement patterns of transplanted Bullsnares that had been re-introduced into a recreated prairie, and the results may not be indicative of natural populations.

In Wisconsin, Bullsnares are known primarily from disjunct populations in the southern and western parts of the state. Many factors are believed to have contributed to the decline of this species in the UMUS. Likely explanations include loss of preferred habitat via conversion to agriculture or encroachment of woody vegetation and mortality due to anthropogenic causes. Only a handful of Bullsnares sites in Wisconsin are found on public land, to which access for research is easily granted. Few of these sites control vegetative succession (invasion of grasslands by woody vegetation resulting from fire suppression), and the persistence of Bullsnares populations at such locations remains uncertain. This, coupled with their rarity in the state, makes

them a difficult species to study if one hopes to achieve the large sample sizes necessary for conclusive results.

The Evolution of a Graduate Student Project

In 2002, my master's research at the University of Wisconsin-La Crosse was drawing to a close. At that time, I remember becoming intensely interested in the colubrine snakes of Wisconsin. Prior to that, I had focused my attention on the survival of tadpoles in agricultural ponds. However, even while collecting data for that research, I recall spending a substantial amount of time digging through piles of debris and flipping cover-boards in hopes of finding a snake or two at my study sites. Although I had enjoyed my research on frogs, my interests obviously were shifting. Soon, I was scouring literature databases for published information on colubrine snakes in the upper Midwest ... and finding very little beyond what was contained in field guides. Clearly, this was the avenue I wanted to pursue as a researcher. Most snakes in this group were interesting ecologically, research on them was uncharted territory in the UMUS, and, most importantly, they were big constrictors (and big equals more fun in my book). Of species native to the region, the biggest (and therefore, likely to be the most fun to research) was the Bullsnares.

Looking back, I realize that I had been fortunate as a graduate student. I wanted to conduct research on Bullsnares, but that was only half the battle. I needed a home at a university, a graduate advisor, and funding (for my research and to pay my bills). Luckily, I was able to convince Dr. James Coggins at the University of Wisconsin-Milwaukee that, although he was a parasitologist by trade, he really needed to take on a wannabe herpetologist as a grad student. I also had the support of the Wisconsin Department of Natural Resources, Bureau of Endangered Resources Herpetologist Bob Hay (an outstanding field herpetologist), who proved a source of excellent advice on countless occasions. In addition, Dr. Erik Wild, a herpetologist I had known for several years from the University of Wisconsin-Stevens Point, agreed to be an adjunct member of my graduate committee, for which I am forever grateful. Had these three individuals not been willing to be a part of my research, it would not have happened. On the downside, I would have to conduct my research on a very tight budget. I was able to acquire small grants that covered transmitters and implantation, PIT tags, and a GPS



This male Bullsnares was the first snake captured and implanted with a transmitter.



This Bullsnares was the only female that survived all three years of radio-telemetry research.



The author holds a male Bullsnake, the largest individual tracked during the study. Unfortunately, it was killed and eaten by a coyote.



This female was killed by a plow during the crop harvest in early fall 2005.

unit. The rest was borrowed or out-of-pocket, but I didn't care — I was going to conduct research.

In the spring of 2003, I began work in southwestern Wisconsin, an area associated with the “Lower Wisconsin River Valley.” At the time, I decided that radio-telemetry, a well-established method for studies of snake ecology, would be employed to track snakes for three years. Prior to this research, I had been involved in a USGS radio-telemetry study on Leopard Frogs (*Lithobates pipiens*) in Minnesota, and had learned the subtleties of using the technology, which seemed (and still seems) to be the best possible option for elucidating detailed information about the habitat selection and movement of such secretive critters. With help, by April of '03 I had found a site likely to yield enough snakes to make good use of the transmitters I could afford (approximately 20).

The first day of fieldwork was quite an experience. Bob (Hay) and I went to the study site in late April, hoping that the snakes had started to emerge from hibernation. We began walking across the prairie on a cloudy day and after only 15 or 20 minutes, I heard Bob say, “There's one, right there!” Sure enough, moving across the edge of a sandblow was a beautiful male Bullsnake. We were both pretty excited. Those who study amphibians and reptiles know that you can spend hours or days searching for some species and not find a single individual.

With our first snake in the bag, we split up. I went west, scouring brushy hillsides, and Bob went straight ahead, toward a more open hillside. As I worked over the slope, I occasionally glanced over at Bob to see if he was having any luck, but never got the feeling that he was finding anything. “That's alright,” I remember thinking to myself, “If I can catch one snake every time I come out here, I'll still have a decent sample by May.” About an hour later, we met in the middle on a large open hillside, with exposed rocky shelves and outcroppings around us. For a few minutes, we considered quitting. What we didn't realize was that things were about to get very busy. After deciding that we shouldn't give up so easily, we both started poking around brushpiles on the hillside where we had met. Within minutes we found another snake — a big one, then another. A few minutes later, we found yet another. I was amazed at how our luck had changed! We could hardly get the pillowcases ready fast enough to hold one snake before finding another. All in all,

our day ended with eight Bullsnares captured and ready for transmitter implantation. What a great start for the research project! At that time, I had no idea how fortunate we had been. Later I was to learn just how difficult these snakes are to find.

Bullsnake Populations and Sources of Mortality

That first year (2003), I ended with 21 adult Bullsnares with implanted transmitters. This included the eight found on the first day of the study and four found with help from a UW-Madison Vertebrate Zoology class of approximately 50 students. This would be my most productive year for finding new snakes. In 2004 and 2005, I found 20 and 15 individuals, respectively. The most troublesome part of this decline in the number of new snakes was that females were encountered less frequently than males. In general, despite the large number of snakes caught that first day, Bullsnares were not very abundant at this site, and I estimated a density of only 0.42 adults per hectare at the end of the study. Recapturing snakes without the aid of telemetry equipment also was very difficult. The low number of recaptures with only one surveyor present (i.e., me) made it unlikely that an adequate estimate of population size could be made. Only with the help of the UW-Madison students was I able to get recaptures within a reasonable amount of time. My only consolation was that low recapture rates in snakes of this genus are not uncommon (Fox 1986, Diller and Wallace 1996, Shewchuk 1996, Fitch 1999).

Bullsnares face numerous daily pressures in addition to the long-term loss of suitable habitat. Traffic, farm equipment, wanton killing by unknowing landowners, and (I found during my research) predators all pose significant threats (Kapfer et al. 2008a). When I began tracking Bullsnares in '03, I felt confident that few, if any, natural predators would consider taking an adult snake. I was fairly certain that birds of prey probably consumed juveniles and numerous predators likely ate hatchlings. However, I never believed that mammalian predators (such as coyotes) would be much of an issue, thinking that more abundant prey would result in a greater caloric payoff per unit effort than snakes. In fact, on numerous occasions, I saw coyote kill sites containing the remains of rabbits, turkeys, pocket gophers, and even deer. However, my assumptions were incorrect. In one year (2004), nearly all of the snakes consumed were taken by coyotes. Most of this mortality corresponded with heavy spring



DAMI NERELO

Snakes frequently came into contact with humans. This individual was found near a farmhouse and might have been killed if the landowner had not been sympathetic toward snakes.

rains, which Jackson (1961) suggested could result in higher than normal leveret (= baby rabbit) mortality due to exposure. Could this have caused coyotes to shift from a preferred prey of rabbits to snakes? Possibly, but without having examined prey availability more closely, I can't say for certain.

In 2003 and 2005, farm equipment was, by far, the greatest cause of mortality in radio-tagged snakes, with females invariably experiencing higher mortality rates than males. In fact, in all three years pooled, the mortality rate for females with implanted transmitters was nearly 44%, compared to 14% in males (and nearly 27% for all snakes). Furthermore, most of the females taken by coyotes were gravid and likely killed prior to egg deposition, which is not a good omen for the persistence of these snakes in the region.

I did find that, despite equipment-related mortality, most local farmers were sensitive to this species. Many actually liked having Bullsnares around, due to their effectiveness as rodent predators. Several of the local landowners actually accompanied me when I tracked my test subjects, hoping to get a look at them and see exactly what I was doing. Yet, agricultural equipment posed a definite threat to Bullsnares survival at this site. I found it strange that, despite the presence of suitable non-agricultural habitat readily available to the snakes I was tracking, many ventured into agricultural fields and often died. Considering my low Bullsnares density estimates compared to apparently abundant prey, competition for food seemed an unlikely reason for them to enter agricultural fields. Regardless, the tendency of this species to enter a burrow when danger approached did not save them from the digging tines of equipment used to harvest crops. Although most of the local farmers would not actively harm Bullsnares, snakes hidden in burrows below crops were inadvertently killed by plows on several occasions.

Preferred Habitat and Movement Patterns

Aside from determining sources of mortality, a principal goal of my research was to document movements and habitat selection. The best available information on preferred habitat of this snake in Wisconsin was anecdotal, and came from Richard C. Vogt's (1981) field guide, *Natural History of Amphibians and Reptiles in Wisconsin* (Milwaukee Public Museum Press). Because Bullsnares are considered rare or declining in several states in the UMUS (i.e., Minnesota, Iowa, and Wisconsin), a rigorous study on preferred habitats and movement patterns was necessary to facilitate their conservation.

Generally, this species is reported to prefer open canopy, short-grass prairie, or grassland habitats. I believed that these would be the habitats selected by the snakes I was tracking as well. The result of my research, however, was not so cut-and-dried. Throughout the year, I located individuals in habitats that I would never have imagined them using. For example, on more than one occasion, I followed individuals through dense underbrush in closed canopy hardwood forests on bluff sides (not a desirable task in the high humidity, 90°-days of July or August). I found later that these habitats were not preferred when their availability was considered (combined with agriculture, they equaled nearly 65% of the available habitat). This was not terribly surprising. What did surprise me, however, was that the traditional Bullsnares habitat (i.e., prairie and grassland) also was not preferred when based on its availability.

The habitat that was preferred by males and females in all three years of the study was open canopy, south- or west-facing bluffs. This was despite the fact that this habitat comprised only ~3% of available habitat (Kapfer et al. 2008b). Communal denning sites often are found on exposed bluff slopes such as these, so I had previously believed this habitat would be important to the Bullsnares only immediately before and after winter dormancy. I had not anticipated that it would be used by snakes more than other available habitats in every season.

What I believe is important regarding my results on habitat preferences is that most long-term plans for prairie habitat management with which I have experience seem to focus mostly on eliminating woody vegetation (even native species, such as oaks) in flatland habitats. While helping native herbaceous

Table 1. Comparison of the percentage of the study site comprised of different habitats and proportion of total snake locations occurring in each habitat type.

Habitat Type	Percent Snakes in Habitat Types	Percent Availability of Habitat Types
Bluffside Forest	10	37
Row Crop	7	28
Flatland Forest	4	5
Pasture	3	5
Roadside	2	2
Edge (ag/nat)	6	3
Open Grassland	13	7
Oak Savanna	15	6
Open Bluff	33	3



Bullsnakes have a unique pattern unlike that of any other snake in the midwestern United States.

prairie vegetation proliferate is obviously important, a habitat with greater structural heterogeneity might be of greater value to wildlife — including reptiles, for which the elimination of woody vegetation tends to eliminate thermoregulatory opportunities. Ground temperatures on sand prairies are very high and often exceed 50 °C (pers. obs.). Although some reptiles may be able to tolerate such temperatures, I found that the average ground temperature where I observed Bullsnakes ranged from 29.8–30.7 °C (with body temperatures of 25.2–26.7 °C; Kapfer et al. 2008c).

Very open, short-grass habitats also contain fewer types of refugia from predators. Bullsnakes, for example, often were observed seeking shelter in fallen oak trees, brushpiles, or tangles of native woody vegetation (e.g., raspberry). If large expanses of such open flatland habitat are the goal for habitat managers, maintenance of edges or savanna-type habitats should also be considered. These can create refuges and movement corridors for wildlife. Regardless, in the UMUS, open south- or west-facing bluffs are critical habitats for this species. Therefore, clearing these slopes, if they are present on a particular site, may be necessary for the persistence of these snakes.



Snakes might be attracted to agricultural fields because winter-wheat fields look like grasslands in early spring. Tim Muehlfeld is an enthusiast and a good friend who assisted the author on numerous occasions.

Understanding the spatial ecology of this species is also important for their conservation. For example, knowing the distances that individuals travel or the areas they typically patrol during the active season can provide insights into the critical sizes of habitats that should be preserved. Something that became apparent early in the study was that these snakes are capable of moving long distances. On average, individuals moved nearly 35 m/day (Kapfer et al. 2008b). They also patrolled large home ranges. I measured home range using two different methods: (1) Minimum convex polygons are determined by simply connecting the outermost locations of an individual on a map, which then becomes the boundary of its home range; and (2) Kernel estimates use the density and spread of location points for a radio-tagged individual as if they were plotted on a histogram, resulting in a greater proportion of the home range centered around areas where the highest density, or intensity, of locations occurs. Isopleth lines are generated, based on relative intensity of point concentrations, which allows core areas of the home range to be delineated. With this method, one can estimate the area that the animal is likely to patrol, while eliminating locations determined to be outliers. Minimum convex polygon home ranges ranged from 20 to nearly 50 hectares in tracked snakes, whereas kernel estimates for the same snakes ranged from 40–95 hectares. Both methods, however, indicated that these snakes moved about in large areas, suggesting that very large habitat preserves might reduce travel into agricultural fields or across roads, where mortality is high.

Although I rarely found snakes in the same location in subsequent observations, they often returned to the same locations after varying periods of time, resulting in a high fidelity for specific spots within their home ranges. This has obvious conservation and management implications: (1) Snakes that return to the same spots frequently may be accidentally killed during intense management practices (i.e., burning or cutting of undesirable vegetation that are conducted at the same locations annually); and (2) unscrupulous snake collectors can have a profound effect on Bullsnake populations by checking the same locations annually.

Finale

The following example of this species' tendency to end up in strange places also illustrates how the unpredictable nature of field research generates a need for future exploration of observed phenomena. This particular event came on a day when a friend of mine (Tim Muehlfeld) and I were tracking a male Bullsnake around a farmhouse. I had heard the snake's signal in the vicinity two days prior, but had not yet been able to ask the landowner for permission to enter his property. On this day, however, we did talk to the gentlemen who owned the property, and he was very willing to let us track the snake. I told him that it might be near his house and he seemed to become even more eager, wanting the snake moved so it would not scare his wife. We obliged and began searching for this snake's signal around the house's foundation, but I was surprised to find that the signal was very weak unless I pointed the antenna almost straight up.

At first I thought the snake might have moved to the backyard, and the signal became slightly stronger when we made our way around to the back of the house and into the entrance to his garage. I wondered if the snake was in the garage, behind the



An open bluff used by Bullsnares in the upper Midwest. Note also the extensive agriculture in the adjacent flatlands.

garbage cans, or in a corner hunting rodents, but the signal seemed to be overhead. Not only was it overhead, it grew stronger as we moved toward the entrance to his house from the garage. I could tell that the landowner was uncomfortable with the thought of the snake being in his house. He looked at us and said, “Do you want to go inside the house?”

Within minutes, and after removing our dirty field shoes, we were cautiously moving about his living room in our stocking feet (I have to admit, it felt strange having to worry about breaking ornamental glassware with a telemetry antenna, which was something I never thought I would have to consider during my research). The signal strength quickly guided us to the upper level of the house, down a hallway, and into the bathroom. My first thought was “you’re kidding! This snake is actually going to be in the toilet — the urban legend will come to life before our eyes!” Fortunately, that was not the case. What we did determine was that the signal was higher still, and strongest in a small area of the ceiling directly above the shower. The landowner immediately turned to me and asked, “Do you want to go into the attic?”



Although snakes used this incredibly thick understory vegetation under a dense canopy, it was used infrequently compared to its prevalence at my study site.

So, with him as our guide, the three of us marched to a ladder that led to a small rectangular opening in the ceiling of his home. Upon entering the attic, Tim and I shared the same feeling of dread. It was incredibly hot and not at all what I imagined a place where I would find a Bullsnares to be like. My first thought was that the animal had been eaten by a raccoon, which had swallowed the transmitter and was now in this man’s attic. Looking back on it, such a scenario was as unlikely as us finding a Sasquatch, but strange things come to mind when you’re in bizarre situations.

The next problem was that the attic was pitch black and not a “finished” room. We had to walk across cross beams between which insulation had been packed. Wearing only socks, balancing on narrow wooden beams in the dark, and holding a large telemetry antenna, I attempted to locate the snake in the beam of two small flashlights. The increasingly strong transmitter signal told us that the snake (or at least its transmitter) was somewhere in the attic.

Trying to get my bearings in the dark, I swung the antenna to the left and the signal got stronger. “It’s somewhere over there,” I said. “We’ve got to get this snake out of here before my wife gets home,” the landowner replied uncomfortably. So, carefully stepping on crossbeams and grabbing anything overhead that we could use to stabilize ourselves, we moved in that direction. As the roof sloped downward, we noticed a long crack that allowed a small amount of light into that corner of the attic and, upon our arrival, saw a small group of birds make a hasty exit through the crack. At that point, I knew if that crack was large enough for birds to get in, it was large enough for a snake — and maybe we weren’t looking for a dead snake after all. Then Tim spoke up: “I see it,” as the beam of his flashlight rested on a Bullsnares coil, barely visible in the insulation. “Can you grab him?” I asked, as my hands were full and Tim was closest to the snake. He leaned against a nearby support beam so that he was almost vertical and snatched up the visible coil. He later confessed to me that he was certain the snake would be “mush” in his hand when he grabbed it (i.e., he’d be grabbing the decaying body of a dead snake). On the contrary, the second he laid a finger on the animal, it instantly curved its neck into a defensive posture and hissed loudly. It was alive and, we determined later, in perfect health.

The man asked me to remove the snake from his property. Although I was reluctant to do this, as it would confound the data I was collecting, he had been pretty understanding about the whole incident. So, I moved the snake nearly half a mile (0.8 kilometers) away and released it within its normal home range. A few days later, however, I discovered that the snake had obviously known where it wanted to be. It had returned to this specific property again, and was resting comfortably in the hollow of a maple tree along the landowner’s driveway.

I’ve always wondered what that snake was doing in that hot, stuffy attic. Eating baby birds? It was too dark to see if any nests were present. What was a “prairie” snake species that is not thought to be very arboreal doing in the attic of a farmhouse? How did it find enough purchase on the house’s exterior to climb up there? Was the attic part of its normal home range (it never did return to the attic)? I have no answers to these questions, but a desire to find such answers (in other words, curiosity) drives



In addition to open grasslands, management should consider preservation of Oak savanna and other habitats that are structurally heterogeneous and could provide refugia for wildlife.

those of use who choose to engage in science. Fortunately for me, snakes seem particularly effective in raising new questions.

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The infamous "attic snake" nearly scared a local landowner and his wife to death!

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RICHARD SUDAK

An adult female Grenada Treeboa (*Corallus grenadensis*) from Pearls, Grenada. This individual has a dorsal ground color of dingy yellow and olive green dorsal markings.

The Shared History of Treeboas (*Corallus grenadensis*) and Humans on Grenada: A Hypothetical Excursion

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Studying reptiles under pristine conditions in the West Indies is virtually impossible today. That said, and because of previous and ongoing development in the Antilles, investigating reptilian ecology in the context of human activity has become increasingly important. Although we can now document how a particular species is responding to an altered environment, we can make only educated guesses as to how it responded pre-historically. Here, based on 20 years of observing Grenada Bank Treeboas (*Corallus grenadensis*), I offer largely hypothetical suggestions regarding the impact of humans on *C. grenadensis* throughout their shared history. When I have data (e.g., on human population density, land use, treeboa natural history) I include it, but much of what follows is conjecture. Pearls, a site close to the windward (eastern) coast in St. Andrew Parish, has been important archaeologically and, by chance, as a primary source of information on the natural history of treeboas, so I focus on that site for some of my hypothetical history.

Pre-human Habitation and Pre-Columbian Period

Typically associated with forest edges, the distribution of *Corallus grenadensis* on Grenada prior to the arrival of humans probably was restricted to natural margins of lakes, rivers, coastlines, and other natural breaks in the distribution of forests, including

those resulting from hurricanes and other natural disturbances. These snakes fed largely on native lizards, especially *Anolis aeneus* and *A. richardii*, both of which also are most abundant along edges, and murid rodents of the genus *Oryzomys*, and were preyed upon by raptors (e.g., *Buteo platypterus*).

Treeboas on Grenada have had a shared history with humans for at least 4,000 years, and possibly longer. Caribbean Archaic sites (ca. 3000–400 BC) are rare and relatively small. These early arrivals were primarily fisher-foragers with an emphasis on marine foods (Newsom and Wing 2004). Treeboa distribution on Grenada likely changed little during this period. If small forest clearings were made, suitable edge habitat may have increased, thereby providing additional treeboa habitat. Treeboas did, however, gain a new enemy, and they almost certainly were killed when encountered by human invaders.

Ceramic-age (400 BC–1500 AD) people established permanent settlements, planted crops, and managed animals. As they probably practiced shifting cultivation to create agricultural plots for manioc and other crops, this “would have resulted in the first major anthropogenic disturbance and disruption of the natural forests and vegetation...” (Newsom and Wing 2004). This presumably would have increased treeboa habitat by increasing the abundance of edge situations. During 0–500 AD (Haviser 1997),



RICHARD SADDAK

A treeboa (*Corallus grenadensis*) with an essentially patternless yellow dorsum from Pearls.



KY HENDERSON

With a dorsal ground color of taupe, this treeboa exhibits the predominant dorsal color that occurs at Pearls.



RICHARD SAIDAK

When foraging for anoles, *Corallus grenadensis* will cruise slowly over leaf and branch surfaces while tongue-flicking, presumably in order to locate the scent of a now-sleeping lizard.



ROBERT POWELL

The smaller of the two anole species that are native to Grenada, *Anolis aeneus* is virtually ubiquitous on the island.



ROBERT POWELL

Like its smaller congeneric, *Anolis richardii* is also widespread on Grenada, occurring from sea level to the highest elevations on the island.

Pearls was a large, 60.7-ha site (Newsom and Wing 2004) on rich agricultural land (Bullen 1964) and a center of Saladoid culture on Ceramic-age Grenada. Although early human activity at Pearls probably altered habitats, large-scale deforestation was unlikely. Likely, a large area would have been cleared for the village with gardens surrounding it. They would have been cleared and planted for 4–5 years, and then allowed to return to secondary forest before they were cleared again (perhaps 20 years later) using a slash-and-burn technique (W. Keegan, in litt., 6.XI.2008). Thus, a waxing and waning of potential treeboia habitat would have been associated with early settlements. Evidence of opossums (*Didelphis marsupialis*) has been recovered from cultural contexts at Ceramic-age sites (Pregill et al. 1994). They were likely introduced during this period, and are known to prey on *C. grenadensis* (Henderson 2002).

The 15th–17th Centuries

At the time of “discovery,” the human population density of the Lesser Antilles was estimated to be about 5/km² (Newsom 1976). Initial attempts at colonization of Grenada by the French occurred in 1609 and again in 1638; both were unsuccessful, due largely to the hostile behavior of Island Caribs (Brizan 1984). The first successful attempt was in 1650, also by the

French. Ultimately, the island was ceded to England in 1763. Large-scale deforestation on Grenada was unlikely prior to the first successful colonization, and *C. grenadensis* distribution may not have been significantly different than during pre-discovery or late Ceramic periods. Although the arrival of Europeans may not initially have had a negative effect on the habitat and distribution of *C. grenadensis*, it did have a potentially deleterious impact on the boa's trophic ecology. The earliest arrivals from Europe were certainly responsible for the introduction of Black Rats (*Rattus rattus*), consequently contributing to the extinction/extirpation of the two species of native Rice Rats (likely *Oryzomys*), almost certainly the primary pre-discovery prey for adult treeboas. Rice Rats have been recovered from Ceramic-age cultural sites on Grenada, indicating that humans also included them in their diets (Pregill et al. 1994) — and this too may have contributed to their disappearance. To date, however, no evidence indicates that Rice Rats and Black Rats co-existed on Grenada. Mona Monkeys (*Cercopithecus mona*) were introduced to Grenada sometime between the late 17th and 18th centuries during the height of the slave trade (Glenn 1998); the monkeys are known to at least molest treeboas.

The 18th and 19th Centuries

The 18th century saw the onset of the plantation system and large-scale deforestation, wherein forests were largely eliminated on all but the steepest slopes of Grenada (Beard 1949). By the middle of that century, the proliferation of estates for the production of sugarcane and other crops had turned low to mid-elevations on Grenada into a mosaic of cleared land and forest patches. In 1700, with a human population of 835 (2.7/km²; Brizan 1984), three plantations were dedicated to sugar. By 1753, the population density was 43/km². By 1772, 125 of 334 estates were devoted to sugar cultivation (Brizan 1984), and those 125 estates extended over nearly 13,000 ha, accounting for 42% of Grenada's surface area (311 km²). Based on those figures, the average sugar estate was 104 ha, or roughly equivalent to the size of about 230 American football fields.

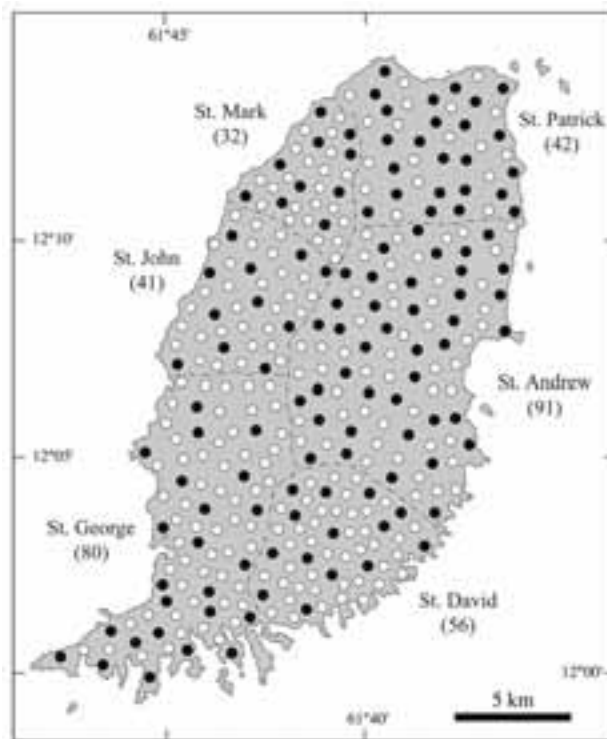
Not all of Grenada is suitable *C. grenadensis* habitat. Treeboas are uncommon or absent at elevations much above 500 m. If roughly 15% of Grenada lies above 500 m, approximately 50% of potential *C. grenadensis* habitat was lost to sugarcane cultivation by 1772. Boas were still restricted to edge situations on the extraordinarily altered island, but the sugar industry had to have had a dramatic impact on treeboa distribution. In 1824, of 342 estates, 123 were devoted to sugar. The number and distribution of estates clearly speaks to the impact they may have had on treeboa distribution. St. Andrew Parish (the site of Pearls) alone supported 91 estates, of which 40 were devoted to sugar. At the peak of sugar production, when the amount of land devoted to sugarcane was at its highest, treeboa numbers may have been at their lowest and their distribution the most contracted. Alternatively, if cane fields were surrounded by trees, even by a tree line one-tree-wide with contiguous crown vegetation, edge habitat may have increased and provided additional habitat for *C. grenadensis*.

Emancipation of slaves on Grenada occurred in 1838, and many became farmers. With emancipation, many new towns and villages were established, and, eventually, many estates were

partitioned into small holdings for former slaves. During his surveys of natural vegetation, Beard (1949) attributed the contemporary lack of rainforest tree species diversity on Grenada to the fact that most of the original forests had been eliminated during the 19th century (but certainly a great deal of deforestation had occurred during the 18th century as well).



This narrow tree line at Westerhall (St. David Parish), Grenada, was surrounded by sugarcane in April 1993, but *C. grenadensis* was nevertheless encountered in the trees.



In 1824, 342 estates dotted the landscape of Grenada. The map shows the distribution of estates by parish (the number of estates in each parish is in parentheses). The solid dots represent estates devoted to sugar, and the open dots those that opted for other forms of produce (e.g., coffee, cotton, cocoa, wood). The placement of the dots has no geographic significance other than to indicate how many estates occurred in each parish, and to convey the impact that agriculture likely had on the distribution and ecology of *Corallus grenadensis*.

During the 1850s (human population density 104/km²), the economy was shifting from sugar cultivation toward cocoa, and, by 1878, the land area devoted to cacao trees surpassed that for sugarcane. By abandoning sugar for cocoa, more land was devoted to habitat that could be exploited by arboreal snakes. Nutmeg was introduced into Grenada in 1843, but not until 1860 was commercial cultivation seriously considered (Brizan 1984). Nutmeg, like cacao, provided new arboreal habitat for treeboas. Bananas also provided arboreal habitat during the 1800s, but not until the 20th century did their cultivation, along with nutmeg, really escalate. Today, orchard trees (e.g., mango, citrus, breadfruit, cacao, nutmeg) often are among the most productive habitats in which to encounter treeboas (e.g., Henderson 2002, Powell et al. 2007). If a near-optimum situation regarding the habitat for *C. grenadensis* ever existed, it might have occurred during the late 19th century when estates were prevalent on the landscape, edge habitat was likely at its peak, orchard trees were widespread, and the human population was still relatively low. Mongooses (*Herpestes javanicus*) were introduced to Grenada midway through the second half of the 19th century (Hoagland et al. 1989). As they will ascend into trees, they are likely at least occasional predators of treeboas.

The 20th and 21st Centuries

In 1901, the population density on Grenada was 204/km² (Brizan 1984). In 1961, 67,100 farmers cultivated land on Grenada (IFAD 2007); in 1962, 7,870 of 8,430 cocoa farmers managed 4 ha or less (Brizan 1984); in 1995, the number of farmers had declined to 43,400 (IFAD 2007), and 6,828 holdings of 0.4 ha or less produced bananas (Anderson et al. 2003). In 2008, approximately 7,000 farmers will produce nutmeg. In

1958, 84% of nearly 5,300 ha were committed to interplanting of banana, nutmeg, and cacao trees, with the banana plants providing temporary shade for young cacao and nutmeg plants. These figures provide some indication of the number of people involved in agriculture during the 20th century, and of the scale at which most agricultural holdings existed. The island may be best envisioned as a mosaic of small towns and villages, fields devoted to various forms of agriculture, patches of forest of one kind or another and of varying expanses, and, when flying over the island, that is exactly how it looks. Although *Corallus grenadensis* occurs over much of the island at elevations below 500 m, it occurs in enclaves separated from each other by treeless expanses.

The landscape of Grenada has changed substantially over the past half-century. Based on satellite image-based mapping, Helmer et al. (2008) calculated that between approximately 1945 and 2000, 9,784 ha were dedicated to herbaceous agriculture and mixed and woody agriculture, a 65% decrease from 1945, when 27,661 ha were devoted to the same types of cultivation — but deciduous forest, semi-deciduous forest, forest/shrub, and shrubland had increased by 716% and evergreen forest and forest/shrub (seasonal evergreen, evergreen, and cloud forest) had increased by 83%, all indications that agriculture is being abandoned and natural vegetation is reclaiming some of what was lost.

In general, these numbers would seem to bode well for *C. grenadensis*, but abandonment of certain types of agricultural activity actually might decrease available treeboa habitat. During the late 1990s and early 2000s, I often encountered 20 or more treeboas in an hour of searching at Pearls. Numbers (especially of adults) have decreased significantly over the past five years,



GOOGLE EARTH

Aerial photo of the Pearls area. Treeboas were at one time abundant in the tree-filled areas north of the abandoned runway. The patchwork nature of the landscape is conspicuously evident.



CRAIG BERG

The range of the Grenada endemic *Pristimantis euphronides* continues to contract (now less than 18 km²) due to habitat alterations and potential competition with introduced *Eleutherodactylus johnstonei*.

and this might be attributable to the decrease in human activity at the site. The absence of human activity results in trails becoming overgrown (= loss of edge habitat) and reduction in the population density of the human commensal *Rattus rattus* (the primary prey species of adult *C. grenadensis*).

Every species of frog and reptile on Grenada has, to one degree or another, been impacted by the activities of humans. Nevertheless, *Corallus grenadensis* has demonstrated an admirable ability to adapt to potentially devastating changes attributable to the relentless activity of humans devoted to altering nature. In 2007 (human population 290/km²), tourism-related development, manufacturing, and residential housing were on the increase, while farming and, I believe, optimum treeboa habitat, were in decline. Urban or built-up land or areas devoid of vegetation have increased by 1,458% between 1945 and 2000 (Helmer et al. 2008). Yet, *C. grenadensis* still persists on the grounds of upscale resorts (including foraging at the edges of lighted parking lots), still enters homes and outbuildings, and still utilizes power lines to cross from one side of a road to the other in small towns. Although *C. grenadensis* may not be as widespread or abundant as it was a century ago (or 10 years ago), one can still go out on virtually any night and eventually find one or more in one or several types of habitat.

During my first visit to Pearls 20 years ago, a young boy approached me and asked if I wanted to buy a pottery artifact that he had found. I told him no thanks, but I did briefly handle the delicate pottery figure (likely an adorno) before handing it back to him. That fleeting encounter with the small figurine provided a physical and emotional connection, albeit distant in time, with the maker of the adorno, one of Pearls' Ceramic-age inhabitants who, like me, surely had memorable encounters with *Corallus grenadensis* more than 1,000 years before my visit.

Acknowledgments

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JUAN CARLOS DIAZ

Inserting a PIT tag into a Texas Horned Lizard (*Phrynosoma cornutum*) allows for individual recognition during the entire study.

The Texas Horned Lizard in Central and Western Texas

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Photographs by Emily Henry except where noted.

The genus *Phrynosoma* contains 13 species inhabiting the grasslands and deserts of the central and southwestern United States and much of Mexico. Horned lizards are characterized by a flattened body and enlarged spines surrounding the head. Their shortened legs and broad body leave them ill suited for speed over longer distances. As protection against potential predators, they depend primarily on their cryptic coloration. When threatened, a horned lizard's first line of defense is to flatten itself against the substrate. If pressed further, it will run a short distance and then "freeze" to reestablish its camouflage or seek cover under nearby vegetation. Horned lizards are well known for another defense mechanism employed primarily against canids, the ability to squirt blood from the eye socket. They are considered dietary specialists, with ants comprising 50% or more of their diet and the remainder of other small arthropods (Sherbrooke 2003).

The suite of characteristics mentioned above makes horned lizards unique among North American lizards. That many of these species have experienced declines in recent years (Fisher et al. 2002, Mathies and Martin 2008, Wone and Beauchamp 2003) is disturbing. The Texas Horned Lizard (*Phrynosoma cornutum*) is listed as threatened in the state of Texas and as a species of special concern in both Oklahoma and Colorado. Several studies have shown a reduction in both its range and

numbers over the last 40–50 years. Habitat conversion for agriculture and urbanization appears to be the leading cause (Donaldson et al. 1994). Activities associated with farming, such as plowing and pesticide use, also may harm horned lizards. The destruction and fragmentation of habitat for urbanization seems to have a negative effect, but lizards are consistently found in suburban areas and even remnant habitats within urban areas (Stark 2000, Endriss et al. 2007, Moody et al. 2007). The introduction and spread of imported Red Fire Ants (*Solenopsis invicta*) also has been linked to the decline of the Texas Horned Lizard (Price 1990). Eradication efforts aimed at the invasive fire ant have included widespread use of insecticides. Although this is not likely to produce direct mortality in horned lizards, it does harm populations of Harvester Ants (*Pogonomyrmex* spp.) and other insects on which the lizards feed. Moreover, the invader effectively competes with native ants. Lastly, collection for the pet industry may have contributed in the past to the Texas Horned Lizards' dwindling numbers (Price 1990).

Since 2005, we have been part of an effort to understand the ecology of this species, determine the proximate causes of its overall decline, and develop management strategies to enhance its long-term survival. As a part of this effort, we have been studying two populations of *P. cornutum* in Texas, one near Post and the other outside of Brownwood.



Although horned lizards usually rely on crypsis to avoid detection by a predator, if discovered, they fill their bodies with air to look as large and fierce as possible.

Study Sites

A portion of this study was conducted on the Beach Ranch, a 3,636-ha private ranch located 21 km east of Post, in Garza County, Texas. Garza County averages 48 cm of rain annually, most of which falls in thunderstorms during May and June. The average minimum temperature in January is just below freezing, and the average maximum in July is 35.0 °C. Soils at the site are primarily clay and fine sandy loams (Richardson et al. 1975). The major vegetation communities are mesquite grasslands and



GALD PERRY

Horned lizard habitat at the Beach Ranch, Post, Texas (top and middle) and Camp Bowie, Brownwood, Texas (bottom).

desert scrub. The dominant woody species is Mesquite (*Prosopis* spp.). Grasses such as Buffalograss (*Buchloe dactyloides*) and Sideoats Grama (*Bouteloua curtipendula*) and cactus species such as Prickly Pear (*Opuntia* spp.) and Cholla (*Opuntia imbricata*) are common. The rolling grasslands are fragmented by rocky valleys, artificial stock ponds, and a fork of the Brazos River. The Beach family leases this land for cattle grazing, but also works hard to restore and maintain it as good habitat for wildlife. No controlled burns have been conducted on the site in recent years, but a recent wildfire burned a large swath of the ranch.

An additional study site was located at Camp Bowie, a military training facility outside of Brownwood, Brown County, Texas. Precipitation in the area follows a bimodal pattern with a large peak in May–June and a smaller peak in September–October. Annual precipitation for Brownwood averages 72 cm (NOAA 2008). The climate is characterized by hot summers and cool, dry winters. Soils on the site are mostly fine sandy loams with clay subsoils (NRCS Soil Data Mart). Camp Bowie is situated in a transition zone between the Western Cross Timbers and Rolling Plains ecoregions (Omernik 1995). As a result, the vegetation varies from wooded areas of Post Oak (*Quercus stellata*) and Blackjack Oak (*Quercus marilandica*) with an understory of Greenbrier (*Smilax* spp.) and grasses to grassland areas with Mesquite (*Prosopis glandulosa*) scrub. The base is managed primarily for National Guard training activities, but some hunting and fishing is allowed by permit. Livestock grazing is currently suspended, but was historically a common practice.



GALD PERRY

Jason Brewer measuring the snout-vent length (SVL) of an adult horned lizard.

Materials and Methods

Each field season began shortly after horned lizards emerged from hibernation in April or early May. Throughout the activity season, we captured lizards by hand and recorded data on collection location, morphology, and weather conditions. Lizards over 20 g were implanted with a passive integrated transponder (PIT tag) for



JUAN CARLOS DIAZ



Recording data on a juvenile Texas Horned Lizard.

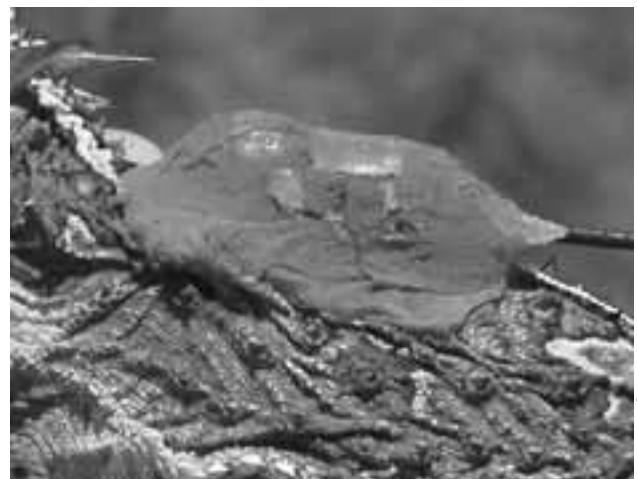


GAD PERRY



JUAN CARLOS DIAZ

Attaching radio-transmitters to horned lizards: To prevent the radio transmitter from becoming separated from the lizard during shedding, a plastic zip tie collar was put around the neck of the lizard and fishing line was used to attach the transmitter to the collar (top); Krista Mougey attaching the radio transmitter to the collar using fishing line (middle); Kelly Bollin sealing a transmitter with silicone (bottom).



JUAN CARLOS DIAZ

After transmitters were attached (top), the transmitter was covered with silicone pressed into dirt to act as camouflage (bottom).

future identification. These tags work somewhat like a barcode; each has a unique number that can be read with a specialized scanner. We fitted each lizard over 40 g with a radio transmitter, attached between the shoulder blades using silicone adhesive, so that it could be located again over the rest of the season. The lizards were re-located at least three times per week during the spring and summer and once or twice per week during the fall, when activity declined greatly. We repeated the morphological



GAD PERRY



GAD PERRY

Once the transmitters were firmly attached (top), animals were released (middle). Emily Henry uses a handheld receiver and antenna to track a lizard (bottom).



JUAN CARLOS DIAZ

Because the effect of radio-transmitters on lizards has been debated in previous studies, during the 2008 season at the Beach Ranch, we fitted lizards with transmitters of varying sizes and weights (top: small; bottom: large). Rocks were added to some for additional weight. Calculations of home range sizes of these lizards will be used to evaluate the impact of different weights.

measurements once a week to keep track of growth and identify when a female had deposited a clutch. We plotted the location information onto satellite images of the study sites and calculated home range size for each animal using the minimum convex polygon method. In 2008, we also characterized habitat use at both study locations, using digital photographs to quantify the availability of bare ground, rocks, grass, and other plants.

Results and Discussion

We observed a total of 442 lizards at the Beach Ranch from 2005–2008 and 26 at Camp Bowie during 2007–2008. As expected, females were significantly larger than males in both populations. Montgomery et al. (2003) suggested that this species follows the reverse of Bergmann's rule and decreases in body size with an increase in latitude (contrary to what is typical of mammals and birds), presumably because the shorter warm season does not allow animals to grow as large. Compared to the mean sizes found in other studies (Stark 2000, Henke 2003, Montgomery and MacKessy 2003, Moeller et al. 2005, Endriss et al. 2007), the lizards at the Post site were somewhat larger than expected and those at Camp Bowie were somewhat



We characterized habitat by using digital photographs to quantify the availability of bare ground, rocks, grass, and other plants.

smaller than expected. We suspect that the larger adult size observed on the Beach Ranch indicates superior habitat; although grazing occurs, the prairie remains mostly in its natural state. A substantial Harvester Ant population has been observed, perhaps because the site is not treated with pesticides. Sex ratios at the two sites were similar, with females slightly outnumbering males at both locations. Previous studies suggest that this may be caused by differences in capture rates, rather than true differences in numbers between the sexes (Sherbrooke 2002). According to capture numbers, adults outnumbered juveniles at both sites. Once again, however, we suspect that this is at least partially a result of differences in detectability; hatchlings are very small, highly cryptic, and very difficult to see in the field.

Mating was observed at both study sites during May and June, with oviposition dates from mid-May to late July. We repeatedly observed double clutching (an instance of a female laying two clutches over a single summer) at the Post location. Hatchlings were generally first seen in early August, but, in 2008, we observed hatchlings at Post in early July. Survivorship at Post ranged from 19–53%, and similar values were noted at Camp Bowie. We have noted mortality resulting from predation by birds (especially Roadrunners and shrikes), mammals (especially coyotes and rodents), and snakes (especially Coachwhips and Diamondback Rattlesnakes). In some cases, death was caused by management actions such as road maintenance during the winter; for others the cause of mortality could not be determined.

Horned lizards were most active when temperatures were between 27 and 35 °C. As in previous studies, activity remained high from April through July and then tapered off, although we



JUAN CARLOS DIAZ



Radio-transmitter-equipped lizards among native grasses and forbs.



In addition to casting shade, forbs and grasses provide lizards with a way to elevate their bellies off the hot substrate.



When mating, the male holds the female's horn in his mouth and wraps his tail around hers.

noted minor variations between the sexes and among years (Henke and Montemayor 1998, Fair and Henke 1999, Montgomery and MacKessy 2003). Based on movement levels, previous studies have noted that lizards remained active throughout the day during the spring and then exhibited a strong bimodal pattern during the summer, with peaks occurring in the cooler hours of morning and evening (Montgomery and MacKessy 2003). We prefer a broader definition of activity, and classified lizards as active if they were engaged in behavior such as moving or foraging, similar to previous researchers, but also if they were stationary but alert, with open eyes and clearly responsive to the environment. Using that definition, lizards on our study sites were indeed active all day during spring, but their activity did not decline much during the summer.

Based on Stark's findings that male lizards moved considerably longer distances than females during the mating season

(Stark 2000, Stark et al. 2005), males would be expected to have correspondingly larger home range sizes. Our results do not support this hypothesis; male and female horned lizards had home ranges of similar sizes at both of our study sites. The variation among individual lizards was much greater than that between the sexes, years, or even between sites. Texas Horned Lizards at Beach Ranch were often found in close proximity to each other and had overlapping home ranges. At both study sites, lizards frequently used dirt roads, cattle trails, and adjacent areas. In 2007, lizards at both sites were almost exclusively found on or in the immediate vicinity of roads, presumably because this was an unusually wet year and the vegetation was particularly dense. In years with low summer rainfall, however, we noticed lower overall activity and found considerably fewer lizards along roadsides. As observed at other locations (Burrow et al. 2001, Fair and Henke 1998) lizards at both of our study sites made use of all



A female horned lizard emerging from her overnight burrow.



GAD PERRY

Even with transmitters providing information, well-camouflaged lizards were sometimes hard to find.

habitat categories except embedded rock. Open areas allow the animals to increase their body temperatures and also facilitate movements. Litter and vegetation shelter them during the hottest parts of the day and provide protection from predators. This mosaic is critical in providing suitable habitat for this species.

Conclusions

Studies carried out on native range habitat such as the Beach Ranch, even in remnant pockets within urban areas (Stark 2000, Endriss et al. 2007, Moody et al. 2007), have shown healthy and stable populations of Texas Horned Lizards. This suggests that loss of habitat is the most important factor in this species' decline, and other factors may have more localized effects. This makes preservation and proper management of remaining habitat especially critical. Common land management practices can have both beneficial and harmful effects on horned lizards. Low to moderate levels of grazing appear to improve the habitat for horned lizards, perhaps by increasing open space at ground level. Fire is likely to have a similarly positive effect on habitat. An increase in mortality from vehicles and maintenance activities can result because lizards often frequent roads and other disturbed areas, but this was minimal at our low-traffic sites.

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CS CURTIN-HARBELL

Knight Anoles (*Anolis equestris*; UF 151376) mating on 1 July 2007 in Bonita Springs, Lee County, Florida.

The Knight Anole (*Anolis equestris*) in Florida

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Abstract.—In this paper, we discuss the likely modes of introduction of the Knight Anole (*Anolis equestris*) into and around Florida, provide data on its current geographic distribution, and summarize life history data in both its native and introduced Florida range. Our field data consist of collections made from 1992 through 2008 and locality data taken from the literature and systematic collections throughout the United States. *Anolis equestris* was first introduced in Miami-Dade County in 1952. The subsequent spread of this species in Florida has been both natural and assisted by human translocations to 10 additional counties, including Brevard, Broward, Collier, Highlands, Lee, Martin, Monroe, Palm Beach, Polk, and St. Lucie. Because this species is nonindigenous and known to consume a wide variety of items, including small vertebrates, it should be removed when encountered in the wild. A comprehensive study detailing its effects on the environment is needed.

Florida is home to a diverse array of amphibian and reptilian species, many of which have been introduced by humans from their native or other donor regions. The Florida herpetofauna currently contains at least 52 recognized species of lizards, 36 (69%) of which are nonindigenous (Krysko et al. 2006, Smith and Krysko 2007). Sixteen (30%) of the total lizard species are classified in the Superfamily Iguania (*sensu* Frost et al. 2001), and only one of the nine *Anolis* (Family Polychrotidae), the Green Anole (*Anolis carolinensis* Voigt 1832), is native to Florida.

The nonindigenous Knight Anole, *Anolis equestris* Merrem 1820, is the largest and most ornate established representative of the genus *Anolis* in Florida. In its native Cuban range, where it is known as a “chipoyo,” this species can measure up to 179 mm snout-vent length (SVL) in males and 167 mm SVL in females (Schwartz and Ogren 1956, Garrido and Schwartz 1972, Schettino 1999). In its introduced range in Miami-Dade County, Florida, males typically are 100–190 mm SVL and females 90–160 mm SVL, with individual masses of 16–84 g (Dalrymple 1980). *Anolis equestris* has large, flat and smooth, non-imbricate (i.e., non-overlapping) dorsal scales that are separated by small, granular interstitial scales; small, circular and smooth ventral scales; digits with widened, smooth subdigital lamellae; a pinkish-white dewlap present in both genders; and a large head with distinct canthal and frontal ridges (especially in adults). Both juveniles and adults are bright green, with yellow stripes below the eyes and others extending onto the shoulder. These lizards are capable of metachromatic color change (pers. obs., Schwartz and Garrido 1972, Schwartz and Henderson 1991, Schettino 1999). However, hatchlings and juveniles have cream-colored transverse bands along the body. Because of its green body coloration and large size, *A. equestris* is occasionally mistaken for the Green Iguana (*Iguana iguana* Linnaeus 1758)



The nonindigenous Knight Anole (*Anolis equestris*) is the largest and most ornate established *Anolis* in Florida. This specimen (UF 137459) is from Allapattah Flats, St. Lucie County, Florida.

(see Meshaka et al. 2004), and people in Miami often refer to them as “iguanas” or “iguanitos” (Bartlett and Bartlett 1999). Since the species’ introduction into Florida during the 1950s, *A. equestris* has been confined mostly to southern peninsular Florida. Herein, we discuss likely modes of introduction of this species into and around Florida, provide data on its current geographic distribution, and summarize life history data in both its native Cuban and introduced Florida range.

Materials and Methods

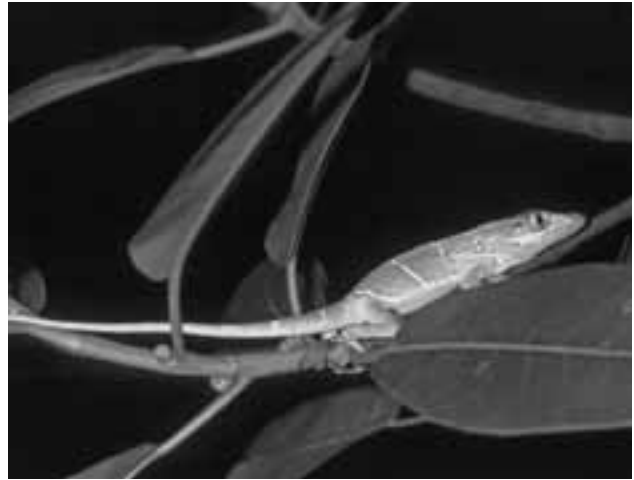
In order to determine the current geographic distribution of *Anolis equestris* in Florida, we made field collections from 1992

through 2008. Specimens were collected opportunistically by hand, with nooses (Strong et al. 1993), blowguns shooting tapered corks (Krysko et al., in press), and fishing rods using invertebrates (mainly dead insects found on the radiators of vehicles, and live domestic crickets) for bait (Krysko 2000). Nooses were made out of dental floss loops tied onto the ends of poles and extended upwards to reach lizards that were high in the tree canopy or on tall structures. When nooses were ineffective, we used a fishing rod to cast a food item as close as possible to a lizard. Lizards typically moved quickly from high on perches or within dense vegetation to eat the bait, and were then easily reeled in and collected. Specimens were deposited in the



KEVIN M. ENGE

Neonate *Anolis equestris* from Miami, Miami-Dade County, Florida, hatched in captivity from an egg found at the bottom of a collecting bag.



KEVIN M. ENGE

Juvenile *Anolis equestris* (UF 131530) from Port Mayaca, Martin County, Florida, found sleeping on low vegetation.



KEVIN M. ENGE

Anolis equestris (UF 131449) from Port Mayaca, Martin County, Florida, illustrating the large head with distinct canthal and frontal ridges, pinkish-white dewlap, and yellow stripes below the eye and extending onto the shoulder.



KENNETH L. KRYSKO

Dead dragonflies (*Odonata*) found on the radiators of vehicles and used to collect *Anolis equestris*.



KRISTIN CHILD

Anolis equestris (UF 144334) perched on palm tree in Lake Worth, Palm Beach County, Florida.



JOSEPH P. BURGESS

Anolis equestris from Miami, Miami-Dade County, Florida, perched high above the ground on vegetation.

Florida Museum of Natural History (FLMNH), University of Florida (UF collection). We also obtained locality data from the literature, systematic collections throughout the United States, photographs sent to us for identification purposes, and personal communications from reliable sources. Source acronyms for collections follow Leviton et al. (1985), with the addition of Everglades National Park (EVER), from which the entire collection is now accessioned into the UF collection (Appendix). All records with locality data were plotted using ArcGIS ver. 9.3 (ESRI).

Results and Discussion

Native Distribution and Natural History.—*Anolis equestris* is native to Cuba and is common throughout much of its natural range (Schettino 1999, Schwartz and Henderson 1991). It occurs at elevations from 0–1,000 m above sea level in many types of mesophilic and occasionally xerophilic habitats, including forests and mangroves, caves, savannas, cultivated areas, and groves or gardens in urban areas (Schwartz and Ogren 1956, Schettino 1999). *Anolis equestris* is a member of the crown-giant ecotype, which is associated with living high in the canopy of

large trees (diameter at breast height [DBH] > 30 cm), including mangoes and palms (Williams 1969, 1972; Schwartz and Henderson 1991; Butterfield et al. 1997).

As an arboricolous (tree-dwelling) species, *Anolis equestris* perches on trunks and high branches of trees (sometimes > 10 m high), spending the greater part of its time in the crown (Collette 1961, Ruibal 1964, Schettino 1999). During the warmest part of the day, *A. equestris* will descend the trunks of trees in an apparent thermoregulatory behavior to avoid excessive sunlight (Schettino 1999). When startled, this species will “squirrel” (move to the opposite side of the tree trunk) and quickly ascend to the canopy (Schettino 1999). *Anolis equestris* is an aggressive species that will attempt to bite an attacker when disturbed, opening its mouth and extending its dewlap in a defensive posture (Schettino 1999). It also is capable of inflicting a painful but harmless bite, and will defend its territory by extending its pinkish dewlap and bobbing its head (Schettino 1999, Schwartz and Henderson 1991).

Little information is known on the reproductive cycle of *Anolis equestris* in its native range. Males typically establish territories high in the canopies of trees, with territorial battles between males occurring frequently. Large groups are uncommon, except in large groves of trees that may support many individuals (Schettino 1999). Courtship and mating generally take place high in the tree canopy, and ovipositioning occurs in burrows excavated by females in the ground or in pre-existing tree cavities (Schettino 1999).

Anolis equestris is an omnivorous, opportunistic species that feeds on a wide range of items, including large amounts of fruit and seeds, insects (especially moths, butterflies, and their larvae, beetles, crickets and grasshoppers, and ants, bees, and wasps), and small vertebrates such as frogs, lizards (including its own species), and small birds (Schettino 1999, Schwartz and Henderson 1991). Although *Anolis equestris* is a sit-and-wait predator and is generally territorial, adults are known to move across phone lines or use open ground to move from tree to tree (Schettino 1999, Schwartz and Henderson 1991). Small vertebrates usually are captured and firmly bitten before consumption (Schettino 1999). The dentition of this species includes small,



KENNETH L. KRYSKO

Anolis equestris (UF 137039) from Naples, Collier County, Florida, illustrating its small, conical, blunt teeth. Despite the belief that a bite causes fever in humans, its teeth do not secrete toxins or venom.

conical, blunt teeth that do not secrete any toxins or venom (Schwartz and Henderson 1991, Schettino 1999). Its relatively large size, appearance, and biting habits are the basis of the false belief that its bite causes fever in humans (Schettino 1999). Small juveniles and subadults are susceptible to predation by birds or even other lizards, which suggests why these size classes are found on low shrubs during both the day and night. Individuals living higher in tree crowns are most easily captured by Sparrow Hawks (*Falco sparverius*), effective canopy predators that often “specialize” in lizards in the West Indies (Schettino 1999).

Florida Distribution and Modes of Introductions.—We compiled 216 vouchered records of *Anolis equestris* from Florida collected between April 1957 and September 2007 (Appendix), 60 of which were collected during our field surveys. We documented *A. equestris* in 11 Florida counties: Brevard, Broward, Collier, Highlands, Lee, Martin, Miami-Dade, Monroe, Palm Beach, Polk, and St. Lucie.

Neill (1957) first reported the introduction of *Anolis equestris* from an unspecified locality in “southern Florida”; however, King and Krakauer (1966) stated that the original introduction occurred in 1952 at the University of Miami’s old North Campus in Coral Gables, Miami-Dade County, by a student in their Department of Biology. The original population was centered in a 20-city-block area in Coral Gables, from Coral Way south to Bird and LeJuene roads west to Segovia Avenue, in the middle of which were the main buildings of the University of Miami’s old North Campus (F.W. King, pers. comm.; King and Krakauer 1966). Although the old North

Campus site is now occupied by University Park, the Ficus trees along Segovia Street (north side of campus) north of Anastasia Avenue were loaded with *A. equestris* in the 1960s (F.W. King, pers. comm.). The first known voucher specimen (LACM 61680) was collected in Coral Gables on 5 April 1957 by D.R. Paulson, supporting King and Krakauer’s (1966) hypothesis.



Geographic distribution of the Knight Anole (*Anolis equestris*) in Florida. The star represents the first known voucher specimen (LACM 61680) collected in Coral Gables, Miami-Dade County, on 5 April 1957. Circles with solid dots represent records consisting of voucher specimens and photographs (N = 218). Open circles represent unverified observations (N = 3; see text) in the previously undocumented counties of Orange and Volusia.

The subsequent spread of this species in Florida has been both natural and assisted by human translocations (Lever 2003). In 1972, *Anolis equestris* was reported from Elliott Key (Brown 1972) and the Miami Seaquarium on Virginia Key, Miami-Dade County (Dalrymple 1980). Crowder (1974) reported that *A. equestris* was secondarily transferred by reptile hobbyists to other areas of Miami-Dade County, including Coral Gables (Fairchild Tropical Gardens; see also Dalrymple 1980), Coconut Grove, Sunset Park, and Peters. Brach (1976) reported that *A. equestris* was further expanding its range by human-assisted means in suburban southern Florida, and Wilson and Porras (1983) reported that *A. equestris* was becoming widespread in Miami-Dade County. In the early 1990s, a single collector caught 50–115 *A. equestris* per day in Miami, especially on Black Olive Trees (*Bucida buceras*) in swales, and sold them in the pet trade (R. St. Pierre, pers. comm.). In 1996–1998, *A. equestris* was recorded at 4013 Douglas Road, Kampong National Tropical Garden (Meshaka 1999b), as well as 5530 SW 72nd Street, Doc Thomas House (Meshaka 1999c). Butterfield et al. (1997) reported an observation of *A. equestris* on Parachute Key in Everglades National Park. Our Miami-Dade County vouchers indicate that *A. equestris* has expanded its range throughout the county, especially in heavily planted suburbs. These locality records include Perrine (1959); Coral Gables (1960–68, 1970, 1973–74, 1976–77, 1987–88, 1994, 1996); South Miami (1964, 1975); Miami (1965, 1986); US 1 & SW 126th Street, Miami Serpentarium (1970); 8500 SW 87th Terrace (1984); SW 57th Avenue along Snapper Creek Canal (1991, 1996, 2001); SW 173rd Street & Old Cutler Road (1996); 7711 Camino Real (1996); SW 88th Street & SW 80th Avenue (1996); SR 997 & SW 304th Street, Homestead (1997); SR 997 & NE 16th Street, Homestead (1998); SR 997 & NE 18th Street (1998); SW 64th Avenue (1999); SW 296th Street & SW 197th Avenue, Homestead (1999); 5815 Suncrest Drive (2000); SW 69th Street & SW 63rd Court (2000); SW 69th Street & SW 64th Avenue, All American Park (2000, 2002); Parachute Key, Everglades National Park (2000); 7440 SW 162nd Street (2001); C-111 & C-113 canals (2001); Key Biscayne, Bill Baggs Cape Florida State Park (2002–03, 2005); NE 204th Street & NE 12th Avenue, Hialeah (2002); SW 134th Street & 122nd Avenue, Kendall (2002); 801 Swan Avenue, Miami Springs (2003–04, 2006–07); SW 70th Street & SW 98th Avenue (2004–05); 16701 SW 72nd Avenue, Charles Deering Estate at Cutler (2005); Key Biscayne, Crandon Park (2005); and 6660 SW 117th Avenue (2005).

Northern range expansion into other counties was first documented in 1974, when the first known voucher specimen (UF 86714) was collected at 7530 Plantation Road, Fort Lauderdale, Broward County. By 1992, numerous *A. equestris* were being collected locally and brought into Strictly Reptiles, Hollywood, for sale in the pet trade (R. Van Nostrand, pers. comm.). We have another Broward County record from 3468 Pierce Street, Hollywood (2003–04). Range expansion northward into Martin County occurred in 1986, when numerous *A. equestris* were intentionally released at 19121 SW Connors Highway, Port Mayaca, on the northeastern side of Lake Okeechobee (J. Watt, pers. comm.). Our Martin County vouchers (UF 131449, 131530) illustrate that this population has been established for more than

20 years despite cold weather and intense commercial collecting pressure (Krysko et al. 2005). Hailman et al. (2005) reported at least one *A. equestris* from Stuart in 2004 and 2005.

Despite its close proximity to Broward County, the first known voucher specimen (TCWC 80508, Boca Raton) was not collected from Palm Beach County until 1997 (Krysko et al. 2005). Hailman et al. (2005) reported an *Anolis equestris* from Ocean Drive, Jupiter Inlet Colony, in 2004. Our other Palm Beach County vouchers include 11 Rennie Street, West Palm Beach (2003); Lake Worth (2004); 5233 Arbor Glen Circle, Lake Worth (2005); 485 Cleary Road, West Palm Beach (2006); 3301 Gun Club Road, West Palm Beach (2006); US 1 & Dixie Highway, Delray Beach (2006); and North 123 Trail, and 0.06 mi south of North 169 Court, Jupiter (2007).

Range expansion also occurred on the southwestern Florida coast, as evidenced by the first voucher specimen (UF 141841, a neonate), collected in 1979 in Fort Myers, Lee County. Our other Lee County vouchers include 5207 Palm Beach Boulevard; Fort Myers (2005); 8880 Colonnades Court, Bonita Springs (2007); and Morse Place and Browning Drive, Fort Myers (2007). In 1995, the first known voucher specimen (UF 100104) for Collier County was collected at 3480 10th Street North, Naples (Noonan 1995), which consists only of an anole head because it was killed and partially eaten by a domestic cat. Our other Collier County vouchers (all from Naples) include Parkview Way (2001); Gulf Shore Boulevard North (2003); and West Boulevard, south of Pelican Bay Boulevard (2003).

The first voucher specimen (UF 52748) from the Florida Keys, Monroe County, was collected in 1981 at Mile Marker 87.5, Overseas Highway, Plantation Key (Achor and Moler 1982). Another Monroe County voucher specimen (UF 151192) collected in 2007 at 323 Whitehead Street, Key West, represents the southernmost locality in the United States (Krysko and Borgia 2007).

Along the Atlantic Coast, additional northward range expansion is believed to have occurred more recently than in other areas in peninsular Florida. In 2003, the first known voucher specimen (UF 137459) from St. Lucie County was collected in the Allapattah Flats, east of Carlton Road and 1.0 mi north of Glades Cutoff Road (Krysko et al. 2005). A reptile dealer in the area was likely responsible for this population of *Anolis equestris* (see Enge and Krysko 2004), which inhabited both citrus groves and pine flatwoods habitat, where they could be spotted at night high up in large Slash Pines (*Pinus elliottii*). In 2004, *A. equestris* could be found in trees along Hickcock Terrace, Port St. Lucie (R. Goushaw, pers. comm.). In 2007, two *A. equestris* were found in Brevard County at 4310 MacTavish Street, Cocoa (Enge and Coben 2007).

In 1995, an adult male *Anolis equestris* was intercepted in an agricultural shipment sent from Miami to Lake Placid, Highlands County (Meshaka et al. 2004). In 2003, the first known voucher specimen (UF 153968) from Highlands County was collected at 101 Green Dragon Drive, Lake Placid (Parker and Krysko, in press). In 2000, four *A. equestris* fell out of a tree during a cold front in Bartow, Polk County (C. Trumbower, pers. comm.). In 2007, the first known voucher specimen (UF 153967) from Polk County was collected at 3832 Avenue Q NE, Winter Haven (Parker and Krysko, in press);

another *A. equestris* was accidentally run over with a lawn mower at this site a few weeks earlier (D.J. Parker, pers. comm.), suggesting that an established population may be present.

Unverified reports of *Anolis equestris* are known from two other previously undocumented Florida counties, including two adults that fell out of trees during a cold front in December 1994 on Katherine Street, Daytona, Volusia County (A.T. Reppas, pers. comm.), and several individuals brought to Gatorland in 2004 from a neighborhood in Orlando, Orange County (F. Morrissey, pers. comm.).

Natural History in Florida.—In Florida, *Anolis equestris* is a diurnally active, heliothermic species that is most frequently observed from May through October (Meshaka and Rice 2005). Its active season generally coincides with mean ambient air temperatures of >29 °C (Wilson and Porras 1983, Meshaka et al. 2004). Peak activity occurs from mid-morning until late afternoon, with activity ceasing around sunset (Meshaka et al. 2004). However, diel activity is unimodal, and ambient temperature better explains activity patterns than such factors as cloud cover, wind velocity, and relative humidity (Meshaka et al. 2004). During diel activity in Miami-Dade County, individuals generally perch above 3 m from the ground during the late morning hours, retreating to the canopies of trees later in the afternoon and into the evening, where they reside until daybreak (Meshaka et al. 2004). Dalrymple (1980) noted that population sizes in southern Florida can range from 3.3/ha in wild Tamarind (*Lysiloma latisiliquum*) groves to 29.5/ha in a tropical garden. On 4 June 2003, KLK collected by hand seven adults on trees in less than 15 minutes along Gulf Shore Boulevard North, Naples, Collier County, illustrating the potential abundance of *A. equestris* in a relatively small area.

Anolis equestris is seen most frequently on trunks of several different tree species (King and Krakauer 1966, Wilson and Porras 1983), including Ficus (*Ficus benjamina*), Umbrella (*Schefflera actinophylla*) (Krysko 2000), Mahogany (*Swietenia mahagoni*), Black Olive, Wild Tamarind, and Mango (*Mangifera indica*) trees (Meshaka 1993, Meshaka et al. 2004), smaller veg-

etation (Brach 1976), and edificarian structures. *Anolis equestris* is omnivorous and feeds on a wide range of invertebrates, fruits and seeds, and small vertebrates, including frogs, lizards, and caged birds (Brach 1976, Dalrymple 1980, Nicholson and Richards 1999, Meshaka 1999a, Meshaka et al. 2004).

Copulating pairs are most frequently observed from April through August (Meshaka et al. 2004, Meshaka and Rice 2005). We were provided with photographs of *Anolis equestris* mating in the wild on 1 July 2007 in Bonita Springs, Lee County. Neonates typically are <4 cm SVL, and development to sexual maturity (100–110 mm SVL) is rapid in males and females (12–13 months, 8–9 months, respectively) (Meshaka 1999a, Meshaka et al. 2004). Populations turn over in about seven years, but adults may live over 10 years in Homestead (Meshaka and Rice 2005). Schettino (1999) reported an individual living over 13 years in captivity.

Anolis equestris is slowly becoming widespread in the state of Florida. Since its initial introduction from Cuba to the University of Miami's old North Campus, 55 years have passed for it to expand its range and be detected in 13 Florida counties. *Anolis equestris* is a large, robust anole with the potential to avoid predation and survive cold winters. Therefore, we believe that the range of this species in Florida will continue to expand, likely with humans being a major factor. Because *Anolis equestris* is nonindigenous to Florida and known to consume a wide variety of items, including small vertebrates, it should be removed whenever encountered in the wild. Additionally, a comprehensive study detailing its effects on the environment is needed.

Acknowledgments

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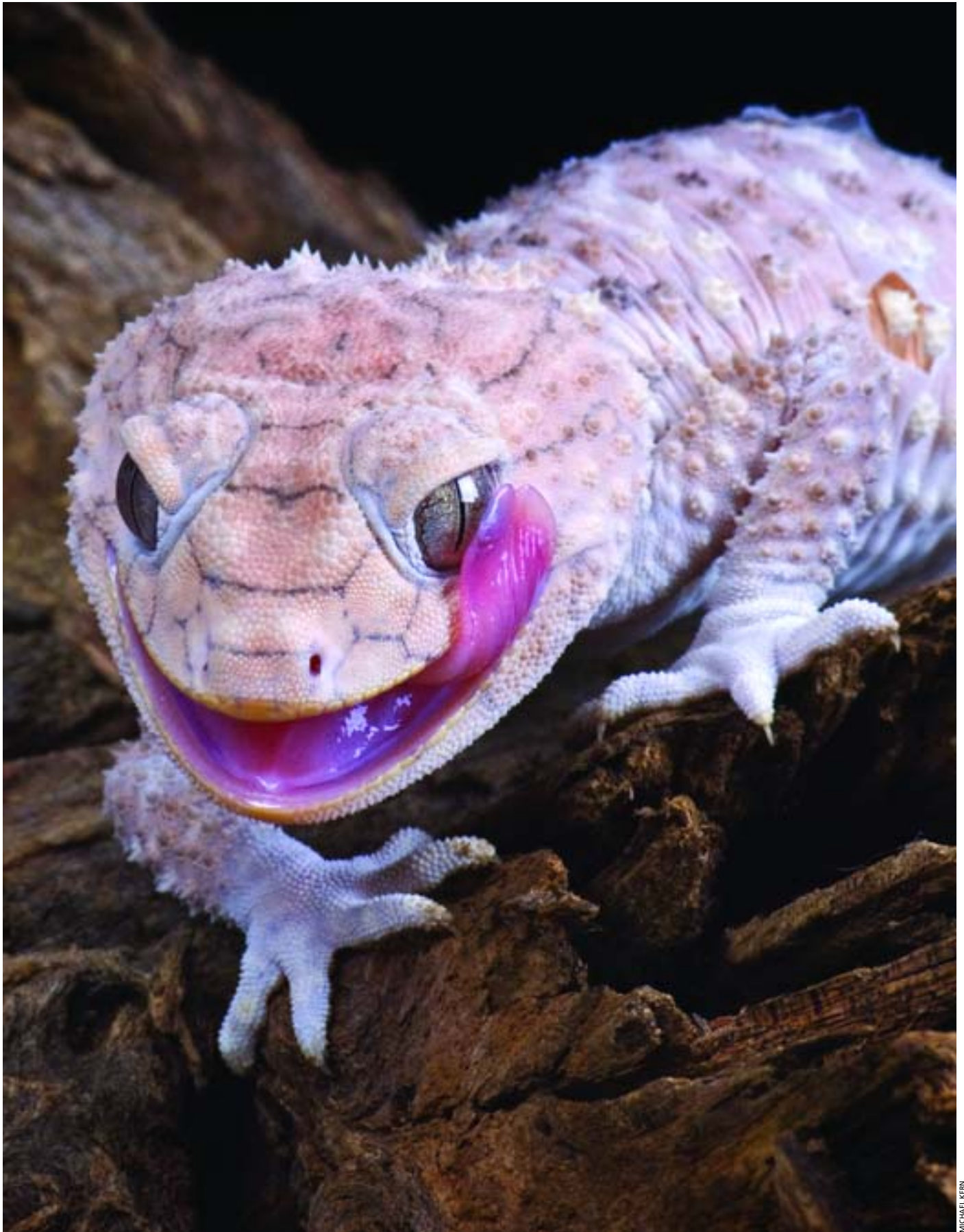
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KENNETH L. KRYSKO

Six of seven adult *Anolis equestris* collected in less than 15 minutes in Naples, Collier County, Florida.



MICHAEL KERN

Rough Knobtail Geckos (*Nephrurus amyae*) are large, robust lizards that occur in rocky outcrops in the Northern Territory of Australia. They are dietary generalists, eating virtually any small animal they can fit in their mouths. Even juveniles respond to threats by elevating their bodies, gaping, and hissing. Like most true geckos, they lack eyelids and use their tongues to clean the scales that cover the eyes.



Jackson's Chameleon (*Chamaeleo jacksonii*) is native to the cooler humid uplands of Kenya and Tanzania in eastern Africa. An introduced population in Hawaii served as the primary source of animals for the pet trade until exportation was prohibited in an effort to prevent the introduction and misuse of other species for commercial purposes. Chameleons use crupsis and very deliberate movements to approach prey (mostly insects) that they capture with an extensible tongue. Males have horns that may be used in slow-motion pushing and shoving matches to establish dominance and defend territories. Unlike most chameleons, which lay eggs, Jackson's Chameleons give birth to live young.



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MICHAEL KERN

Parker's Tree Frog (*Leptopelis parkeri*) is "vulnerable" to extinction because its distribution is severely fragmented and the extent of its forest habitat in the Eastern Arc Mountains of Tanzania (Africa) is declining. It cannot survive in seriously disturbed habitats and is threatened by expanding human settlements, agriculture, deforestation, and illegal gold mining. It breeds in slow-flowing streams, although its eggs are laid in a nest on land close to water.



MICHAEL KERN

African Coral Cobras (*Aspidelaps lubricus lubricus*) are native to southern Africa. These snakes are nocturnal and fossorial, spending the day underground in rodent burrows, although they have been found in rock crevices and in abandoned termite mounds. They eat small rodents, lizards, and possibly other snakes, and have been known to eat reptilian eggs.

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Appendix. Specimens examined from Florida counties. Note that Everglades National Park (EVER) specimens are now accessioned into the Florida Museum of Natural History (UF) collection.

Brevard: UF 150871. *Broward*: UF 86714, 137715, 140586, 141120, 142894–96, 145031–34. *Collier*: UF 100104, 137037–42; USNM 547963. *Lee*: UF 141841, 144191, 145694, 151376, 152335. *Martin*: UF 131449, 131530. *Miami-Dade*: AMNH 89355; AUM 35823; EVER 302917–18, 302961–75, 303151–58, 303509, 303996–00, 306531, 306539, 307138, 308170, 308776, 39977; KU 172917, 220258; LACM 61680–86, 74878–80; LSUMZ 24010, 30725, 42087, 56737; MCZ 85093, 85564, 93445, 131609, 140112, 142470, 143901–09, 171444–47, 174816, 175020–21, 182994; MPM 19142–44, 25669; MVZ 214996–99; UF 21908–09, 22022–37, 40618, 42432, 63077–82, 66920–21, 74958, 80343, 83799, 89569–74, 90925, 99187, 99674, 100104, 121125, 121425, 121445–48, 122474–75, 130653, 130685, 131449, 131477, 131489, 131530, 132727, 134839, 134916, 137037–42, 137714, 138394, 141229, 141576, 141841, 144135, 144191, 144220, 145027–29, 145216, 145359–61, 145694, 150534, 150732, 151359, 151376, 152322, 152335; UMMZ 225093–97, 227717; USNM 194847, 245588–89, 252596–99, 523789, 547963; UTA 35597; YPM HER.R. 7023, 7028; *Monroe*: TCWC 80508; UF 52748, 137015, 141949, 144334, 149862, 150533, 150535, 151192, 151601; *St. Lucie*: UF 137459.



FERDINAND REUS

The status of a few mammalian species has improved in recent years. For example, the African Elephant (*Loxodonta africana*) moved from "Vulnerable" to "Near Threatened," although its status varies considerably across its range.

CONSERVATION ALERT

World's Mammals in Crisis¹

The most comprehensive assessment of the world's mammals has confirmed an extinction crisis, with almost one in four at risk of disappearing forever. According to The IUCN Red List of Threatened Species, the new study assessing the conservation status of the world's mammals shows at least 1,141 of the 5,487 mammals on Earth are known to be threatened with extinction, and at least 76 mammals have become extinct since 1500. "Within our lifetime, hundreds of species could be lost as a result of our own actions, a frightening sign of what is happening to the ecosystems where they live," says Julia Marton-Lefèvre, IUCN Director General. "We must now set clear targets for the future to reverse this trend to ensure that our enduring legacy is not to wipe out many of our closest relatives."

The IUCN Red List of Threatened Species (www.iucn.org/redlist) classifies species according to their extinction risk. It is a searchable online database containing the global status and supporting information on 45,000 species. Its primary goal is to identify and document the species most in need of conservation attention and provide an index of the state of biodiversity. The IUCN Red List threat categories are, in descending order of threat: "Extinct" or "Extinct in the Wild," "Critically Endangered," "Endangered," and "Vulnerable" (all for species threatened with global extinction), "Near Threatened" (species close to the threatened thresholds or that would be threatened without ongoing specific conservation measures), "Least Concern" (species evaluated with a low risk of extinction), and "Data Deficient" (species not assessed because of insufficient data). "Critically Endangered-Possibly Extinct" is not a new Red List category, but is a flag developed to identify those Critically Endangered species that are in all probability already Extinct but for which confirmation is required (for example, through more extensive surveys being carried out and failing to find any individuals).

The real situation could be much worse, as 836 species are listed as "Data Deficient." With better information, more species may well prove to be in danger of extinction. "The reality is that the number of threatened mammals could be as high as 36%," says Jan Schipper, of Conservation International and lead author of a forthcoming article in *Science*. "This indicates that conservation action backed by research is a clear priority for the future, not only to improve the data so that we can evaluate

"Reliable data are the foundation for conservation planning that hopes to drive effective conservation action on the most endangered species and sites. For the first time, good data, contributed and validated by the best experts on Earth, show the patterns and extent of the pressures on the viability of mammal species. This trend is particularly dramatic for Southeast Asia which suffers from increasing human activities, deforestation being the major issue."
 Prof. Luigi Boitani, Sapienza Università di Roma.

threats to these poorly known species, but to investigate means to recover threatened species and populations."

The results show 188 mammals are in the highest threat category ("Critically Endangered"), including the Iberian Lynx (*Lynx pardinus*), which has a population of just 84–143 adults and has continued to decline due to a shortage of its primary



WIKIPEDIA



GIORGIO FERRELLINI

The Iberian Lynx (*Lynx pardinus*) is "Critically Endangered," and has continued to decline due to a shortage of its primary prey, the European Rabbit (*Oryctolagus cuniculus*).

¹ Adapted from a 06 October 2008 IUCN Press Release.

prey, the European Rabbit (*Oryctolagus cuniculus*). China's Père David's Deer (*Elaphurus davidianus*), is listed as "Extinct in the Wild." However, the captive and semi-captive populations have increased in recent years, and truly wild populations could be re-established soon. The time may already have passed to save the

"This assessment establishes a platform from which all future conservation efforts can be measured. It captures data on the mammal fauna of the world in a unique database that has been structured to highlight conservation, and which is designed to be a living database to incorporate future data and trends on mammals. This effort will hopefully spur greater attention on the conservation of mammals and the habitats they occupy, for the benefit of all biodiversity." Dr. Andrew Smith, School of Life Sciences, Arizona State University.

additional 29 species that have been flagged as "Critically Endangered-Possibly Extinct," including Cuba's Little Earth Hutia (*Mesocapromys sanfelipensis*), which has not been seen in nearly 40 years.

Nearly 450 mammals have been listed as "Endangered," including the Tasmanian Devil (*Sarcophilus harrisi*), which moved from "Least Concern" to "Endangered" after the global



ALICIA HIGGINS

The Fishing Cat (*Prionailurus viverrinus*) of southeastern Asia moved from "Vulnerable" to "Endangered" due to habitat loss in wetlands.



WIKIPEDIA

China's Père David's Deer (*Elaphurus davidianus*) is listed as "Extinct in the Wild." However, the captive and semi-captive populations have increased in recent years, and truly wild populations could be re-established soon.



WAYNE MCGEAN

The Tasmanian Devil (*Sarcophilus harrisi*) moved from "Least Concern" to "Endangered" after the global population declined by more than 60% in the last 10 years.

population declined by more than 60% in the last 10 years due to a fatal infectious facial cancer. The Fishing Cat (*Prionailurus viverrinus*), found in southeastern Asia, moved from "Vulnerable" to "Endangered" due to habitat loss in wetlands. Similarly, the Caspian Seal (*Pusa caspica*) moved from "Vulnerable" to "Endangered." Its population has declined by 90% in the last 100 years due to unsustainable hunting and habitat degradation — and numbers continue to decline.

Habitat loss and degradation affect 40% of the world's mammals. It is most extreme in Central and South America, western, eastern, and central Africa, Madagascar, and in southern and southeastern Asia. Over-harvesting is wiping out larger mammals, especially in southeastern Asia, but also in parts of Africa and South America. The Grey-faced Sengi or Elephant-shrew (*Rhynchocyon udzungwensis*) is known from only two forests in the Udzungwa Mountains of Tanzania, both of which



LINDA FEUREN

Cuba's Little Earth Hutia (*Mesocapromys sanfelipensis*) has not been seen in nearly 40 years and is considered "Critically Endangered-Possibly Extinct."

are fully protected but vulnerable to fires. The species was first described this year and has been listed as "Vulnerable."

However, the study also shows that conservation can bring species back from the brink of extinction, with 5% of currently threatened mammals showing signs of recovery in the wild. The Black-footed Ferret (*Mustela nigripes*) moved from "Extinct in the



MIKHAIL YERSHIN

The Black-footed Ferret (*Mustela nigripes*) moved from "Extinct in the Wild" to "Endangered" after a successful reintroduction by the U.S. Fish and Wildlife Service.

Wild" to "Endangered" after a successful reintroduction by the U.S. Fish and Wildlife Service into eight western states and Mexico from 1991–2008. Similarly, the Wild Horse (*Equus ferus*) moved from "Extinct in the Wild" in 1996 to "Critically Endangered" this year after successful reintroductions started in Mongolia in the early 1990s. The African Elephant (*Loxodonta africana*) moved from "Vulnerable" to "Near Threatened," although its status varies considerably across its range. The move reflects the recent and ongoing population increases in major populations in southern and eastern Africa. For the moment, these increases outweigh any decreases taking place elsewhere.

"The longer we wait, the more expensive it will be to prevent future extinctions," says Dr. Jane Smart, Head of IUCN's Species Program. "We now know what species are threatened, what the threats are and where — we have no more excuses to watch from the sidelines."



FRANCESCO ROVERO

The Grey-faced Sengi or Elephant-shrew (*Rhynchocyon udzungwensis*) was first described this year. Known from only two forests in the Udzungwa Mountains of Tanzania, the species has been listed as "Vulnerable."

The project to assess the world's mammals was conducted with help from more than 1,800 scientists from over 130 countries. It was made possible by the volunteer help of IUCN Species Survival Commission's specialist groups and the collaborations between top institutions and universities, including Conservation International, Sapienza Università di Roma, Arizona State University, Texas A&M University, University of Virginia, and the Zoological Society of London.

More Than Mammals

Overall, the IUCN Red List now includes 44,838 species, of which 16,928 (38%) are threatened with extinction. Of these, 3,246 are in the highest category of threat, "Critically Endangered," 4,770 are "Endangered," and 8,912 are "Vulnerable." New groups of species have appeared on the IUCN Red List for the first time, increasing the diversity and richness of the data. Indian Tarantulas (*Poecilotheria regalis*), highly prized by collectors and threatened by the international pet trade, have made their first appearance on the IUCN Red List. They face habitat loss due to new roads and settlements.

"No other tool is as valuable for conservation as the Red List, which provides scientists and decision makers with an important set of information, freely available to the public, to improve the effectiveness of our conservation efforts." Dr. Russell Mittermeier, Chair of IUCN's Primate Specialist Group and president of Conservation International.



JOHN BELL

Indian Tarantulas (*Poecilotheria regalis*) are highly prized by collectors and threatened by the international pet trade. The species has made its first appearance on the IUCN Red List due to habitat loss.



PHILIPP MAITZ

The Squaretail Coral Grouper (*Plectropomus areolatus*) is listed as “Vulnerable;” it is fished unsustainably at its spawning aggregations.

The Rameshwaram Parachute Spider (*Poecilotheria hanumavilasumica*) has been listed as “Critically Endangered” as its natural habitat has been almost completely destroyed.



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Costa Rica’s Holdridge’s Toad (*Incilius holdridgei*) moved from “Critically Endangered” to “Extinct,” as it has not been seen since 1986.



The La Palma Giant Lizard (*Gallotia auaritae*) from the Canary Island of La Palma was thought to be extinct, but was rediscovered last year and is now listed as “Critically Endangered.”



IUCN

The Cuban Crocodile (*Crocodylus rhombifer*) moved from “Endangered” to “Critically Endangered” because of illicit hunting.

For the first time, all 161 species of groupers have been assessed, revealing that 20 of them are threatened with extinction. The Squaretail Coral Grouper (*Plectropomus areolatus*) from the coral reefs of the Indo-Pacific has been listed as “Vulnerable.” The fish is seen as a luxury live food, and is fished unsustainably at its spawning aggregations, a major threat for many grouper species.

Amphibians are facing an extinction crisis, with 366 species added to the IUCN Red List this year. A total of 1,983 species (32%) are either threatened or extinct.² In Costa Rica, Holdridge’s Toad (*Incilius holdridgeri*), an endemic species, moved from “Critically Endangered” to “Extinct,” as it has not been seen since 1986 despite intensive surveys. New reptiles assessed

this year include the La Palma Giant Lizard (*Gallotia avaritae*). Found on the Canary Island of La Palma and thought to have become extinct in the last 500 years, it was rediscovered last year and is now listed as “Critically Endangered.” The Cuban Crocodile (*Crocodylus rhombifer*) is another “Critically Endangered” reptile, moved from “Endangered” because of population declines caused by illicit hunting for its meat and skin, which is used in clothing.

² See also the book review on p. 243.

The “Dow Jones Index” of Biodiversity

The IUCN Sampled Red List Index (SRLI) is a new initiative of the IUCN Red List, developed in collaboration with the Zoological Society of London. It is set to revolutionize our understanding of the conservation status of the world’s species. The approach takes a randomized sample of species from a taxonomic group to calculate the trends in extinction risk within that group, in much the same way that an exit poll from a polling station can be used to calculate voting trends. This means that tracking the fate of these species is possible, in the same way as the Dow Jones Index tracks the movement of the financial markets.

Although species coverage on the IUCN Red List has increased in number each year, assessments have in general been restricted to the better-known species groups such as birds and mammals. As a consequence, until recently, the conservation status of less than four percent of the world’s described biodiversity has been known. Basing conservation decisions on such a

restricted subset of species can no longer be considered appropriate, and the SRLI, which is more representative of global biodiversity, can be used to provide a broader picture. “We are now emerging from the dark ages of conservation knowledge, when we relied on data from a highly restricted subset of species,” says Dr Jonathan Baillie, Director of Conservation Programs at the Zoological Society of London (ZSL). “In the future we will expand the scope of our species knowledge to include a far broader range of groups, thus informing and assisting policy makers in a hugely more objective and representative manner.”

Designed to broaden the types of species covered in the IUCN Red List, the SRLI uses a sample of at least 1,500 species from selected groups to show trends in extinction risk. All the world’s birds, amphibians, and mammals have now been assessed for the IUCN Red List. The first results from the SRLI were revealed this year. They include results for reptilian species, giving us a clearer indication of the status of terrestrial vertebrates, as well as other less well-known groups such as freshwater crabs. One of the newly assessed freshwater crab species, the Purple Marsh Crab (*Afrithelphusa monodosa*) from western Africa, was almost completely unknown to science until recently. The first living specimen was found in 2005, and the species has been listed as “Endangered” because of habitat disturbance and deforestation from agriculture in all parts of the Upper Guinea forest.

In the future, the SRLI will sample other lesser-known groups such as beetles, molluscs, mushrooms, lichens, and plants like mosses and liverworts, as well as flowering plants. Over the coming years, this new approach will enable us to build a clearer picture of the status of all the world’s species, not just the furry and feathered. “Over the years, the rigor of the IUCN Red List process has built it into the ‘global gold standard’ for monitoring the conservation status and trends of species and the threats they face worldwide,” said Dr. Holly Dublin, Chair of IUCN’s Species Survival Commission (SSC). “The SSC is the largest and oldest IUCN Commission, its members are proud to contribute their knowledge and expertise to delivering this amazing conservation tool to the world.”



IUCN

The first living specimen of the Purple Marsh Crab (*Afrithelphusa monodosa*) from western Africa was found in 2005. The species has been listed as “Endangered” because of habitat disturbance and deforestation from agriculture in all parts of the Upper Guinea forest.



Male and female Central Notted Dragons (*Ctenophorus nuchalis*).

H U S B A N D R Y

Captive Care of the Central Netted Dragon¹

Shannon Plummer

New Farm, Queensland 4005, Australia (centralnetteddragon@mac.com)

Photographs by the author except where noted.

With their easy-going temperament and unusual color combinations, Central Netted Dragons (*Ctenophorus nuchalis*) have become increasingly popular pets. Central Netted Dragons are small, energetic agamid lizards with a calm temperament that allows them to be handled easily. One of the reasons these lizards are so popular is their striking appearance. A dark reticulated pattern overlays a body color of pale brick-brown with a pallid unpatterned belly. They have a rounded



A dark reticulated pattern overlays a body color of pale brick-brown with a pallid unpatterned belly.

head with a row of enlarged scales curving under both eyes and above each exposed ear, and small spines made up of soft skin around their head and nape. Central Netted Dragons are sexually dimorphic. Adult males average 250–280 mm (9–11") in total length and 100 mm (4") from snout to vent (SVL). Females are usually smaller. Males also have larger heads in relation to their bodies.

Habitat

Central Netted Dragons inhabit a vast area of central Australia, occurring throughout the desert plains of Western Australia, the Northern Territory, and also in western Queensland and parts of New South Wales. They are abundant in open sandy areas with sparse vegetation, increasing substantially in number in areas artificially cleared of vegetation.

These lizards are diurnal and terrestrial, spending their days basking on logs, stones, and termite mounds. Predators include birds of prey, larger reptiles such as monitors and snakes, and mammals such as foxes and feral cats. When the desert temper-



Two females (left) are distinctly smaller than the two males (right).

About the Author

Shannon Plummer is a wildlife photographer. Her style of fine art photography caught the attention of the international photography community where she won several prestigious international awards and acclaim from her peers. She is also a wildlife rehabilitator for sick, injured, and orphaned Australian wildlife, specializing in reptiles. Shannon has a deep interest in dragons, monitors, and pythons, which she keeps and breeds along with various other reptiles needing rehabilitation.

¹ This article is excerpted from *Captive Care of the Central Netted Dragon* by Shannon Plummer. For more complete and detailed care information, you can obtain a copy through selected pet stores or by logging onto www.centralnetteddragon.com.

atures peak during the middle of the day, Central Netted Dragons retreat into their cool burrows. They are known to have several burrows, usually found at the base of *Spinifex* shrubs or stumps.

Life Span

Although the life expectancy of most wild reptiles is difficult to estimate, the general consensus is that Central Netted Dragons are relatively short-lived. Captive lizards are expected to live around 6–7 years; however, some have been reported to live more than nine years. In the wild, where they are subject to

predators, disease, and lack of food and water, they generally survive only 2–3 years.

Outdoor Housing

If you live in an area with a climate similar to that of the Australian regions inhabited by the Central Netted Dragon, an outdoor enclosure is ideal, as it mimics the lizards' natural environment. You should add several retreats, basking areas, and shade, while providing a balanced diet and clean water. The walls will need to be high enough to prevent escape attempts, and enclosure design should take into account the height and position of potential basking areas such as shrubs or stumps. These lizards have very strong limbs and are quite capable of jumping a considerable height. Walls of the enclosure should be smooth to avoid injury, as your lizard will initially spend a lot of time trying to escape (rubbing its snout on the walls and trying to climb out). You can also cover the enclosure with wire or shade cloth to keep predators out.

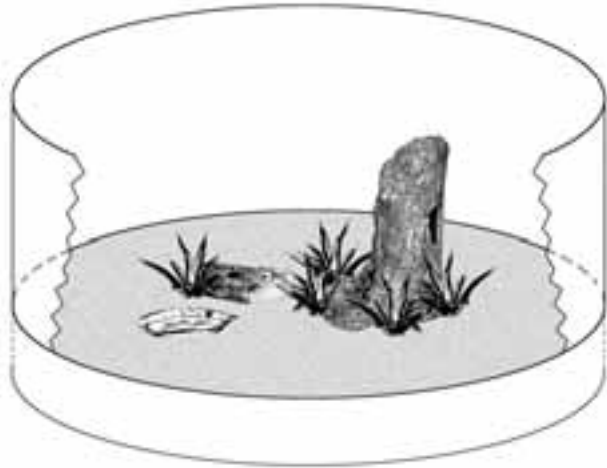
The enclosure should be as large as possible to allow your lizards adequate space to run and dig. Position your enclosure where it will receive the maximum amount of sunlight, but remember that adequate shade must be available at all times. Even though the Central Netted Dragon is a desert-dwelling lizard, fresh water must always be provided, either from a water dish changed daily or a pool at ground level. Make sure the sides of the pool have a gradual descent to allow easy access. Alternatively, a large rock or branch set in the pool gives the lizard something to cling to while submerged or drinking. Central



The natural distribution of Central Netted Dragons.



Typical *Ctenophorus nuchalis* habitat.



Example of an outdoor enclosure design.

Netted Dragons are capable swimmers, but prefer to be touching something in the water if they cannot reach the bottom.

The water quality can be maintained by the addition of a “waste degrader” such as Exo Terra’s® Biotoze™, a probiotic waste digester that contains natural, healthy bacteria that eliminate organic waste. Water still needs to be changed at least once a week, and, if feces can be seen in the water, it must be changed immediately and the container cleaned and sanitized. Heavy rain can flood an outdoor enclosure, so sufficient drainage is important. This also provides a shady area protected from the elements. Elevated features such as stumps, logs, or stones will provide a retreat should water accumulate.

If the enclosure is positioned to take full advantage of the sun, no extra heat or light is needed. However, if the enclosure is not in an ideal location, providing an additional basking spot by using a heat lamp or ceramic heat emitter is beneficial.

Indoor Housing

An indoor enclosure provides the most versatile housing for keepers in any climate and provides a good opportunity to observe your lizard. Keep in mind that Central Netted Dragons are terrestrial and are best kept in the largest enclosure you can afford. A guide for minimum sizing is 100 x 40 cm (40 x 16”) with a reasonable height of at least 400 mm (16”). An enclosure of this size will accommodate as many as three lizards. If you want to keep more than one lizard, don’t house males together. Central Netted Dragons are highly territorial, and battles for dominance will result in stress and possible injury. House a male with one or more females, or keep only females if you don’t want to breed them.

Ventilation is important and best provided by using some form of mesh for the top or even for part of one side of the enclosure. If you choose to vent one side, make sure you install the mesh at the “cool” end of the cage. However, be careful when using wire mesh or screens — if the reptiles can reach the wire they will rub their snouts trying to escape and injure themselves. With this in mind, position any side ventilation about halfway up the enclosure. An open-mesh top is critical for allowing the passage of light and heat.

The enclosure should be easy to clean, ideally with smooth, watertight surfaces. The substrate should be selected to replicate the lizards’ natural environment, which for Central Netted Dragons means sand. Many varieties of sand are available, from reptile-specific sands purchased at a pet store to sand from your local hardware store. An economical option is bulk sand such as that used in children’s sandboxes. Be sure to choose sand that can be used for water filtration; this is a safer option than sand that has been heavily bleached or chemically treated. Central Netted Dragons are avid diggers, so provide as much sand depth as possible to allow them to engage in natural behavior.

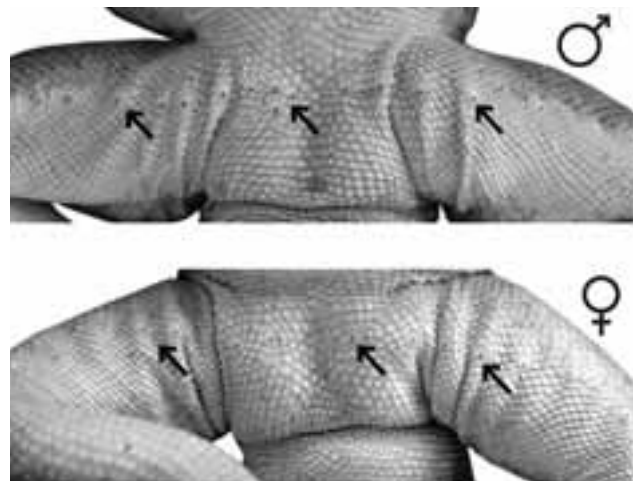
The most important features in an enclosure are retreats that give lizards a place to hide when they feel threatened. Some dragons also like to sleep in a protected area, so a retreat is essential for minimizing stress levels. When housing more than one lizard, each animal should have an individual retreat. Because these lizards love to dig, features should be positioned so they are steady and won’t tumble onto your lizard if it digs under or around them. As a general rule, try to place heavy items so their bases are in contact with the bottom of the enclosure and surrounded by packed sand so that your lizard cannot get stuck under them and subsequently be injured or suffocate.

The addition of some plants will add a finishing touch and make it feel more like home for your lizards. Plants like *Spinifex* or succulents can be used as long as they don’t have spikes that can cause injury. You also can choose from a variety of artificial silk or plastic plants.

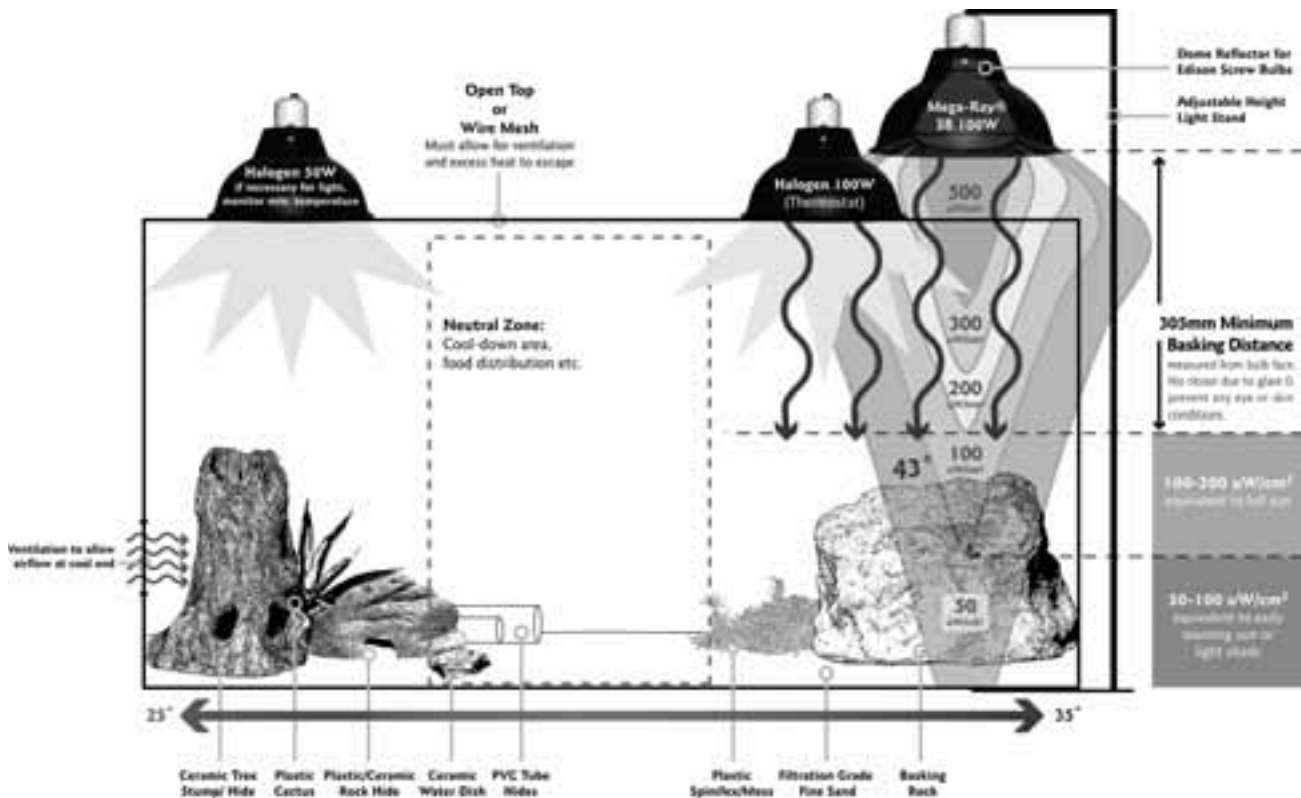
Make sure the water you provide is in a solid container that cannot be spilled. The container must be cleaned and water replaced daily. When using tap water, condition the water by using a reptile water conditioner that will remove chlorine and chloramines as well as ammonia. If you see any feces in the water, you need to empty the container and clean and sanitize it before putting it back in the enclosure. I recommend using a veterinary grade disinfectant such as Chlorhexidine for cleaning features and the enclosure itself.

Heating and Lighting

A temperature gradient allows your dragon to thermoregulate by shuttling between low and high temperature areas in the



Comparing femoral pores is one way to determine sex.



An indoor habitat showing proper heat and lighting.

enclosure. The ambient daytime temperature should be around 25 °C (77 °F) at the cold end of the enclosure, whereas the hot end and basking areas should be maintained at 35–40 °C (95–104 °F). These temperatures should be constant with minimal fluctuations.

Place a thermometer in the basking area to make sure the temperature does not exceed a maximum temperature of 43 °C (109 °F). Depending on the size of the enclosure, the light generated from the basking area may be enough for the entire enclosure; however, if you feel the cooler end is not bright enough, use a low-wattage fluorescent or halogen globe positioned so that it will not affect the minimum temperature range. Make sure you have a second thermometer placed in the cold end to monitor the gradient.

Lights in summer should generally be on from 0500–1830 h. This provides at least 13 solid hours of UV light and closely replicates a summer day. During winter, the photoperiod should be reduced to 8–10 hours a day, and overall temperatures reduced.

Because Central Netted Dragons are desert-dwelling lizards, lighting is one of the most important aspects of caring for your dragons. Providing ideal lighting is absolutely critical for their physical and psychological health. In the wild, the sun fulfills all the dragons' heat and light requirements. Reptiles are tetrachromatic, meaning that their eyes possess four types of cones (light receptors that respond to different wavelengths or colors of light). This gives them the ability to view a portion of the UVA range. Studies show that correct reptile color rendering of artificial light is not only necessary for intersexual recognition, but also for motion perception during foraging and for maintaining

an animal's sense of well being. The immune system is as dependant on the correct heat and light as it is on nutrients derived from diet.

While no artificial light can replicate the full benefits of direct sunlight, current technology can fulfill a dragon's needs. This cannot be done with a single lamp and must be accomplished with a combination of specific bulbs. While I don't have the opportunity to go into fine detail in this article about the pros and cons of various lamps and how to use them appropriately, note that my book, from which this article is extracted, does explore this subject in much greater detail.

Ultraviolet light is very important to your dragon's health, in particular that portion in the spectrum known as UVB. UVB-light allows lizards to synthesize Vitamin D3 in their skin, which in turn mediates the absorption of calcium and the development of strong, healthy bones. Vitamin D3 also is needed for the health of the immune system and of muscles, including those of the gut and reproductive system. Without UVB, dragons of any age can develop Metabolic Bone Disease (MBD). However, UVB light will not prevent MBD without adequate levels of calcium. Vitamin D3 allows a reptile's body to absorb the calcium needed for bone strength. Central Netted Dragons are mainly insectivorous and are susceptible to MBD since most insects are not rich in calcium. This is why a calcium supplement is vital.

UVA and UVB can be obtained through the provision of a Mercury Vapor Lamp or fluorescent tube; however, not all brands are alike and making the right choice will greatly affect the health of your dragon. I recommend researching www.uvguide.co.uk, a website dedicated to testing and publish-

ing information on various brands of UV-emitting bulbs. Replace Mercury Vapor bulbs every 12–18 months and fluorescent bulbs every 6–12 months. Mark the installation date on the bulb so you remember when to replace it.

Diet

Central Nettle Dragons wait for insects to pass before striking, often leaving an elevated basking spot to feed on a passing insect before returning to bask. An 18-month field study of Central Nettle Dragons in 1970 in Alice Springs and the Simpson Desert investigated stomach contents from 156 individuals over all seasons. The study found that the diet of dragons in natural habitats was composed of 71.9% insect prey, 24.3% vegetation, and 3.7% sand and debris. The remaining 0.1% was a lizard in one of the 156 stomachs.

A safe and healthy diet is crucial for optimal health. Use only live insects that have not been exposed to insecticides or chemicals. Feed adult dragons two or three times a week and allow them to eat as much as they want over the course of about 20 minutes. Some authorities suggest feeding small reptiles like Central Nettle Dragons more frequently, as many as five times a week. However, if not very carefully monitored, this can result in an overweight dragon with health problems such as a fatty liver. However, growing juveniles should be fed as many as five times a week.

The most popular choices for a staple diet are crickets and cockroaches (also known as “woodies”), but dragons also love mealworms and silkworms, which can be used occasionally to add variety. Whether you choose crickets or woodies, they should always be “gut loaded” before feeding them to your dragon to provide the highest nutritional value. To prepare the insects, you can feed them vegetables and fruit as well as cat or dog food, moist or dry. I use pieces of oranges, apples, and carrots sprinkled with a vitamin supplement for insectivores, as well as a calcium powder. The fruit keeps the insects well hydrated without having to use additional water sources. To avoid



Central Nettle Dragons relish small insects such as crickets and woodies.

impaction, feed your dragon only insects that are equal to or smaller than the width of the dragon’s head. If in doubt, go smaller. No crickets or woodies should be left in the enclosure after each dragon has finished feeding. These insects are experts at hiding until nightfall, when they come out and harass and bite your dragons. Aside from interrupting their sleep, bites can result in open sores, especially in young dragons. Dragons should receive a balance of vitamins and minerals, such as a multi-vitamin supplement, to avoid common deficiencies. Too much can also be harmful, so don’t use the multi-vitamin more than once a week.

Some dragons will enthusiastically eat certain leaves and flowers, while others will refuse. For dragons that accept them, fresh leaves and flowers should be offered on a regular basis. Some plants can induce diarrhea, and others are toxic or provide little or no nutritional value (e.g., iceberg lettuce), so be careful what you offer. The most popular plant is the dandelion, and for good reason. Dandelion leaves are high in calcium and Vitamin



Central Nettle Dragons are sexually dimorphic as seen here with the smaller female in front.



A male *Ctenophorus nuchalis* bites a female's nape while attempting copulation.

And dragons usually love the young flower buds. Bok Choy also is high in calcium and Vitamin A and seems to be accepted by dragons that enjoy dandelions. Hibiscus flowers also are a favorite, but be sure they have not been exposed to pesticides or insecticides.

Breeding

For breeding purposes, your dragons need to be healthy and maintained in as natural an environment as possible in order to encourage mating. The sex of a Central Netted Dragon can be determined by comparing the following characteristics: (1) Males have a larger head-to-body ratio compared to females; (2) males have larger and more distinct femoral pores (located on the underside of hind thighs; known as pre-anal pores when situated above the vent); (3) a male's tail will taper gradually to the end, whereas a female's tail will start out thick at the vent and then rapidly taper for the remainder of the tail length. Accurately determining the sex of younger dragons is difficult, and the only certain way is to take the lizard to a reptile veterinarian to be probed.



The enlarged abdomen of this female indicates that she is gravid and due to lay soon.

Like many other lizards, Central Netted Dragons demonstrate very interesting courtship behaviors. When a male and female are housed together, the male will display his dominance



A hatchling may take several hours or even more than a day to fully emerge from the egg.



A hatchling breaks through the soft egg and takes its first breath.



Hatchling *Ctenophorus nuchalis* are tiny (seen here next to an Australian 20-cent piece).

by vigorous head bobbing and chasing the female around the enclosure. The female will respond with subdued head bobbing and slow arm waving as signs of submission. The male will attempt to bite the female at the back of the neck and then mate with her.

Females are oviparous (= egg laying), laying 2–3 clutches of 2–6 eggs during spring and summer. Gravid females need warm summer temperatures to effectively develop eggs. A specific covered area filled with moistened sand or vermiculite is most appropriate as a nesting site. The same medium is used during the incubation process. Covering the nesting area enables the female to feel less vulnerable, especially if she is still housed with the male.



Hatchlings quickly establish a hierarchy.

Be careful if you have water bowls in the enclosure, as gravid females may use these for nesting areas, which will spoil the eggs. They may want to drink regularly, so providing regular access to water is important, although this should be supervised until eggs are deposited. The female will become quite restless prior to laying her eggs and will dig all over the enclosure looking for the perfect spot. A gravid female usually will stop eating during the weeks prior to laying. You will notice that after she has laid, she will seem to have suddenly lost a substantial amount of weight. This is the best indication that the enclosure needs to be searched carefully for eggs. When you locate the eggs, they should be carefully excavated without



Central Netted Dragons (*Ctenophorus nuchalis*) will reward proper housing and care with a calm temperament, a willingness to interact with the keeper, and, if desired, a disposition to reproduce in captivity.

being turned. The soft leathery white eggs should be handled with care and placed in the incubation medium in the same orientation in which they were found. Eggs should be incubated at temperatures of 28–32 °C (82–90 °F) and will take 8–11 weeks to hatch.

Hatchlings require considerably more care than juveniles or adults. They should not be housed with older dragons, as they will be seen as food and quickly killed. Keep them in a very simple set-up at first. Use damp paper towel as flooring and provide a basking area and several retreats in various temperature ranges. Keep the paper towel moist by misting with filtered water several times a day for the first week or so, and once a day thereafter. Offer food immediately. Suitable prey includes small crickets and tiny woodies, as well as access to fresh, finely chopped dandelion leaves.

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Kraig in a section of his massive library, where he can often be found working.

P R O F I L E

Kraig Adler: A Lifetime Promoting Herpetology

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The Society for the Study of Amphibians and Reptiles (SSAR) has been an important herpetological institution for more than half a century. Kraig Adler has been involved from the beginning and has helped make the Society what it is today. He has been an enormous influence in modern herpetology, as one of the founders of the SSAR, as a major contributor to our knowledge of amphibians and reptiles, and as a source of inspiration for future herpetologists.

Kraig was born in Lima, Ohio, and moved to Columbus when he was nine. Columbus is where his interest in herps blossomed, and where, only three years later, he met Dave Dennis while herping at the O'Shaughnessy Dam on the Scioto River. Upon meeting, each had a bag full of snakes, Kraig with Northern Watersnakes found under rocks, and Dave with Queen Snakes found on tree branches — an early lesson in microhabitat selection. The two used Roger Conant's *Reptiles of Ohio* as their "bible," reading and re-reading it, marking the



JACQUELINE GRANT

Kraig showing off his billiard skills while socializing at the 1998 joint meeting of the SSAR, Herpetologists League, and the American Society of Ichthyologists and Herpetologists. To the left is Dr. John Moriarty, University of Minnesota (and editor of the SSAR Herpetological Circulars program) and to the right is Dr. Michael Bernard as an undergraduate, now an Assistant Professor at Case Western University. Mike is one of many of Kraig's students to continue with a successful career in biology.



DAVE DENNIS

Kraig (in the foreground) and Dave Dennis working with Barry Valentine at Ohio State University.

maps with their own records, in a quest to fill the large gaps that existed in distributional information. In their undergraduate years (Dave at Ohio State University and Kraig at Ohio Wesleyan University), they met Dr. Barry Valentine at OSU, who opened his lab to the two, guiding them down the road to real science.

During those early years, Kraig and Dave met Ray Ashton, Joseph T. Collins, Corson Hirschfeld, from the Cincinnati area, and somewhat later, Jim Murphy. As the "Columbus boys," Kraig and Dave were "refined gentlemen" according to Jim Murphy, whereas the "Cincy boys," as Kraig would call them, were "always suspect in polite society." In 1957, Kraig, at 16 years old and Dave at 17, officially formed The Ohio Herpetological Society (OHS), with Kraig as the president. He was already a walking encyclopedia of herpetology, had already started building his massive library (now among the largest private herpetological libraries in the world), and was always out herping.

The entire group formed a sort of herpetological Dead Poets Society, and comprised a major component of the OHS. Whoever was in Columbus would attend "stapling parties" in Dave's basement, where they would print the OHS journals,



JOHN OLTHOFF

On the most recent trip to observe Hellbenders, Kraig (bottom right) with Cornell undergraduate and graduate students, led by Ken Roblee, New York State DEC Biologist, near Olean, New York.

and set the pages around the room. Practically every horizontal surface in the room had pages on it, and everyone went around collating and stapling the pages. Every stapling party would be accompanied by Dave's guitar-playing and singing, and closed with a bottle of Madeira wine, which could not be uncorked until they were finished.

In 1967 the OHS became the SSAR (to represent its rapid growth into an international organization), and throughout his career, Kraig has remained an important figure, filling various roles in the Society. For example, in 1979 he started the book series, "Contributions to Herpetology", in which 22 volumes have been published, with more to come. Kraig was also elected the Secretary-General of the first World Congress of Herpetology, which was held in 1989 in Canterbury, U.K. This was the first major international meeting of herpetologists, and the largest gathering of herpetologists held to date (1,600 persons).

Kraig also has had a very productive academic career, spending most of it at Cornell University. He received his Ph.D. at the University of Michigan in 1968, and spent four years in a faculty position at Notre Dame before moving to Cornell in 1972. He has written over 150 technical articles and nine books, among them the popular *Encyclopedia of Reptiles and Amphibians*, co-authored with Tim Halliday, and the renowned *Herpetology of China*, with Ermi Zhao. In his publications, Kraig was the first to describe important principles of amphibian behavior such as magnetic, extraocular, and polarized light perception for navigation, as well as kin recognition in tadpoles. He has also published extensively on zooarchaeology, particularly with regard to turtles, as well as on amphibian systematics, describing a dozen new species of frogs and salamanders, mostly from northern Mexico. As a faculty member in the Department



BETSY DARLINGTON

A group of students from the Cornell Herpetological Society enjoying a lunchtime chat with Kraig during a field trip to the Parker Nature Preserve of the Finger Lakes Land Trust.

of Neurobiology and Behavior at Cornell, he has served as department chair (currently for the third time), and, during 1998–2000, was Cornell's Vice-Provost of Life Sciences, where he oversaw 500 professors and was responsible for hiring 60 new faculty members. In this position, Kraig also was instrumental in funding and breaking ground for the construction of \$300 million of new research facilities on campus.

Many of Kraig's activities illustrate his commitment to the future of herpetology, particularly through the recruitment of new members to the discipline. Even while in college, he taught summer herpetology courses at Culver Military Academy in

Indiana, from which he graduated in 1957. One story many of his students have heard him tell refers to a favored field site, Lake Maxinkuckee. Juvenile turtles would bask on a mat of aquatic vegetation and get stuck while trying to retreat to the water. The group would sit watching turtles from just over a small hill, and students would take turns picking one to catch. Every student, no matter how out of shape, could reliably experience the joy and excitement of catching one. Continuing in that vein, since 1993, almost from its inception, Kraig has served as faculty advisor to the undergraduate-founded Cornell Herpetological Society (CHS). This is where I and many others first met him. Although the CHS is entirely student-run, Kraig provides valuable assistance, using his professional network to help arrange trips to zoos and universities, bring in guest lecturers, and generally enhance the experience of participating students. He attends virtually every event, and gets to know the students, often serving as an informal, if not a formal academic advisor. He facilitates students' involvement in herpetology collectively and individually, in part by helping them develop a network of contacts through participation in professional meetings and research internships.

One of the favorite annual CHS events is a trip to western New York to see Hellbenders. These trips have been unique opportunities to observe these awesome amphibians, and they also provided occasions for students to interact with herpetologists like Ken Roblee of the New York State Department of Environmental Conservation and the late Dr. Richard Bothner from St. Bonaventure University.

Kraig always strives to achieve the highest quality in all that he does. Although we all make mistakes, finding as much as a typo in any of his work is rare. He tends to expect the same quality of work from everyone else, and many of us are undoubtedly better for it.

Kraig's close colleagues sometimes regard him as an atypical herpetologist. At a meeting, some of them realized he was the



JAN SHELLEY

Kraig with a Hellbender in hand in 2006. As always, when in the field, he is a representative of Cornell University, to which his "Big Red" hat clearly testifies.



JOHN OLTHOFF

The Cornell Herpetological Society on their most recent fall trip to the reptile house of the Philadelphia Zoo. On the same trip, they also visited with Drs. Aaron Bauer and Todd Jackman at Villanova University. As per usual on these trips, Kraig is wearing his red Cornell hat. Other faculty members often participate in CHS events, evident here in the form of Professor emeritus of Veterinary Medicine, Dr. Howie Evans (on Kraig's left) and Howie's wife, Erica (far left).

only one who was "married once, did not have long hair or facial hair, never cussed (well almost never), and was never into rock-and-roll or anything fun — only herps and herp books." However, Kraig does have a sense of humor, albeit herp-based, seen in his secret weakness for inaccurate (and sometimes ridiculous) herpetologically oriented movies (e.g., *Anaconda* and *Anaconda 2: Search for the Blood Orchid*), an obsession few ever see. Kraig's humor also is evident in a story he often tells about a trip to Mexico with Dave Dennis while he was at Notre Dame. While at dinner, upon seeing a gecko on the ceiling, Kraig instinctively stunned it with a rubber band, knocking it onto another occupied table. These rubber-banding skills have gone a long way, from disturbing the patrons at this restaurant, to impressing people in various parts of the world (including China and Mexican police at a traffic stop), and, of course, they have contributed immensely to the collection of museum specimens.

Kraig is an amazing biologist, teacher, mentor, and person. Herpetology is lucky to have him, and the field certainly would not be the same without him.



A male Ornate Box Turtle (*Terrapene ornata ornata*) approaches a tasty Spiderwort (*Tradescantia bracteata*) for breakfast.

COMMENTARY

The Turtles Have Been Watching Me

Eric Gangloff

Colorado Box Turtle Project & Colorado Reptile Humane Society (eric@corhs.org)

Photographs by the author.

The turtles have been watching me for two years now. Each week during their active season, from late March until early October, I've been visiting these Ornate Box Turtles (*Terrapene ornata ornata*) in eastern Colorado. While I'm there, the turtles observe me, if not eagerly then diligently, as I patiently patrol the sandhills. By now, they are surely quite familiar with my habits, where I park the car, the circuitous routes I roam, the regular visits to a puddle from an overflowing stocktank, and the intensity of my groundward gaze. Occasionally, the turtles may allow themselves to be spotted, although most of the time they use their camouflage and silence to regard me without being detected, confounding my best efforts to find them. They are better at this than I am.

I visit these sandhills to study the turtles. This is a scientific investigation, conducted only after extensive literature reviews, the receipt of permits from the state, and time spent with other researchers learning the art and skill of chelonian studies. We're using sound methods and working hard to produce data that will inform scientists and the public alike (should we draw such distinctions). We hope to better understand how turtles use the land, how they find mates, and what it is, exactly, that they do all day. Ideally, this information will be used to influence decisions and policy, both private and public, that impact these animals and the stark landscapes to which they belong. Hopefully, roads will not be built, strip-malls won't be constructed, and animals won't be stolen for the pet trade. We know, of course, that we don't want these things to happen, that turtles don't want these things to happen — but, to convince others, we'll need numbers and facts, charts and graphs.

The reason we founded the Colorado Box Turtle Project is simple; we love these animals and we want to protect them. Does this passion obfuscate our science? Of course not. Ardor is the impetus for science. Too often, animals, plants, and ecosystems are intensely studied so that they can be efficiently exploited: How do we best clear-cut a forest? dam a river? Herpetologists, thankfully, seem to operate largely outside this questionable paradigm. The study of reptiles and amphibians offers little in the way of economic benefits. We are not providing data to increase the bottom line of major corporations or, for that matter, ourselves. We dedicate ourselves for other reasons — we care about these fascinating animals, their well being, and their future.

As field researchers, we must recognize that our studies are a mutual exchange; just as we are collecting data about turtles, they are doing the same on us (although most likely in less quantifiable terms). My intention on the sandhills is not merely to accrue scientific data about turtles, but to build a relationship with these animals and the place they call home. This summer,

partly due to expensive gasoline and partly due to my preference for sleeping under the stars, I timed my visits to make the best of the turtles' activity periods. I worked in the evening once the air had cooled, spent the night in the company of the rising moon and curious beetles, then worked again in the morning before the heat of midday became thick and tangible. I wanted to know this place in a way beyond what can be garnered with calipers and GPS units. I hoped to at least become a welcome visitor in a place to which I'll never fully belong. I learned that not finding a turtle for hours on end was not a waste of time, but a valuable endeavor in itself. I watched the different plants and noted their blooming schedules: The early-summer ubiquity of Spiderwort (*Tradescantia bracteata*) and the delicate, late blooms of the Sand Lily (*Mentzelia nuda*), the spinsters of the sandhills who wait until midsummer to display their magnificence. I learned to distinguish the three species of *Opuntia* cactus (*O. macrorhiza*, *O. fragilis*, and *O. polyacantha*) and how the Sand Verbena's (*Abronia fragrans*) deliciously sweet scent earned it a fitting Latin name. I watched wide-eyed as miniature lizards, the Lesser Earless Lizards (*Holbrookia maculata*) and the Prairie and Plateau lizards (*Sceloporus undulatus*), scurried across open sand at remarkable speeds, despite emerging from eggs only days earlier. While rewarding in itself, these interactions also helped me to better understand the turtles I sought. To really get to know someone, sometimes it's best to ask the neighbors.

Occasionally, however, my visits were not well received. One July evening, as I was driving through the expansive ranch and farm on which our study site sits, I approached a Red-tailed Hawk (*Buteo jamaicensis*) perched on a fencepost. She flew par-



A male turtle tells us very politely that he'd prefer not to be bothered today — thank you very much.



The fragrant Sand Verbena (*Abronia fragrans*) in bloom.



A male turtle in the long shadows of morning.



The morning sun reflects off the grasses of the sandhills, mostly Thread-and-needle Grass (*Stipa comata*).



Yucca (*Yucca glauca*) in bloom.



A female turtle enjoys the morning sun amidst the grasses of the sandhills.

allel with the car for a few moments, as if in greeting — or that's what I thought at the time. Several hours later, after finding a fresh road-killed turtle (the first I'd observed on the ranch), and a frantic hour spent in search of a new and expensive camera I thought was lost, I realized that she was not greeting, but warning. Now when I see a Red-tailed Hawk, it's a great reminder to drive slowly and keep my head on straight. Other birds are less

apt to remind me of anything other than the fact that I don't entirely belong here. Mourning Doves (*Zenaida macroura*) can explode with frightening rapidity from a nearby Sagebrush (*Artemisia filifolia*) and the Killdeer (*Charadrius vociferus*) make it clear, in no uncertain terms, that I should leave. Their perfection of the art of distraction, via shrill warning cries and ridiculous antics, have earned them, even more than the Sand Verbena, the perfect Latin name. Less dramatic but no less prescient, the Prairie Rattlesnake (*Crotalus viridis*) provides its own alarm, so unique and poignant it is, thankfully, impossible not to heed. While I have thoroughly enjoyed this intimacy with the sandhills and their residents, it is the turtles who have brought me here. Each time I spot one, usually from an embarrassingly close distance from which the turtle has been observing me for several minutes, I feel a burst of delight. Here's a turtle! In the wild! It's healthy! And living where it should! I stop and photograph the animal where it is before doing anything else, noting direction and vegetation. Sometimes, I pause and watch for a time to see what the turtle will do. The answer, invariably, is the same — nothing. The turtle has long since stopped its task at hand and waits, patiently, for me to move on so it can resume. When processing the animals, I can't help but be enamored of the vibrant and distinctive sunbursts on each carapace scute, the deep, patient gaze of the wizened females and the showy green-blue-orange of a male's head and forelegs. Sometimes, I must abashedly admit, I talk to the turtles. No, I must be honest, I always talk to the turtles. I call them "sweetie" and "handsome" and "beautiful" or other terms of endearment usually reserved for children and spouses. Once, an intern from the local univer-



An exuberant stand of Prickly Poppy (*Argemone polyanthemus*).



A male chows on a box turtle favorite (Spiderwort, *Tradescantia bracteata*).

sity sarcastically commented, “That’s real scientific, Eric.” Of course it’s not, but it doesn’t hurt the scientific. For science to be pertinent and powerful in the dire circumstances of our world, the days of dispassion must be over. If we do not care about the objects of our study, we risk perpetuating the damage of past endeavors done in the name of science.

I recently read a book that beseeched us humans to start listening to the natural world, not in a metaphorical sense but in the literal sense. We had much to learn, the author claimed,



A male turtle begins his morning rounds.



A female turtle walks off after a morning drink at the stock tank overflow puddle.



A Lesser Earless Lizard (*Holbrookia maculata*) pauses in ready curiosity.



A male turtle watches the sunrise over his beloved sandhills.



A male turtle strikes a frightening pose to ward us off; he was unsuccessful.

from the trees and coyotes and rivers. The book was unscientific and, at times, proudly so. I don’t see this as a shortcoming compared to the rigors of scientific investigation, only a difference of approach to the same quest for knowledge and understanding. I’ve also read countless papers and journal articles about box turtles and sandhill ecosystems, all facts and figures and irrefutable numbers. I’ve learned a great deal from these as well, and do not grow bored from their lack of personal voice or narrative. They help me better understand an animal to which I’ve dedicated a great deal of my life’s energy. These differing approaches should not be held in opposition; rather, we must rededicate ourselves to serving this world around us, our friends and neighbors, with both inquiry and passion, hard facts and endearing nicknames. Derrick Jensen, author of the aforementioned book, stated that the question we should be asking is, “What can I learn from this forest [or sandhill] community that will teach me to better serve it?” I am lucky to have learned what I have about these turtles, activity periods and size-to-mass ratios and habitat preferences. Hopefully, we can put this knowledge to use in service of these turtles and their fellow sandhill residents. I am also lucky to have learned from these turtles to stop walking when I want to look around and to be patient when coming or going, valuable lessons that are applicable beyond the sandhills. This learning is at once quantifiable and profound. It is meticulous. It is fueled by passion. Science, in these times, cannot afford to be otherwise.

BOOK REVIEW

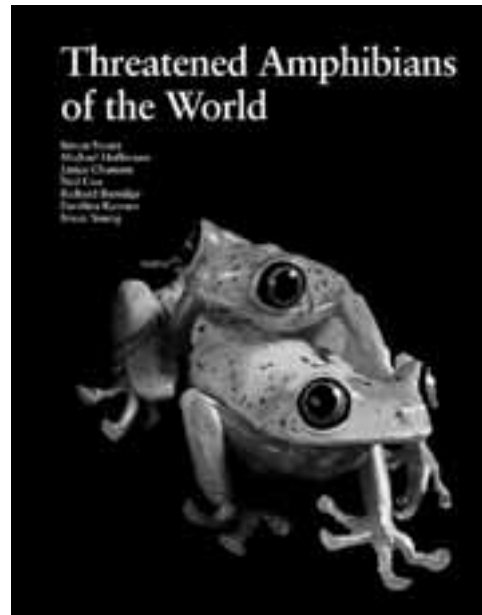
Threatened Amphibians of the World

Threatened Amphibians of the World. 2008. Edited by S.N. Stuart, M. Hoffmann, J.S. Chanson, N.A. Cox, R. Berridge, P. Ramani, and B.E. Young. Lynx Ediciones, with IUCN - The World Conservation Union, Conservation International, and NatureServe. Barcelona, Spain. xv + 758 pp. Hardback – ISBN: 84-96553-41-8. \$124.00.

Declining amphibian populations have received considerable attention in recent years, largely due to the unexplained causes responsible for those declines. Increasing evidence suggests that many species are already extinct and many others are on the verge, leading to a growing concern that amphibians are the canaries in the coal mine — indicators of problems that soon will affect other, momentarily more resilient forms of life, including us.

This massive, profusely illustrated tome provides a comprehensive assessment of the conservation status of the world's amphibians, with descriptions of distributions (with maps), habitats, natural histories, threats, and current or needed conservation plans for the ~1,900 species known to be threatened with extinction — and color photographs are provided for most of them.

Forewords by noted conservationists Julia Marton-Lefèvre (Director General of the IUCN), Russell A. Mittermeier (President, Conservation International), Mary L. Klein (President and CEO, NatureServe), and Holly T. Dublin (Chair, IUCN Species Survival Commission) paint a gloomy picture, with Mittermeier saying that we should “hope that a second edition of this book does not require two volumes...” Prefaces by scientists Karen R. Lipps and Joseph R. Mendelson III and



Claude Gascon and James P. Collins (Co-Chairs, IUCN-SSC Amphibian Specialist Group Secretariat) provide a bit more detail, but the tone is equally dour. Acknowledgements to contributors, donors, and conservation partners round out the introductory section.

Following are “introductory” chapters on amphibians, why we should save them, the history, objectives, and methods of the Global Amphibians Assessment (GAA), the current state of amphibians, and a series of chapters organized by zoogeograph-



ROBERT POWELL

St. Vincent Frogs (*Pristimantis shrevei*) occur only at higher elevations on St. Vincent in the Lesser Antilles. The species is listed as “endangered” because of a limited extent of occurrence, all individuals are in fewer than five locations, and the extent and quality of the habitat continues to decline.



ROBERT POWELL

Windward Ditch Frogs (*Leptodactylus validus*) are listed as being of “least concern.” Although the extent of occurrence is limited, the species is common and adaptable, the population is presumably large, and it is unlikely to be declining fast enough to qualify for listing in a more threatened category.

ical realms (essentially corresponding to the continents), followed by a concluding chapter summarizing the necessary responses to the global declines of these animals. Chapters are overflowing with data, maps, charts, graphs, tables, and photographs illustrating species representative of varying responses to myriad concerns and a selection of people actively engaged in their conservation. Most of the chapters are supplemented by “essays” written by experts on more detailed aspects of the problems facing amphibians or on geographic areas of particular concern within the broader regions addressed by the relevant chapter (e.g., California within the Nearctic Realm). These, too, are profusely illustrated.

Next comes the heart and soul of the volume, ten pages devoted to accounts of species known to have gone extinct in historical times, 464 pages to accounts of species threatened with extinction (“critically endangered,” “endangered,” or “vulnerable” in terms of IUCN Red List criteria), and another 36 pages to species considered to be “near threatened.” Individual accounts vary in length, but most provide only short statements about geographic range, population, habitat and ecology, major threats, conservation measures, a short bibliography, and the names of the “experts” who provided the data. A few accounts of species that have received considerable attention are much longer — but the small number of such accounts speaks eloquently to the sad reality that very little is known about many of these animals. Every account is accompanied by a distribution map and most by a color photograph (a very few by colored illustrations) of the species in question.

A 48-page bibliography of cited references, a phenomenally valuable tool for anyone seeking information on the current state of the world’s threatened amphibians, precedes 15 appendices that provide IUCN Red List categories, a summary of the criteria used to evaluate the status of species, definitions of the regions for which data were collected, a summary of IUCN Red List status by genus, species listed by territory, the declaration of an Amphibian Conservation Action Plan, the scale of conservation needs, the nature of required landscape-scale conservation action, a list of critically endangered and endangered species for which captive breeding is an essential need, lists of species in each of the IUCN Red List categories (including “data deficient”), differences in status listed for some Brazilian species, a glossary, and a list of websites and related resources. An index to species accounts completes the book.

This volume represents a critically important step in the conservation of one group of animals that can and will serve as a model for future volumes addressing other groups. I found little to criticize. The inevitable time lag between the GAA, which commenced in 2001, and the publication of the book resulted in some instances of out-of-date taxonomy (changes published during the period devoted to compilation, editing, and printing). Although biologists working with amphibians will have no difficulties tracking the species in which they are interested, conservationists less familiar with these animals might be confused by generic or even familial assignments that differ from those in the current literature. In the chapters and accounts dealing with taxa with which I am conversant I found only one error in content (a statement that a species had not been encountered since 1991, although my students and I had studied a population of that species in the late 1990s — the error undoubtedly attribut-



ROBERT POWELL

Cane Toads (*Bufo marinus* [*Rhinella marina*]) are of “least concern.” Not only is the species extremely adaptable, it has been introduced widely (ostensibly to control insect pests in sugarcane fields), where it may threaten native species by competition or predation.



JOHN MAGOR

Cuban Treefrogs (*Osteopilus septentrionalis*), like Cane Toads, are of “least concern,” voracious predators, and have been widely introduced. Unlike most amphibians, which are sensitive to environmental changes, these two species may one day be part of a circumtropical herpetofauna composed of a few extremely adaptable species.

able to the difficulty in compiling information on so many taxa and communicating with an almost equal number of biologists). I noticed no typographical errors, which reflects the efforts and expertise of the editors.

Testament to a biological catastrophe that may have progressed far enough to preclude preventative or even mitigating efforts in many instances, this is not a happy book. However, it is a phenomenally valuable and authoritative resource for herpetologists and conservation biologists, but one so rich in information that anyone with an interest in these animals and the state of our world would benefit from reading it. Although the large format (–9.5 x 12”) replete with color is suggestive of a coffee-table volume, the depressing topic and plethora of data will probably cause it to be relegated to the bookshelves of those concerned about the future of amphibians and our world.

Robert Powell
Department of Biology
Avila University, Kansas City, Missouri

CONSERVATION RESEARCH REPORTS

New Pacific Iguana

The Pacific iguanas of the Fijian and Tongan archipelagos are a biogeographic enigma in that their closest relatives are found only in the Western Hemisphere. These iguanas were thought to comprise two genera and four species of extinct and extant taxa. The two currently recognized extant species, *Brachylophus fasciatus*, from Fiji, Tonga, and Vanuatu, and *Brachylophus vitiensis*, from western Fiji, are of considerable conservation concern, with *B. vitiensis* listed as critically endangered. In a recent molecular study, KEOGH ET AL. (2008. *Philosophical Transactions of the Royal Society B (Biological Sciences)* 363:3413–3426) showed that *Brachylophus* comprised three evolutionarily significant units. To test these conclusions and to reevaluate the phylogenetic and biogeographic relationships within *Brachylophus*, the authors generated a mitochondrial DNA dataset for 61 individuals from 13 islands, representing both currently recognized species of *Brachylophus*. The data rejected the monophyly of specimens previously believed to comprise *B. fasciatus*, instead demonstrating that *Brachylophus* includes three distinct species: *B. fasciatus* from the Lau group of Fiji and Tonga, a new species, *B. bulabula*, from the central regions of Fiji, populations which until now were considered



Top predators such as Nile Monitors (*Varanus niloticus*) may be at risk of reduced fitness and population declines due to cumulative effects of persistent environmental contaminants to which they are exposed over long life spans.

to be *B. fasciatus* or *B. vitiensis*. These molecular and taxonomic results have important implications for future conservation initiatives for Pacific iguanas.

Emerging Threats to Long-lived Vertebrates

Persistent contaminants are ubiquitous in the environment, often present at concentrations that may jeopardize reproductive fitness only after long periods of exposure. As the duration of exposure is largely regulated by life span, long-lived species of high trophic status, such as many reptiles, birds, and mammals, may be at risk of reduced fitness and population decline. ROWE (2008. *BioScience* 58:623–631) suggested that delayed maturation and iteroparity (repeated production of offspring at intervals throughout the life cycle) confer the potential for cumulative effects to be expressed prior to reproduction, and large parental investments in yolk and milk may threaten offspring because of exposure during critical developmental periods. Long generation times may delay emergence of obvious effects on populations, perhaps eluding early intervention, while constraining rates at which populations may recover if conditions subsequently improve. Life history theory thus suggests that the suite of traits that optimized reproductive fitness throughout long-lived species' evolution-

ary histories may ultimately put them in peril in the modern anthropogenically altered environment.

Frogs with Disease-resistance Genes May Escape Extinction

As frog populations die off around the world, researchers have identified certain genes that can help the amphibians develop resistance to harmful bacteria and disease. The discovery may provide new strategies to protect frog populations in the wild. New research examines how genes encoding the major histocompatibility (MHC) complex affect the ability of frogs to resist infection by a bacterium that is commonly associated with frog population declines.

“In the short term, captive management of frogs with complementary disease-resistance genes may offer the best hope for saving species from extinction,” says Bruce Waldman, a biologist at Lincoln University in New Zealand and one of the paper’s authors. “Management practices that maintain or enhance diversity in MHC genes may prove the key to safeguarding frog populations in the wild.” “Massive die-offs of frogs may indicate environmental problems that ultimately will affect other species, including humans,” Waldman says. “But, despite the concern, little is known about factors that make individuals susceptible to disease.”



PETER HARLOW

Populations from central regions of Fiji, formerly assigned to *Brachylophus fasciatus*, were shown to represent a new species, *B. bulabula*.



ERIC BSELEE

A study of tadpoles of African Clawed Frogs (*Xenopus laevis*) indicated that some individuals with disease resistant genes grew more slowly.

BARRIBEAU ET AL. (*PLoS One* 3: e2692, <www.plosone.org/article/info:doi/10.1371/journal.pone.0002692>) exposed African Clawed Frog tadpoles to several doses of the bacterium *Aeromonas hydrophila* and examined the number of tadpoles that survived and measured how fast they grew. Certain genes allowed tadpoles to survive bacterial infection but at a cost, as these tadpoles sometimes grew more slowly. Among siblings, patterns of disease resistance corresponded to tadpoles' MHC genes rather than other genes that they shared, demonstrating that the MHC genes conferred immunity.

Programs currently are underway to rescue frogs from declining wild populations and breed them in captivity to ensure that species are not lost to extinction. This study suggests that selective breeding of individuals with known disease-resistance genes might produce frogs that can survive infection by pathogens, even after the frogs are reintroduced into the wild.

The research team studied the African Clawed Frog because its immune system already had been well characterized, but as most frogs and toads have similar immune systems, they believe that their results will be generally applicable to all threatened and endangered amphibians.

New Approach to Conserving Amphibians

The global extinction crisis demands immediate action to conserve species at risk. However, if entire groups such as superfamilies are at risk due to shared evolutionary history, a shift towards conserving such groups rather than individual species may be needed. Using phylo-

genetic autocorrelation analysis, COREY AND WAITE (2008. *Diversity and Distributions* 14:614–629) demonstrated that multiple kinds of extinction threat clump within the amphibian tree of life. Their study provided insight into how these threats might collectively influence the extinction risk of whole groups, consistent with the supposition that related species, with similar traits, share an intrinsic vulnerability to common kinds of threat. Most strikingly, they found a significant concentration of 'enigmatic' decline and critically endangered status within families of the hyloid frogs. This phylogenetic clumping of risk is also geographically concentrated, with most threats found in Central and South America, and Australia, coinciding with reported outbreaks of chytridiomycosis. They speculated that the phylogenetic clumping of threat represents, in part, shared extinction proneness due to shared evolutionary history. However, even if the phylogenetic clumping of threat were simply a by-product of shared geography, this concordance between phylogenetic and geographical patterns represents a prime opportunity. Where practical, conservation plans should focus on biogeographical regions where threatened groups occur, thereby improving the capacity for conserving species. This approach could outperform the usual triage approach of saving individual species after they have become critically endangered.



A clumping of threats to groups of frogs, especially the hyloid frogs such as this Red-eyed Treefrog (*Agalychnis callidryas*), might represent, at least in part, a shared extinction proneness due to shared evolutionary history.

Surveying Herpetofaunal Mortality on Rural Highways

Road mortality can contribute to local and regional declines in amphibian and reptilian populations. Consequently, accurately and efficiently identifying hotspots of road-mortality is necessary for hazard assessment and mitigation. In 2002, LANGEN ET AL. (2007. *Journal of Wildlife Management* 71:1361–1368) conducted walking and driving surveys throughout an extensive rural highway network in northern New York to evaluate survey methods and to quantify spatial and temporal patterns of herpetofaunal road-mortality. In 2004, they repeated the surveys at a subset of locations to quantify interannual repeatability. Reptilian and amphibian species had different peak periods of road-mortality because they differed in the causes of movements that resulted in crossings.



CHUCK SCHAEFER

Reptilian and amphibian species had different peak periods of road-mortality because they differed in the causes of movements that resulted in crossings. Spatial locations of herpetofaunal road-mortality were concentrated at a limited number of hotspots, such as those used by female turtles moving to nesting areas.

Spatial locations of herpetofaunal road-mortality were concentrated at a limited number of hotspots. Hotspots overlapped across species and were located at consistent locations across years. Results of walking and driving surveys were highly repeatable among survey teams, but driving surveys underestimated the density of road-mortality because many animals were missed. Detection failure was higher in some taxa (e.g., frogs) than others (e.g., turtles). Their results indicated that designing a valid, efficient methodology for locating hotspots of reptilian and amphibian road-mortality along a road network is possible, thus pinpointing priority sites for mitigation.

NATURAL HISTORY RESEARCH REPORTS

Pitvipers in the Sea

Envisioning how terrestrial vertebrates could invade the sea is difficult, and little is known about the transitional evolutionary processes that produce secondarily marine animals. The utilization of marine resources in the intertidal zone is likely to be an important first step for invasion. LILLYWHITE ET AL. (2008. *BioScience* 58:947–955) described marine scavenging by the Florida Cottonmouths (*Aegistrodon piscivorus conanti*) that inhabit Gulf Coast islands. These snakes principally consume dead fish that are dropped from colonial nesting bird rookeries, but they also scavenge beaches for intertidal carrion, consuming dead fish and marine plants, and occasionally enter seawater. Thus, allochthonous marine productivity supports the insular Cottonmouth population through two pathways, and one of these pathways connects the snakes directly to the sea. The trophic ecology and behaviors of this unusual snake population suggest a requisite evolutionary scenario for the successful transition of vertebrates from a terrestrial to a marine existence.



SUZANNE L. COLLINS, CNIAH

Florida Cottonmouths (*Aegistrodon piscivorus conanti*) on Gulf Coast islands feed on dead fish dropped from colonial nesting bird rookeries and scavenged intertidal carrion, and occasionally enter seawater.

Female Promiscuity Insures Against Nest Failure

Female Bibron's Toadlets (*Pseudophryne bibronii*) distribute their eggs between the nests of as many as eight different males. Such sequential polyandry may have evolved as an insurance mechanism to reduce the risk of choosing a mate that is infertile, closely related, genetically inferior, or genetically incompatible, but polyandry also might insure against nest failure in unpredictable environments.



WIKIPEDIA

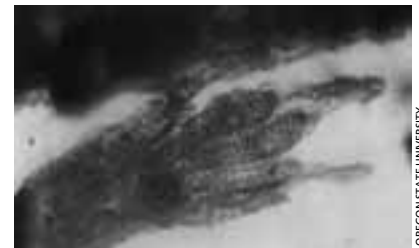
Female Bibron's Toadlets (*Pseudophryne bibronii*) distribute their eggs between the nests of up to eight different males.

Most animals are oviparous, and in species where males provide nest sites with substantial and unpredictable variations in quality, polyandrous females might insure offspring success by distributing their eggs across multiple nests. BYRNE AND KEOGH (2008. *Proceedings of the Royal Society B Biological Sciences* 276: 115–120) tested this hypothesis in a wild population of an Australian terrestrial toadlet, a polyandrous species in which males construct nests and remain with broods. The authors found that females partitioned their eggs across the nests of two to eight males and that more polyandrous females gained a significant increase in mean offspring survivorship. These results provide evidence for the most extreme case of sequential polyandry yet discovered in a vertebrate and also suggest that insurance against nest failure might favor the evolution of polyandry. The authors proposed that insurance against nest failure might be widespread among oviparous taxa and might provide an important explanation for the prevalence of sequential polyandry in nature.

A 100-million Year-old Gecko Preserved in Amber

ARNOLDI AND POINAR (2008. *Zootaxa* 1847: 62–68) described a new genus and species of gecko from a posterior lower limb and foot and a partial tail preserved in Lower Cretaceous amber from Myanmar that is 97–110 million years old. It appears to be the oldest unequivocal fossil gecko, predating fragmentary skeletal remains from the Upper Cretaceous and being 43–56 million years older than *Yanatarogekko* from the

Lower Eocene, previously the oldest known gecko preserved in amber. It also provides firm evidence that gekkotans and possibly gekkonids were in Asia at this time. The Myanmar specimen shows that the distinctive foot proportions and sophisticated adhesive mechanism involving pads on the toes with transverse lamellae, probably bearing numerous hairlike setae found in many modern geckos, had already evolved around 100 million years ago. The specimen is very small, even compared with juveniles of the smallest living geckos. However, the high numbers of lamellae on its toe pads suggest it is from a juvenile of a species with relatively large adult body size.



OREGON STATE UNIVERSITY

An amber fossil, from 97–110 million years ago in the tropical forests of Myanmar, contained the foot and partial tail of the world's oldest known gecko: *Cretaceogekko burmae*, named for its age (Cretaceous) and origin (Burma is the traditional name for Myanmar).

Chuckwallas in Metropolitan Phoenix

Understanding the responses of reptilian populations to habitat fragmentation and degradation due to urbanization has generated considerable interest. SULLIVAN AND SULLIVAN (2008. *Herpetological Conservation and Biology* 3:149–154) surveyed populations of the Common Chuckwalla (*Sauromalus ater*) in preserves of the Phoenix Mountains and adjacent areas near the Phoenix Metropolitan region during the spring of 2008. Fecal dropping counts were used to assess the current populations in relation to those sampled in 1995. The results revealed a strong correlation between estimates gathered in 1995 and 2008. Additionally, one intensively sampled site established that, although estimates could vary somewhat in relation to the number of individuals conducting



Common Chuckwalla (*Sauromalus ater*) populations appear to be stable in islands of suitable habitat in a “sea” of urban development.

the survey, they were stable over a 13-year period. The survey results suggest that Common Chuckwalla populations are stable in these island preserves in a sea of urban development.

Hurricane Katrina and Mississippi Turtles

The Yellow-blotched Sawback (*Graptemys flavimaculata*) is a riverine turtle that is endemic to the Pascagoula River system of southern Mississippi. Population declines led to Federal listing as a threatened species in 1991, with the most robust population inhabiting the Lower Pascagoula River near Vancleave

(~24 river km from the Pascagoula River mouth). SELMANI AND QUALLS (2008. *Herpetological Conservation and Biology* 3:224–230) conducted a mark-resight survey of this population during the spring and summer of 2005–2006. On 29 August 2005, Hurricane Katrina entered the Mississippi Gulf Coast, the location of their study site. On 13 October 2005, they conducted a one-hour preliminary visual survey by boat through the study area and identified eight individuals that had been marked prior to Katrina’s landfall, demonstrating that at least some of the 49 previously marked individuals remained in the study area. In October 2005–2006, the

authors conducted more extensive mark-resight surveys within the same section of river. The population estimate for 2006 was significantly lower than the 2005 population estimate for the same stretch of river, suggesting that numbers substantially decreased during the year following the hurricane. Of the plausible explanations for this pattern, the available evidence most strongly supports a real decline in population, presumably due to the long-term impact of Hurricane Katrina. Possible reasons for such a long-term effect include hurricane induced saltwater intrusion and low levels of dissolved oxygen with direct effects on individuals or indirect effects on the prey populations (e.g., gastropods and other aquatic macroinvertebrates).



BILL LOVE

Population sizes of Yellow-blotched Sawbacks (*Graptemyis flavimaculata*) dropped during the year following Hurricane Katrina, probably due to saltwater intrusions and low dissolved oxygen levels affecting turtles directly or their prey.

NEWS BRIEFS

California Tiger Salamander Moves Closer to Protection

The California state appeals court ruled that the California Fish and Game Commission must consider a petition to list the California Tiger Salamander (*Ambystoma californiense*) as an endangered species under the California Endangered Species Act. In a decision with potential implications for other poorly monitored species, the court ruled that the Fish and Game Commission must consider a listing petition if the information would “lead a reasonable person to conclude there is a substantial possibility” that the species could be listed. “The Fish and Game Commission ignored the multitude of known threats to the Tiger Salamander and dismissed the petition, falsely claiming it did not contain all of the data necessary to prove

the salamander population may deserve protection,” said Brian Nowicki of the Center for Biological Diversity. “Today’s ruling should set the listing process back on the right track and ultimately result in the Tiger Salamander getting the state-protected status it deserves.”



GARY NAFFS

The California state appeals court ruled that the California Fish and Game Commission must consider a petition to list the California Tiger Salamander (*Ambystoma californiense*) as an endangered species under the California Endangered Species Act.

The California Tiger Salamander is now set to advance to the status of candidate for state listing. The Santa Barbara County salamander population has been listed as Endangered under the federal Endangered Species Act since 2000, as has the Sonoma County population since 2003. The central California population has been federally listed as Threatened since 2004. The California Tiger Salamander depends on ephemeral vernal pools for breeding, but in recent decades, 95% of California’s vernal pools have already been lost, and at least 75% of the salamander’s habitat throughout the state has been eliminated. In Sonoma County, 95% of the fragmented and minimal remaining salamander habitat is threatened by development; the Santa Barbara population also is on the verge of extinction.

Proposal to Increase Critical Habitat for California Frogs

Under scrutiny for political corruption regarding numerous endangered species decisions and facing a lawsuit over improper tampering with protected critical habitat, the U.S. Fish and Wildlife Service is proposing to restore significant areas of critical habitat for the California Red-legged Frog (*Rana draytonii*). The Service has proposed quadrupling the protected areas by designating approximately 1,804,865 acres of critical habitat for the frog in 28 California counties. “No endangered species can survive without its habitat intact, and the Red-legged Frog desperately needs protection of adequate wetlands habitat throughout its former range,” said Jeff Miller, conservation advocate with the Center for Biological Diversity. “Today’s proposal is step toward biologically meaningful protections for the frog, but unfortunately numerous other endangered species still have inadequate habitat protections because bureaucrats have illegally slashed millions of acres from proposals by agency scientists.”

In November 2007, under pressure brought about by the Center and the media highlighting Interior Department corruption, the Service announced the reversal of six illegal Endangered Species Act decisions, including the California Red-legged Frog’s 2006 critical habitat designation. The Service listed the Red-legged Frog as a threatened species in 1996. It published a proposed rule to designate 4,138,064 acres of critical habitat in 2004. In response to a lawsuit by developers, the Service revised the proposal in 2005 to only 737,912 acres, and finalized the rule in 2006 with just 450,288 acres — a reduction of 90% from the original proposed rule.



GARY M. FELLEIS, USGS

The California Red-legged Frog (*Rana draytonii*) has lost more than 70% of its historic habitat. Frog populations have declined due to habitat loss from urbanization and introduction of exotic species such as Bullfrogs.

This proposal would increase the critical habitat by approximately 1,354,577 acres. “Even with the announced increase in acreage, the Red-legged Frog will receive habitat protection for less than half the areas that agency biologists have identified as essential for the recovery of the species,” said Miller. “Under the Bush administration, the Fish and Wildlife Service has consistently slashed the size of proposed critical habitats, so we will be watching the final designation closely.”

Made famous in the Mark Twain story, “The Celebrated Jumping Frog of Calaveras County,” the California Red-legged Frog has lost more than 70% of its historic habitat. Frog populations have declined due to habitat loss from urbanization and introduction of exotic species such as Bullfrogs. The Red-legged Frog is believed to be extinct in the Central Valley and is extirpated from 99% of its Sierra Nevada range. Currently, the strongest breeding populations remaining are found along the coast from San Mateo to San Luis Obispo counties. The Red-legged Frog prefers ponds, marshes, and creeks with still water. It requires riparian and upland areas with dense vegetation and open areas for cover, aestivation (summertime hibernation), food, and basking. Undisturbed riparian vegetation also is necessary for female frogs to attach their egg masses, which float on the surface until they hatch in 5–7 months.

Agreement Protects Native Fish and Amphibians from Fish-stocking

The Pacific Rivers Council and the Center for Biological Diversity reached an agreement with the California Department of Fish and Game on interim measures to limit harm to native species caused by fish-stocking. The intent is to minimize the harm that hatchery-raised fish inflict on sensitive native fish and amphibian species while the Department prepares an Environmental Impact Report under the California Environmental Quality Act. The Agreement was spurred by a tentative order issued by Sacramento Superior Court Judge Patrick Marlette finding that stocking could cause irreparable harm to native species. “Interim measures limiting stocking are needed to help save California’s native fish and frogs from extinction,” said Noah Greenwald,



WALTER STEGMUND



SHALUA HEDWALL



DIMITAR BOJANTCHEV

The Cascades Frog (*Rana cascadae*, top), Northern Leopard Frog (*Lithobates [Rana] pipiens*, middle), and Oregon Spotted Frog (*Rana pretiosa*, bottom) are among the amphibian species that will benefit from a new agreement limiting the stocking of non-native fish to many California waters.

biodiversity program director for the Center for Biological Diversity. “Fish and Game will still be able to stock hatchery fish, but mainly in places where they won’t harm native species.”

Florida Turtles Need a Reprieve

Several of the world’s leading turtle scientists have called on the Governor of Florida to end the commercial hunting of turtles which supplies eastern Asia. The experts, brought together by the Tortoise and Freshwater Turtle Specialist Group of IUCN’s Species Survival Commission, made their plea in a letter to Governor Charlie Crist. “Florida’s freshwater turtles are being harvested at an unsustainable rate to supply East Asian food and medicinal markets,” the letter said. “New rules recently implemented by the Florida Fish and Wildlife Conservation Commission (FWC) do not resolve this issue.”

On 17 September 2008, the FWC had voted to allow commercial fishermen to catch 20 softshell turtles a day. “Although this was an improvement, as

previously there were no catch limits, the limit is still too high,” says Anders Rhodin, Chair of IUCN’s Tortoise and Freshwater Turtle Specialist Group. “Two fishermen working five days a week could take 200 animals or three-quarters of a ton of turtles a week. That is not adequate protection for Florida’s wild turtle populations.”

The 32 turtle experts recommended that the FWC make a rule that allows individuals to take no more than one turtle a day from the wild and two turtles a day per group of individuals. They called on Governor Crist to ask the Commission to enact this rule.

The FWC had argued that most turtles exported from Florida are farm-raised, but according to the experts the numbers are misleading. Although 90% of the individual turtles exported from Florida are from farms, these are nearly all tiny hatchlings, they say, and the bulk of shipments by weight appear to be wild-caught adult turtles.

“An FWC Law Enforcement Intelligence Bulletin from March 2008 reported 1,600–3,000 lbs of live turtles flown out of Tampa weekly,” says Matt Aresco, a spokesperson for the IUCN Tortoise and Freshwater Turtle Specialist Group. “It seems unlikely that these are all farmed hatchlings, which only weigh about one third of an ounce each.”

The experts said their best guess is that these are mostly adult Florida Softshell Turtles (*Apalone ferox*), but added they don’t know for sure because

FWC does not collect data on the species, sizes, or numbers of turtles that are being sent out of state. They recommended a permanent end to the commercial harvest of turtles in Florida.

In a welcome and strong demonstration of political support for wildlife protection, Governor Crist responded to the letter by urging the FWC to consider moving toward a complete ban on harvesting of wild turtles in Florida.

IUCN, 25 November 2008

Don’t Muddy Ohio Waters

The Ohio Environmental Protection Agency should be in charge of protecting the state’s waterways from pollution, whether that pollution comes from a factory pipe, a large-scale farm, or the byproducts of mining coal. A proposed bill to put state mining officials in charge of granting water-pollution permits for coalmines is a bad idea.

State Senator Timothy J. Grendell (R-Chesterland) is behind the bill to switch authority from the EPA to mining bureaucrats in the Ohio Department of Natural Resources. This proposal is similar to a 2001 state law — also a bad idea — that transferred the state EPA’s authority to regulate large-scale livestock farms to the Department of Agriculture. That transfer still isn’t final, because the U.S. EPA, which has ultimate responsibility for enforcing the 1972 federal Clean Water Act, hasn’t approved it.

In a recent public-comment meeting, opponents of the farm-regulation switch



Endangered Hellbenders (*Cryptobranchus alleganiensis*) occur in Ohio streams affected by pollution from coalmines.

pointed out that the Department of Agriculture’s mission is to promote farming in Ohio, not to be a watchdog. The same potential for conflict of interest exists in putting ODNR’s Division of Mineral Resources Management in charge of water-pollution permits for mines.

The timing of the bill lends weight to the suspicion that the real goal is to allow an end run by a major mine company that has been denied a permit by the EPA. Murray Energy Corp., owner of Ohio’s largest underground coalmines, wants to bury Casey Run, a 2-mile-long stream in eastern Ohio, under a 1.85-billion-gallon coal-slurry lagoon. Slurry is water contaminated with coal dust after it has been used to wash coal. In 2005, a broken slurry pipeline from a Murray Energy-owned mine blackened 2,300 feet of Belmont County’s Captina Creek, killing thousands of fish in a habitat that supports the endangered Hellbender salamander.

Casey Run is a tributary of Captina Creek. EPA scientists, in recommending denial of the permit for the massive lagoon, said it would pose “insurmountable” environmental concerns for the high-quality water resource. Murray officials say they’ll have to close two mines employing about 1,000 people if they can’t build the slurry lagoon, but EPA and ODNR officials said the company could find other ways to dispose of its waste.

Murray Energy’s checkered track record of multiple environmental and safety violations in Ohio and elsewhere, including the Crandall Canyon mine cave-in that killed six men in Utah in August 2007, argues against easing regulation of the company. Regardless of one company’s history, safeguarding Ohio’s waterways should remain with the agency for which environmental protection is the core mission.



Most of the 1,600–3,000 lbs of live turtles flown out of Tampa each week probably are Florida Softshell Turtles (*Apalone ferox*) destined for East Asian food and medicinal markets.

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Changes are coming to IGUANA, some of them big and most of them in response to comments from you. For one thing, our name will be changing in 2009! To better reflect the IRCF Statement of Purpose (see below), the name of the journal will become **CONSERVATION AND NATURAL HISTORY OF REPTILES**. Although many of our regular features will continue, a new section called "Conservation Alert" begins with the issue you are now holding. The exquisite photographs we feature will continue — in this issue, photographs by Michael Kern grace the centerfold and back cover. In addition, because many of you who responded to our recent questionnaire indicated that more color photographs would enhance the journal, we are pleased to announce that, beginning with the first issue of 2009, we will feature color throughout. Finally, we will be expanding our focus to include more information about amphibians. We hope you appreciate these changes. Please don't wait until we send another questionnaire to let us know how you feel about our efforts, to suggest improvements, and — as always — to provide content that educates, entertains, and promotes the study and conservation of reptiles and amphibians and their habitats.

The Editors of IGUANA

Statement of Purpose

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

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

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FOCUS ON CONSERVATION

Saving Grand Cayman's Blue Iguana (*Cyclura lewisi*)



JOHN BINNS

The strategic plan to save Grand Cayman's Blue Iguana (*Cyclura lewisi*) has been updated for the third time and provides hope that the long-term goal of the Blue Iguana Recovery Program (BIRP) can be achieved. The newest version of the plan hinges on promised action by the Cayman Islands Government to grant protected status to an area of Crown land in the east interior of Grand Cayman.

The renewed Species Recovery Plan calls for continued education and awareness, as well as captive breeding and iguana releases along with establishment and management of protected areas. Many aspects depend on the new protected area proposal, including an EU-funded project to build a visitor center and shrubland education center within the reserve, forming a major new nature tourist attraction in the East End.

BIRP Director Fred Burton believes the program to restore a viable population of 1,000 Blues in the wild is at a pivotal stage. "We have over 100 hatchlings this year that will be ready for release by 2010, and unless we can secure some more protected shrubland habitat, these animals will have nowhere to go." Specifically, the iguanas require 300–500 acres of shrubland, a rugged, almost harsh, landscape where they can be safe and the population can expand unthreatened. Two potentially suitable parcels of land exist, both supporting unique plant life found nowhere else in the world. With development in the eastern districts proceeding at an exponential rate, the time to secure appropriate habitat is now.

The Blue Iguana Recovery Program is supported by the Department of Environment and the National Trust of the Cayman Islands along with international partners, the Durrell Wildlife Conservation Trust (Jersey, UK), and the International Reptile Conservation Foundation (California).

For more information or to make a donation to help save the Grand Cayman Blue Iguana, see the IRCF website or www.BlueIguana.KY.



JOHN BINNS

Green Iguanas (*Iguana iguana*) are frequently edificarian on Grand Cayman. These abundant invasives often are confused with critically endangered endemic Grand Cayman Blue Iguanas (*Cyclura lewisi*), complicating efforts to protect the latter.



Known variously as Peters' Forest Dragon, Doria's Anglehead Lizard, or Abbott's Anglehead Lizard (depending on subspecies), *Gonocephalus doriae* is known from southern Thailand, western Malaysia, and Indonesia west of Wallace's Line (a biogeographic division between islands associated with Asia and those with plants and animals more closely related to those on Australia). They live in remaining forested areas to elevations of 1,600 m (4,800 ft), where they spend most of their time high in trees near streams, either clinging to vertical trunks or sitting on the ends of thin branches. Their conservation status has not been assessed.