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REPTILES & AMPHIBIANS

CONSERVATION AND NATURAL HISTORY

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L. LEE GRISMER

McGuire's Rock Gecko (*Cnemaspis mcguirei*) is one of 30 new species of lizards described from the Malaysian Peninsula during the past five years.

JAMES REARDON

The Maud Island Frog (*Leiopelma pakeka*) is one of four species of endemic New Zealand frogs and one of two restricted to predator-free islands.

FEDERICO P. KACOLIRIS

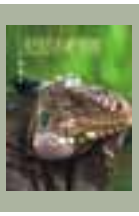
The Argentine Sand Dune Lizard (*Liolaemus multimaculatus*) is restricted to coastal habitats threatened by development and human activities.

EDWARD KABAY

The Impressed Tortoise (*Manouria impressa*) continues to be harvested for markets in China and is showing up in shipments from Myanmar.

BRAD WILSON

The specific name of *Cruziohyla craspedopus* is from the Greek *craspedo*, meaning bordered, in reference to the fleshy fringe on the limbs.

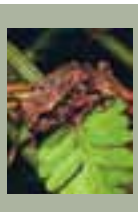


Front Cover: Jeffrey W. Ackley

Lesser Antillean Iguanas (*Iguana delicatissima*) are among the threatened species most at risk in the current human-induced mass extinction. See the commentary on p. 106.

Back Cover: James Reardon

Archey's Frog (*Leiopelma archeyi*) of New Zealand has the dubious honor of being the world's most evolutionarily distinct and globally endangered amphibian. See the article on p. 66.



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CONSERVATION AND NATURAL HISTORY

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Archey's Frog (*Leiopelma archeyi*) has the dubious distinction of being ranked the the world's most evolutionarily distinct and globally endangered (EDGE) amphibian.

CONSERVATION ALERT

The Plight of the World's Most Archaic Frogs

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Mention New Zealand to most people and many will have heard of it, although most may not know exactly where it is. This tiny nation in the South Pacific, with ten times as many sheep as people, has become famous for a number of things, from the scenery behind the *Lord of the Rings* movies to mountaineers such as Sir Edmund Hillary and amazing wildlife found nowhere else in the world. The last of these, the country's unique fauna, draws visitors and scientists from around the globe. Due to its unique geological history and lack of native mammalian predators (the only native terrestrial mammals are two species of bats), New Zealand is home to some truly exceptional animals: Species such as the flightless Kiwi and the Tuatara (large lizard-like creatures that are the sole survivors of the order Sphenodontia) are found nowhere else in the world. While tourists flock to take photos of penguins and millions of dollars of conservation money are devoted to saving numerous species of native flightless birds, another group of animals goes largely unnoticed by both New Zealanders and the rest of the world. These amazing little creatures are the country's endemic leiopelmatid frogs.

JOHN BINNS

New Zealand is an island nation in the southern Pacific Ocean.

JAMES REARDON

New Zealand is home to species like the Tuatara (*Sphenodon punctatus*) that are found nowhere else in the world.

New Zealand's native frogs are the world's most archaic frogs and, although they may look like any other frog at first glance, they are quite extraordinary. A recent ranking by the Zoological Society of London of over 6,000 species of amphibians has placed all four of New Zealand's native species in the top 60 of the world's most evolutionarily distinct and globally endangered (EDGE) amphibians, with Archey's Frog (*Leiopelma archeyi*) having the dubious honor of being ranked the #1 EDGE amphibian (www.edgeofexistence.org/amphibians/default.php).

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While tourists flock to take photos of penguins and millions of dollars of conservation money are devoted to saving species of native flightless birds, New Zealand's endemic leiopelmatid frogs go largely unnoticed. This is a dark green morph of Archey's Frog (*Leiopelma archeyi*).

Leiopelmatid frogs possess a number of primitive traits that set them apart from other frogs. These include presacral ribs, an extra tail-wagging muscle, amphicoelous vertebrae, and the lack of a tympanic membrane and middle ear structures (Stephenson and Stephenson 1957, Bell 1994). The last of these features, the lack of an external eardrum, is responsible for another distinctive characteristic of these frogs — they are silent, a trait that makes the distinction of native New Zealand frogs from introduced and common Australian imports easy for even the most amateur herpetologist. Unlike most frog species, in which the males' calls echo through rainy nights in their efforts to find mates, leiopelmatid frogs communicate chemically, a characteristic that makes these species more similar to salamanders than other anurans. In addition to these primitive features, the native New Zealand frogs are long-lived. Dr. Ben Bell of Victoria University has been leading some of the world's longest running population studies on frogs and has shown that native frogs can survive for over 30 years in the wild, with the oldest known frog being over 37 years old! These frogs produce small clutches of fewer than 20 eggs at a time. The males of the terrestrial species show parental care, guarding egg clutches that hatch directly into free-living froglets without a tadpole phase. These froglets then crawl onto the backs of males and are carried until they can survive on their own. Of the four extant species, three are terrestrial (*Leiopelma hamiltoni, L. pakeka, L. archeyi*) and only one (*L. hochstetteri*) inhabits rocky stream environments.

The world is facing a global amphibian extinction crisis, with over a third of all known amphibians currently threatened with extinction, and as many as 122 species going extinct since the 1980s (Stuart et al. 2004). Unfortunately, New Zealand's remote location has not spared its endemic frog fauna. Three frog species have gone extinct since the arrival of humans, who introduced mammalian predators such as rats, mice, and stoats to this land of naïve wildlife. The frogs' natural instinct when approached is to freeze, relying on their cryptic coloration to hide them from avian predators. Although this tactic may have worked for the native predator suite with which the frogs evolved, like most of New Zealand's reptilian and avian species, these frogs have become easy prey for nocturnal mammalian predators with a keen sense of smell.

JAMES REARDON

Searching for Hochstetter's Frogs in rocky streambeds.

JAMES REARDON

Archey's Frog (*Leiopelma archeyi*) and Hochstetter's Frog (*L. hochstetteri*) have persisted on New Zealand's North Island despite the presence of introduced mammals, but fossils indicate that they were formerly much more widely distributed. Here, researchers search for frogs in the Whareorino Forest.

According to the World Conservation Union (IUCN 2008), all four of the remaining native frogs are threatened with extinction. Two closely related forms distinguishable only with genetic testing, the Maud Island Frog (*L. pakeka*) and Hamilton's Frog (*L. hamiltoni*), are restricted to small offshore, predator-free islands. Even

JAMES REARDON

Unlike most frogs, New Zealand's native species are silent, communicating instead by using chemical signals. This is the Maud Island Frog (*Leiopelma pakeka*), one of two extant species found only on predator-free offshore islands.

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New Zealand's frogs, such as this Archey's Frog (*Leiopelma archeyi*) freeze when approached, relying on cryptic coloration to hide them from the avian predators with which they evolved. Unfortunately, they become easy prey for introduced mammalian predators with a keen sense of smell.


JEN GERMANO


PHIL BISHOP

Maud Island Frogs (*Leiopelma pakeka*) and Hamilton's Frogs (*L. hamiltoni*) are restricted to small offshore, predator-free islands.

so, the total population of Hamilton's Frogs is less than 400 individuals. The remaining two species, Archey's Frog (*L. archeyi*) and Hochstetter's Frog (*L. hochstetteri*), have persisted on New Zealand's North Island despite the presence of introduced mammals, but fossil remains indicate that they were formerly much more widely distributed (Worthy 1987).

The persistence of remnant populations does not necessarily indicate that these species are safe from the risk of extinction. In the past decade, populations of Archey's Frog have declined by nearly 90% (Bell et al. 2004). This decline has been attributed to the introduction of the amphibian chytrid fungus, a deadly infection that has killed frogs throughout the world and is known to be present in all Archey's Frog populations. Hochstetter's Frogs are the most abundant and widespread of the native frog species and, so far, do not seem to have contracted this life-threatening infection. They are, however, under threat from habitat degradation and loss throughout their range. In addition, many of the Hochstetter's Frog populations are geographically isolated, and recent genetic work suggests that each population should be managed as an independent unit (Gemmell et al. 2003).

Researchers from universities, zoos, and the New Zealand Department of Conservation (DOC) have been working hard to try to bring the leiopelmatid frogs back from the brink of extinction. The establishment of captive populations, research into rodent predation and disease susceptibility, and the translocation of frogs to create populations in new areas are just some of the conservation techniques being used. The transfer of frogs (into either a captive situation or new location in the wild) allows the establishment of "security" populations, while research into threats such as predation and disease helps develop the long-term management strategies for these species.

Since introduced mammalian predators pose one of the greatest threats to native frogs, the DOC is conducting research into the effects of rodent control on the survival and recruitment of established Archey's Frog populations. This research was prompted by the discovery of dead frogs displaying bite marks characteristic of rat predation. Mark-recapture monitoring in rat-trapped and untrapped habitat has been carried out over the past four years using the distinctive patterns and markings of Archey's Frogs for individual identification. Initial results suggest that predator control is helping the frogs, but findings to date are inconclusive.

While monitoring on the mainland is an important part of native frog recovery in New Zealand, one of the best conservation options available to wildlife managers is translocation to offshore islands. With introduced mammals posing the greatest threat to native fauna and with the availability of numerous small offshore islands, New Zealand conservationists have been developing techniques to rid islands of introduced species for decades, and their successes and ingenuity have made them world leaders in this work. Today, over 19,000 ha of pest-free habitat have been re-created with rats removed from 37% of the rodent-infested offshore islands over 5 ha in size (Towns and Broome 2003). This has opened up a huge amount of habitat to which native fauna can be reintroduced.


JAMES READDON


JAMES READDON

Populations of Archey's Frog have declined by nearly 90%, largely attributable to the introduction of the deadly chytrid fungus, which has been identified in all populations. Consequently, extreme caution is necessary when handling frogs to prevent transmission of the fungus.


LISA DAGLISH

Research into the effects of rodent control on survival and recruitment in established Archey's Frog populations was prompted by the discovery of dead frogs displaying bite marks characteristic of rat predation.


KAYA KLOP-TOKER

Hochstetter's Frogs (*Leiopelma hochstetteri*) are the most abundant and widespread of the native frog species.

Over the past three decades, eight translocations of New Zealand frogs have taken place, with most to mammal-free islands and mainland sanctuaries. Although some have failed, we have learned from them, and guidelines have been established for the transfer of amphibians to island habitats. Long-term success has been seen in two translocations of Maud Island Frogs, and a more recent translocation of Hamilton's Frog is showing initial positive signs of survival and reproduction. The lessons learned from these island translocations are now being applied to frog transfers on the mainland, with the first Archey's Frog translocation taking place in late 2006. While the threat of introduced mammals cannot be completely eliminated on the mainland, this transfer is providing information on whether a translocation can succeed if pest numbers are kept low through targeted rodent control. Preliminary monitoring has detected breeding in both seasons since the release, and shown survival of young to sub-adult size. This indicates that predator-controlled mainland sites may be appropriate for use in transfers of endangered amphibians in the absence of predator-free sites.

In addition to the creation of new frog populations through wild-to-wild transfers, two New Zealand zoos are working with the DOC in an attempt to establish healthy captive populations of Archey's and Hochstetter's frogs. In addition, the Orana Wildlife


JAMES READDON

The distinctive patterns and markings of Archey's Frogs are used for individual identification and documented by photographing each frog on a photo stage.


JAMES MUIR

Collecting urine from frogs is a minimally invasive method for identifying sex in individuals and monitoring their reproductive condition. Here, the senior author is taking a urine sample from a Maud Island Frog (*Leiopelma pakeka*).

Trust is on its way to setting up a third facility, focusing on Maud Island Frogs. While many wild translocations have been successful, captive populations are recognized as an important part of native frog recovery, as they can provide insurance in the case of catastrophic declines in the wild and should be able to produce greater numbers of frogs than possible in the wild. However, maintaining amphibians in captivity is a challenging task.

Since these frogs are unique and so much about their biology remains unknown, attempts at keeping them in captivity have highlighted many of the important areas in which further research is needed. The zoo populations were started at Auckland Zoo in 2005 and Hamilton Zoo in 2006. Although a handful of egg clusters have been produced at both zoos, no healthy froglets have survived in either of the captive populations.

One problem faced by both zoo staff and by field researchers is the fact that these frogs are monomorphic (lacking obvious outward physical differences capable of distinguishing males from females). Additionally, since these frogs are silent, we also lack the behavioral sex difference of males calling to attract mates that occurs in most species of frogs. This is a huge problem when trying to match potential mates in captive situations and for selecting individuals to translocate. The senior author at the University of Otago (in collaboration with Frank Molinia from Landcare Research and supervisors Phil Bishop and Alison Cree) has found a new non-invasive technique that may help with this problem. She has been measuring hormone concentrations in the frogs' urine and has found that the sex of the frogs can be determined from their hormone metabolite

LISA DAGLISH

The first Archey's Frog translocation took place in late 2006.

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Drs. Russell Poulter and Phil Bishop (in his lab at the University of Otago) have discovered that the antibiotic chloramphenicol is an effective cure for the chytrid fungus in two species of introduced frogs.

levels. This non-invasive technique will not only help with future management of the frogs, but will also aid in revealing more information about the timing of breeding in these cryptic frogs.

In addition to studies concerning captive breeding programs, New Zealand researchers also have been busy investigating the effects of amphibian chytrid on native frogs and searching for a cure for this fatal disease. These studies are considered particularly important for Archey's Frog, given that amphibian chytrid is present in all populations and a large decline in one population has been attributed to the presence of the fungus (Bell et al. 2004).

Recognizing the huge threat that amphibian chytrid poses, Drs. Russell Poulter and Phil Bishop have begun to search for a substance that would eliminate the fungus without adversely affecting the frogs. Having discovered that the antibiotic chloramphenicol (found in eye ointment and used in human and veterinary medicine) could destroy the disease *in vitro*, they proceeded to test its effectiveness on live amphibians using two species of introduced frogs, and discovered it was an effective cure for these introduced species. They continued with the research, applying the treatment to wild-caught Archey's Frogs that had been naturally infected with the fungus. Eleven of the 12 frogs cleared their infections naturally and the remaining frog cleared the infection after treatment, without apparent ill effects (Bishop et al. 2009). This is excellent news and, although further testing is recommended to confirm that the

JAMES REARDON

Biosecurity measures are employed when venturing into frog habitat. Here, boots worn into the field are sanitized before they are used again.

JAMES REARDON

Having to work by flashlight at night makes catching and handling these tiny frogs a difficult proposition.

technique is safe, it is a potential tool for treatment of sick captive or wild-caught individuals.

The strong commitment to research and management of native frogs shown by researchers and organizations in New Zealand has led to substantive advances in our knowledge and understanding of these unique amphibians. While the threats have not lessened, the suite of tools available to protect and conserve these species is constantly increasing. Active conservation and management of these species should help the world's most archaic frogs survive long into the future.

JAMES REARDON

Department of Conservation ranger Lisa Daglish with buckets full of *Leiopelma archeyi* in biosecure bags for rapid processing before re-release at precise points of capture.

To learn more about New Zealand frogs or to help support their conservation and research in New Zealand, please visit the NZFRoG website at www.NZfrogs.org. NZFRoG is the New Zealand Frog Research Group, comprised of researchers and conservationists across the country, for the purpose of encouraging interactions among people working with frogs and to promote public awareness of native frogs and their declines.

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Sand Dune Lizards (*Liolaemus multimaculatus*) are endemic to Pampean coastal areas of Buenos Aires and Río Negro provinces in Argentina.

Biology and Conservation of the Sand Dune Lizard (*Liolaemus multimaculatus*)

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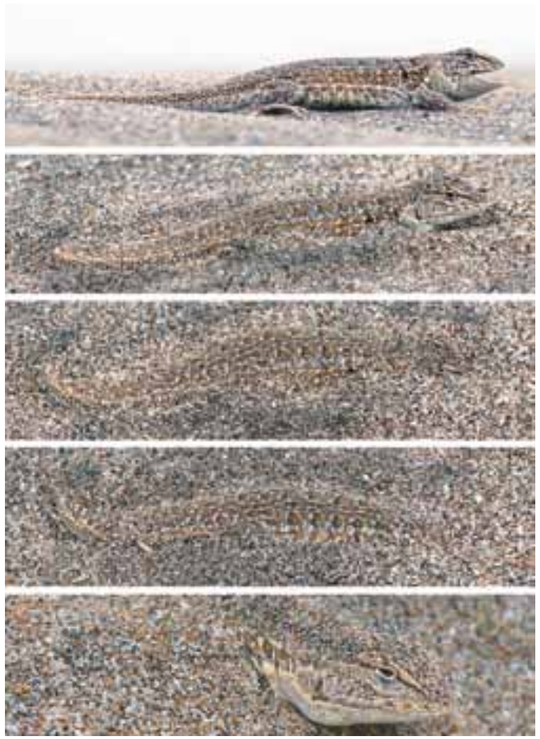
Photographs by the author.

Since 2005, with IRCF aid, the "Sand Dune Lizard Study and Conservation Project" has addressed its goal of protecting the endemic and vulnerable Sand Dune Lizard (*Liolaemus multimaculatus*) and its habitat in the pampas coastal dunes in Argentina. New information generated about the species' ecology during 2008 and 2009 has been instrumental in the development of management tools. We also developed educational programs to inform children, local people, and tourists about the threats facing these lizards and their sand dune habitat.

Diverse coastal ecosystems support numerous native plant and animal species that are threatened to varying degrees. Several of these species are poorly known, and some are in danger of extinction, as is the case with the Sand Dune Lizard. The populations of endemic fauna and flora, that is, those species that evolved in and can only survive in coastal habitats, are the most affected by these activities, and they could be wiped off the face of the Earth within a few years. The Sand Dune Lizard is one of these species, and its populations already are severely compromised.

Coastal ecosystems support numerous native plant and animal species that are threatened to varying degrees. Populations of species that evolved in and can only survive in coastal habitats are particularly vulnerable to extinction.

Sand Dune Lizards are small, less than 70 mm from snout to vent, with flattened bodies and stout heads.



"Sand-burying" is one of the main escape strategies of these Sand Dune Lizards.

Basic Biology

The Sand Dune Lizard (*Liolaemus multimaculatus*) is a small saurian, less than 70 mm long from snout to vent, with a flattened body and stout head. Its dorsal coloration shows a somewhat irregular pattern of dark spots in transverse series on a brownish background. The spots are outlined posteriorly by white scales, which give them a sand-like appearance. These lizards display obvious sexual dimorphism in size and ventral coloration (males are larger and have scattered ventral spots). They usually are seen on dunes with low or sparse plant cover as they scurry away. When not in motion, the lizards are virtually undetectable; their coloration and texture are a perfect match for the substrate. For sand-burying and sand-swimming (two of the main escape strategies of these lizards), they require loose sandy substrate, which does not occur in areas with abundant vegetation, such as those planted with exotic species like pines (*Pinus* sp.) and acacias (*Acacia* sp.). The Sand Dune Lizards are endemic to Pampean coastal areas of Buenos Aires and Río Negro provinces in Argentina (Cei 1993).

Threats

Due to its restricted distribution, low abundance, and human disturbances of their habitat, the species is considered vulnerable to extinction (Lavilla et al. 2000). These lizards are highly specialized for life in the sand. Their sand-burying and sand-swimming abilities, as well as their cryptic coloration and habitat preferences, attest to the close evolutionary ties between these reptiles and the coastal dunes.

Further information about wild Sand Dune Lizard populations is critically needed in order to devise conservation strategies. Suitable habitats are still available. However, such habitats are highly fragmented and shrinking rapidly. Coastal reserves and dune areas are suffering in particular, mainly due to uncontrolled tourism and the expansion of coastal urban areas. Sand Dune Lizards also face

Sand Dune Lizards usually occur on dunes with low or sparse plant cover.

JOHN BINNS

Dune sectors in Buenos Aires Province, Argentina. The two large brown sectors correspond to the Barrera Medanosa Oriental and the Barrera Medanosa Austral respectively. The figure also shows the reserves within each dune sector.

the risks associated with all small populations, such as the increased likelihood of extinction triggered by stochastic events (Miller and Lacy 2005). This lizard also must confront threats associated with all highly specialized species especially dependent on undisturbed habitat. Previous studies demonstrated that anthropogenic factors, such as habitat fragmentation and loss of native plant species in coastal dunes, could be reducing the abundance of these lizards, increasing the frequency of local extinctions (Vega et al. 2000).

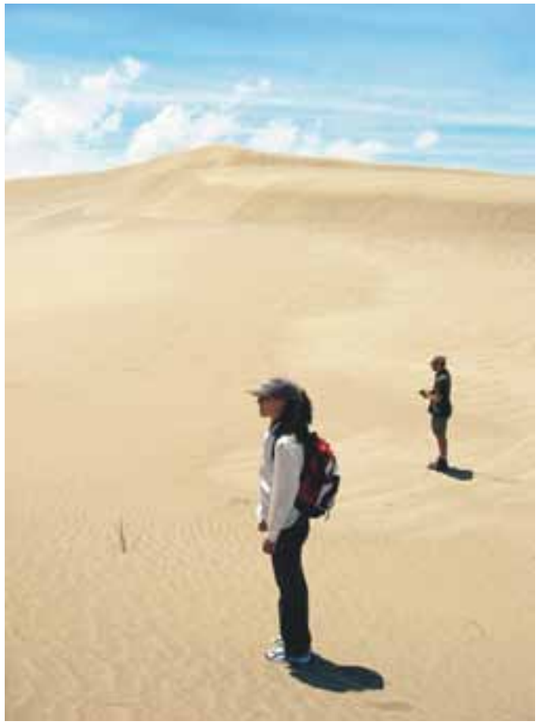
Habitat

Total suitable Sand Dune Lizard habitat covers approximately 20,000 ha, but much of it is threatened by human encroachment. Moreover, populations are isolated by natural and human barriers, some of which impede the lizards from interbreeding.

The marine coastal zone of Buenos Aires Province is particularly diverse in natural environments that include sandy beaches, cliffs, extensive sand dunes, and a large brackish lagoon (Mar Chiquita). The coastal dunes are divided into two large sectors by a natural barrier near the city of Mar del Plata. These sectors are the Barrera Medanosa Oriental (in the northeast of the province) and the Barrera Medanosa Austral (in the southwest of the province). Both sectors are further subdivided by smaller natural and human barriers such as rivers, towns, and cities. Several sites are designated as reserves, but only one, the Mar Chiquita Natural Reserve, effectively protects Sand Dune Lizard populations (Kacoliris et al. 2006).

Coastal environments represent about 8% of Earth's surface, and they are considered among the most threatened environments on the planet. Most human-generated threats to biodiversity are exacerbated in these areas, mainly because human populations have always flourished along shorelines. Over half of the world's population (about 3.2 billion people) lives within 200 km of oceans and seas (only 10% of Earth's land surface). With this population distribution, increasing human numbers and mounting developmental pressures are taking a grim toll on coastal and near-shore resources.

The Mar del Plata hills clearly divide populations into two isolated groups that are unable to interbreed, and other smaller barriers also could be impeding interbreeding between populations (Chevez and Kacoliris 2008). Four of these dunes areas are considered to be "Valuable Grassland Areas" in South America (Bilenca and Miñarro 2004) because they are important for the conservation of Pampean biodiversity. These areas encompass 80% of the current distribution of Sand Dune Lizards.



Observers employing distance sampling techniques along transects were used to develop estimates of Sand Dune Lizard population sizes.

Research

The explicit goal of the "Sand Dune Lizard Study and Conservation Project" is to study fundamental aspects of population dynamics and viability (spatial ecology, population density, survival, and mortality), autoecology (habitat use, home range), and any additional factors that allow us to assess more effectively the status of wild populations, such as the study of fluctuating asymmetry (a bioindicator of environmental stress that is expressed in populations subject to primarily antropic impacts producing size differences between left and right body sides) and any decreases in genetic variability due to population isolation. Knowledge of the basic ecology of a species is essential for establishing management guidelines and initiating conservation action.

The most recent field season (August 2008 to May 2009) focused on three sites, all of them "Valuable Grassland Areas" in South America: (1) Mar Chiquita Provincial Reserve (Barrera Medanosa Oriental); (2) Arroyo Zabála Reserve (Barrera Medanosa Austral); and, (3) Balneario Marisol, located between the Arroyo Zabála and the Pehuen Có-Monte Hermoso reserves (Barrera Medanosa Austral). Although Mar Chiquita and Arroyo Zabála are Natural Reserves, vehicular traffic in the dunes of the latter is unregulated, whereas such activity is regulated by park rangers in Mar Chiquita. Although also affected by vehicle transit, the Balneario Marisol is currently being considered as a possible site for a new reserve. Educational activities have been initiated in these as well as other areas.

Population Sizes

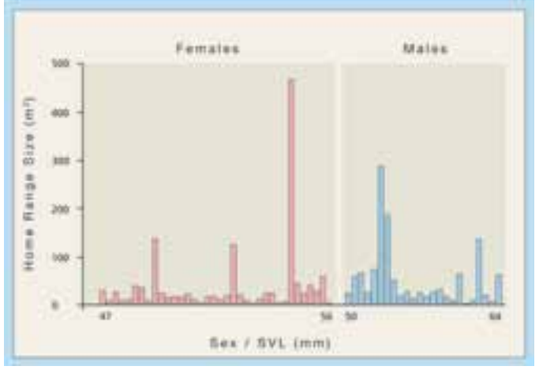
Knowing population density and how it changes over time is the key to understanding population dynamics and viability. We estimated Sand Dune Lizard population sizes in the three dune sectors using distance sampling techniques. Previous results have shown that this method is appropriate for this species in this habitat (allowing all model assumptions). We worked with a systematic line transect design. Transects were crossed by three observers until we obtained the critical number of detections necessary to generate robust models for density estimates. Population densities varied little between sectors: Mar Chiquita 5.4 lizards/ha (95% confidence interval: 3.6–8.1), Arroyo Zabála 5.6 lizards/ha (3.8–8.2), and Balneario Marisol 5.9 (3.2–10.9). However, all densities were low according to Zug et al. (2001), who considered densities with fewer than 10 individuals/ha to be "low." Low densities suggest that the long-term viability of Sand Dune Lizards, especially of smaller populations, is of considerable concern.

Because the three sectors are subjected to different degrees and types of human impact, these results could indicate that the lizards are not severely affected by some types of disturbances, that the degree of disturbance has not reached a critical level, or that effects are not reflected in lizard population density. Further studies in dune sectors with higher levels of disturbance are necessary to corroborate the possible existence of any effect.

Microhabitat Use

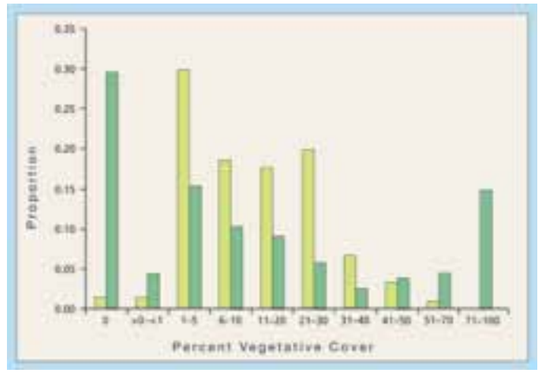
Knowledge of spatial ecology is critical to planning and promoting the conservation of threatened species. We assessed the lizards' preferences regarding certain microhabitat variables such as plant types, vegetation cover, and vegetation structure (sizes of shrubs used as shelters). We employed a use-availability comparison to evaluate whether microhabitats were used as often as their frequency would predict (Manly et al. 1993).

Our results indicate that Sand Dune Lizards do not use habitat in a random fashion. Instead, they select microhabitat with low to medium vegetation cover (1–50% coverage), composed primarily of herbaceous species. This could be related to the sand-burying and sand-swimming behaviors used by lizards to escape from predators. Microhabitats with higher vegetation cover impede this behavior due to sand compaction.



Sand Dune Lizard home ranges; individuals are arranged first by sex and secondarily by SVL.

Assessments of microhabitat variables such as plant types, vegetation cover, and vegetation structure were employed to evaluate whether microhabitats were used as often as their frequency would predict.



Frequency of use and availability of vegetation cover categories. Yellow columns represent availability, whereas green columns represent use by Sand Dune Lizards.

In terms of vegetative structure, lizards most frequently sought shelter under shrubs of intermediate size. This could be related to smaller plants providing only limited cover and large plants restricting visibility for detecting predators, prey, and mates. However, the availability of ideal refugia is too low to permit each lizard access to one shrub. Only adults used shrubs, suggesting that juveniles are excluded from these shelters.

Previous studies demonstrated that human disturbances (such as vehicle transit) of sand dunes dramatically affect vegetation, promoting the loss of plants and reducing vegetative cover. These kind

When not in motion, lizards are virtually undetectable; their coloration and texture is a perfect match for the sandy substrate.

Educational campaigns are held in schools and community centers. Information about problems facing the coastal dunes and the Sand Dune Lizards are used to encourage local people to become engaged in conservation.

of disturbances could reduce the amount of habitat available for escape and thermoregulatory behaviors to the extent of triggering local extinctions (Iribarne et al. 2001).

Home Ranges

A home range is the space used by an individual, and determining home range sizes is crucial to understanding social systems. With the aim of assessing home range sizes and overlap in Sand Dune Lizards, we recorded the location, sex, and size of lizards. Home ranges and overlap were calculated using the minimum convex polygon method.

Because *L. multimaculatus* is insectivorous and relies on sit-and-wait predation, it does not need to cover large areas to find food. Mean home range sizes differed between sexes, with those of males (33.5 ± 24.6 m^2) significantly larger than those of females (21.3 ± 17.6 m^2). As in many lizard species (Perry and Garland 2002), dominant males probably require large home ranges to meet both energy and mating requirements. A small number of lizards of both sexes occupied home ranges that were much larger than those of the majority of individuals, which is suggestive of a hierarchical social system. Overlap in home ranges was high (22–58%) for both males and females.

Educational Programs

Another goal of this program is to provide clear and understandable information about the severe threats affecting Sand Dune Lizards and the coastal dunes. Results of the research program are conveyed to the local community in an effort to create a greater awareness of these issues. Using a conservationist approach, we emphasize information on the benefits of conserving the coastal natural resources.

We undertook a number of educational campaigns from July 2008 through May 2009 in several coastal cities: San Bernardo, Mar del Tuyú, Marisol, Pehuen-Có, and Villa Gesell. We held meetings in schools and community centers to reach conservation and governmental organizations as well as local people. Using presentations and handouts (pamphlets and posters), we provided information about the problems facing the coastal dunes and the Sand Dune Lizards, and encouraged local people to undertake conservation actions.

Conservation Status

According to IUCN Red List criteria, the Sand Dune Lizard is critically endangered based on a small area of occupancy, low and apparently declining population densities, and a high degree of specialization with respect to habitat and microhabitat use. Small disturbances affecting the dunes in which lizards live could promote local extinctions through the loss and fragmentation of suitable habitats, the main cause of which is uncontrolled access of vehicles, which destroys the native vegetation that lizards use for shelter and nesting.

Current Needs

Sand Dune Lizards are best protected at the Mar Chiquita Reserve. Human disturbances are low because park rangers work hard to regulate them. However, considerable exotic forest cover exists in this area and is expanding. In these exotic forests, the microhabitats most frequently used by Sand Dune Lizards have been altered, excluding them from these areas. The primary need at this site is to develop strategies to halt and diminish the expansion of exotic forests.

Arroyo Zabála is one of the larger areas inhabited by Sand Dune Lizards within the coastal dunes. Although this area has been designated as a reserve, no park rangers have been hired and no management plans or conservation actions have been developed. Disturbances are increasing in frequency. A strong educational campaign is needed and local authorities must be encouraged to regulate indiscriminate access of vehicles in the dunes.

Marisol is a large area in which a large population of Sand Dune Lizards can be protected. Although disturbances exist in this area, they currently are relatively low. Marisol could be categorized as a natural reserve. We are working toward this objective in collaboration with other conservation groups, and the local people appear to be very enthusiastic about our proposal. Aside from the restriction of vehicles in the dunes, educational activities are necessary to demonstrate to local people the benefits of establishing a natural reserve in this dune sector.

Sand Dune Lizards excavate burrows in the sand into which they retreat from inclement conditions and hide from predators.

Future Work

We need to continue both research and educational activities. Future studies will assess the degree of genetic isolation of each Sand Dune Lizard population, measure the effects of disturbances and isolation (fluctuating asymmetry), and evaluate extinction probabilities using models that consider further habitat reductions and various management strategies. Educational activities will continue with the development of new handout material, scientific information, and meetings targeting schools and local people. We need to work intensely with governmental agencies to promote the regulation of some disturbances, most notably the transit of vehicles. We also need to evaluate the possibility of implementing a plan to restrict the expansion of exotic forests and restore native grasslands in dune sectors like the Mar Chiquita Natural Reserve. We need to explore other dune areas in order to evaluate the status of additional Sand Dune Lizard populations and the requirements for promoting their protection.

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BRAD WILSON

Ranitomeya fantastica: Some species are simply so amazing in appearance that their specific name should so indicate!

Discovering and Naming New Species of Amphibians

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Scientists currently recognize **6,478 species of amphibians (www.amphibiaweb.org; 28 March 2009)** in the world. Of these, about 560 are salamanders, about 170 are caecilians, and the remaining thousands represent the vast diversity of frogs. However, nearly every new trip into the yet underexplored regions of the planet results in the discovery of more previously unknown species. In fact, according to the IUCN Amphibian Conservation Action Plan published in 2007, known amphibian species have increased by about 40%, and perhaps 50% of all extant amphibians remain undiscovered and undescribed — a serious underestimation of biodiversity on earth! Indeed, as we are battling to prevent the extinction of many amphibians, we are continuing to discover new species every year. This means, of course, that as the amphibian extinction crisis continues, we doubtlessly are losing species that we never knew existed.

The processes of cataloging, describing, and naming species and groups of species are known as the science of taxonomy. The closely related field of systematics seeks to understand the evolutionary relationships among all species. Amphibian taxonomists, working with data from anatomy, behavior, DNA, and all sorts of other information, work to discover, describe, and name new species. Such efforts are basic to cataloging life on earth and also for addressing the increasingly imperative conservation needs of amphibians. Indeed, taxonomic studies are a basic component of conservation efforts — conserving a species that is not known to exist and that does not even have a name is difficult at best. Taxonomists will admit that realizing that you are the first scientist

MICHAEL D. KERN

Anotheca spinosa: The specific name refers to the unusual bony ornamentation that crowns the head of this species.

RON HOLT

Centrolene ilex: The specific name is Latin for the Holly plant. In this case, the name was chosen in honor of well-published herpetologist Priscilla Hollister "Holly" Starrett.

— perhaps the first human — to see a particular species is quite a thrill, and coining the permanent scientific name for an animal is a great honor. Occasionally, a headline will announce the discovery of a particularly unusual new species of amphibian (e.g., the truly bizarre Purple Frog, *Nasikabatrachus sahyadrensis*, that turned up in the Western Ghats of India a few years ago), but new species typically are announced to the world in the pages of scientific journals, where only academic herpetologists and the most ardent hobbyists are likely to become aware of the discovery.

As exciting as are discoveries of the new species, the path to discovery can take different routes. Sometimes, the first sighting in

JOSEPH R. MENDELSON III

Charadrahyla nephila: The specific name is derived from the Greek *nephos,* meaning cloud, and *philia,* meaning fondness, alluding to the cloud forest habitat to which this species is restricted.

MICHAEL D. KERN

Cochranella albomaculata: The specific name is composed of the Latin *albus,* meaning white, and *macula*, meaning spotted, in clear reference to the spotted pattern of the species.

the field is all that is necessary; such was the case when William Duellman and I found the first specimen of *Hylomantis hulli* in Loreto, Peru, one night in the mid-1990s. In other situations, field workers may think that they have a new species at hand, but it can only be verified by considerable efforts back in the laboratory to compare (using anatomical and/or molecular tools) the newly collected material with other specimens. Sometimes, in such situations, a considerable delay separates the original discovery from the verification — as was the case when Martin Bustamante and I discovered *Pristimantis gagliardoi* in Cañar, Ecuador, in 2004, or, during my first trip to Mesoamerica, when I found *Incilius* (= *Bufo*) *campbelli* in Alta Verapaz, Guatemala, in 1989. Other times, new species become apparent only after exhaustive studies of geographic variation among museum specimens of what was previously considered to be a widespread species that had been collected over decades or centuries. This is how we "discovered" several new species of Mesoamerican toads that had previously been referred to as *Incilius coccifer*, including *I. signifer* from central Panama. Finally, sometimes anatomy can be difficult or downright misleading. I struggled for years, examining many hundreds of specimens of the familiar Gulf Coast Toad (*I. valliceps*), convinced that populations in the USA and northern Mexico represented a different species than those in southern Mexico and Central America — but I simply could not pinpoint where (presumably in central Mexico) they separated. An objective read from DNA profiles, collected over my years of driving up and down the Caribbean Coast of Mexico, finally helped find the contact zone (with no evidence of hybridization, which was somewhat surprising) near the small village of Palma Sola in Veracruz, Mexico. Interestingly enough, my graduate student at the time, Daniel Mulcahy (lead author on that particular paper) had identified that exact spot on a topographic map as being the contact zone between the two species — and he had never been to Mexico! I always thought the contact zone would be found much farther to the North, which underscores the importance of bringing an objective mind to any ongoing project. This particular study led not to the naming of a new species, but rather to the resurrection of an old name that had been officially "retired" into synonymy. Thus, the long-forgotten name *I. nebulifer* (originally coined by Girard in 1854) came to be applied to the more northerly populations of this strikingly crested toad. I can tell you that some people were not happy to have the scientific name of such a common backyard toad in Texas and Louisiana suddenly changed — and my experience suggests that US herpetologists are more resistant to taxonomic changes than are most of our international colleagues, although I can't tell you why.

New species names are most often published in peer-reviewed scientific journals. In general, authors are expected to conduct

RON HOLT

Cochranella granulosa: The specific name refers to the distinctive granular texture of the skin that is clearly evident in this photograph.

MICHAEL D. KERN

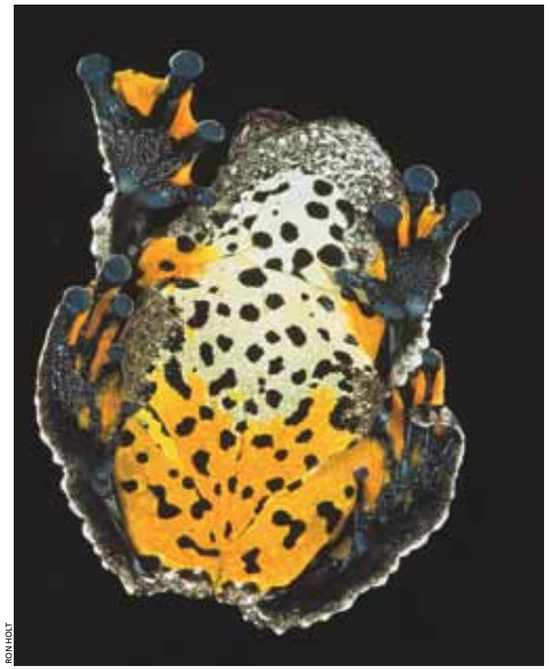
Craugastor megacephalus: *Mega* is Greek for large, and *cephalo* refers to head, the name was evidently chosen to describe both the morphology of this species and, perhaps, to serve as a patronym for a great many herpetologists.

some kind of analysis involving an examination of specimens that are available to the scientific community, such as those housed in natural history museums. An author usually is expected to designate a holotype, a single specimen that "bears the name of the new species." Additional material, sometimes referred to as paratypes, might also be described, and relevant information, such as individual variation and sexual dimorphism, might be learned from these. The commonly used term "type locality" refers to the site from which the holotype was collected. After the original description is published, the name may be used in subsequent literature, field guides, zoo signage, etc… If a name is used prematurely (i.e., before the formal publication), it may be forced into early — and permanent — retirement by the ICZN (International Code of Zoological Nomenclature). Certainly some taxonomists have experienced this blunder by mentioning the new, unpublished name to the news media or another published outlet. In this case, a new name must be chosen, which could be very disappointing for all involved.

What's in a Name?

In theory, taxonomy is a simple process based on the simple rule "A single name for each species." Of course, nature can be tricky and consistent application of such a simple rule is sometimes quite difficult. The rules governing names (ICZN) are notoriously confusing, ambiguous, and conflicting — and they often are misinterpreted and incorrectly implemented, even by experienced taxonomists!

Genus & species: Most practicing taxonomists use a system of binomial (two names) nomenclature to identify each unique species (the "species" name) and the category of genus to help identify its evolutionary relationships with other species. These names are usually derived from Latin or Greek, but words from other languages may be used. Using the scientific name for the Green Treefrog as an example, the first word in the binomial is the genus and is always capitalized (***Hyla*** *cinerea*). The second word in the binomial is the specific epithet and it is not capitalized (*Hyla* ***cinerea***). A species name will always be used for a given species, unless further research indicates that species is not, in fact, different from other previously described species. In this case, the invalid name is synonymized and effectively retired from use. The name of the genus may change when, for example, new information indicates a different classification better reflects the evolutionary histories of a given species. An example here would be the recent work by our colleagues at The American Museum of Natural History (http://research.amnh.org/herpetology) that has changed the generic allocations of many species of amphibians (http://digitallibrary.amnh.org/dspace/handle/2246/5781). Such name changes sometimes annoy biologists and hobbyists, as the names of their focal creatures keeps changing! However, this is a necessary evil that reflects progress in our understanding of evolutionary history. Sometimes, when a species is transferred to another genus, the gender of the specific name must be changed to match that of the new genus, thus we can see



RON HOLT

Dendropsophus marmoratus: *Marmor* means marble in Greek, and was applied to this species in reference to the marbled cryptic coloration on the dorsal surfaces of this frog.

subtle changes such as the case of the Cane Toad, which changed from masculine (*Bufo* ***marinus***) to feminine *(Rhinella* ***marina****)* to reflect the gender of its current generic allocation. Such a change reflects the rules of Latin grammar and does not have any biological significance.

Recent common practice requires that authors include an etymology section in their paper that explains what the new name means, how they constructed it, and why they chose that name. Frequently, these can be the most interesting aspects of an entire paper (well, maybe beyond the illustrations of the new species). In previous generations, etymologies were rarely included, leaving modern scientists to guess why a particular name was chosen. In some cases, the name choice may seem obvious and appropriate — one can assume to understand why Shaw chose the name *maculatum* (meaning spotted) for the common Spotted Salamander (*Ambystoma maculatum*). However, one can only wonder why Linnaeus chose to name the familiar Cane Toad *Rhinella marina*, apparently referring to the ocean — the last time I checked, Cane Toads don't live in saltwater.

Although ICZN rules allow any word (from any language) to be used as a species name, in most cases, species names are formed from Greek words, Latin words, or "Latinized" words. Several dictionaries provide word roots and combinations (e.g., Borror's *Dictionary of Word Roots and Combining Forms;* Mayfield Publishing Company) that are quite useful when forming a new name or simply "translating" the names of one's favorite creatures. Some commonly used themes and constructions include:

Geography: Geographic names often are used as a basis for forming a new name, and frequently are constructed using the suffix *–ensis,* which denotes place, locality, or country. An example would be the treefrog *Plectrohyla guatemalensis.* This name implies "the *Plectrohyla* from Guatemala." An example from the U.S. would be the Narrowmouth Toad, *Gastrophyrne carolinensis.* Another approach to using geographic place names simply Latinizes the place name itself in an adjectival form. For example, the name of the toad *Anaxyrus* (= *Bufo*) *mexicanus* translates into "the Mexican *Anaxyrus.*" Other examples include the Woodland Salamander, *Plethodon neomexicanus* (in which case the name "New Mexico" was Latinized, which is not strictly required by ICZN), or the familiar toad, *Anaxyrus americanus.* A slightly different approach uses the place name more directly, for example, the caecilian *Dermophis oaxacae*, which translates into "the Oaxaca *Dermophis*" (rather than the *Dermophis* from Oaxaca or the Oaxacan *Dermophis*). Another example of this approach would be the U.S. Torrent Salamander, *Rhyacotriton cascadae.* A similar method does not even Latinize the place name; for example the Costa Rican toad *Crepidophryne chompipe* is from a mountain called Chompipe.

Patronyms: Honoring a person or persons is another common practice. Although clearly frowned upon professionally, the ICZN does not explicitly prohibit an author from naming a new species in honor of him- or herself. Certainly some megalomaniacal taxonomists have attempted such at some points, and perhaps have even succeeded! To bestow the honor of a specific patronym for a new species upon someone can be accomplished in several ways. The most usual approach is to simply Latinize their last name. I did this in honor of Jonathan A. Campbell with the description of *Incilius campbelli.* Another Mexican frog, *Plectrohyla hazelae*, was named by E.H. Taylor, one of the most prolific herpetologists of the 20th Century, in honor of Hazel Roberts, who assisted with fieldwork (note that the female ending of the specific epithet reflects gender). If one wishes to honor more than one person in the same family, then a plural ending could be used, as was done in the case of *Hyla wrightorum*, which was named to honor Anna Allen and

BRAD WILSON

Ecnomiohyla rabborum: The name honors equally the conservationists George and Mary Rabb. Note the suffix *–orum.* If the frog were named solely for George Rabb, the name would be *E. rabbi* (e.g., the Mexican salamander *Dendrotriton rabbi*), and if it had been named for Mary Rabb, the name would have been cast as the feminine *E. rabbae.*

SUZANNE L. COLLINS, CNAH

Eurycea splelaea: This species was named after its cave- and aquifer-dwelling habits, as *speleum* is Latin for cave. In this case, the name was modified to the feminine to match the feminine gender of the generic name.

SUZANNE L. COLLINS, CNAH

Herpele squalostoma: The specific name is a compound word that translates to "shark mouth," *squalus* is Latin for shark, and *stoma* means mouth. Caecilians have a powerful bite, and this species is no exception.

Albert Hazen Wright. A creative use of this construction may be found when the taxonomist forms the patronym such that it honors a group or culture, rather than a specific person or persons; *Eleutherodactylus avicporum*, refers to "bird catchers," thus honoring a group of ornithologists who helped discover the species in Peru. Some names reference the language or beliefs of the people living in the region where the animal occurs. For example, The Rain Frog, *Craugastor chac,* named in reference to *Chac,* the mighty God of Rain in traditional Mayan culture. Taxonomists have fun bestowing such a great honor on their heroes and friends, so patronyms are quite common on taxonomic checklists for all taxa.

Characteristics of the animal or its habitat: Another commonly used approach to forming names for new species is to base them on a distinctive feature possessed by the new taxon. Salient morphological characteristics of the animal may be singled out, such as in the case of the Mexican Toad, *Incilius spiculatus*, which has particularly spiny tubercles on the skin, or the Web-toed Salamander, *Hydromantes*

MICHAEL D. KERN

Hypsiboas rufitelus: The bright red webbing between the digits on this species is reflected in its name, which is derived from the Latin *rufus*, meaning red, and *tela*, meaning weave (usually used in reference to cloth).

EDWARD KABAY

Incilius signifer: The name is derived from the Latin *signifer*, meaning marked, and was chosen in reference to the distinctly marked ventral pattern of this toad — a ventral pattern that is unique among the closely related members of the Central American *Incilius coccifer* Group.

SUZANNE L. COLLINS, CNAH

Plethodon caddoensis: This salamander is endemic to the Caddo Mountains of southeastern Oklahoma and adjacent Arkansas. The name translates to "the *Plethodon* from Caddo" and is a clear reference to the mountains of the same name.

SUZANNE L. COLLINS, CNAH

Ambystoma maculatum: The name is from the Latin *macula*, meaning spot, in reference to the spots that comprise the dorsal pattern of this salamander.

MARTIN BUSTAMANTE

Pristimantis gagliardoi: A recently named species honoring amphibian biologist and conservationist Ron Gagliardo of The Amphibian Ark.

platycephalus, where *platy* means flat and *cephalus* refers to the head, providing a particularly appropriate description of this flat-headed species. The characteristic may be behavioral as well, such as in the Central American Leaf Frog, *Agalychnis saltator,* known for its leaping proclivities, in which *saltator* means jumper, or our familiar Slimy Salamander, for which *Plethodon glutinosus* is a clear reference to its famously glutinous skin secretions. Sometimes authors will look to the habitat of the species and derive a name from that, such as the cloudforest-dwelling Mexican Treefrog, *Charadrahyla nephila,* where *nephila* is derived from the Greek *nephos,* meaning cloud, and *philia,* meaning fondness; when combined, these two words allude to the cloudforest habitat to which this species is restricted. A simpler example may be found with the US salamander, *Eurycea aquatica*, clearly named for its aquatic habits.

Unlike scientific names, common names are not regulated by any code and often vary from one place to another (see Powell 2002. Understanding animal classification. *Iguana Times* 9:18–26.). Obviously, an English common name would differ from the Spanish name for the same species. In addition, various names might be used for the same animal in various parts of its range by indigenous peoples or local residents. Scientists generally avoid the inevitable confusion by using scientific names that are unique to each species, but some efforts have been made to provide "standard" common names for amphibians and reptiles, such as those that have been used for years by ornithologists for birds. For example, the official name list of the American Society of Ichythologists and Herpetologists (ASIH), Herpetologists' League (HL), and the Society for the Study of Amphibians and Reptiles (SSAR) provides English common names for species in the United States and Canada (B.I. Crother, ed., 2008. *Scientific and Standard English Names of Amphibians and Reptiles of North America, North of Mexico, with Comments Regarding Confidence in our Understanding*. 6th edition. SSAR) and the Center for North American Herpetology has published *Standard Common and Current Scientific Names for North American Amphibians, Turtles, Reptiles, and Crocodilians* by J.T. Collins and T.W. Taggart (2009). The SSAR also published *Nombres Estandar en Espanol en Ingles y Nombres Cientificos de los Anfibios y Reptiles de Mexico / Standard Spanish, English, and Scientific Names of the Amphibians and Reptiles of Mexico* by E.A. Liner and G. Casas-Andreu (2008, 2nd ed.). Standardized common names are certainly useful, but ultimately no authority can dictate what local people should call the animals in their own backyards — what may be a *Desmognathus* or Seal Salamander to one person may well be a "Spring Lizard" to the caretaker of an Appalachian seep. This is not a problem, as long as scientific names are governed by stable rules acknowledged by scientists and enforced by the ICZN.

BRAD WILSON

Ranitomeya summersi: A recently named species honoring amphibian biologist Kyle Summers, who has published extensively on Poison Dart Frogs.

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SUZANNE L. COLLINS, CNAH

Rhyacotriton cascadae: This is a geography-based name that translates as "the Cascades *Rhyacotriton*" and was applied in reference to the Cascades Range northwestern North America.

Cnemaspis biocellata Grismer, Chan, Nurolhuda, and Sumontha 2008

New Faces from Ancient Places: Uncovering Peninsular Malaysia's Hidden Lizard Diversity Part I: Geckos

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Photographs by L. Lee Grismer.

Deeply embedded in the tropical latitudes of Southeast Asia's Greater Sunda Shelf, sculpted by millions of years of tectonic upheavals and accretion, and re-shaped by thousands of years of fluctuating sea levels, peninsular Malaysia is emerging as one of the world's premiere megadiversity hotspots. Its dynamic geological history has been the environmental engine driving the evolution of some the world's most amazing species. Emblematic in this emergence is peninsular Malaysia's rapidly growing lizard fauna, wherein 30 new species have been discovered and described within the last five years (28 from our labs). This is more species than were described during the entire previous century. The irony that these numbers illustrate is that, prior to 2002, we didn't even know enough about the lizard fauna to recognize that we didn't know anything. Whereas today, we have finally acquired enough knowledge to be certain that we know practically nothing! Any time you see an increase of this magnitude in the number of species from a given area in such a short period of time, it is an indication that we have a significant knowledge deficit and that much still remains to be learned. As exciting as this may sound, it comes with a disturbing dark side. We view this deficit as an indictment of the scientific community for not protecting and cataloging the diversity of this community in light of the accelerating decline of global biodiversity.

The two largest groups of lizards in peninsular Malaysia are geckos and skinks; so, that these lizards account for the greatest number of the region's newly discovered species is not surprising. Among the geckos, two genera in particular lead this charge: The Rock Geckos (*Cnemaspis*) and the Bent-toed Geckos (*Cyrtodactylus*). *Cnemaspis* ranges throughout much of Indochina, and all species share a general body plan of broad, flattened heads and bodies; large, upwardly directed eyes; and long, widely splayed limbs with slender digits. Although such characters give them a rather cartoonish appearance, they are well suited for this group's specialized rock-climbing habits and for seeking refuge within crevices. This sedentary life style in restrictive microhabitats has contributed to their isolation and the evolution of many new species in localized regions such as mountaintops, karst formations, and islands. In fact,

Cnemaspis bayuensis
Grismer, Grismer, Wood, and Chan 2008

Cnemaspis karsticola
Grismer, Grismer, Wood, and Chan 2008

Cnemaspis monachorum
Grismer, Norhayati, Chan, Daicus, Muin, Wood, and Grismer 2009

Cnemaspis pemanggilensis
Grismer and Das 2006

Cnemaspis baueri
Das and Grismer 2003

Cnemaspis perhentianensis
Grismer and Chan 2008

Cnemaspis mcguirei
Grismer , Grismer, Wood, and Chan 2008

Cnemaspis pseudomcguirei
Grismer, Norhayati, Chan, Daicus, Muin, Wood, and Grismer 2009

13 of the 19 species of *Cnemaspis* in peninsular Malaysia are found nowhere else in the world, and 11 of these were described within the last five years (Chan and Grismer 2008; Das and Grismer 2003; Grismer 2008; Grismer and Chan 2008; Grismer and Das 2006; Grismer et al. 2008a, 2008b, 2009).

Four of these new species, *Cnemaspis bayuensis* from southwestern Pahang, *C. biocellata* from northern Perlis, *C. karsticola* from northern Kelantan, and *C. monachorum* from Pulau Langkawi are remarkable, diminutive lizards that are restricted to living on karst formations. *Cnemaspis monachorum* is so small (<32 mm SVL) that

Cnemaspis flavigaster
Chan and Grismer 2008

Cnemaspis limi
Das and Grismer 2003

Cyrtodactylus seribuatensis
Youmans and Grismer 2006

Cyrtodactylus batucolus
Grismer, Chan, Grismer, Wood, and Daicus 2008

Cyrtodactylus pantiensis
Grismer, Chan, Grismer, Wood, and Daicus 2008

Cyrtodactylus macrotuberculatus
Grismer and Norhayati 2008

females can carry only one egg. *Cnemaspis limi, C. pemanggilensis, C. baueri,* and *C. perhentianensis* are island endemics restricted to outcroppings of granitic boulders in the Seribuat Archipelago on the islands of Tioman, Pemanggil, and Aur, and on Pulau Perhentian, respectively. Of these four species, the activity of *C. perhentianensis* is unique in that it is closely tied to periods of rain — no rain, no geckos.

Two other new species, *Cnemaspis mcguirei* and *C. pseudomcguirei*, come from the same upland locality at Bukit Larut in Perak. These two species are remarkably similar in color pattern. When we

Cyrtodactylus jarakensis
Grismer, Chan, Grismer, Wood, and Daicus 2008

were collecting and describing the larger *C. mcguirei*, we thought the smaller lizards were juveniles. What tipped us off was when we began to realize that *C. mcguirei* was found only on granitic boulders and *C. pseudomcguirei* was on the vegetation next to the boulders as well as under logs and rocks on the forest floor. The final piece of information came when we found a gravid (carrying eggs) 34-mm long *C. pseudomcguirei* sleeping on a leaf in the middle of the forest, kilometers away from any rock outcrops. The smallest, gravid *C. mcguirei* we recorded was just under 60 mm, and these lizards never leave the rocks. We are currently examining the genetics of this species pair as an example of cryptic speciation.

Our biggest surprise, however, was the discovery of *Cnemaspis flavigaster* (Chan and Grismer 2008), which had remained hidden for years in the well-explored and studied Forest Research Institute Malaysia (FRIM) just a few kilometers from Kuala Lumpur! In fact, this population was found along the most popular trails just before the entrance onto the famous canopy walk.

Peninsular Malaysia's Bent-toed Geckos (*Cyrtodactylus*) exhibit a far greater range of anatomical diversity than that seen in the Rock Geckos. This probably accounts for its more varied ecological diversity and wider distribution throughout most of Asia and Australasia. In fact, this is the world's largest and fastest growing group of geckos. Fourteen species are known to occur in peninsular Malaysia; 11 of them are endemic and, of those, six have been described during the last three years (Grismer 2005, Grismer and Leong 2005, Grismer and Norhayati 2008, Grismer et al. 2008c).

Five of these species are islands forms, attesting to this group's ability to colonize, evolve, and adapt to the new selection pressures attendant with insular ecosystems. On Pulau Aur, in the Serinuat Archipelago, *Cyrtodactylus aurensis* makes its living in a relatively specialized habitat beneath overhanging vegetation on granitic boulders, whereas *C. seribuatensis* ekes out a living in the harsh, intertidal zone on seven tiny islands. Changing tides result in an hourly state of flux in this hypersaline environment. This poses huge challenges to this species that we have not yet begun to understand. This may be the world's only exclusively intertidal gecko — and we have no idea where it goes at high tide or even what it eats. On Pulau Besar in the Water Islands off the coast of Meleka, *C. batucolus* is clearly the most abundant nocturnal lizard on the island. We found this robust, tuberculate species on rocks, trees, in caves, and even on the sides of buildings. How did such an abundant, obvious lizard go unnoticed? Clearly the most isolated insular endemic is *C. jarakensis* from the small, rocky island of Jarak, 45 km off the western coast of Perak. We still have much to learn about this species, which was described on the basis of a single adult female. The problem is that many of the characters used to diagnose the different species of *Cyrtodactylus* are secondary sexual characters found only in males. However, this single female was so distinctive that we were sure that she was the sole representative of a new species. We will still have to fill in the "character gaps" for this species when males become available. Our most recent discovery was the beautiful and elegant *C. macrotuberculatus* from Pulau Langkawi. For years this species was misidentified as the more common *C. pulchellus.* We had always questioned this species assignment, but only after the accumulation of enough material were we able to demonstrate that it was clearly not *C. pulchellus.* Because both species occur on Pulau Langkawi and they are similar in appearance, we also are looking at the genetics of these populations.

Two new Bent-toed Geckos discovered in lowlands of southern Johor State nicely illustrate how closely related species of similar sizes can occur in the same habitat and avoid competition. We discovered *Cyrtodactylus pantiensis* in a semi-swampy riparian area living alongside *C. semenanjungensis,* a species we had described from this area a few years earlier. What we discovered last year was that *C. pantiensis* appears to restrict its activity to the edges of slow-moving streams and is always found in the vicinity of dense root tangles into which it takes refuge. *Cyrtodactylus semenanjungensis*, on the other hand, is a more widely ranging forest species that is not restricted to the edges of streams and, as such, avoids direct competition with *C. pantiensis.* The most bizarre and rarest of the recently described new species is *C. stresemanni* (Rösler and Glaw 2008). This species too is known only from a single specimen, but this one is a male. This individual was actually collected in the early 1900s in the vicinity of Batang Padang, Perak by a Dutch explorer, but was not "discovered" and described until 2008, when it was found in a jar during a museum inventory. Rösler and Glaw's (2008) description left no doubt as to its distinctive species status. Its body morphology and color pattern suggest that it may be an arboreal leaf-mimic. It will be an exciting day when one of these new geckos is found again and we can evaluate it in the light of what we have learned about Bent-toed Geckos in the recent past.

So why the rapid and sudden increase in the lizard diversity of peninsular Malaysia? Did nature all of a sudden decide to whip up a new batch of species for us to discover? Such a scenario is unlikely. These species evolved a long time ago and the reason for us not noticing they were here is that we never really looked. Many regions in peninsular Malaysia remain woefully unexplored, and we will need much more than a few visits to understand their faunal complexity. Additionally, many of the places we believe are well explored aren't. Just because people have been going there for many years doesn't mean that new discoveries aren't there to be made. For example, we discovered three new species of lizards from Pulau Langkawi since 2007, three new species at Bukit Larut since 2008, three new species from Pulau Tioman since 2003, two new species in the Gunung Panti Forest Reserve since 2005, two new species from Fraser's Hill and Cameron Highlands since 2007, and a new species from FRIM in 2008. These are all very well known areas that are often explored — and we have not even mentioned the new species of frogs and snakes we discovered.

Most disturbing, however, is the fact that we are not looking closely enough at the specimens we collect or those already collected and sitting in jars. For example, we originally believed *Cyrtodactylus macrotuberculatus* of Pulau Langkawi was *C. pulchellus* and that *Cnemaspis mcguirei* of Bukit Larut was either *C. affinis* or *C. kenadllii* simply because we never looked closely enough at what we had. The point is that the knowledge deficit is our fault, not something romantically and beautifully elusive about nature, as we are so fond of claiming. Simply stated, we are not thoroughly exploring as many places as we should be and we are not studying the material we collect in enough detail — if at all! Some may posit that, in this era of molecular systematics, the identification of new species is much easier — and this is why we are seeing such a dramatic increase in new discoveries. We disagree — and note that the 39 new species of frogs, lizards, and snakes that we have described from peninsular Malaysia in the past five years were done the old fashioned way — with a microscope, literature, and hard work. We believe that, if scientists are not going to carefully examine the material they collect, then perhaps that material is better left in the wild. This is difficult for us to say, being that we are systematic biologists who view collecting as the cornerstone for knowledge-based conservation efforts — but we can only conserve what we understand and we can only understand what we study.

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Grismer and Leong 2005

Cyrtodactylus aurensis
Grismer 2005

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An undescribed species in the *Gekko smithii* species complex from peninsular Malaysia.

EDWARD KABAY/ZOO ATLANTA

The Impressed Tortoise (*Manouria impressa*) is listed as "vulnerable" on the IUCN Red List.

HUSBANDRY

Keeping and Breeding Impressed Tortoises (*Manouria impressa*)

Jason Brock

Zoo Atlanta

Photographs by the author, except where noted.

The Impressed Tortoise (*Manouria impressa*) of southeastern Asia is a specialized animal that can do quite well in captivity if its needs are understood and met. These rare tortoises come from high mountain forests in Vietnam, Cambodia, Thailand, Laos, Burma, southern China, and Malaysia. They prefer dense evergreen and bamboo forests at elevations above 700 m. These areas receive daily rainfall, and the forest floor remains moist even in the dryer months. Humidity is 70–100% and rarely drops below 65%. Tortoises typically are found hiding under fallen trees, bamboo tubes, or buried in leaf litter. In open areas, they will always stay hidden. Temperatures in suitable habitat usually are 21–27 °C (70–80 °F) during the day, with lows of 10–18 °C (50–64 °F) at night. These conditions, along with the dense canopy, are perfect for their primary food source, mushrooms. These fungivores will consume some low-lying vegetation, but feed mainly on the wide variety of mushrooms that grow in these damp montane forests. Some reports indicate that they will feed on bamboo shoots, although this has not been observed in captive animals. These tortoises prefer not to bask in open sun, but stay close to tree roots and cover. They are not known to soak in the wild unless temperatures are extremely high. However, captive specimens regularly soak in shallow pools and water sources.

When preparing an artificial habitat for Impressed Tortoises, first determine if outdoor pens are an option. If weather conditions allow, this is always the preferred method. Large pens with heavily planted hills are best suited. Be sure to add as much leaf litter as possible, as

EDWARD KABAY/ZOO ATLANTA

The Impressed Tortoise (*Manouria impressa*) comes from southeastern Asian montane forests, where the weather is warm and rainy most of the year.

EDWARD KABAY/ZOO ATLANTA

Impressed Tortoises spend most of their time settled into leaf litter. This individual has burrowed under the layers of leaves with only its head exposed.

Large enclosures should be planted with heavy vegetation for ample shade. Leaf litter can be added to allow for nest building and hiding behavior. Shallow ponds are a good idea for captive animals.

Impressed Tortoises build large nests during the breeding season. In one collection, a 1.3 adult breeding group is housed in a space covering more than 90 m^2 (300 ft^2), with several large trees to allow for plenty of shade. A 1.1 adult pair should have at least 45 m^2 of space. Lots of bamboo trees or other canopy coverage should be provided, and leaf litter should be added several times during the year.

Avoiding dehydration, which contributes to a lack of appetite and other health issues, is critically important, so daily misting is definitely recommended. If possible, use misting heads placed at 1.5-m intervals around the perimeter of the enclosure. At least twice a week, a sprinkler can be used for heavy soaking of plants and leaf litter, but be sure to mist the habitat daily for about one hour.

If temperatures drop below 10 °C (50 °F) at night, the tortoises must be housed inside. Be sure to provide ultraviolet light with a quality UV-bulb during the day. *Manouria impressa* is best housed individually when inside, as this will help reduce stress on animals kept in close contact. Enclosures can have mulch or moistened sphagnum substrate with leaf litter to allow the animals to bury, and should be at least 2.25 m^2 for an average adult. Spray the enclosure daily and provide regular soakings every other day. The best method for this is a fine mist for about an hour in a box with drainage. Usually, when this is offered, Impressed Tortoises will start drinking immediately. They are rarely observed drinking from water bowls, although a shallow dish with clean water should be provided.

Manouria impressa can be fed a salad twice a week, but be sure to mix greens and vegetables with their primary diet of mushrooms. Captive animals seem to like a variety of greens such as bok choy and collard greens, along with yellow squash, zucchini, sweet potato, and carrots. Oyster Mushrooms seem to be well accepted and have a high calcium content, making them an excellent captive diet, especially for breeding females. Some stubborn feeders have shown an interest in fruits, flowers, and even prepared pellet foods. They can be offered mushrooms as browse once or twice a week between regular feedings.

Breeding groups can be maintained well in captivity and babies grow quickly with proper conditions. Mating usually occurs in early spring and will continue all summer. Eggs are generally laid in June and July. Females build large nests by walking around in increasingly larger circles, pulling together the leaf litter to form a tightly woven pile. This usually is done next to a wall or fence, and the finished pile will be up to 1 m high. The female will clear out a center hole about 30–35 cm deep and deposit 10–20 eggs. She will then cover them using the same method of circling to collect leaves, pulling any vegetation together to insulate the eggs.

Manouria impressa can be fed a salad of mixed greens, vegetables, and mushrooms twice a week.

Oyster Mushrooms are a great source of calcium and are readily accepted by captive Impressed Tortoises.

The eggs can be removed from the nest and placed in moistened vermiculite at a 1:1 weight ratio with water. The species is subject to temperature-dependant sex determination (TSD), with females incubated at 28.8–30.0 °C (84–86 °F) and males at 26.6 °C (80 °F). At these temperatures, they will hatch in 64–79 days. Babies should be housed in moistened sphagnum moss with leaf litter and a small hide. A shallow water dish should be provided to allow for soaking, which babies do quite often in captivity, although rarely in the wild.

Young tortoises should continue to gain weight weekly if housed in small groups of two or three. Watch for any weight loss, as this is usually a sign of crowded conditions indicating that these animals might need to be separated. Once separated, smaller individuals will typically continue to grow. Babies should be fed a finely chopped version of the adult diet. Misting of babies when offering food might encourage problem feeders. Impressed Tortoises also have been observed feeding on pelleted diets, such as Mazuri Tortoise Chow. When moistened with water, pellets can be added to the chopped diet. This combination has produced higher growth rates than a diet without pellets in at least two individuals in captivity. As for adults, regular misting is extremely important.

Reptilian health issues are difficult to detect and even more difficult to treat. Impressed Tortoises can suffer from many of the same ailments that affect other species. Most of these problems occur when transitioning from outdoor to indoor enclosures for winter. This would point to stress as a strong catalyst for disease. Most commonly, adult tortoises have issues with internal parasites, such as amoebas. Progression can be rapid after initial signs, such as lethargy and weight loss, are observed. Proper diagnosis and treatment must be prompt, as these animals usually hide in leaf litter and weight loss may not be detected quickly. Accurate records and regular weighing are necessary to catch these issues early.

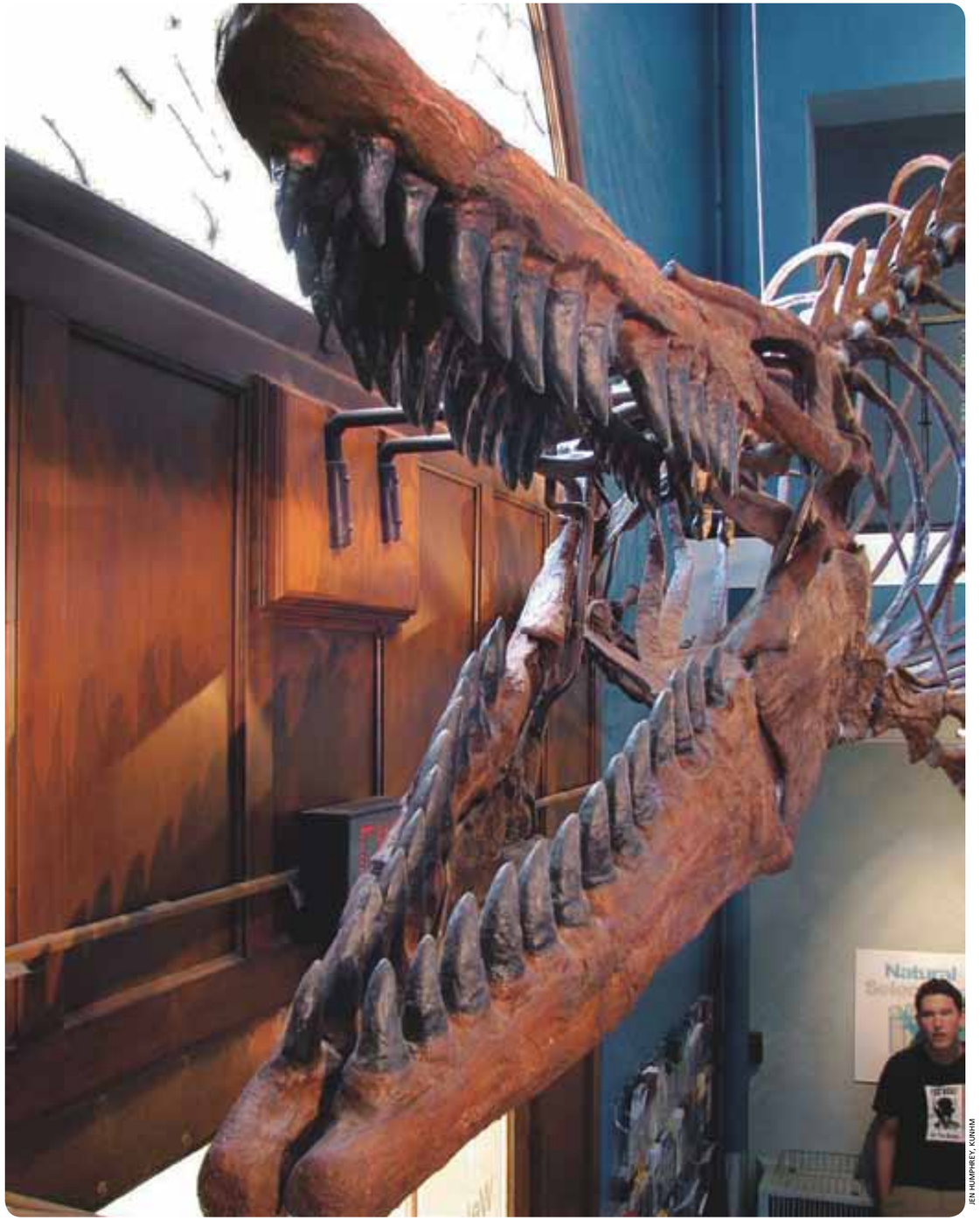
Individually housing adults during the non-breeding season is the best way to avoid undue stress. A common problem in imported adults is the presence of gastric foreign bodies. Some adults that came into the United States from southeastern Asia were obtained from the food trade, where they often consume rocks and other non-digestible objects while provided with inadequate care. In several animals, surgery was performed and rocks were removed. They were treated with pain medications, given antibiotics, and regular fluids. All had to be tube-fed a liquid diet for several weeks until they began to eat. Two of the animals on which operations had been conducted began to breed the following year.

With proper understanding and care, these amazing and rare tortoises can be wonderful fixtures in a collection. Impressed Tortoises require specialized food and habitat conditions to flourish — or even survive. Their care is demanding but the rewards are great. With continued research, we can learn more about these animals and become increasingly successful with captive breeding. They are currently listed as vulnerable on the IUCN Red List, but with help from captive breeding and continued conservation efforts, their status could be improved.

Tortoises build large nests (to 1m high) using leaf litter.

Eggs are buried as deep as 35 cm to maintain proper temperatures. Wet leaves are woven tightly to secure the nest.

Hard-shelled eggs are typically the size of ping-pong balls. This species is subject to temperature-dependant sex determination (TSD).



JEN HUMPHREY, KUNHM

The Mosasaur exhibit in the Natural History Museum and Biodiversity Research Center at the University of Kansas, retains "the special appeal of the museum — its fundamental weirdness as a public space." Visitors are awed by the thought that giant marine lizards once ruled the sea that covered much of what is now Kansas.

COMMENTARIES

Revisiting Natural Science[1]

Thomas H. Benton[2]

Toward the end of *The Catcher in the Rye,* Holden Caulfield — depressed, confused, adrift — wanders into the American Museum of Natural History: "I loved that damn museum. I remember you had to go through the Indian Room to get to the auditorium. It was a long, long room, and you were only supposed to whisper. ... The best thing, though, in that museum was that everything stayed right where it was. Nobody'd move. You could go there a hundred thousand times, and that Eskimo would still be just finished catching those two fish, the birds would still be on their way south, the deers would still be drinking out of that water hole. ... Nobody'd be different. The only thing that would be different would be you."

A couple years ago, I wrote an essay about the "Decline of the Natural History Museum" (*The Chronicle of Higher Education*, 13 October 2006[3]). It was a lament about the way such museums have changed from how I remembered them as a child. I was moved, in particular, by the renovation of Dinosaur Hall at the Academy of Natural Sciences in Philadelphia, which struck me — after being away for many years and returning with my own children — like the destruction of Penn Station might have hit a long-absent New Yorker.

In *Dry Storeroom No. 1: The Secret Life of the Natural History Museum* (Knopf, 2008), Richard Fortey describes the transformation of the museum where he worked as a paleontologist from 1970 until his retirement in 2006. In many respects, his memoir shares the elegiac tone of recent memoirs of the book trade and librarianship (*The Chronicle of Higher Education*, 10 October 2008). Just as books are supposedly being replaced by electronic media, and libraries are being filled with computer terminals, so the familiar material culture of the museum — oak cabinets with brass hardware, exotic butterflies, lacquered bones, taxidermied beasts: the apotheosis of Victorian maximalist eclecticism — have yielded to the aesthetics and values of Modernist minimalism: chrome, concrete, walls of glass, a white emptiness so overpowering that there is nowhere for the mysterious to hide from the scrutinizing power of modern science.

Fortey affirms the sensibilities of those who chafe under the tyranny of the clean, well-lighted museum. "I well recall," he writes, "how specimens were put away back behind the scenes — down to the vaults from which they had once emerged: less was regarded as more, providing it was dramatically lit and accompanied by signage to satisfy all groups."

Over the course of his career, the shift from comparative anatomy to genomics as the dominant method of natural science com-

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[2] Thomas H. Benton is the pen name of William Pannapacker, an associate professor of English at Hope College, in Holland, Michigan. He welcomes reader mail directed to his attention at careers@chronicle.com. For an archive of his previous columns, see http://chronicle.com/jobs/news/archives/columns/an_academic_in_america.

[3] Reprinted with permission in *IGUANA* 15(3): 175–176.

MILWAUKEE PUBLIC MUSEUM

A diorama at the Milwaukee Public Museum takes visitor 66 million years back in time to Hell Creek of eastern Montana.

KEVIN DE QUEIROZ, NMNH

Small dioramas, such as this exhibit at the National Museum of Natural History of the Smithsonian Institution, immerse visitors into the natural world.

JEN HUMPHREY, KUNHM

Smilodon, the Saber-toothed Cat, lived during the Pleistocene (~1.6 million years ago to ~11,000 years ago). Today's children can experience the real thing only in museum exhibits.

pletely altered the nature of museum displays. Once one could teach evolution with a series of articulated skeletons showing the development of the eohippus into the modern horse, but how does one create a display for research that is conducted primarily with microscopes and computers? What is there to do but put the scientists themselves at the center of the museum experience? The visitor can observe them through a window the same way one might tour the facilities of McDonnell Douglas. Meanwhile, behind the glass, Fortey writes, conversation focused on "the virtues or deficiencies of a new piece of software rather than the discovery of a new species of butterfly."

The title of Fortey's memoir refers to a type of space, unique to natural-history museums, that arouses mingled feelings of awe, curiosity, and whimsy through the gathering of unlikely natural and man-made objects: "Science, treasure, rarity, beauty, scholarship: this hidden gallery made me understand again the heterogeneous attraction of museum life."

Like the old Dinosaur Hall, such storerooms are warehouses of human consciousness; they dramatize the transience of our attempts to explain and control the natural world. There are shadowy corners, mislabeled objects, expedition boxes that have never been opened, the apparatus of failed experiments, the history of natural history and the people who pursued it. Of course, natural-history museums are primarily scientific and educational institutions, but with the passage of time, they can become works of art as poignant as the lives of the workers who staffed them.

In addition to his loving descriptions of the collections, Fortey provides an account of the lives of the people behind the display cabinets. A couple of generations ago, young scientists could take up daily residence in one of the hidden rooms of the natural-history museum and disappear, for all practical purposes, to everyone but their families and perhaps the small, international community of scholars specializing in the crinoids of the Middle Jurassic. Some of those scholars continued to work long after their official retirement, like a member of the spectral cast of *Harry Potter:* "Professor Binns had been very old indeed when he had fallen asleep in front of the staff-room fire and got up next morning to teach, leaving his body behind him." Such people are one more reason to cherish museums that resemble Hogwarts School of Witchcraft and Wizardry more than antiseptic, corporate research bunkers imagineered by smug Scandinavian starchitects who wear only black.

As Fortey rightly observes, "Those who have devoted their lives to collections — obdurate people, odd people, admirable people —

"Sue," at the Field Museum of Natural History in Chicago, evokes "something spiritual" in museum visitors — something that cannot be elicited by interactive exhibits relying on the newest technology.

CREDIT?

The renovation of the Dinosaur Hall at the Academy of Natural Sciences in Philadelphia struck the author much like the destruction of Penn Station might have hit a New Yorker returning home after a long time away.

KEVIN DE QUEIROZ, NMNH

Like exhibits that take visitors back in time, those that document endangered species and threatened habitats may be the closest encounter many youngsters will ever have with such animals and ecosystems. Those inclined to look beyond the obvious message will be enticed to meditate on the role played by humans.

actually make a museum what it is and should be." With nearly Pythonesque humor, Fortey shows how gifted eccentrics were once sheltered by natural-history museums, which were unpredictably enhanced by alcoholic, chain-smoking whale-defleshers and curmudgeonly obsessives who had spent so many years with bats — or beetles, or barnacles — that they began to resemble them and mimic their behavior.

"Formerly," Fortey writes, "there was more leisure for people behind the scenes to cultivate their eccentricities like prize vegetable marrows, mulching them regularly with their prejudices and fertilizing them with long draughts of solitude."

Curators had tenure in those days, so they were free to express themselves naughtily by, say, installing a secret distillery in the belly of the blue whale, or, perhaps, by furtively dining on a hunk of thawed mastodon (who knew what its taste would reveal?). Such people once had the freedom to spend 20 years producing a magisterial book on weevils that might save a billion lives — someday.

But over the course of Fortey's career, that mix of self-governing professionals and genteel amateurs has given way to a business culture in which the eccentricities of introverted curators — their peculiar means of coping and rejuvenating — can no longer be tolerated: Public-relations specialists "attempted to bring out the scruffy old scientists from their hidden redoubts. Their elbow patches were confiscated. Corporate culture had arrived."

As state support dwindled, every square foot had to be turned to profit; there was no more room for the mysterious, no more scientifically suspect displays left over from the era of P.T. Barnum. "The requirement to bring in as much money as possible led to the expansion of the shopping area in the galleries and the proliferation of all manner of trinkets for sale," Fortey writes. "Small, fluffy tyrannosaurs will growl at you and sing the theme song from The Sound of Music."

The special appeal of the museum — its fundamental weirdness as a public space — was replaced by the ethos of bland consumerism and banal spectacle.

While I share many of Fortey's sensibilities, I am admittedly no scientist. From the ages of about 4 to 10, I thought I wanted to be a paleontologist, not because I was fascinated by the science — or at least not the precise, mathematical work that undergirds it — but because there was something about the natural-history museum that appealed to me as an aesthetic experience, though I wouldn't have used that word at the time.

Unlike the open-air, circuslike experience of zoos, there continues to be something spiritual about the older natural-history museums. They are dark and quiet; you are on your best behavior; your mind wanders, freely associating objects. You approach the displays with a kind of reverence for the dead, as one might approach the coffin at a funeral. As Fortey writes, such museums give children a rare "encounter with the bony truth"; they have "overdosed on simulations on their computers at home and just want to see something solid — a fact of life." The last thing the young visitor probably wants is an experience mediated by technology that seems dated before it even arrives at the museum, like an old teacher trying to be hip.

Living in the rural Midwest, I don't get to natural-history museums as much as I used to. Sometimes I am able to sneak away from a conference in Washington or New York to visit their museums, but, for whatever reason, I now find the experience is best shared with my children. Chicago's Field Museum — one of the finest in the world, with a good mix of the old and new — is about three hours away, and we have driven there a couple of times. But for the most part, our family interest in natural history is satisfied by collecting shells, leaves, rocks, and insects — and, increasingly, as my kids get older, by reading nonspecialist books on natural history, particularly the ones with lots of illustrations that almost capture the experience of visiting a real museum.

There isn't room in this short essay to review all of the books we've enjoyed over the past few years, but I recommend a couple that evoke the sensibilities I find so appealing in Fortey's memoir: *The Rarest of the Rare: Stories Behind the Treasures at the Harvard Museum of Natural History* (Harvard, 2004) and *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History* (Abrams, 2006). One forthcoming book of a similar kind sounds particularly promising: *Treasures of the Natural History Museum* showcases at least 200 of that London museum's most notable items. The book is scheduled for release in January.

JEN HUMPHREY, KUNHM

Effective dioramas draw the visitor into ecosystems and trigger the desire to look for the tiny details that bring such exhibits to life.

If one wants to delve into the ancestry of natural-history museums, *Cabinets of Curiosities* (Thames & Hudson, 2002) is the most gloriously illustrated work on the subject. *Amazing Rare Things: The Art of Natural History in the Age of Discovery* (Yale, 2007) is a fine anthology of drawings and engravings. And if you are prepared to splurge, *Albertus Seba's Cabinet of Natural Curiosities* (Taschen, 2001) is a jumbo, slipcased volume that includes hundreds of color illustrations from the early years of natural history.

Several books published in recent years that are more scholarly — not for the kids, but not over the heads of the average nonscientist — focus on the history of natural history: *Stuffed Animals and Pickled Heads: The Culture and Evolution of Natural History Museums* (Oxford, 2001) is the most engaging comprehensive history that I have read. More-focused studies include *A History of Paleontology Illustration* (Indiana, 2008), and *Victorians and the Prehistoric: Tracks to a Lost World* (Yale, 2004), and *The Legacy of the Mastodon: The Golden Age of Fossils in America* (Yale, 2008), which chronicles the wild-west era of paleontology in the 19th century, when the great museums were building their collections. *Nature's Museums: Victorian Science and the Architecture of Display* (Princeton Architectural, 2005) makes the case for the ideological significance of museums and the importance of preserving them for cultural reasons as much as for their scientific value.

Fortey asserts — rightly, I think — that the older, interdisciplinary, vocational culture of natural history can no longer comfortably exist in the context of the modern museum. Such work is now wholly professionalized and dependent on advanced, specialized education, expensive technology, and access to the latest research. It depends on the same kind of management strategies and values that are transforming our universities along similar lines. And the experience can be quite alienating. One can only gape at the astounding power of technology. There is not much room left for the museum visitor who is as fascinated by a timeworn marble staircase as by the cast skull of a *T. rex* in a Lucite box.

One goes to a natural-history museum not just to contemplate the minutiae of comparative anatomy — or to watch scientists demonstrate the insidious might of their corporate sponsors — but also to meditate, like Holden Caulfield, on the meaning of time, death, change, and the succession of generations.

Dead Reckoning: Calculating the Costs of an Ongoing Mass Extinction[1]

Scott LaFee

San Diego Union Tribune

On 2 March 2009, an asteroid discovered just three days earlier narrowly missed the Earth. Dubbed 2009 DD45, it passed within 47,000 miles of the planet — a distance only slightly more than twice the altitude of a geostationary communications satellite. The moon is five times farther away.

It was a relatively small asteroid: 100–130 ft in diameter, roughly the size of the comet or asteroid that flattened Russia's Tunguska River region in 1908. If 2009 DD45 had actually collided with Earth, it would not have ended life as we know it. We're doing that ourselves.

Over the past 500 million years, the Earth has endured five mass-extinction events, periods when 50 to more than 90% of all known species perished. The last event — the Cretaceous-Tertiary event 65 million years ago, which spelled the end of the dinosaurs — was likely instigated by the impact of an asteroid far larger than 2009 DD45, but other phenomena have been cited as possible causes of mass-extinction events, including massive volcanism and extreme climate change. Now, most scientists agree, we're in the midst of a sixth mass extinction, this one human-induced. What remains to be seen is just how bad it will be.

"Extinction is a difficult phenomenon to measure because we are still counting and describing the number of living species on Earth," said Mark Wilson, a professor of geology at the College of Wooster in Ohio. "We may be losing tens of thousands of species every year which we haven't even met yet." However, the sense among researchers is that the current mass extinction, known as the Holocene Event, will be very bad indeed. In the past, the Earth invariably rebounded, different but alive, eventually refilling with new and more diverse creatures and plants. Life moved on.

Odds are, humans will, too. At this point, scientists tend to think humanity will persist in some form or fashion. As a species, we are remarkably adaptable and resourceful.

The planet, not so much. Phenomena like global climate change and habitat destruction, both powerfully propelled by modern human activities, have fundamentally changed the rules. A University of Leeds study says current emission trends may raise global temperatures by the end of the century to levels not seen in

[1] Published originally in the *San Diego Union Tribune* on 23 March 2009.

Credits for photographs (left to right, top to bottom): Gary Nafis, Jeff Lemm, Gerald Kuchling, Michael A. Powell, Kenneth L. Krysko, IUCN, Adam Crane, John Binns, Olivier Born, Philipp Maitz, Hans-Jürgen Bräuer, and Wikipedia.

Giant Garter Snake
(*Thamnophis gigas*)

Mountain Yellow-legged Frog
(*Rana muscosa*)

Yangtze River Softshell Turtle
(*Rafetus swinhoei*)

Hawaiian Goose
(*Branta sandvicensis*)

Mushroomtongue Salamander
(*Bolitoglossa diaphora*)

Purple Marsh Crab
(*Afrithelphusa monodosa*)

Hellbender
(*Cryptobranchus alleganiensis*)

Grand Cayman Blue Iguana
(*Cyclura lewisi*)

Gharial
(*Gavialis gangeticus*)

Squaretail Coral Grouper
(*Plectropomus areolatus*)

Living Rock Cactus
(*Ariocarpus bravoanus*)

Iberian Lynx
(*Lynx pardinus*)

The rare and endangered species shown here are among those at risk in the current human-induced mass extinction.


ROBERT POWELL

Although not as dramatic as the impact that marked the Cretaceous-Tertiary boundary 65 million years ago, being eaten by humans or their domestic companions can be just as lethal. The Navassa Island Iguana (*Cyclura onchiopsis*) presumably was driven to extinction through overexploitation by miners extracting mineralized guano during the late 19th Century. Only a few museum specimens remain.

30 million years. Humans already use about half of all available land on Earth.

"There's this idea of resilience," said Rebecca Lewison, an assistant professor of biology at San Diego State University. "How far can ecosystems be pushed before they permanently collapse? How much ecological havoc can we effect before there can be no rebound? We don't really know what the boundaries are."

Going Rate

Extinction is a part of life, with new species inevitably replacing those less able to adapt or compete. Evolution means that more than 90% of all species that have ever lived on Earth are now extinct — but how long should a species persist? Based on the fossil record, the average lifetime of an invertebrate species, from origination to extinction, is estimated at 5–10 million years. Mammalian species come and go much more quickly, usually within 1–2 million years.

Scientists say that the "normal background extinction rate" is one species per million per year, with maybe 10 to 25 species disappearing in a year. The current extinction rate is projected at 100–1,000 times higher than the normal background rate.

"It's unprecedented," said Lewison. The United Nations Convention on Biological Diversity estimates three species become extinct each hour. That's 72 every day; 26,280 each year. Exact numbers are debatable, but the point is not: Much of the planet's biota is imperiled. The International Union for the Conservation of Nature, which maintains a highly regarded "Red List" of endangered and threatened species, estimates that more than 16,300 species of animals and plants are on the verge of extinction; more than 41,000 are threatened.

The group says one-eighth of all birds, one-third of all amphibians, and half of the world's turtles are in jeopardy. Seventy percent of the world's plants are considered at risk.

Blame people, says conservation biologist Michael Soule, who asserts that modern extinctions are almost entirely the result of human activity — everything from habitat destruction and the introduction of non-native species to pollution, overexploitation, and disease.

For example, the United Nations estimates 32 million acres of forest are lost annually, almost half of that total consisting of forest previously undisturbed by man. Ocean acidity is rising, the result of seawater absorbing more atmospheric carbon dioxide emitted by industry and automobiles. Increased ocean acidity blocks the ability of corals and hard-shelled marine creatures to form, and hinders the growth and reproduction rates of plankton and fish. In central Africa, the gorilla population has declined 60% in the last quarter-century due to local wars, the bush-meat trade, and the Ebola virus.

Remnants and Recovery

The ramifications of lost biodiversity are almost impossible to overstate. Recent studies have shown that grassland ecosystems with fewer plant species generally produce less biomass (living matter) than ecosystems with more species. Less plant biomass means less atmospheric carbon dioxide is absorbed and less oxygen is produced. A global decline in vegetable biomass can change the composition of gasses in the atmosphere. It means fewer plants for herbivores to eat. Entire food chains may be disrupted.

In a recently published paper, Paul Ehrlich, the Bing Professor of population studies at Stanford University, and his wife, Anne, a senior research scientist, noted that, since 1993, an astounding 408 new species — of mammals alone — have been discovered. That might seem like news to celebrate, but Ehrlich, famous for his 1968 book, *The Population Bomb,* suggests that it also reveals how little we know about the planet's biosphere. "Our analysis indicates how much more varied biodiversity is than we thought and how much bigger our conservation problems are if we're going to maintain the life-support services that we need from biodiversity," Ehrlich said. He compares nature's biodiversity to the engineered redundancy in an airplane. The "rivet hypothesis" holds that you can lose some rivets in a plane's wing and it will continue to fly, said Ehrlich. At some point, however, the loss of just one more rivet becomes catastrophic. "Even though you don't know the value of each rivet," said Ehrlich, "you know it's nuttier than hell to keep removing them. There is some redundancy (in nature), but we don't know how much — and facing serious climate disruption, humanity is going to need more redundancy in the little rivets, the species and populations that run the world."

However, nothing will improve as long as human behavior and activity do not, said Barry Goldstein, a biology professor at the University of Puget Sound in Washington. "The current event will last as long as habitat loss and rapid climate change continue to occur at the present rate" — and, if mass extinction goes on long enough (past events have lasted from hundreds of thousands to millions of years), what's left may consist only of "weedy survivors," said Peter Ward, a paleontologist at the University of Washington. These are animals supremely adaptable and opportunistic, such as flies, rats, crows, coyotes, and intestinal parasites.

These "recovery fauna" might be the dominant organisms on Earth for a very long time. In a 2000 paper, UC Berkeley environmental scientist James Kirchner and Duke University paleontologist Ann Weil found that the average amount of time it took for the Earth's biodiversity to regain levels prior to a mass extinction event was 10 million years. The length of time didn't vary whether an extinction event was large or small. That's far beyond any human time scale. Modern humans have only been around for a few hundred thousand years. Ancestral hominids date back only a few million years. A recovery period of 10 million years, said Kirchner at the time of his study, "is well past the expected life span of the human species, or even of the genus *Homo*."

Mass Extinctions of the Past

Cretaceous-Tertiary, 65 million years ago: Most likely caused or aggravated by a miles-wide asteroid striking what is now the Gulf of Mexico. Climate change and massive volcanic eruptions also are blamed. Sixteen percent of marine families and 18% of land vertebrate families died out, including dinosaurs.

Triassic-Jurassic, 205 million years ago: Probably due to massive lava floods in the central Atlantic region, an event that triggered the opening of the Atlantic Ocean. Volcanism could have led to catastrophic global warming. The death toll included 22% of marine families; land vertebrate losses are unclear, but included most non-dinosaurian archosaurs and large amphibians.

Permian-Triassic, 251 million years ago: Multiple causes cited — asteroid impact, volcanism, long-term atmospheric change — but no conclusive evidence for any one of them. This was the worst mass extinction of all, sometimes called "The Great Dying": 90% of marine species, 70% of land species perish.

Late Devonian, 364 million years ago: Actually a series of extinction events; temperatures dropped sharply, but the specific cause is not known. Twenty-two percent of marine families disappeared; little is known about land organisms at the time.

Ordovician-Silurian, 439 million years ago: Attributed to extensive glaciation, falling sea levels, global cooling. The toll included 27% of marine families.


C. HORWITZ

Passenger Pigeons (*Ectopistes migratorius*) were perhaps the most numerous birds on the planet. Over-hunting and the clearing of forests to make way for agriculture doomed the species. The last nesting birds were reported in the Great Lakes region in the 1890s. The last reported individuals in the wild were shot at Babcock, Wisconsin in 1899, and in Pike County, Ohio on 24 March 1900. Some individuals, however, remained in captivity. The last Passenger Pigeon, named Martha, died alone at the Cincinnati Zoo at about 1 pm on 1 September 1914.

Like all sea turtles, Green Turtles (*Chelonia mydas*) are threatened by predators such as dogs, mongooses, and rats (often introduced by humans), as well as humans themselves. In addition, they are killed in fishing nets and by boat strikes, and their nesting sites are increasingly rendered unusable as a consequence of coastal development.

The Cuban Crocodile (*Crocodylus rhombifer*) has the smallest known natural distribution of any extant crocodilian. In addition to illegal hunting for food and sales of mounted specimens as souvenirs and live juveniles as pets, hybridization with the American Crocodile (*C. acutus*) threatens the genetic purity of the few remaining wild populations.

GILBERTO SALAZAR

The Nature Reserve in the Motagua Valley is meant to protect a variety of endangered animal species as well as their endangered semi-dry tropical forest habitat.

CONSERVATION UPDATE

Project Heloderma and Project Palearis: Progress Toward an *In-Situ* Reproduction Center

Luis F. Alvarado Z.

Operations Manager, Zootropic

The Guatemalan Beaded Lizard (*Heloderma horridum charlesbogerti*) and the Guatemalan Black Iguana (*Ctenosaura palearis*) are endangered species endemic to the semi-dry forest remnants of Guatemala's Motagua Valley. Based on research undertaken by Daniel Ariano, a species recovery plan for the Beaded Lizard was created in December 2003. Known as Project Heloderma, the project is being implemented by Organización Zootropic, in collaboration with local and international partners, the International Reptile Conservation Foundation (IRCF) and ZooAtlanta. Project Palearis was created by those same partners in September 2006 to evaluate the conservation status of the Black Iguana and undertake any necessary protective measures.

STEPHANIE SCANLIN, ZOOATLANTA

DANIEL ARIANO

The Guatemalan Beaded Lizard (*Heloderma horridum charlesbogerti*; top) and the Guatemalan Black Iguana (*Ctenosaura palearis*; bottom) are endangered species endemic to the semi-dry forest remnants of Guatemala's Motagua Valley.

JOHN BARNES

DANIEL ARIANO

The location of the Motagua Valley in the rugged highlands of Guatemala.

For both Project Heloderma and Project Palearis, as with conservation efforts for any species or habitat, progress is ultimately dependent on the ability to gain and maintain local community support for the program. Of the many tools used to gain support, educational programs are one of the most powerful and effective. These programs serve to bring the vision and awareness of the conservation program goals directly to local inhabitants and community leaders. The aim of this particular educational program is to visit each of 20 village schools surrounding Beaded Lizard habitat in the Motagua Valley each month.

A grant from the Disney Worldwide Conservation Fund provided funding for educational programs during the 2007–8 and

JOHN BINNS

An overview of the Motagua Valley.

2008–9 school years. The program is based on ten different modules (full-day presentations for each module) and each school is exposed to all ten modules during a single year. The full program of modules teaches many aspects of regional conservation. These include: Beaded Lizard and Guatemalan Black Iguana conservation, general conservation of the region's flora and fauna, waste management, and water recycling. Each program or presentation is accompanied by live animals, interactive materials that illustrate the particular concept of the module being taught, and a questionnaire to evaluate the effectiveness and need for that module.

One of the main villages within critical Heloderma habitat is El Arenal. The villagers have been working with Zootropic since 2003, and now work with Projects Heloderma and Palearis. In December 2008, a small Christmas party was held by Project Heloderma for the villagers of El Arenal as a way of thanking them for all their help and assistance with our efforts.

Other vital aspects of the conservation program include research, the establishment of protected areas, and captive breeding. The research program covers studies performed with radiotelemetry to learn more about the ecology of the species, as well as analyses of major threats facing each of the species. To date, research has conclusively identified three primary threats to the remaining population of *H. h. charlesbogerti*. They are:

1. Agricultural development of remaining dry forest remnants and other practices and efforts that lead to development in pristine wildlife habitat: The remaining habitat of *H. h. charlesbogeti* within the Motagua Valley is fragmented, consisting of small patches of dry forest and a few significant areas of mixed (= patch) forest. The greatest loss of habitat is to subsistence crops, primarily maize, which is grown by small farmers who rent undeveloped patch forest from larger landowners. The effects of destroying critical remaining habitat are two-fold: The forests are cleared to grow maize, and the land is subsequently used to graze cattle.

2. Needless killing of *H. h. charlesbogerti* that is based on fear and superstition and/or ignorance attributable to inadequate awareness education: Historically, myths about *H. h. charlesbogerti* have been passed from generation to generation. These myths, along with the reputation of *Heloderma* for being extremely poisonous, are deeply rooted in local communities, and even in communities outside the animal's range. This results in animals being killed whenever they are encountered, undoubtedly contributing to the decline of the species at the same time as development proceeds in its range.

3. Illegal extraction and exploitation of wildlife from the Motagua Valley: Illegally collected lizards are sold to private collectors, zoological institutions, and taxidermists. The elevation of this species to CITES I does provide some international protection; however, illegal trafficking remains a significant problem. Ariano estimated that approximately 35 *H. h. charlesbogerti* were taken from their habitat and sold during the 1990s to foreign or local collectors. This estimate was determined by interviewing local people within the range of the species, and reviewing the complaint registry specific to illegal extraction.

GILBERTO SALAZAR

A grant from the Disney Worldwide Conservation Fund provided funding for educational programs during the 2007–8 and 2008–9 school years. The educator pictured here is Antonio Urbino.

GILBERTO SALAZAR

ANTONIO URBINO

Villagers in El Arenal (top) have been working with Zootropic since 2003. In December 2008, Project Heloderma held a small Christmas party for the villagers of El Arenal to thank them for their support.

Another component of the research program involves determining and characterizing actual and potential habitat of *C. palearis*. To this end, information was compiled for specimens preserved in national and international collections. These data were used to produce a map to show the actual and potential distribution of the species in the Motagua Valley. Our investigations also have revealed that poaching is a serious threat to the survival of the Guatemalan Black Iguana. Whereas the local people may occasionally take one or two animals for food, much larger numbers are collected and sold into the pet trade.

In 2007, to inaugurate the protected areas program, we were able to purchase 139 acres within the Motagua Valley thanks to the fund-raising efforts of Zootropic, the IRCF, and ZooAtlanta. The reserve facilitates conservation of vegetation and wildlife, helps conserve streams by protecting trees along the shores of rivers and small streams, and ensures the sustainable growth of wood and timber by preventing illegal logging. Most of all, it provides the Beaded Lizards, Black Iguanas, and other wildlife that inhabit the area an opportunity to exist, assuring them food and shelter. We hope this purchase is the first step toward repopulating surrounding areas with these amazing reptiles, which have been on the verge of extinction. Project Heloderma continues to assess other properties for possible acquisition.

A New Threat Arises

In late 2008, the reserve and its wildlife faced a significant new threat. An open-cast (strip) mining operation for copper, iron, lead, and manganese was proposed for the areas surrounding the reserve. In Guatemala, proposed mining operations require an Environmental Impact Study in which the applicant presents an analysis of potential environmental damage and proposes mitigation measures. This study was presented on 30 September 2008.

In the interim, Project Heloderma asked for a review of the project and presented what is known as Critical Opposition. We found substantial inaccuracies in the environmental impact study, which stated that: (1) The area surrounding the reserve for which the project was proposed lacked any type of forest cover and its main use was as grassland; and (2) The proposed mining would not

JOHN BINNS

Protected land in the Motagua Valley.

JOHN BINNS

Much of the terrain in the protected area is rugged, but portions with less relief had been vulnerable to clearing and development.

affect any animal species, particularly no endangered species, since none were present in the area.

Since Project Heloderma had been conducting research in forestry, biology, and ecology within the area, we were able to present scientific evidence of forest variation and species richness in the reserve and its surroundings. As part of the awareness programs in the area and as a means for letting the mining companies know that the area is critical for the conservation of various species, the perimeter of the reserve was clearly defined. The mere suggestion of mining triggered an escalation in land prices, which has prohibited Project Heloderma from continuing in its efforts to acquire conjoining and other property to expand the protected area.

In February 2009, we were pleased to hear that the mining company had announced that it would be leaving the area, negatively affecting only a small portion of the forest. However, some time will pass before real estate prices settle back to their original value. Project Heloderma will continually monitor real estate opportunities as prices fall.

Captive Breeding

Part of the original charters for both Project Heloderma and Project Palearis involved the development of a captive breeding and headstarting facility to help restore populations of Beaded Lizards and Black Iguanas. We are proud to announce that the first *in-situ* captive reproduction/headstart facility for both endangered species is slated to be in place by the end of 2009. Construction of the center is partly funded by the Tropical Forest Conservation Fund (FCA), which will act as manager of the funds generated by the program "Debt for Nature Swap" between the U.S. government and Guatemala. Other funds derived from international contributions through the efforts of the IRCF and ZooAtlanta will supplement the governmental efforts.

The Heloderma Breeding Center will be designed by Project Heloderma partners, which include civil engineers, forest engineers, and biologists. The center is part of the National Strategy for the Conservation of the Beaded Lizard, which includes reproduction *in-situ* and *ex-situ* as a vital component in the effort to conserve this species. The structure will be built on a quarter-acre site of degraded habitat that is part of the Projects' protected land located at the property's entry point. The cost of construction is estimated at US $25,000.

The center will provide Project Heloderma and Project Palearis with a physical location to implement the study of captive husbandry and reproduction. Current plans are to devote 80% of the breeding area to *Heloderma horridum charlesbogerti* and 20% to *Ctenosaura palearis*. Along with the reproductive facilities, the center will serve as the base for the reserve's permanent staff and as a reception area for eco-tourists and visiting scientists. In order to meet these needs, the center will have a guest room, two bedrooms, a laboratory, a reception area, a bathroom, and reproductive pens for Beaded Lizards and

DANIEL ARIANO

The Heloderma Breeding Center will be built on a quarter-acre site of degraded habitat that is part of the Projects' protected land located at the property's entry point.

BRAD LOCK, ZOOATLANTA

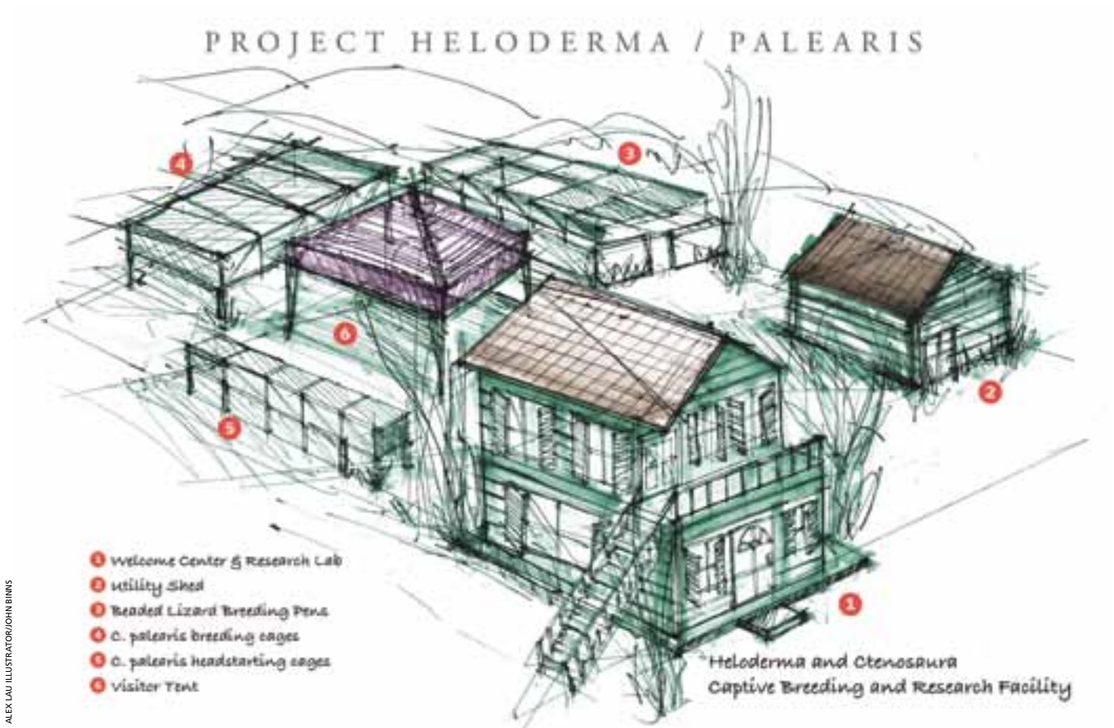
Breeding and husbandry lessons learned at ZooAtlanta will be implemented when the new facility becomes operational.

caged enclosures for Black Iguanas. However, the cost of breeding enclosures is not covered by current expense estimates. Each of the ten enclosures is expected to cost $600.

The 5 X 2-m wire mesh enclosures for *Heloderma* are to be constructed along a dry gulley alongside the station, an area that mimics the microhabitat used by Beaded Lizards during the breeding season. The pens will provide ample shelter, trees for climbing, and natural vegetation, such as *Hechtia guatemalensis* (a ground bromeliad). The tops of the pens will be open, allowing exposure to natural sunlight, as well as the prevailing photoperiod and temperatures. Each pen will be situated so that inhabitants will have no visual contact with their neighbors until the onset of the breeding season. We hope all of these factors will combine to promote breeding behavior.

Construction Options

The two options considered for the construction were mampostery (a type of stone and mortar construction adapted from Spanish building methods) and the use of lignified (compressed) wood. After reviewing bids from three different companies, we found the most attractive and cost-effective option was construction with lignified wood. The proposal by Casas Tipo Canadiense (www.casastipocanadienses.com) fits within the budget (US$21,098) and is a hybrid between two different designs, the Tipica 5B & Tipica 10. These designs include two rooms, a laboratory, one bathroom, and a reception area. A guest room and another bathroom will be added later. The price given by the company is for design, construction, and materials. However, electrical installation, interior walls, and other details are not included. This type of construction is in harmony with the landscape, and provides Projects Heloderma and Palearis with a top-of-the-line, modern center that imposes a minimal visual impact on the surroundings. The Breeding Center will be a world-class attraction, generating substantial scientific interest and a positive economic impact on the area.



ALEX LAU ILLUSTRATOR/JOHN BINNS

In addition to reproductive pens for Beaded Lizards and caged enclosures for Black Iguanas, the center will serve as the base for the reserve's permanent staff and as a reception area for eco-tourists and visiting scientists.

BOOK REVIEWS

Mean and Lowly Things

Mean and Lowly Things: Snakes, Science, and Survival in the Congo. 2008. Kate Jackson. Harvard University Press, Cambridge, Massachusetts. 336 pp., 49 color illustrations and 2 maps. Hardcover — ISBN 13: 978-0-674-02974-3, ISBN 10: 0-674-02974-7. $27.95.

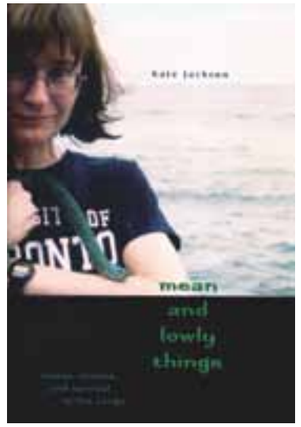
For anyone who has conducted fieldwork in developing nations, this book inevitably brings back memories of one's own experiences. Some of those memories are warm and fuzzy, such as the excitement of discovery, meeting new people who share one's interests and obsessions, and, usually only after one's return, the realization that one has survived another adventure. However, Kate Jackson's tale also awakens recollections of frustration, discomfort, and even danger, at least some of which can be attributed to one's own inexperience or outright stupidity. The synopsis used to promote the book summarizes both quite adequately:

In 2005, Kate Jackson ventured into the remote swamp forests of the northern Congo to collect reptiles and amphibians. Her camping equipment was rudimentary, her knowledge of Congolese customs even more so. She knew how to string a net and set a pitfall trap, but she never imagined the physical and cultural difficulties that awaited her. Culled from the mud-spattered pages of her journals, Mean and Lowly Things *reads like a fast-paced adventure story. It is Jackson's unvarnished account of her research on the front lines of the global biodiversity crisis — coping with interminable delays in obtaining permits, learning to outrun advancing army ants, subsisting on a diet of Spam and manioc, and ultimately falling in love with the strangely beautiful flooded forest.*

The reptilian fauna of the Republic of Congo was all but undescribed, and Jackson's mission was to carry out the most basic study of the amphibians and reptiles of the swamp forest, to create a simple list of the species that exist there — a crucial first step toward efforts to protect them. When the snakes evaded her carefully set traps, Jackson enlisted people from the villages to bring her specimens. She trained her guide to tag frogs and skinks and to fix them in formalin. As her expensive camera rusted and her Western soap melted, Jackson learned what it took to swim with the snakes — and that there's a right way and a wrong way to get a baby cobra out of a bottle.

I have to admit I enjoyed the book. I liked Dr. Jackson's straightforward prose and her matter-of-fact accounts of hair-raising events. However, I also came away with a sense of discomfort, which I attribute largely to the impression that the author, possibly as a consequence of having survived trials and tribulations most of us will never experience, developed a somewhat inflated impression of herself and her contributions to science. I don't want to imply that the latter are inconsequential — establishing baseline data for a poorly known fauna is exceedingly important — but I got the distinct feeling that when Jackson equated her experiences in Africa with those in the United States, the former inevitably lost something in the comparison.

Yes, she experienced "interminable delays" in acquiring permits, largely attributable to local turf battles, an inefficient bureaucracy comprised of elements that never seem to talk to one another, maybe even some corruption, and certainly some instances of individuals wielding their authority only to demonstrate that they could. While this is much less likely to occur in North America, it is a reality in the developing world that can be offset only by fostering the proper local connections over sometimes extensive periods of time. I wanted to see some acknowledgement of that fact, and instead got only one critique after another of how poorly the authorities dealt with her situation.



Also, although she obviously developed an appreciation for the people with whom she worked and maybe even came to like some of them, Jackson spent far more time expressing her exasperation with those who didn't understand what she was doing and sought only to profit in some way from her presence. Rather than explain how foreign she must have appeared to the local populace and how truly bizarre her endeavors were perceived, or even acknowledge how "rich" she was in light of their day-to-day reality, she rants and raves excessively about the profit-mongering and those who merely got in her way. For the most part, I came away thinking that she really didn't enjoy having to interact with folks who weren't like her.

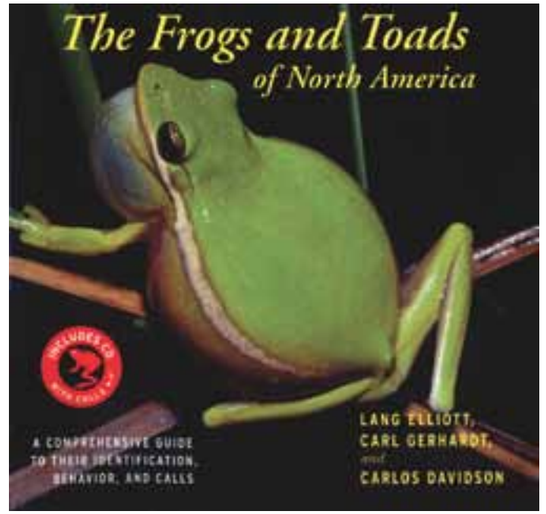
Finally, I was really disturbed by Jackson's interaction with a student who was motivated by accounts of Africa and wanted to venture out on her own. Instead of taking advantage of the student's excitement and enthusiasm to mentor a prospective biologist, she tells her to do it on her own: "'Leaf through the atlas until you find a place you're interested in and then just go there, and figure it out for yourself.' 'That's what I did,' I tell her." After reading about just how she did that, especially considering the difficulties she encountered, I can't figure out why, short of a sadistic streak or an inexcusable pomposity all too frequently associated with academic professionals, she would want to subject anyone to such often unnecessary adversities. Especially in light of the fact that Dr. Jackson is now an educator, I found that episode rather distressing.

Nevertheless, my perceptions of the author's personality aside, she did survive and sometimes thrived under adverse conditions most field biologists will never experience, and reading her account of those adventures is both entertaining and worthwhile. I came away both a bit envious that I'll never be able to lay claim to having endured anything like what Jackson withstood — and glad that I haven't. Everyone with an interest in biodiversity should read this book, if only to begin developing an appreciation of those adventurous scientists whose quest for knowledge provides us with the little we know about the natural world.

BOOK REVIEWS

Wet Places

The Frogs and Toads of North America: A Comprehensive Guide to their Identification, Behavior, and Calls. 2009. Lang Elliott, Carl Gerhardt, and Carlos Davidson. Houghton Mifflin Harcourt, Boston and New York. 344 pp., innumerable color illustrations, distribution maps for all species, and a CD with recordings of calls. Softcover — ISBN 13: 978-0-618-66399-6, ISBN 10: 0-618-66399-1. $19.95.



Legendary turtle conservationist Archie Carr said it best in his book *The Windward Road*: "*I have always liked frogs. I liked them before I ever took up zoology as a profession; and nothing I have had to learn about them since has marred the attachment. I like the looks of frogs, and their outlook, and especially the way they get together in wet places and sing about sex.*"

This exquisitely illustrated field guide is a tribute to that legacy. It provides photographs and descriptions of the 101 currently recognized species of frogs and toads found in the continental United States and Canada. Each species is covered in a minimum of two pages, with common and current scientific names, a range map, and a short discussion of appearance, range and habitat, behavior, and voice. All species accounts are illustrated, some profusely; many show calling males and a number depict color morphs of variable taxa. The most unique feature of this book, however, is the accompanying CD that features recordings of the calls of every species (except the two that never vocalize).

The book begins with a short introduction that features a Sigurd Olson quote that speaks of a "primeval chorus" and, somewhat unexpectedly, a 17th-century haiku. A brief overview of classification (just enough, but not too much) precedes an 11-page synopsis of anuran natural history (itself an introductory course in basic frog biology), a 4-page abstract of evolution and speciation (that addresses some of the challenges to understanding relationships of species in a dynamic world), and a 5-page summary of conservation issues that concludes with a section on "what you can do." Next follow some "miscellaneous explanations" that range from how to coordinate use of the CD with the text to seemingly ever-changing scientific names. The individual accounts follow a list of species and recorded tracks. A section on "finding, observing, catching, and keeping" frogs, another on "the making of the book," acknowledgements, credits, detailed descriptions of the recordings, a list of relevant sources, and an index to species and groups completes the volume.

The only flaws are minor. The size of the book facilitates an appreciation of the remarkable photographs, but resists convenient use in the field — a problem with a "field guide." Also, as is clearly stated in the text, the phenomenally rapid acquisition of new information inevitably results in some scientific names being out of date. By listing newly coined combinations, the authors almost managed to stay ahead of the curve, but very recent work with species previously assigned to the genus *Eleutherodactylus* and the elevation of that group to a family of its own (Eleutherodactylidae) is not reflected, undoubtedly appearing just as this volume was in final production.

I must admit that I was predisposed to like this book. I share a common history with the senior author (Elliott). We learned much of what we know today from the late Dean Metter, whose undergraduate course in herpetology inspired us both. The second author (Gerhardt) served on my graduate committee and, although he probably wondered if I'd ever amount to anything, kindly kept it to himself. Nevertheless, the amount of information, the spectacular photographs, and the recordings speak eloquently to a quality that obviates any biases I may have brought to this review. Every time I open the book, I encounter a photograph that triggers a desire to get out and find frogs. Not only are the images diagnostic (essential for a guide), they provide insights into anuran biology that are better experienced only by spending time in wet places. The authors' invitation to "relax to the choruses of the frogs" speaks for itself. And, who cannot like a book dedicated to its subjects:

"*Last but not least, we applaud the frogs and toads themselves, who have given us the opportunity to celebrate their lives. We trust that humankind will keep their habitats healthy and diverse, so that they forever continue to delight us with their leaping, splashing, and calling.*"

Robert Powell
Avila University
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CONSERVATION RESEARCH REPORTS

Egg Relocation in Loggerhead Turtles

Relocation of eggs is a common strategy for conserving declining reptilian populations around the world. If individuals exhibit consistency in nest-site selection and if nest-site selection is a heritable trait, relocating eggs deposited in vulnerable locations may impose artificial selection that would maintain traits favoring unsuccessful nest-site selection. Conversely, if most individuals scatter nesting effort and individuals that consistently select unsuccessful nest sites are uncommon, then artificial selection would be less of a concern. During the 2005 nesting season of Loggerhead Turtles (*Caretta caretta*) at Mon Repos Beach, Queensland, Australia, **Pfaller et al.** (2009. *Conservation Biology* 23:72–80) measured the perpendicular distance from the original nest site to a stationary dune baseline for *in situ* (unrelocated) and relocated clutches of eggs. They observed the fate of *in situ* clutches and predicted what would have been the fate of relocated clutches if they had not been moved by mapping tidal inundation and storm erosion lines. In 2005, turtles deposited an average of 3.84 nests and did not consistently select nest sites at particular distances from the stationary dune baseline. Selection of unsuccessful nest sites was distributed across the nesting population; 80.3% of the turtles selected at least one unsuccessful nest site and when previous breeding seasons were included, 97% selected at least one unsuccessful nest site. Females with nesting experience selected more successful nest sites than females with little or no experience. Relocating eggs vulnerable to tidal inundation and erosion saves the progeny from a large percentage of the population and the progeny from individuals that may in subsequent years nest successfully. Results suggest that doomed-egg relocation does not substantially distort the gene pool in the eastern Australian Loggerhead stock and should not be abandoned as a strategy for the conservation of marine turtle populations.


NATBIOINFOINSTRASTRUCTURE

Relocating eggs from unsuccessful Loggerhead Turtle (*Caretta caretta*) nest sites should be retained as a strategy for the conservation of marine turtle populations.

Habitat Quality and Landscape Connectivity Promote Persistence of Endangered Natterjack Toads

The Natterjack Toad (*Bufo calamita*) is endangered in several parts of its range, including Belgium, where it occurs mainly in artificial habitats. **Stevens and Baguette** (2009. *Conservation Biology* 22:1194–1204) tested the sensitivity of a model for Natterjack population viability analysis to changes in the values of basic parameters. The authors then assessed the relative efficiency of various conservation measures in two situations: A small isolated population and a system of four populations connected by rare dispersal movements. Simulated Natterjack populations were highly sensitive to habitat quality (particularly pond drying), to dispersal from surrounding local populations, and to a lesser extent to values of fecundity and survival of terrestrial stages. Population trajectories were nearly insensitive to initial abundances, carrying capacities, and the frequency of extreme climatic conditions. The simulations showed that in habitats with highly ephemeral ponds, where premetamorphic mortality was high, Natterjack populations nearly always had a very high extinction risk. The model also illustrated how low dispersal rates (<1 dispersing individual/generation) efficiently rescued declining local populations. Such source-sink dynamics demonstrate that the identification and management of source populations should be a high priority for conserving the species.


PIET SPAANS

Endangered Natterjack Toads (*Bufo calamita*), which often occur in artificial habitats, are highly sensitive to pond drying and opportunities for dispersal from surrounding local populations.

Savanna Snake Invasions into African Rainforest

Freedman et al. (2009. *Conservation Biology* 23:81–92) used a species-distribution modeling approach, ground-based climate data sets, and newly available remote-sensing data on vegetation to investigate the combined effects of human-caused habitat alterations and climate on potential invasions of rainforest by three savanna snake species in Cameroon, Central Africa: Night Adder (*Causus maculatus*), Olympic Lined Snake (*Dromophis lineatus*), and African House Snake (*Lamprophis fuliginosus*).


TRISHA SHEARS

Models with varying sets of data predict different responses of anthropogenic deforestation and climate change on the likelihood of savanna snakes, such as the African House Snake (*Lamprophis fuliginosus*), invading altered African rainforests.

Models with contemporary climate variables and localities from native savanna habitats showed that the current climate in undisturbed rainforest was unsuitable for any of the snake species due to high precipitation. Limited availability of thermally suitable nest sites and mismatches between important life-history events and prey availability are a likely explanation for the predicted exclusion from undisturbed rainforest. Models with only vegetation variables and savanna localities predicted invasion in disturbed areas within the rainforest zone, which suggests that human removal of forest cover creates suitable microhabitats that facilitate invasions into rainforest. Models with a combination of contemporary climate, vegetation variables, and forest and

savanna localities predicted extensive invasion into rainforest caused by rainforest loss. In contrast, a projection of the present-day species-climate envelope on future climate suggested a reduction in invasion potential within the rainforest zone as a consequence of predicted increases in precipitation. These results emphasize that the combined responses of deforestation and climate change will likely be complex in tropical rainforest systems.

Rapid Evolution in the Wild

Rapid evolution caused by human exploitation of wildlife is not usually addressed in studies of such exploitation despite its direct relevance to population persistence. Japanese Mamushi (*Gloydius blomhoffii*), an endemic venomous snake of the Japanese Archipelago, has been heavily hunted by humans, and many populations appear to be declining or are already extirpated. **Sasaki et al.** (2009. *Conservation Biology* 23:93–102) compared local populations that have been hunted regularly with populations that have not been hunted. Mamushi in hunted populations were smaller, had fewer vertebrae, produced more and smaller offspring, had increased reproductive effort among smaller females, fled at greater distances from an approaching human in nature, and were less defensive than Mamushi in unhunted populations, as predicted from life-history theory. Heritability estimates for body size, number of vertebrae, and antipredator behavior were statistically significant, and neonates from hunted sites showed the same distribution of altered characters (compared with those from unhunted sites) as adults. Thus, distribution of the divergent trait between hunted and unhunted sites appeared in part to be genetically based, which suggests rapid evolution in response to human predation pressures. Trait distributions in hunted populations probably deviate from naturally (as opposed to anthropogenically) selected optima and, therefore, may have long-term negative repercussions on population persistence. Because rapid evolution affects a suite of parameters that characterize exploited populations, accurate understanding of the effects of exploitation and effective resource management and conservation can only be achieved if evolutionary consequences are considered explicitly.

WIKIPEDIA

Evidence suggests that Japanese Mamushi (*Gloydius blomhoffii*) respond rapidly to human predation pressures.

Effects of Burning on Reptilian Assemblages in Tropical Savannas

Fire is frequently used for land management purposes and may be crucial for effective control of invasive non-native plants. Nevertheless, fire modifies environments and may affect nontarget native biodiversity, which can cause conflicts for conservation managers. Native Australian reptiles avoid habitat invaded by the alien Rubber Vine (*Cryptostegia grandiflora*) and may be susceptible to the effects of burning, a situation that provides a model system in which to examine possible conservation trade-offs between managing invasive plants and maintaining native biodiversity. **Valentine and Schwarzkopf** (2009. *Conservation Biology* 23:103–113) used replicated, experimental fire treatments (unburned, dry-season burned, and wet-season burned) in two habitats (riparian and adjacent open woodland) to examine the short- (within 12 months of fire) and longer-term (within 3 years of fire) changes in reptilian assemblages in response to wet- and dry-season burning for weed management in tropical savannas of northern Australia. Within 12 months of fire, abundances of the skink *Carlia munda* were higher in the burned sites, but overall reptilian composition was structured by habitat type rather than by effects of burning. Within three years of a fire, however, effects of fire were evident. Reptiles, especially the gecko *Heteronotia binoei*, were least abundant in dry-season burned sites; litter-associated species, including *Carlia pectoralis*, were rarely observed in burned habitat; and fewer species were present in wet-season burned sites. Reptilian abundance was associated with vegetation structure, which suggests that fire-induced changes detrimentally altered the availability of resources for some species, particularly leaf-litter species. Invasive alien plants, such as Rubber Vine, have severe effects on native biodiversity, and control of such species is a fundamental land management objective. Nevertheless, fire management of invasive alien plants may adversely affect native biodiversity, creating a conservation conundrum. In such scenarios, land managers will need to identify the most desired conservation goal and consider the consequences for native biota.

TEEJAYBEE

Geckos (*Heteronotia binoei*) were least abundant in savanna sites subjected to dry-season burning to control invasive alien plants.

Riparian Buffers and Semiaquatic Amphibians

Studies on riparian buffers have usually focused on the amount of land needed as habitat for the terrestrial life stages of semiaquatic species. Nevertheless, the landscape surrounding wetlands is also important for other key processes, such as dispersal and the dynamics of metapopulations. Multiple elements that influence these processes should therefore be considered in the delineation of buffers. **Ficetola et al.** (2009. *Conservation Biology* 23:114–123) analyzed landscape elements (forest cover, density of roads, and hydrographic network) in concentric buffers to evaluate the scale at which they influence stream amphibians in 77 distinct landscapes. Amphibians required buffers of 100–400 m of suitable terrestrial habitat, but interspecific differences in the amount of habitat were large. The presence of amphibians was related to roads and the hydrographic network at larger spatial scales (300–1,500 m), which suggests that wider buffers are needed when these elements are factors. Furthermore, in some cases, analyses performed on different sets of landscapes provided different results, which suggests that caution should be used when conservation recommendations are applied to disparate areas. Establishment of riparian buffers should not be focused only on riparian habitat, but should take a landscape perspective because semiaquatic species use multiple elements for different functions.

SUZANNE L. COLLINS, CNAH

Semiaquatic amphibians, such as Eastern Tiger Salamanders (*Ambystoma tigrinum*) require buffers of suitable terrestrial habitat surrounding wetlands, but interspecific differences in the amount of habitat were large.

Oxapampa Poison Frog Rediscovered

The Oxapampa Poison Frog (*Ameerega planipaleae*) was discovered in 1996 and described in 1998 based on only four specimens from the central Andes of Peru. The species had been reported just once (in 1999) since its discovery. *Ameerega planipaleae* may have the highest elevational range of any dendrobatid frog. Habitat loss and fragmentation at the type locality led to the species being classified as Critically Endangered on the IUCN Red List and by the Peruvian government. This frog is known only from the type locality, and its ecology and natural history are practically unknown.

GERMÁN CHÁVEZ

The Oxapampa Poison Frog (*Ameerega planipaleae*) was rediscovered in 2007 after only one report of its presence since its original description in 1998.

From 2007 to 2009, **Chávez and Enciso** (2009. *Froglog* 91:1–4) surveyed streams and forest habitats at elevations of 1,900–2,300 m. They found the first individual in August 2007 and, since then, have found eighteen additional animals through January 2009. These frogs appear to prefer rocky habitats close to streams and, like other Poison Frogs, are active by day. The call was not recorded and tadpoles are unknown.

The greatest immediate threat to these frogs is habitat degradation caused by agricultural activities, with increasing amounts of agrochemicals in the soil and water. Additionally, garbage is not recycled in this area, and exotic species are present. To date, no evidence of chytridiomycosis exists, but high-elevation anurans associated with mesic habitats appear to be particularly vulnerable to the disease.

Declines in Neotropical Salamanders

Rovito et al. (2009. *Proceedings of the National Academy of Sciences of the United States of America* 106:3231–3236) documented major declines of many species of salamanders at several sites in Central America and Mexico, with particular emphasis on the San Marcos region of Guatemala, one of the best-studied and most diverse salamander communities in the Neotropics. They revealed profound declines of several formerly abundant species, including two apparent extinctions. Terrestrial microhabitat specialists at mid- to high elevations have declined more than microhabitat generalists. These terrestrial microhabitat specialists have largely disappeared from multiple sites in western Guatemala, including well-protected areas, suggesting that the phenomenon cannot be explained solely by localized habitat destruction. Major declines in southern Mexican plethodontid salamanders occurred in the late 1970s to early 1980s, concurrent with or preceding many reported frog declines. The species in decline comprise several major evolutionary lineages of tropical salamanders, underscoring the risk faced by significant portions of the phylogenetic diversity of Neotropical salamanders. These results highlight the urgent need to document and understand Neotropical salamander declines as part of the larger effort to conserve global amphibian diversity.

BROOKE L. TALLEY

Populations in several major evolutionary lineages of Neotropical plethodontid salamanders, such as this *Cryptotriton nasalis* from Honduras, appear to be declining. Such changes need to be documented as part of the larger effort to conserve global amphibian diversity.

Citizen Science: Can Volunteers Do Real Research?

Nationwide, people are volunteering as "citizen scientists," participating as field assistants in scientific studies. Citizen scientists typically don't analyze data or write scientific papers, but they participate in a vital component of the research process. **Cohn** (2008. *BioScience* 58:192–197) explores what volunteers have to offer to scientific research, and why they are valuable tools to the development of science.

FRED BURTON

Citizen scientists use sophisticated techniques to collect data. Here Desiree Wong is radiotracking Grand Cayman Blue Iguanas (*Cyclura lewisi*) in the Salina Reserve.

The idea of working with citizen scientists isn't a new concept. The National Audubon Society's annual Christmas bird count began in 1900, and currently has 60,000–80,000 volunteers who participate. Additionally, citizen scientists are now collecting data such as documenting behavior and identifying plant or animal species, and monitoring air and water quality to assist wildlife biologists, botanists, and land managers.

The scope of what citizen scientists do today is much larger, from the number of volunteers enlisting in studies to the sophisticated techniques they use to collect data. Citizen scientists range in age and profession, and vary from students to teachers and retirees. The use of volunteers allows

scientists to gather data on a larger scale geographically and over a longer period of time, which in turn helps researchers distinguish trends and understand differences among geographic areas. Citizen scientists have largely been able to learn to use equipment and collect results with a reasonable degree of accuracy as long as they are properly trained and are provided with the correct tools, such as guide books and other printed materials. By pairing trained staff and scientists with volunteers, scientists can compare data to determine its reliability, and therefore keep variable data to a minimum.

The science of citizen research is still a work in progress, but it is evident that it has enabled scientists to broaden their scope of study, while getting people involved in the scientific process and enhancing the appreciation of the natural world.

Earlier Breeding of Japanese Amphibians

Reports of declines in amphibian populations from all over the world have been attributed to global climate change. Warming trends affect a wide range of ecological processes, including epidemic diseases in amphibians. Climate change also has led to documented long-term shifts toward earlier breeding in at least some amphibian populations in Europe and North America.

Kusano and Inoue (2008. *Journal of Herpetology* 42:608–614) monitored four breeding populations of three species of Japanese amphibians (*Hynobius tokyoensis*, *Rana ornativentris*, and *Rhacophorus arboreus*) to identify shifts in breeding patterns of amphibians in eastern Asia. The study was conducted at two sites in the suburbs of Tokyo for 12–31-year periods. The authors analyzed long-term data sets for first spawning and correlations between time of breeding and climatic factors. All of the amphibian populations analyzed showed significant trends toward earlier breeding. A relationship between the monthly mean air temperature in February and the dates of first spawning of *H. tokyoensis* showed that as the mean monthly temperature increased, the timing of breeding tended to become earlier.

AOMORIKUMA

Several species of Japanese amphibians, such as the Montane Brown Frog (*Rana ornativentris*), are breeding earlier in the year, a change almost certainly driven by warming climatic conditions.

The advance in dates of first spawning almost certainly is driven by a warming climate. Dates of first spawning were strongly correlated with temperature. However, earlier spawning may not necessarily imply a shift in entire breeding periods, especially if populations are growing. Consequently, some caution in interpreting the results is appropriate. Nevertheless, this study clearly demonstrated that significant long-term trends of warming in the region have affected timing of breeding in some species or populations.

Clearcut Logging Affects Gray Treefrog Tadpole Performance

Clearcutting is a major cause of many declining amphibian populations due to habitat alteration and loss. However, a previous study determined that Gray Treefrogs (*Hyla versicolor*) prefer breeding in ponds in clearcuts near forested habitat rather than in closed canopy ponds. **Hocking and Semlitsch** (2008. *Journal of Herpetology* 42:689–698) examined how biotic and abiotic factors influenced tadpole performance to test the implications of this apparent preference. The study was conducted in the Daniel Boone Conservation Area in Warren County, Missouri. Cattle tanks were set up in clear cuts and control forests at three replicate sites. Each site represented habitats associated with logged forests: Clearcut, clearcut-edge, forest-edge, and forest treatments. Tadpoles were measured during the larval period, size at metamorphosis, and by survival. The authors also evaluated the influence of temperature and food sources, such as periphyton productivity and invertebrate predator abundances.

SUZANNE L. COLLINS, CNAH

Gray Treefrog (*Hyla versicolor*) tadpoles in clearcuts metamorphosed an average of 6.9 days sooner than tadpoles in forested areas.

Tadpoles in the clearcut treatments metamorphosed an average of 6.9 days sooner than tadpoles in forested treatments. The ability to metamorphose quickly from ephemeral ponds in clearcuts may enhance survival, which was 8.5% higher for tadpoles in clearcut than in forest ponds. However, tadpoles in clearcuts tended to be smaller in size at metamorphosis than those in forest treatments. Smaller size can reduce fitness through lower energy stores, delayed reproductive maturity, reduced fecundity of females, and lower survival, and may make them more susceptible to desiccation. Invertebrate predators did not have an influence. Further research should be done to examine the effects of clearcutting on competitive and predatory interactions among amphibians.

Madagascar's Biodiversity Vastly Underestimated

Amphibians are in decline worldwide. However, patterns of diversity, especially in the tropics, are not well understood, mainly because of incomplete information on taxonomy and distribution. **Vieites et al.** (2009. *Proceedings of the National Academy of Sciences*, published online before print 4 May 2009, doi: 10.1073/pnas.0810821106) assessed morphological, bioacoustic, and genetic variation of Madagascar's amphibians, one of the first near-complete taxon samplings from a biodiversity hotspot. Based on DNA sequences of 2,850 specimens sampled from over 170 localities, their analyses revealed an extreme proportion of amphibian diversity, projecting an almost two-fold increase in species numbers from the currently described 244 species to a minimum of 373 and as many as 465. This diversity is widespread geographically and across most major phylogenetic lineages, except a few previously well-studied genera, and is not restricted to morphologically cryptic clades. Results suggest that the spatial pattern of amphibian richness and endemism in Madagascar must be revisited, and current habitat destruction may be affecting more species than previously thought, in amphibians as well as in other animal groups. This case study suggests that worldwide tropical amphibian diversity is probably underestimated at an unprecedented level and stresses the need for integrated taxonomic surveys as a basis for prioritizing conservation efforts within biodiversity hotspots.

DAVID VIEITES

Guibe's Treefrog (*Guibemantis guibei*) is only one of the species that increased the known amphibian diversity on Madagascar from 244 to a minimum of 373 and as many as 465 species.

NATURAL HISTORY RESEARCH REPORTS

Geographic Overlap Drives Reproductive Character Displacement in Frogs

Theoretical models suggest that populations overlapping geographically with different combinations of other species can evolve traits that increase the likelihood of proper mate recognition. When such phenomena occur, they are recognized as examples of reproductive character displacement. **Lemmon** (2009. *Evolution* 63:1155–1170) tested this hypothesis by assessing differences in mating calls (patterns of acoustic signals) in two- and three-species assemblages of Chorus Frogs (*Pseudacris*), focusing in particular on *P. feriarum* and *P. nigrita*, and determined that only the rarer species displayed substantial displacement in this trait (*P. feriarum* in three cases and *P. nigrita* in one instance). Moreover, the three displaced *P. feriarum* populations diverged in different signal traits across the contact zone, evolving in directions that increased the energetic cost of calling over that incurred by populations free from competition. Divergences invariably maximized differences from other species present. Females in the same geographic area also diverged in their preference for mating calls, thus reducing an inclination to hybridize. Together, signal and preference data suggested that interactions between species can promote diversification within species, potentially contributing to reproductive isolation among conspecific populations.

SUZANNE L. COLLINS, CNAH

Upland Chorus Frogs (*Pseudacris feriarum*) modified their calls when found in the same areas with the Southern Chorus Frog (*P. nigrita*).

Lizard Rolls Over to Avoid Sex

In some lizards, females develop bright coloration to signal reproductive status and exhibit behavioral repertoires to incite male courtship and/or reduce male harassment and forced copulation. Sex steroids, including progesterone and testosterone, might influence female reproductive coloration and behavior. **Jessop et al.** (2009. *Journal of Comparative Physiology. A, Neuroethology, Sensory, Neural, and Behavioral Physiology*. Epub.) measured associations among plasma profiles of testosterone and progesterone with variation in color expression and reproductive behavior, including unique courtship rejection behaviors, in female Lake Eyre Dragon Lizards (*Ctenophorus maculosus*). At onset of breeding, progesterone and testosterone increased with vitellogenesis, coincident with color intensification and sexual receptivity, indicated by acceptance of copulations. As steroid levels peaked around the inferred ovulation time, maximal color development occurred and sexual receptivity declined. When females were gravid and exhibited maximal mate rejection behaviors, progesterone levels remained consistently high, while testosterone exhibited a discrete second peak. At oviposition, significant declines in plasma steroid levels, fading of coloration and a dramatic decrease in male rejection behaviors co-occurred. These results indicate a generally concordant association among steroid levels, coloration, behavior, and reproductive events. However, the prolonged elevation in progesterone and a second peak of testosterone was unrelated to reproductive state or further color change, possibly suggesting selection on females to retain high steroid levels for inducing rejection behaviors.

DEVI MEAN STUART-FOX

Male Lake Eyre Dragon Lizards (*Ctenophorus maculosus*) are really persistent, attempting to force females to copulate, harassing them all through the breeding season. Unreceptive females scare off advancing males by taking on a threatening posture. If that doesn't work, they throw themselves on their backs and reveal their bright orange underside. Males can't force themselves onto a female when she's on her back.

Small Snakes Use Active Ant Nests as Hibernacula

Ant mounds offer potential hibernacula both for small snake species and also for juveniles of many species, although this potential may be offset by aggression from ants in active nests and the concomitant

SUZANNE L. COLLINS, CNAH

Snakes, such as Western Worm Snakes (*Carphophis vermis*), that are not adapted for burrowing in dense or rocky soils, might benefit from using active ant nests as hibernacula despite the risk of aggression from ants.

risk of death for snakes, especially juveniles. Despite this risk, **PISANI** (2009. *Transactions of the Kansas Academy of Science* 112:113–118) suggested that such hibernacula may be especially important for snake species not adapted for burrowing in habitats where soils are dense, or rocky, and difficult for snakes to excavate. Thermal characteristics of ant nests appear only to offer snakes access to survivable temperatures below the frost line, rather than temperatures notably warmer than surrounding soils.

Thermal Ecology and Reproduction

The Eastern Massasauga (*Sistrurus catenatus catenatus*) is a viviparous rattlesnake that is a species of "special concern" in Michigan and listed as state-threatened or endangered throughout the rest of its range. Viviparous species typically have unique thermal needs associated with the internal development of young, and these needs can influence vegetation selection patterns. **FOSTER ET AL.** (2009. *Herpetological Conservation and Biology* 4:48–54) investigated the thermal ecology and vegetation selection of female *S. c. catenatus*. They radio-tracked eight gravid and six non-gravid females implanted with temperature-sensitive transmitters in southwestern Michigan during May–August 2004 and 2005. Gravid *S. c. catenatus* generally maintained higher average body temperatures (T_b; 29.1–34.1°C) throughout the season than non-gravid females (22.2–30.8°C), and also maintained plateau temperatures longer in the diel cycle. Gravid females maintained significantly higher mean temperatures above ambient compared with non-gravids early (i.e., May; gravid = 11.7°C; non-gravid = 6.1°C) and late (i.e., July and August; gravid = 7.1°C; non-gravid = 4.9°C) in the season. These results suggest that gravid females were thermoregulating to facilitate embryogenesis. Gravid *S. c. catenatus* selected early/mid-successional deciduous upland vegetation, and these areas had significantly higher mean soil temperatures (19.9°C) than early/midsuccessional wetlands (17.4°C). Therefore, the authors recommended that upland areas adjacent to wetlands supporting *S. c. catenatus* be maintained in early successional vegetation types with limited woody encroachment. This vegetation type provides gravid females with favorable thermal conditions to meet their reproductive requirements.

MICHAEL REDMER

Gravid Eastern Massasaugas (*Sistrurus catenatus catenatus*) maintain higher body temperatures than non-gravid females.

NEWSBRIEFS

Dead Mountain Chickens Litter the Streams of Montserrat

Montserrat's "Mountain Chicken" (not a chicken, but a frog) has become the latest victim of the killer fungal disease that is devastating amphibians worldwide. Only two small pockets of the animals on the tiny Caribbean island remain disease-free. The Mountain Chicken (*Leptodactylus fallax*) is one of the world's largest frogs, and appears on the coat of arms of neighboring Dominica.

Conservationists suspect the chytrid fungus entered Montserrat on small frogs stowing away in consignments of produce from Dominica. "We've always been afraid that frogs coming in banana consignments from Dominica would bring chytrid, and that it would then spread into the center of the island," said John Fa, director of conservation science at Durrell Wildlife Conservation Trust. "The northern populations are closer to the port, and the disease appears to have spread southward along the river systems. Essentially, all populations to the north and north-west of the Centre Hills have been decimated, and there are just two remaining populations of seemingly healthy animals in the southeastern corner." An expedition in 2005 found no sign of fungal infection.

TIM VICKERS

Montserrat's "Mountain Chicken" (*Leptodactylus fallax*) has become the latest victim of the killer fungal disease that is devastating amphibians worldwide.

The frogs are called "Mountain Chickens" because their meat tastes like chicken. On both Montserrat and Dominica — the only places where they now occur naturally — hunting was already impacting populations before the arrival of chytrid. Most of the Montserrat populations also were affected by the volcanic eruptions that began in 1995, although the creation of an "exclusion zone" around the volcano's slopes has provided some help to wildlife by freeing it from human pressures.

Events on Montserrat now appear to be mimicking what happened on Dominica in 2002. Within 15 months of the fungus arriving, about 80% of that island's Mountain Chickens had been wiped out.

First identified just over a decade ago, the fungus (*Batrachochytrium dendrobatidis*) has spread through hundreds of amphibian species on different continents. It sweeps some to extinction in a matter of months, while others are apparently immune. "We still don't know how chytrid kills frogs, and there's some very basic stuff about the biology of the fungus that we need to understand," observed Andrew Cunningham from the Zoological Society of London. "We've known about it for 10 years, but so little money has been spent on it. If this was killing mammals or birds in the same way it's killing amphibians, millions and millions would have been spent on it."

In captivity, chemicals can be used to rid amphibians of the fungus, but no cure for wild populations is known, nor can infected bodies of water be cleansed. As a result, many conservation groups are focusing their energies on establishing captive populations. Durrell and other conservation organizations already have Mountain Chickens in captivity, and will be taking more from the apparently healthy Montserrat populations. In contrast to some other operations, however, it plans to treat and return some frogs to the wild within a couple of years, placing them in areas that appear to be free of chytrid.

Richard Black
Environment Correspondent, BBC News website

Fighting for Forest Frogs

Nineteen species of frogs native to Sri Lanka have gone extinct due to continuing habitat loss essentially caused by smallholder farming activities and logging. Drought and the use of agrochemicals in cardamom cultivation are additional threats. No other country in the world has more documented amphibian extinctions. Therefore, protecting the remaining forests in Sri Lanka is an urgent priority to prevent further losses of species.

The IUCN SSC Amphibian Specialist Group identified a 1,000-hectare cloud forest called Morningside as a top priority because a total of 11 globally threatened amphibians, three endemic lizards, and three species of endemic freshwater crabs are native to this threatened forest. The Morningside Cloud Forest, where Conservation International has now been working for the past five years, is located in southeastern Sri Lanka just east of the Sinharaja World Heritage Site.

The IUCN SSC Amphibian Specialist Group and local partners, including Conservation International, the Wildlife Heritage Trust of Sri Lanka, IUCN Sri Lanka, and the Forest Department of Sri Lanka convinced the government of Sri Lanka to designate all 1,000 hectares of the Morningside Cloud Forest as a Forest Reserve for Biodiversity Conservation, which ensures its protection in perpetuity.

Concerned about the local economy for people in the region around Morningside, IUCN and Conservation International staff are developing and implementing a management plan that targets the sustainable harvest of cardamom within portions of the Morningside Cloud Forest. Cardamom plants, which do not tolerate direct sunlight, are currently grown in the understory of the forest, where cloud forest trees provide necessary shade. However, the cardamom is being grown in a way that is not only incompatible with maintaining a tree canopy, but is also potentially harming threatened frog species in other ways.

The IUCN SSC Amphibian Specialist Group and local partners are now developing and implementing a management plan to enable reserve staff to effectively protect threatened species within Morningside. Because both cardamom plants and threatened species benefit from a healthy cloud forest habitat, the management plan will focus on how to cultivate cardamom efficiently, providing revenue to the local community without negatively impacting cloud forest trees and the threatened species that inhabit the forest.

In addition, the IUCN SSC Amphibian Specialist Group is working with IUCN Sri Lanka to incorporate the Morningside Cloud Forest Reserve within the Sinharaja World Heritage Site, which will help ensure the long-term allocation of funds to protect and manage the species unique to Morningside.

IUCN News story
23 April 2009

Florida Leads the Way for Freshwater Turtles

The Florida Fish and Wildlife Conservation Commission voted unanimously to ban the commercial harvest of freshwater turtles throughout the state on Wednesday, April 15. This move comes after several of the world's leading turtle scientists called on Florida's Governor Charlie Crist to end the commercial hunting of turtles, which supplies eastern Asian food markets. The experts, brought together by the Tortoise and Freshwater Turtle Specialist Group of the IUCN's Species Survival Commission, alerted the Governor that the state's turtles were at high risk of being wiped out by the expanding global trade in turtles that had recently begun to target Florida's fairly robust turtle populations. That trade has been driven by the almost insatiable

CRISTINA MITTERMEIER

Poppy's Shrub Frog (*Philautus poppiae*) is native to Sri Lanka and lives in closed canopy cloud forest. It is classified as Endangered on The IUCN Red List of Threatened Species due to the ongoing decline in the quality and extent of its forest habitat.

SUZANNE L. COLLINS, CNAH

The Florida Fish and Wildlife Conservation Commission voted unanimously to ban the commercial harvest of freshwater turtles throughout the state. Species such as this Florida Softshell Turtle (*Apalone ferox*) are beneficiaries of the new regulations.

demand for turtle meat and medicinal products in Chinese markets and led to the previously destructive Asian turtle trade, which has driven many populations of wild turtles in Asia into near extinction.

Governor Crist demonstrated true conservation leadership by publicly supporting a ban in the turtle trade, and instructed his Wildlife Commission to study the matter carefully and take appropriate action. "This is a great victory for turtle conservation," says Anders Rhodin, Chair of the IUCN's Tortoise and Freshwater Turtle Specialist Group. "The regulations will be the strictest in the U.S. and mean the U.S. is finally facing up to the growing threat of this global consumptive turtle trade. The IUCN Tortoise and Freshwater Turtle Specialist Group was central in helping to achieve this victory."

Turtle biologists such as Matt Aresco first raised warnings about what was happening. "All the scientists who study Florida's turtles are unanimous: We believe that the mass commercial hunting of wild turtles must end," Aresco said in response to the wildlife commission decision.

"If we allowed it, the Chinese — more than one billion Chinese — could and probably would eat every single turtle in existence in Florida in one year," said biologist Dale Jackson. In China, one species of softshell turtle is down to the last two individuals, said Peter Meylan of Eckerd College in St. Petersburg. Scientists said Florida shouldn't wait for turtles there to disappear before taking action.

The Florida commercial turtle harvest ban will be enacted later this year. The draft rule would ban the commercial take or sale of wild freshwater turtles, and would also prohibit taking turtles from the wild that are listed on Florida's endangered species list. In addition, the collection of eggs would be prohibited. Individuals would be allowed to take one freshwater turtle per day per person from the wild for noncommercial use. The transport of more than one turtle per day would be prohibited.

In a letter to the Florida Fish and Wildlife Conservation Commission, the turtle experts said: "The proposed new regulations will provide the best protection for freshwater turtles in any state in the U.S. and establish Florida as a leader on this issue in North America. "Other states are watching Florida," it continued. "As we noted in our earlier letter, Florida is one of the two centers of highest turtle diversity in the world, and it is important that we demonstrate our stewardship of this important natural heritage."

IUCN News story
23 April 2009

Project Heloderma Receives Disney Grant

Project Heloderma and its main partners, the IRCF and ZooAtlanta, received a grant from the Disney Worldwide Conservation Fund in the amount of $24,100. This grant will support the highly effective educational program administered by the project's initiator, Zootropic, for 2009–2010 (see also the Conservation Update on p. 110).

CITES Listing for the *Ctenosaura palearis* Clade

The *Ctenosaura palearis* clade is comprised of four species (*Ctenosaura palearis, C. bakeri, C. oedirhina* and *C. melanosterna*), all with narrow ranges and endemic to eastern Guatemala and the Caribbean versant and Bay Islands of Honduras. In 2004, all four species were listed as Critically Endangered (CR) on the IUCN Red List. These species face a variety of threats, including habitat destruction and over-harvesting for human consumption and the pet trade.

Early this year the CAFTA-DR program of the U.S. Department of the Interior granted support for a proposal by Daniel Ariano, Zootropic, and Stesha Pasachnik, University of Tennessee, to evaluate the potential for listing species in the genus *Ctenosaura* under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Participants listen to a presentation by Daniel Ariano (Zootropic) at the meeting and workshop held in La Ceiba, Honduras to gain support for a proposal to list the entire *C. palearis* clade under the CITES Convention.

Specifically, the goals of the proposal were to determine which CITES Appendix is most applicable for these species and to evaluate the viability of a CITES proposal for only selected species (i.e., *C. palearis* and *C. melanosterna*), for the entire *C. palearis* clade, or the entire genus.

On 8 May 2009, Daniel Ariano, Stesha Pasachnik, and the Bay Islands Foundation hosted a meeting and workshop in La Ceiba, Honduras to gain support for a proposal to list the entire *C. palearis* clade. Scientific and administrative authorities from throughout the country were in attendance. Following the presentation of trade data, participants unanimously supported a decision to list these four species under CITES Appendix II. The proposal now has the full support of both the Guatemalan and Honduran governments, as well as a variety of NGOs. At the end of June, the official CITES proposal will be presented at another meeting with the highest-level government administrators in order to affirm their cooperation.

Editor's Remarks

In concert with our emphasis on conservation and natural history, we feature in this issue articles dealing with some of the world's most endangered frogs, husbandry and breeding of a threatened tortoise, two project with which the IRCF is actively involved, and two dealing with efforts to better understand the biodiversity of life. We also feature two commentaries on topics that should be of interest to all of our readers, changes affecting natural history museums, which have motivated so many scientists over the years, and the ongoing mass extinction, the extent and impact of which we can only imagine at this time.

We are very pleased with the enthusiastic response to the addition of color to our pages, and hope that you enjoy the variety of species and topics addressed. Please feel free to contact any of us with suggestions about articles you'd like to see in future issues.

The Editors of *Reptiles & Amphibians*

CHUCK SCHAFFER

Erratum: The image in *Reptiles & Amphibians*, vol. 16, no. 1, p. 62, labeled "*Cuora amboinensis*" is a photograph of a Bell's Turtle (*Elseya belli*), which is endemic to eastern Australia. A Southeast Asian Box Turtle (*Cuora amboinensis*) is illustrated here. This species is disappearing from parts of Indonesia where it once was common.

STATEMENT OF PURPOSE

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

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

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Save the Pirri Harlequin Frog from Extinction

BILL KONSTANT

Nearly 2,000 amphibian species are threatened with extinction. Most of them are facing threats that can be mitigated in time to prevent their extinction, and we should all continue to support the organizations that are working to protect these species in the wild. However, perhaps 500 species are facing threats (e.g., disease, climate change) that cannot be mitigated in time to save them in the wild. The Amphibian Ark (AArk) selects species that would otherwise go extinct and maintains them in captivity until they can be secured in the wild. Partner organizations around the world already are working with nearly 50 priority species in captivity and continuously working to increase our capacity to save more.

One such project is helping AArk partners in Panama save the Pirri Harlequin Frog (*Atelopus glyphus*). This species occurs in the highlands of extreme eastern Panama in the Serranía de Pirre and the adjacent Chocó region of Colombia. The Pirri Harlequin Frog occurs in two protected parks, yet it has been classified as Critically Endangered by the IUCN and as a priority for rescue by the AArk because of the imminent arrival of the amphibian chytrid fungus. Of approximately 113 species in the genus *Atelopus*, 30 are presumed extinct and only ten can be found in 'stable' populations today. We predict that the Pirri Harlequin Frog will be hit (and possibly driven extinct) by the fungus within five years.

Prospects for success with this species in captivity are high, mainly because preliminary husbandry research conducted at the El Valle Amphibian Conservation Center (EVACC) has shown that they are readily kept and bred. The rescue facility will be a modified, refrigerated shipping container, a cost-effective, biosecurity-friendly system pioneered at the Amphibian Research Centre in Australia. The "amphibian pod" will be established at the Summit Zoo on the eastern side of the Panama Canal. Long-term management of the facility will be the responsibility of a consortium involving multiple institutions, including the Houston Zoo, which established and supports EVACC to the west of the canal.

Saving the Pirri Harlequin Frog from imminent extinction will cost $53,000. This includes $41,000 for the purchase, outfitting, and installation of the facility (e.g., shelves, tanks, lights, generator), and $12,000 for the first year of operation (e.g., staff, live food, veterinary services). The facility will hold approximately 20 wild-caught adult pairs plus a managed group of offspring for a total of about 500 animals required for proper genetic management.

✿ Never before has it been so easy to be a part of preventing an imminent extinction. Please, do your part to save the Pirri Harlequin Frog by sending donations to the Amphibian Ark (www.amphibianark.org).

amphibian ark
2008 YEAR OF THE FROG

JEFF LEMM

The Stout Iguana (*Cyclura pinguis*) once occupied the entire Puerto Rico Bank, but the only surviving natural population lives on Anegada Island in the British Virgin Islands. Captive breeding programs on Anegada and at the San Diego Zoo, where this individual resides, and populations re-established on other islands in the region increase the likelihood that the species will survive the current human-mediated mass extinction. See the Commentary on p. 106.