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About Our Cover: *Zonosaurus maramaintso*

The remarkable herpetofauna of Madagascar remains woefully underexplored. Many species have long been known from single type specimens collected over 100 years ago. However, a resurgence of exploratory interest over the last two decades has yielded new specimens of very poorly known species as well as numerous animals previously undescribed. Among the former is *Zonosaurus boettgeri*, described by Steindachner in 1891 from a single specimen obtained on the island of Nosy Be near the northwestern coast of Madagascar. Field work by Malagasy and American herpetologists beginning in 1993 yielded additional specimens of *Z. boettgeri*, along with new information about its diet and arboreal habits (Raselimanana, Nussbaum, and Raxworthy 2006. *Occasional Papers of the Museum of Zoology, University of Michigan*, No. 739, 16 pp.). Exploration of the Antsalova region in western Madagascar in late 1996 yielded a single specimen of a new species—*Z. maramaintso*, which seems to be closely related to *Z. boettgeri*. Both species are strongly arboreal canopy specialists, restricted to low elevation primary forests. Likely predators include Serpent Eagles, nocturnal lemurs, and arboreal snakes. Apparently rare—or at least rarely observed—*Z. maramaintso* is known only from an imprecise type locality and warrants conservation attention.
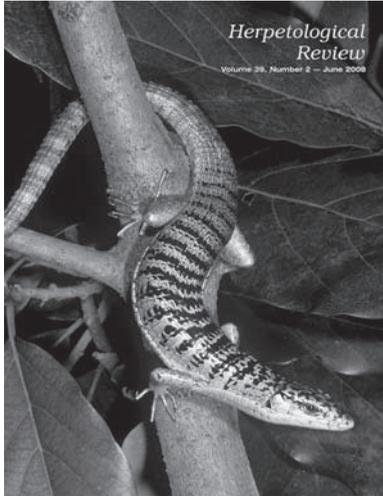
The cover image of *Z. maramaintso* was obtained by **Bill Love** at Olaf Pronk's export compound in Antananarivo. A collector had found the 46 cm long lizard in the Plateau de Bemaraha southwest of the capital, an isolated region of mixed forest and karst limestone ("tsingy") that was virtually unknown herpetologically at the time. Love recorded this image using a Nikon F90X camera with a Nikkor 55mm macro lens, Nikon SB29 ring flash unit, and Fujichrome RVP slide film. Bill is a photographer, writer, lecturer, and ecotour leader through his company Blue Chameleon Ventures (www.BlueChameleon.org). He is perhaps best known for his monthly column in *REPTILES* magazine. Bill resides in rural Lee County, Florida on wild acreage with wife Kathy and their captive colony of corn snakes and other herps.

NEWSNOTES

W. Frank Blair Eminent Naturalist Award

The W. Frank Blair Eminent Naturalist Award recognizes excellence in a lifetime of commitment to outstanding study or conservation of the flora or fauna of the southwestern United States, Mexico, and Central America. For 2007, this award, which is sponsored by the Southwestern Association of Naturalists (SWAN), was given to two herpetologists well known to SSAR members:

PHOTO BY CARL J. FRANKLIN.

PHOTO COURTESY OF KRAIG ADLER.
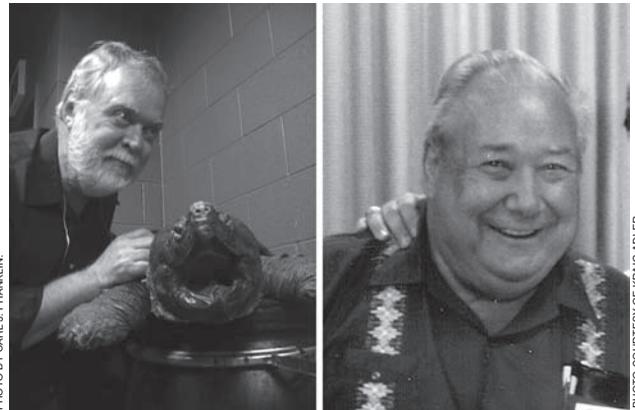
Jonathan A. Campbell (University of Texas at Arlington; above left) and Ernest A. Liner (Houma, Louisiana; above right). The awards were presented at the SWAN annual meeting in Memphis, Tennessee in April 2008. SSAR congratulates Jon and Ernie for this well-deserved recognition.

USGS National Amphibian Atlas

The USGS Patuxent Wildlife Research Center has launched a new website, the National Amphibian Atlas (http://www.pwrc.usgs.gov/naa). This website replaces the former website, ARMI National Atlas for Amphibian Distributions (http://www.pwrc.usgs.gov/armiatlas). The National Amphibian Atlas displays amphibian distribution maps that are a compilation of current and historic records of amphibian occurrences. These maps are based on the original dataset assembled as background for the book edited by Dr. Michael Lannoo, *Amphibian Declines: The Conservation Status of United States Species*. The dataset has been revised to include new information, such as from recent editions of *Herpetological Review* and other sources.

New Features

- Users can select species by common or scientific name
- Maps allow users to zoom in
- Maps display data quality supporting the species occurrence, using 3 color codes to represent museum records, published records, or presumed presence. See website for more information.
- Maps are updated from the former version, which had last been updated in 2004. See Version Information in the Information section for more details.

- Maps will be periodically updated based on data from *Hepetological Review*, Herp Atlases, and other sources.
- Map images can be downloaded for PowerPoint presentations or other uses.

Coming Soon
- Download GIS layers
- View or Download data source information
- Print friendly version of maps

Please help to make better maps

Maps will be periodically updated based on museum and published data, including *Herpetological Review*, Herp Atlas Projects, and other sources. If you have data to contribute, please contact me. All data contributors are credited in the Acknowledgments section on the website.

National Amphibian Atlas website address is: http://www.pwrc.usgs.gov/naa

Contact information:
Linda Weir, USGS Patuxent Wildlife Research Center, 12100 Beech Forest Road, Laurel, Maryland 20708-4038, USA; e-mail: lweir@usgs.gov.

MEETINGS

2008 Gopher Tortoise Council Meeting Announcement and Call for Papers

Please join us for the Annual Meeting of the Gopher Tortoise Council at beautiful Jekyll Island, Georgia, 3–4 October 2008. The meeting will feature a special session on Friday of presentations on Wildlife and Ecosystem Health, with confirmed presentaitons by Elliot Jacobson, Sonya Hernandez Divers, Charles Innis, Steven H. Divers, Terry Norton, John Maerz, Scott Connelly, Nancy Stedman, Lori Wendland, Matt Aresco, Kimberely Andrews, and Greg Lewbart. Saturday the scientific program continues with contributed presentations and posters on any topic relating to the Gopher Tortoise and the Longleaf Pine ecosystem. There will be plenty of time for relaxing and socializing, and enjoying good food and drink at a Low Country Boil Friday night and a Barbecue Saturday night. Also, a tour of the Georgia Sea Turtle Center will be offered Friday evening. For more information and registration information, please visit the Gopher Tortoise Council's website: http://www.gophertortoisecouncil.org/events.php.

Meetings Calendar

Meeting announcement information should be sent directly to the Editor (rwh13@csufresno.edu) well in advance of the event.

CURRENT RESEARCH

The purpose of **Current Research** is to present brief summaries and citations for selected papers from journals other than those published by the American Society of Ichthyologists and Herpetologists, The Herpetologists' League, and the Society for the Study of Amphibians and Reptiles. Limited space prohibits comprehensive coverage of the literature, but an effort will be made to cover a variety of taxa and topics. To ensure that the coverage is as broad and current as possible, authors are invited to send reprints to the Current Research section editors, **Joshua Hale** or **Ben Lowe**; postal and e-mail addresses may be found on the inside front cover.

The current contents of various herpetological journals and other publications can be found at: http://www.herplit.com/contents.

Assessment of Two Antivenoms for Coral Snakes

There are three species of coral snakes within the United States and all are considered extremely lethal. However, as one of them, *Micruroides euryxanthus*, is elusive, only two species, *Micrurus tener tener* and *Micrurus fulvius fulvius*, are considered medically relevant. Medical intervention involves treatment with antivenom, and while no deaths have been reported since antivenom became available, previously 10% of cases proved fatal. The North American Coral Snake Anitvenom (NACSA), produced by the pharmaceutical company Wyeth, was discontinued in 2006, necessitating development of an alternative antivenom. In this study, the authors compared the NACSA with Carolmyn, an antivenom produced by Mexican company Bioclon. The results of a number of trials using laboratory mice demonstrated that *M. f. fulvius* venom was 3.4 times more toxic than *M. t. tener* venom, consistent with past research. Importantly, results indicated that Carolmyn is more effective than NACSA at neutralizing venom from both clinically important coral snake species, with Carolmyn therefore representing a viable replacement for NASCA.

Sánchez, E. E., J. C. Lopez-Johnston, A. Rodriguez-Acosta, and J. C. Pérez. 2008. Neutralization of two North American coral snake venoms with United States and Mexican antivenoms. Toxicon 51:297–303.

Correspondence to: Elda E. Sánchez, Natural Toxins Research Center, 975 W. Avenue B, MSC 158, Texas A & M University-Kingsville, Kingsville, Texas 78363, USA; e-mail: elda.sanchez@tamuk.edu.

Prey-specific Predatory Behavior in a Snake

In predator-prey relationships, selection is generally much stronger on the prey, which may lose its life, than on the predator, which is only risking a meal. However, this situation is different when the prey is toxic. The Floodplain Death Adder, *Acanthophis praelongus*, from Northern Australia, feeds primarily on frogs. Of these frogs, some are non-toxic, like *Litoria nasuta*, others secrete sticky mucous, like *Limnodynastes convexiusculus*, and one species, *Litoria dahlia,* is highly toxic. Observation trials revealed that adders consume these prey items in different and specific ways. While non-toxic prey were consumed immediately, other taxa were envenomated, released, and consumed at a later time. As the toxins and glue-like mucous degrade within about 20 minutes, adders circumvent prey defenses by delaying consumption. The authors suggest that this highly specific predatory behavior is a consequence of the selective asymmetry operating on the predator and prey.

PHILLIPS, B., AND R. SHINE. 2007. When dinner is dangerous: toxic frogs elicit species-specific responses from a generalist predator. The American Naturalist 170:936–942.

Correspondence to: Ben Phillips, School of Biological Science A08, University of Sydney, Sydney, NSW 2006, Australia; mail: bphi4487@mail.usyd.edu.au.

Traffic Noise Masks Frog Calls

As reproduction in anurans is highly dependent on auditory communication, they are particularly vulnerable to anthropogenic noise which may interfere with calling behavior. Road traffic is a common source of anthropogenic noise. In this study, the authors tested the impact of traffic noise on acoustic signaling in the Grey Treefrog, *Hyla chrysoscelis*, in Minnesota. Females in amplexus were collected in the field and transported to the laboratory where they underwent a number of phonotaxis trials. Females were presented with recorded calls at one of nine signal levels (37–85 dB at 6 dB increments), without background noise, with a simulated chorus, or with recorded traffic noise. In trials where the signal was masked by traffic noise or the simulated chorus, females took longer to respond (by moving toward the signal source), and only responded to relatively loud signals. Although anthropogenic noise may significantly interfere with acoustic signaling in anurans, the authors suggest that more study is required to understand how plastic behavioral or physiological responses may potentially overcome this interference.

BEE, M. A., AND E. M. SWANSON. 2007. Auditory masking of anuran advertisement calls by road traffic noise. Animal Behaviour 74:1765–1776.

Correspondence to: Mark A. Bee, Department of Ecology, Evolution, and Behavior, University of Minnesota, 100 Ecology, 1987 Upper Buford Circle, St. Paul, Minnestoa 55108, USA; e-mail: mbee@unm.edu.

Survey of Chytrid Fungus in Hong Kong

Chytridiomycosis has been implicated in the decline and extinction of a number of amphibian species globally. *Batrachochytrium dendrobatidis*, the pathogen that causes Chytridiomycosis, is present in wild populations on every continent except Asia. However, little research has been completed in this region. For this study, the authors conducted a large scale survey for *B. dendrobatidis* in Hong Kong, the first systematic survey of this type undertaken in Asia. Four species of native amphibians, considered at high risk of infection, were examined, with none of the 274 individuals testing positive to *B. dendrobatidis* infection. A large number of amphibians are imported into Hong Kong each year as part of the pet and food trade representing a possible means of pathogen transmission. Despite this, the authors did not detect *B. dendrobatidis* on any of the 137 imported amphibians sampled. The authors concluded that, until it is confirmed that *B. dendrobatidis* is present in Hong Kong, management effort should be targeted at preventing it from entering the country and spreading into wild populations.

ROWLEY, J. J. L., S. K. F. CHAN, W. S. TANG, R. SPEARE, L. F. SKERRATT, R. A. ALFORD, K. S. CHEUNG, C. Y. HO, AND R. CAMPBELL. 2007. Survey for the amphibian chytrid *Batrachochytrium dendrobatidis* in Hong Kong in native amphibians and the international amphibian trade. Diseases of Aquatic Organisms 78:87–95.

Correspondence to: Jodi Rowley, School of Marine and Tropical Biology and Amphibian Disease Ecology Group, James Cook University Townsville, Queensland, Australia 4811; e-mail: jodi.rowley@gmail.com.

Convergence on Ultrasonic Communication in Southeast Asian Frogs

Odorrana tormota (previously *Amolops tormotus*), is the first non-mammalian vertebrate demonstrated to communicate with ultrasound. It is also one of two anuran species that possess tympanic membranes embedded in the skull, similar to mammals. Like *O. tormota*, the other anuran with sunken tympana, *Huia cavitympanum*, is both a southeast Asian member of the family Ranidae, and calls near rushing streams. However, they are not related at the generic level, and their distributions do not overlap. In this study, the authors investigated calls of *H. cavitympanum*, to determine if this species also communicates using ultrasound. Analysis of recordings of spontaneous male calls indicated that this species produces a number of high frequency calls, some of which are entirely ultrasonic. Along with the Blue-throated Hummingbird, *H. cavitympanum* is the only other non-mammalian vertebrate to produce purely ultrasonic vocalizations. The authors suggest that the convergence of call characteristics between *O. tormota* and *H. cavitympanum* may be a response to their calling environment, which is dominated by low frequency ambient stream noise. The authors also suggest that ultrasonic vocalization may confer an energetic advantage.

ARCH, V. S., T. U. GRAFE, AND P. M. NARINS. 2008. Ultrasonic signaling by a Bornean frog. Biology Letters 4:19–22.

Correspondence to: Peter M. Narins, Department of Ecology and Evolutionary Biology and Department of Physiological Science, University of California, Los Angeles, 621 Charles E. Young Drive S., Los Angeles, California 90095, USA; e-mail: pnarins@ucla.edu.

Species, Rather Than Body Size, Determines Social Dominance in Lizards

Large body size often confers a significant advantage in both intra- and interspecific resource competition, generally indicating superior fighting ability or strength. This has proven problematic to confirm experimentally, because if the dominant taxon consists solely of individuals larger than the subordinate taxon, then separating the influence of species from the influence of size becomes difficult. In this study, the authors separated the influence of species identity and body size in interspecific interactions by conducting laboratory shelter-choice trials using five sympatric montane skink species from southeastern Australia: *Egernia cunninghami, Egernia saxatilis, Egernia whitii, Eulamprus heatwolei,* and *Eulamprus tympanum.* Combinations of juveniles and adults from a number of the species were forced to compete for a desirable resource (in this case a 'hot' shelter maintained at 36.5°C, in contrast to a 'cold' shelter at 21°C). Interestingly, juveniles of larger species were as successful as conspecific adults at deterring adults of smaller species, even when much smaller than the adults they displaced. Analysis of bite force confirmed that juveniles posed limited threat to large heterospecifics. The authors conclude that in this system, species identity is more important than body size in determining interspecific dominance.

LANGKILDE, T., AND R. SHINE. 2007. Interspecific conflict in lizards: social dominance depends upon an individual's species not its body size. Austral Ecology 32:869–877.

Correspondence to: Tracy Langkilde, Department of Biology, 208 Mueller Laboratory, The Pennsylvania State University, University Park, Pennsylvania 16802, USA; e-mail: t1130@psu.edu.

Identifying Divergent mtDNA Lineages in a Lizard

Molecular research on hybrid zones has primarily focused on mtDNA, which displays substantial variation both between and within species. However, large scale sequencing is both costly and labor-intensive. In this study, the authors developed a quick, cost effective polymerase chain reaction (PCR)-based method to identify divergent lineages within a contact zone in a North American lizard, eliminating the need to sequence large numbers of individuals. Two highly divergent clades of the Side-blotched Lizard, *Uta stansburiana*, form a contact zone on the peninsula of Baja California in northwestern Mexico. The authors used lineage-selective primers generated from sequence data from 15 individuals to amplify a PCR product diagnostic of each of the two mitochondrial lineages. This assay was then applied to an additional 132 specimens from a transect spanning the contact zone to identify mitochondrial lineages. The authors suggest that this cost effective and reliable technique could be used in other species where diagnostic lineage variation occurs.

LINDELL, J., AND R. W. MURPHY. 2008. Simple identification of mitochondrial lineages in contact zones based on lineage-selective primers. Molecular Ecology Resources 8:66–73.

Correspondence to: Johan Lindell, Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks Street, Toronto, Ontario, Canada M5S 3B2; e-mail: johan.lindell@utoronto.ca.

Cost of Phenotypic Plasticity in the Wood Frog

Phenotypic plasticity can allow an organism to respond to temporal changes in its environment; however, plastic responses in one trait can have negative fitness consequences for another. In this study, the authors examined the impact of a plastic trait expressed at the larval stage on post-metamorphic fitness in the Wood Frog, *Rana sylvatica*. This species breeds in temporary ponds, and can accelerate larval development to avoid desiccation, but this has potential impacts on postmetamorphic immune functioning. To examine this, tadpoles housed in the laboratory were exposed to one of four desiccation treatments. Subsequently, individual immune function was assessed by administering a single phytohaemagglutinin (PHA) injection, which causes inflammation around the injection point, with greater inflammation representing a stronger immune response. Leucocyte counts were also conducted to assess immune functioning. Tadpoles exposed to desiccation developed faster than those from control conditions, but had reduced postmetamorphic immune functioning, as determined by both the PHA injection and leucocyte counts. The authors suggest that this reduction in immune functioning may result from a trade-off between rapid development of traits essential for terrestrial life and traits that may not be immediately important. While the duration of immune depression is currently unknown, the authors suggest that even a temporary period may be highly costly to individuals following metamorphosis.

GERVASI, S. G., AND J. FOUFOPOULOS. 2008. Costs of plasticity: responses to desiccation decrease post-metamorphic immune function in a pond-breeding amphibian. Functional Ecology 22:100–108.

Correspondence to: Stephanie Gervasi, Department of Zoology, Oregon State University, 3029 Cordley Hall, Corvallis, Oregon 97331, USA; e-mail: gervasis@science.oregonstate.edu.

Maternal Care in the Dwarf Newt

Most amphibian species do not demonstrate parental care, and there is an extremely high mortality at aquatic larval stages. However, females of the Dwarf Newt, *Triturus pygmaeus*, from the Iberian Peninsula, may indirectly affect embryonic survival by wrapping their eggs in leaves from aquatic plants. In this study, the authors investigated whether wrapping protects the eggs from contamination by ammonium nitrate, a compound commonly found in fertilizer, and water acidification. First, females were collected in the field (N = 54) and exposed in the laboratory to one of three treatments; water containing ammonium nitrate, acid water or a control treatment. Results indicated that low pH altered oviposition behavior, with the percentage of wrapped eggs lower in the

acid water treatment than in the controls. Second, to investigate the impact of egg wrapping on embryonic survival, pre-wrapped eggs were either unwrapped or left wrapped and then exposed to the three water treatments. In the ammonium nitrate treatment, unwrapped eggs suffered higher mortality than wrapped eggs, but there was no difference in the other treatments. The authors suggested that more research is needed to understand the complex interrelatedness between water pollution and egg wrapping behavior in this species.

ORTIZ-SANTALIESTRA, M. E., A. MARCO, M. J. FERNÁNDEZ-BENÉITEZ, AND M. LIZANA. 2007. Effects of ammonium nitrate exposure and water acidification on the dwarf newt: the protective effect of oviposition behavior on embryonic survival. Aquatic Toxicology 85:251–257.

Correspondence to: Manuel Ortiz-Santaliestra, Department of Animal Biology, University of Salamanca, Campus Miguel de Unamuno, Salamanca 37007, Spain; e-mail: meortiz@usal.es.

Costs of Tail Autotomy in the Cape Dwarf Gecko

The survival benefits of tail autotomy to avoid predation are well established; however, the loss of other tail functions may be costly. In this study, the authors compared the locomotor performance of autotomized and intact Cape Dwarf Geckos, *Lygodactylus capensis*, from Pretoria, South Africa. Intact geckos were tested for escape speed and distance, across both horizontal and vertical surfaces. Geckos were subsequently autotomized and retested. Results of repeated measures ANOVA demonstrated that autotomized geckos were slower than intact geckos on the vertical surface, but that there was no difference in performance on the horizontal surface. The authors propose that the observed differences in performance reflect the tail's importance in supporting the body against the vertical surface. The authors also suggested that the tail may not be of great use in horizontal movement, although more research is required. Finally, the authors discuss the impact of autotomization on behavior, suggesting that autotomized geckos may select denser, more horizontal habitats, to maximize escape speed and avoid predation.

MEDGER, K., L. VERBURGT, AND P. W. BATEMAN. 2008. The influence of tail autotomy on the escape response of the Cape Dwarf Gecko, *Lygodactylus capensis*. Ethology 114:42–52.

Correspondence to: Phillip Bateman, Department of Zoology and Entomology, University of Pretoria, Pretoria 0002, South Africa; e-mail: pwbateman@zoology.up.ac.za.

ZOO VIEW

"CROCODILIANS MAY PERHAPS LIVE TO A GREAT AGE: PROBABLY LONGER IN THE SHELTERED CONDITIONS OF CAPTIVITY THAN WHEN EXPOSED TO THE ACTIVE, COMBATANT, COMPETITIVE CAREER THAT IS THEIRS IN NATURE."

——MAJOR STANLEY SMYTH FLOWER (1925)

Crocodiles may have been the first zoo animals and they remain mysterious, frightening, yet popular with visitors, due to their large size, predatory habits, and occasional attacks upon humans. In my opinion, the most significant zoo program with crocodilians has been the one at the Bronx Zoo/Wildlife Conservation Society. There have been a number of crocodilian papers on a variety of topics, mostly by F. Wayne King, Herndon Dowling, John Behler, Peter Brazaitis, George Amato, and John Thorbjarnarson. One example is the publication by Dowling and Brazaitis (1966), who recorded size and growth of American and Chinese alligators, and Black Caiman, with extensive data on the Nile Crocodile. They provided a table of weight-length measurements for 14 species. In addition to the titles listed in the paper here by Peter Brazaitis and Joe Abene, staff members at the Zoo have published the following studies, focusing in large part on the protection and conservation of these endangered animals.

BEHLER, J. 1978. Feasibility of the establishment of a captive-breeding population of the American crocodile. National Park Service Report T-509, 94 pp.
———, AND D. A. BEHLER. 1998. Alligators & Crocodiles. Voyageur Press, Inc., Stillwater, Minnesota.
———, AND F. W. KING. 1979. The Audubon Society Field Guide to North American Reptiles and Amphibians. Alfred A. Knopf, Inc., New York.
BRAZAITIS, P. 1969. Determination of sex in living crocodilians. Brit. J. Herpetol. 4:54–58.
———. 1969. Occurrence and ingestion of gastrolith in two crocodilians. Herpetologica 25:63–64.
———. 1981. Maxillary regeneration in a marsh crocodile, *Crocodylus palustris*. J. Herpetol. 15:360–362.
———. 1982. International Union for Conservation of Nature and Natural Resources. Red Data Book, Brian Groombridge (ed.). Species accounts of eight species of endangered South American crocodilians.
———. 1983. Crocodiles as a Resource for the Tropics. National Academy of Sciences, Washington, D.C. Revision and update: 3 May 1996.
———. 1984. The U.S. trade in crocodilian hides and products, a current perspective, p. 103–107. Proc. 6th Working Meet., IUCN/SSC Crocodile Specialist Group, Victoria Falls, Zimbabwe and St. Lucia Estuary, Repub. South Africa, Sept. 19–30, 1982.
———. 1984. Problems in the identification of commercial crocodilian hides and products, and the effect upon law enforcement, p. 110–116. Proc. 6th Working Meet., IUCN/SSC Crocodile Specialist Group, Victoria Falls, Zimbabwe and St. Lucia Estuary, Repub. South Africa, Sept. 19–30, 1982.
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———. 1986. Reptile leather trade: the forensic science examiner's role in litigation and wildlife law enforcement. J. Forensic Sci. 31:621–629.
———. 1986. Biochemical techniques: new tools for the forensic identification of crocodilian hides and products, p. 384–388. Proc. 7th Working Meet., IUCN/SSC Crocodile Specialist Group, Caracas, Venezuela Oct. 21–28, 1984.

Imagining that larger crocodilians can attack, kill and eat them with gusto, these impressive reptiles have always fascinated zoo visitors. From *Histoire naturelle de Lacépède, comprenant les cétacés, les quadrupèdes ovipares, les serpents et les poissons* by Bernard Germain Etienne de La Ville sur Illon La Cépède (Count de Lacepède) in 1860. Imprint: Paris, Furne, 1860.

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———. 1990. Trade in crocodilian hides and products in the USA. Traffic USA 10(2):4–5.

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———. 2003. You Belong in a Zoo. Tales from a Lifetime Spent with Cobras, Crocs, and Other Creatures. Villard Books, New York.

———, G. Amato, G. H. Rêbelo, C. Yamashita, and J. Gatesy. 1993. Report to CITES on the biochemical systematics study of Yacare caiman, *Caiman yacare* of central South America, Office of CITES Secretariat, Lausanne, Switzerland.

———, and T. Joanen. 1984. Report on the status of the captive breeding program for the Chinese alligator *Alligator sinensis* in the United States. Proc. 6th Working Meet., IUCN/SSC Crocodile Specialist Group, Victoria Falls, Zimbabwe and St. Lucia Estuary, Repub. South Africa, Sept. 19–30, 1982, pp. 117–121.

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———, and M. E. Watanabe. 1982. The Doppler, a new tool for reptile and amphibian hematological studies. J. Herpetol. 16:1–6.

———, and ———. 1990. Los crocodylia en Venezuela—un recurso natural renovable no aprovechado. Natura 88:34–39.

———, ———, and G. Amato. 1998. The caiman trade. Sci. Amer. 278(3):53–58.

———, and M. Wise. 1994. Conservation of commercially important reptiles today: an analysis based on crocodilians. *In* J. B. Murphy, K. Adler, and J. T. Collins (eds.), Captive Management and Conservation of Amphibians and Reptiles, pp. 209–221. Society for the Study of Amphibians and Reptiles. Contributions to Herpetology, volume 11, Ithaca, New York.

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Campbell, H. W. 1973. Observations on the acoustic behavior of crocodilians. Zoologica (New York) 58(1):1–11. [acoustic behavior in the American alligator and crocodile, and black and spectacled caimans.].

Dowling, H. G. 1968. The karyotype of the Chinese alligator (*Alligator sinensis*). Mamm. Chromosomes Newsl. 9:81–82.

Hornaday, W. T. 1993. The Experiences of a Hunter and Naturalist in the Malay Peninsula and Borneo. Oxford Univ. Press, Kuala Lumpur, Malaysia. [originally published in 1883].

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THORBJARNARSON, J. 1986. The present status and distribution of *Crocodylus acutus* on the Caribbean island of Hispaniola. Crocodiles: Proc. 7th Working Meeting of the IUCN/SSC Crocodile Specialist Group, Caracas, Venezuela, pp. 195–202. IUCN Publ. N.S., Gland, Switzerland.

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—*James B. Murphy, Section Editor*

A History of Crocodilian Science at the Bronx Zoo, Wildlife Conservation Society

PETER BRAZAITIS
Department of Vertebrate Zoology, Yale Peabody Museum of Natural History
170 Whitney Avenue, P.O. Box 208118
New Haven, Conneccticut 06520-8118, USA
e-mail: croc1@99main.com

and
JOE ABENE
Department of Herpetology, WCS/Bronx Zoo
2300 Southern Blvd., Bronx, New York 10460-1099, USA

Crocodilians have been an important element of the reptile collections at the Bronx Zoo since the original plans for the New York Zoological Park and a reptile house were finalized and set into motion on September 27, 1897. However, the history and evolution of crocodilian science at the Bronx Zoo does not stand alone. It is an inseparable part of the discoveries and achievements that were taking place in a wide range of scientific disciplines by new generations of scientists in many places at the same time. Table 1 provides a time line of crocodilian history and reproduction at the Bronx Zoo from 1900 to the present.

Throughout the 1800s, scientific collections of crocodilians, and the scholars who studied and wrote about them, resided largely in museums and universities located in the world's major cities. Collections included fossils, preserved carcasses, skulls, bones, and dried skins, often collected during expeditions to remote regions of the world. Crocodilians had not escaped the scrutiny of the scientific community and there was a wealth of biological information published in scientific journals and books (Brisbin 1986). Yet, what we knew about crocodilians predominantly involved paleontology, taxonomy, anatomy, and osteology. Despite the existence of fewer than two dozen known species, some of which might grow to lengths in excess of 6 m and regularly eat people, crocodilian species identification was based largely on skulls (Boulenger 1889; Mertens 1943; Mook 1921; Wermuth and Mertens 1961,

TABLE 1. Time-line history of crocodilian science at the Bronx Zoo.

Year	Event
1898	Raymond L. Ditmars, Curator (1898–1942)
1898	Bronx Zoo reptile house opens with American Alligators
1933	Hatched American Alligator eggs taken from the wild
1933	Mixed crocodilian collection exhibited (first time)
1944	John Tee-Van, interim Curator (1943–1945)
1945	Brayton Eddy, Curator (1945–1950)
1951	Dr. James A. Oliver, Curator (1951–1958)
1953	Reptile house renovated for the first time
1954	Peter Brazaitis, tenure as Keeper/Superintendent (1954–1988)
1954	Reptile house reopens with adult American Alligators as central exhibit
1957	Mixed collection emerges
1958	Herndon G. Dowling, Curator (1958–1967)
1960	Four large American Alligators leave reptile house
1960	Smooth-fronted Caiman, *Paleosuchus trigonatus*, unanticipated breeding
1962	Reptile house renovated second time
1963	Crocodilian sexing technique developed (Brazaitis 1966)
1964	First museum quality record keeping system (Dowling and Gilboa 1968)
1964	First attempt to breed Chinese Alligators, *Alligator sinensis*
1965	West African Dwarf Crocodile, *Osteolaemus tetraspis*. unanticipated breeding
1966	Endangered Species Act, amended 1969, 1981, 1988
1966	Crocodilian size and growth documented (Dowling and Brazaitis 1966)
1967	Dr. F. Wayne King, Curator (1967–1973)
1970	First crocodilian genetics study (Cohen and Gans 1970)
1971	Species identification of crocodilian hides and products (King and Brazaitis 1971)
1971	IUCN Crocodile Specialist Group founded
1973	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
1973	Comprehensive identification account of living crocodilians (Brazaitis 1973a)
1973	Identity of *Crocodylus siamensis* confirmed (Brazaitis 1973b)
1973	John L. Behler, Curator (1973–2006)
1974	Second floor renovated to include crocodilian rearing facilities
1977	First successful breeding of Chinese Alligator, *Alligator sinensis* (Behler and Brazaitis 1982)
1977	Les Garrick, Crocodilian behavior studies (Garrick and Lang 1977)
1979	Crocodilian diets modified; improved 1981
1979	First Mugger Crocodile, *Crocodylus palustris* reproduction
1980	Yacare Caiman, *Caiman yacare*, bred (Brazaitis 1986)
1980	Captive breeding protocols implemented/breeding calendar
1980	Chinese Alligator SSP/studbook initiated to coordinate breeding efforts
1980	Siamese Crocodiles, *Crocodylus siamensis*, bred (Brazaitis and Watanabe 1983)
1981	West crocodilian pools retrofitted for multi-species breeding
1981	Black light/Vita light protocols initiated (Townsend and Cole 1985)
1983	Ultrasound scanning of *C. siamensis* eggs (Brazaitis and Watanabe 1983)
1983	Cuban Crocodile, *Crocodylus rhombifer*, bred
1985	Malayan False Gharial, *Tomistoma schlegelii*, bred (Brazaitis 1999)
1986	AZA Crocodilian Advisory Group founded
1988	William Holmstrom, Collection Manager (1988–present)
1988	Dwarf Caiman, *Paleosuchus palpebrosus*, bred
1989	Broad-snouted Caiman, *Caiman latirostris*, bred
2006	Dr. Jennifer Pramuk, Curator (2006–present)

1977; Werner 1933). Medem and Marx (1955) provided one of the first keys to the living New World species of crocodilians. Comprehensive papers on the species identification of living crocodilians, directed toward live animals and visible physical morphology, appeared in the 1970s (Brazaitis 1971, 1973a, 1973b).

What appeared to be lacking were behavioral, natural history, and reproductive data. One of the earliest comprehensive reports on observations and natural history of a crocodilian was made by E. A. McIlhenny of Louisiana in his classic work, *The Alligator's Life History*, first published in 1935, and reprinted in 1987. McIlhenny reported shooting and killing one of the largest wild alligators ever recorded, 584 cm in length, on January 2, 1890.

Probably the most knowledgeable group of crocodilian experts of the 1800s and early 1900s was composed of the hide hunters and crocodilian skin dealers who derived their livelihoods and profits from knowing where and when to find crocodiles. They had to know basic crocodilian behavior and habits if they were to avoid being killed or maimed during the course of their dangerous nightly work of hunting crocodiles. Some crocodile entrepreneurs put their knowledge to use to short-circuit the problem of having to spend numerous uncomfortable nights in mosquito-infested swamps to capture only a handful of crocodiles, or none, by starting crocodile farms in the hope of breeding the animals and increasing manyfold the number of skins they could have available to sell. Rather than sharing their knowledge, much of what they knew about crocodilian reproduction and behavior was kept secret, lest a competitor out-produce them.

Collections of living crocodilians were generally confined to considerably less than natural circumstances of captivity in private roadside attractions, circuses, and zoos, and they were managed by entertainment entrepreneurs. The Saint Augustine Alligator Farm, St. Augustine, Florida, opened to the public in May, 1893, is the oldest major exhibitor of crocodilians in the United States. The name is a misnomer as it was never a "farm" for breeding and producing alligators. The Alligator Farm, as it is still locally referred to, is now a registered national historical site and exhibits all of the 23 generally accepted species of crocodilians under natural conditions. The Alligator Farm is considered a world center for crocodilian study, reproductive biology, and conservation, and serves as an important repository and bank for crocodilians that are potentially part of captive endangered species breeding programs.

Zoos probably contributed least to the then-known lexicon of crocodilian knowledge. Space was limited and better devoted to large mammals and colorful birds that were more in the public or zoo director's interest. In the 1800s, exotic birds already enjoyed a great scientific following, augmented by a global cadre of serious collectors and breeders of live birds, who produced a wealth of scientific and popular writings. We knew a lot about birds and mammals, including that crocodiles were prone to eat some of our favorite species. Reptiles, including crocodilians, were usually reviled by the average zoo visitor, who wished only to see them
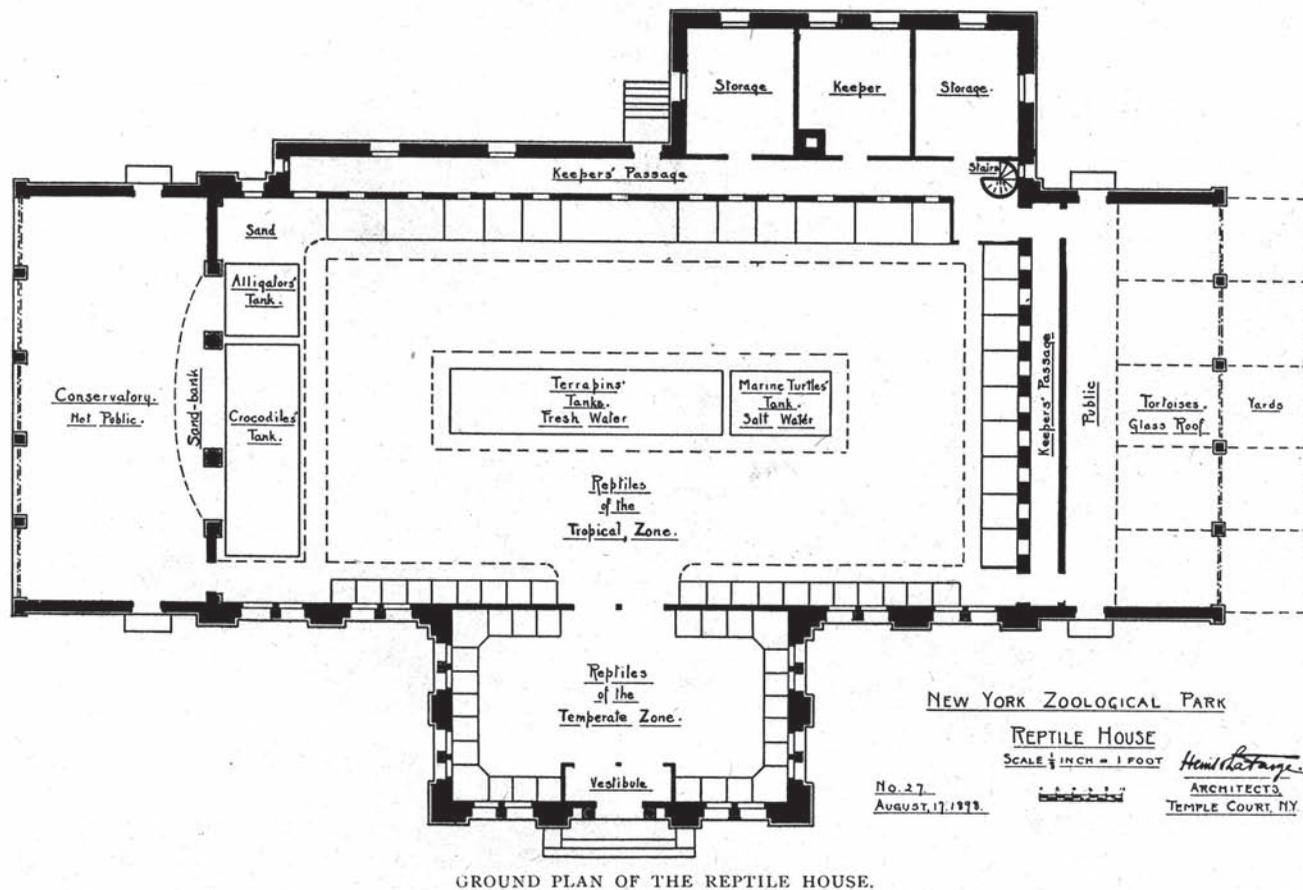
GROUND PLAN OF THE REPTILE HOUSE.

FIG. 1. Original floor plan of the reptile house. The alligator pools are major exhibits at the left, at the west end of the building. They are referred to as "The West Pools."

FIG. 2. The Reptile House at the Bronx Zoo as it appeared in 1898. West pools conservatory is to the left.

out of curiosity as ferocious potential man-eaters. It was generally held, even by the curatorial staff, that as crocodilians inhabited the warm tropical and sub-tropical wetlands of the world, they could be exhibited only at considerable cost in space and utilities if they were to be kept alive at all, especially in northern climates. Certainly, they would not reproduce.

A House for Reptiles in New York City

The Reptile House at the Bronx Zoo was one of the first buildings to be constructed in the newly chartered New York Zoological Park. Opened to the public in 1898, the Reptile House was immediately of immense popularity with the general public. Curator Raymond L. Ditmars (1899–1942) wrote in the zoological society's fifth annual report for 1900: "The Reptile House is permanently fixed in the minds of visitors as a center of attraction," and "All things considered, the alligator pool is perhaps the satisfactory single feature in the Reptile House" (anon., 1898, 1900). Fig. 1. shows the original floorplan of the Reptile House as it was constructed in 1898, in a spacious, state-of-the-art, modern building of the times (Fig. 2). To this day, the exterior of the reptile house remains much as it was originally constructed, a sturdy struc-
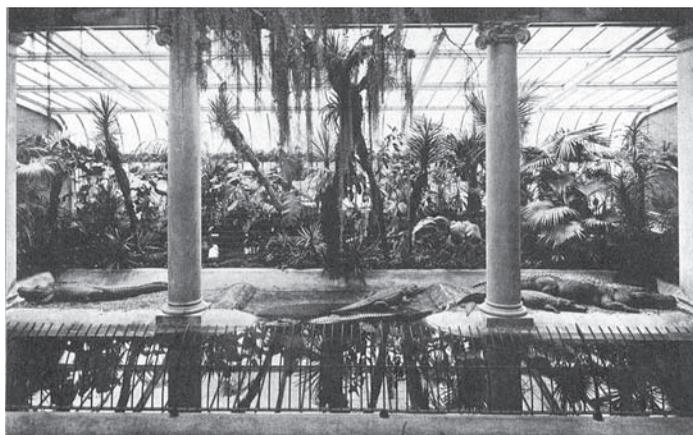
FIG. 3. Alligator pools in the conservatory at the west end of the reptile house in 1900.

ture of steel and dense, fire-kilned brick. Its roofline and cornices are festooned with the sculptured cement heads of reptiles and amphibians to mark the presence of its scaly inhabitants. These were especially created by the well known animal sculptor of the time, Mr. A. P. Proctor. The alligator pools at the west end of the building were designed to be main attractions and meant to house only American Alligators (Fig. 3).

Ditmars was well aware that a constant warm environment was essential to the health of crocodilians. He had insisted that heating pipes carrying warm water, immersed along the perimeter of the alligator pools to maintain pool water temperatures in the range of 27–30°C, be included in the construction of the 1898 building.

The Most Beautiful Reptile House in the World

The Reptile House remained largely unaltered until 1954, when, under the curatorship of Dr. James A. Oliver (1951–1958), it underwent its first renovation and modernization. Oliver's article in *Animal Kingdom* was aptly titled, "The most beautiful reptile house in the world" (Oliver 1954). The curved glass-walled conservatory can still be seen, designed to allow the overhead sunlight to brighten the alligator pools and their luxuriant plantings at the west end of the Reptile House (Fig. 4). Oliver's designs for the renovated reptile house advanced the heated pool concept and included a state-of-the art heating system for all of the reptile exhibits, with heated concrete slabs for basking crocodilians. An open nursery with an unobstructed view of juvenile crocodilians was added to the major exhibits, to exhibit the many public donations of alligators. Visitors were treated to a frenzy of crocodilian activity as the keeper staff provided regular feeding demonstrations several times a week (Fig. 5). True to the original concept, the renovated Reptile House exhibited only adult American Alligators, *Alligator mississippiensis*, in the center main pool. However, the east end of the Reptile House now included a spacious crocodile exhibit, patterned after an Egyptian tomb, and a doorway painted with pictograms taken from the *Book of the Dead*, attributed to Sobk, the Egyptian crocodile god, son of Neith (Faulkner 1985). The exhibit housed a single 3.7 m long Nile Crocodile, *Crocodylus niloticus*, named "Joe." The public would be greeted by a bevy of large alligators in a tropical setting as they entered the reptile house and leave with the image of a fearsome maneating crocodile. While the 1954 Reptile House included a nursery for rearing baby crocodilians, a main pool designed to exhibit a few spectacular animals, and two smaller flanking pools for exhibiting special species of interest, there was still no provision for breeding crocodilians, incubating a potentially large number of eggs, or housing a multi-species collection of crocodilians of various sizes and life stages.

The Early Bronx Zoo Collection

The 1900 annual report lists two species of crocodilians in the reptile collection. In September, 1899, Ditmars specifically called attention to the rapid growth of a 395 cm long alligator (Ditmars 1900) (Fig. 6). However, it is unclear how extensive a plan there was for increasing the diversity of crocodilian species in the Bronx Zoo collections between 1898 and the first major renovation in 1954. In the original zoo plan, there was some limited space for

small crocodilians but only two primary exhibit pools and no holding enclosures for larger animals. The exhibition of American Alligators in the main pool was an absolute given, while the acquisition of crocodilians of other species was most often one of chance rather than of design. Crocodilians, like all reptiles, were freely available in the exotic pet trade to anyone who might wish such a pet. Inevitably, if the pet survived poor care, it might be brought to the Reptile House as a donation. Such donations were commonplace, were routinely accepted, and were added to the collection without medical quarantine or concern for possible infectious diseases.

Ditmars proudly wrote in 1913 that the crocodile nursery displayed a mound of baby American Alligators, brought to the zoo by tourists who had vacationed in Florida, and a few crocodiles. By then, he reported that the collection included a number of rare species that included the Indian Gharial, *Gavialis gangeticus*; Senegal Crocodile (West African Slender-snouted Crocodile), *Crocodylus cataphractus*; Salt Marsh Crocodile (Saltwater Crocodile), *Crocodylus porosus*; Orinoco Crocodile, *Crocodylus intermedius*; American Crocodile, *Crocodylus acutus*; West African Broad-nosed Crocodile, *Osteolaemus tetraspis*; and Rough-eyed Caiman (spectacled caiman), *Caiman crocodilus*, as well as American Alligators (Ditmars 1913). Ditmars eloquently wrote of his visit to a ship, "a big freighter from the east," in New York harbor, whose holds were crammed with cages and boxes of large cats, hoofed stock, giant snakes, and crocodiles in long boxes, of which he purchased three. Ditmars did not have easy access to the scholarly literature, and had to depend on the dealers' anecdotal information for origin and species when he purchased animals for the zoo collections. We know that C. Ralph DeSola (1933) published a comprehensive article on crocodilians in the *Zoological Society Bulletin*, with a foreword by Ditmars, that suggested that a number of crocodilian species were on hand, and that the general philosophy among zoological institutions of the period was to outcompete each other by virtue of the number and rarity of species they exhibited. An outdoor pool located immediately to the east of the Reptile House, useable for crocodilians only during warm summer months, is shown to contain a number of basking animals, including several alligators and a crocodile (Fig. 7).

Lack of Technology

No good record-keeping system for the reptile collection existed until 1964. Records included a small box of index cards on the head keeper's desk, with a card for each animal marked #1, 2, 3, etc. within each species. Should #2 die, the next animal of that species to arrive would assume the position of #2. Thus, it is retroactively impossible to track longevity of any individual animal within the collection other than, perhaps, an animal that might have some special notoriety attached to it. Herndon G. Dowling assumed the department curatorship in 1958 (1958–1966) and soon initiated a museum-based system of records keeping that included the permanent marking of individual animals for identification and a system of cataloging the collections (Dowling and Gilboa 1968). One of us (Brazaitis) had been unofficially recording crocodilian size data for many years, and the publication of these data gave the crocodilian collection new value, as a wide range of captive crocodilian growth data would be critical for planning future pro-

Fig. 4. The west alligator pools as they appeared in 1954, after the first reptile house renovation since 1898. The modernized configuration and supporting columns remain true to the original 1898 floor plan. The center pool houses four large alligators. Two smaller pools, designed to hold smaller crocodilians, lie just out of sight to the left and right. The large alligators were replaced with a multi-species group in the early 1960s.

grams (Dowling and Brazaitis 1966). Dowling brought with him a new direction that positioned the collection and staff for a leap forward in science and the new era of conservation that was at hand.

A number of basic technological issues needed to be resolved before crocodilian collections could gain the scientific importance that avian collections had achieved after many bird species had been decimated by the milliners demand for fashionable feathers and commercial hunters had obliterated passenger pigeon populations. Globally, crocodilians had suffered a similar fate. The wild populations for most species were abusively over-utilized for the skin and pet trades, species were disappearing from many wild places, and even populations of common species were plummeting. The state of the art at the Bronx Zoo mirrored the state of the art throughout the zoological community: collection management and conservation were not yet in sight.

The sex of animals in the crocodilian collection generally re-

Fig. 5. A crocodilian nursery and public feeding enhanced the visitor experience in the modernized reptile house in 1954.

FIG. 6. A 3.9 m (12' 11½") American Alligator was a center of attraction in the 1898 reptile house.

YOUNG ALLIGATORS IN THEIR SUMMER HOME.

FIG. 7. Outdoor summer pool for crocodilians with a crocodile at the far right. About 1930. From the Bulletin of the Society.

mained unknown until they grew to adult sizes and displayed what might be construed as male behavior. Mature males might be identified, but the identification of females often remained dubious. Animals that might have been maintained for years in the hope of future reproduction might ultimately be found to be of the same sex. When Brazaitis arrived as a keeper in the reptile house (1954), the main west pools housed four large alligators, acquired in the hope that they constituted two breeding pairs. As they grew in size, their incessant combats led to their medication with hormones in an effort to reduce their belligerence. The animals were eventually disposed of to an animal dealer and the main pools were then dedicated to holding the array of crocodilian species that were accumulating.

Fig. 8 shows the northeast pool and two Indian Gharial, *Gavialis gangeticus*. The animal in the foreground lacks a lower jaw and was the oldest crocodilian in the collection, having been purchased for $100 from an animal dealer in 1946. Its importance as a rare species was immediately recognized. Measuring 116 cm on arrival, the animal was presumed to be a female. In 1954, at about 178 cm in length, the animal damaged its lower jaw in a gate accident and the lower jaw was amputated immediately anterior to the mandibular symphysis, at about the 20th mandibular tooth. Thereafter, all feeding had to be accomplished by a keeper using a long forceps, holding food in the animal's mouth until it could be swallowed. The animal thoroughly learned the technique and trained many new keepers, including Brazaitis, in its use. It died of unknown causes in 1974 at a length of 295 cm, having been in the collection for about 28 years. The second animal in Fig. 8 is one of four animals acquired around 1952, for the future opening of the newly renovated Reptile House. The sex of these animals was unknown, and all eventually perished from causes of undetermined etiology. Not until 1985, with the opening of Jungle World in the Wild Asia exhibit at the Bronx Zoo was the species exhibited again. five sub-adult gharial from Orissa, India, were added to the collection, to become the nucleus of a future captive breeding program for this critically endangered species.

Still, by 1954, there was no plan for breeding crocodilians. It was not until 1963 that a reliable method of sexing crocodilians

was discovered at the Reptile House (Brazaitis 1969), when five American Alligators were placed on their backs and compared for any sexual dimorphism. The management of crocodilian collections, planned reproduction, and the interpretation of behaviors was now possible.

However, breeding potential was still haphazard. Most crocodilians died well before maturity due to dietary deficiencies or conflicts with larger animals as they approached adulthood. Rapidly growing juvenile crocodilians often suffered developmental anomalies. For food, zoos generally provided only those species of fish that were commercially available in human food markets, and it was yet unknown that certain fatty saltwater species, particularly after being frozen and thawed, were detrimental to crocodilians, prohibiting the absorption of critically needed vitamins and minerals, and adversely affecting fertility. Frozen saltwater fish, horsemeat, liver and heart meats, as well as all vitamin supplements, were removed from all crocodilian diets beginning in September 1979 and replaced with fresh-killed whole rodents, poultry, and live freshwater fish. In addition, color-corrected and ultraviolet lighting regimens, developed by Townsend and Cole (1985) at the American Museum of Natural History for enhancing reproduction of parthenogenic lizards, were applied to hatchling and rapidly growing crocodilians and proved equally successful. The management changes precipitated an unparalleled era of reproductive success.

Golden Age of Discovery in Crocodilian Science

Our ignorance of crocodilian behavior and reproductive biology was quickly being dissipated by a cadre of new scientists, inspired by awareness of the plight of threatened and critically endangered species. We had been working in the "dark ages" by the "seat of our pants," and there seemed to be no time left as species populations were designated by the international community as either threatened or endangered.

Ted Joanen, of the Louisiana Department of Fur, Fish and Game, was perhaps one of the most forward and practical thinkers of the times in conservation biology. Joanen understood the need for endangered species to have value if they were to be preserved for future generations, and he also set about developing management

Fig. 8. Indian Gharial, about 1957. The animal on the left has lower jaw amputated as a result of an earlier injury. It survived for more than 26 years by hand feeding. Photo by Peter Brazaitis.

protocols for captive breeding and husbandry that still stand as a model. Tracts of various types of alligator habitats were identified in Louisiana, along with their endemic alligator populations and ecology, to monitor the effects of human and natural predation, weather, and environmental changes on population dynamics, nesting, and reproductive success. Most important, a population of captive alligators was established under intensive control and study to compare the success of captive management techniques with the reproductive success of wild populations. His was the only study of its kind for any species anywhere in the world, where a known population of individually identified crocodilians was continuously monitored and documented through successive generations.

The facilities of the Rockefeller Refuge in Grand Chenier, Louisiana, which Joanen headed, and its invaluable wild and domestic alligator populations provided unparalleled opportunities that were utilized by scientists and students for many years. Data provided comparative standards for the management of wild populations and for developing the husbandry for any species of crocodilians in captivity. Much of what we know of crocodilian reproductive biology and behavior was generated from Joanen, his staff, and their work at Rockefeller Refuge (Joanen 1969; Joanen and McNease 1971, 1975, 1980). Much of this knowledge allowed the State of Louisiana to determine its alligator population and ways to manage it through controlled harvesting. Alligator populations and their habitats became a renewable, desirable, and highly profitable natural resource by allowing for sale of harvested animal hides and meat.

Unfortunately, upon his retirement around 2003, Joanen's domestic captive alligator research population was destroyed for lack of support funding and interest (Joanen, pers. comm.).

While Joanen provided ongoing data on reproduction and captive population management, a new field of animal behavior emerged. Myrna Watanabe, a graduate student from New York University, noted that little was known of maternal behavior in alligators or other crocodilians, and set about to observe alligators attending their nests and throughout the parenting process. In 1976, Watanabe was the first to record the litany of vocalizations and behaviors between mother alligators and their hatching young. Her reports of nest excavation by female alligators to liberate hatching young, of carrying hatchlings to the water in her jaws, and of pro-

viding ongoing protection and maternal care documented that true to their evolutionary ancestry, alligators continue to practice behaviors generally attributed to birds (Watanabe 1977, 1979, 1980, 1981, 1982a, 1982b, 1986a). Such observations were transmitted to Bronx zoo staff on a daily basis, as Bronx zoo crocodilians nested and produced offspring.

After first completing American Alligator studies at Rockefeller Wildlife Refuge, Watanabe, fluent in Chinese, continued her research in China, joining with Chinese scientists (Watanabe 1983, 1986a,b) to document the secretive behavior and biology of the Chinese Alligator, *Alligator sinensis*, the only relative of the American Alligator. They provided field data that promoted an understanding of the breeding behaviors of Chinese Alligators in captivity. By then, she estimated that the species had been reduced in the wild to fewer than 500 individuals, and it was designated the most endangered species of crocodilian. Her early reports indicated that nearly all wild individuals and their habitats were close to extinction, and the remaining wild population had been relegated to tree farms and cultivated areas, where they continued to be decimated. The first government-sponsored Chinese Alligator farm was established in 1981. Her collaborations with the Wildlife Conservation Society and National Geographic contributed greatly to the success of the Bronx Zoo's Chinese Alligator propagation program.

In St. Lucia, Natal, South Africa, Anthony (Tony) Pooley was also documenting Nile Crocodile nesting and maternal care behaviors and demonstrated that female crocodiles were so in-tune to the maternal care of their young that he recorded a 4-m-long female Nile Crocodile gently take her hatchling directly from Tony's hand (Pooley 1982; pers. comm.). Other researchers were working to understand crocodilian behaviors as well. Leslie D. Garrick, a crocodilian research intern at the Bronx Zoo, and Jeffrey Lang, then of the University of Minnesota, collaborated at the Zoo to document the social signals of crocodilians (Garrick 1974, 1975; Garrick and Lang 1977); and Kent Vliet, University of Florida, documented alligator social behavior (Vliet 2001) by observing their activities from the alligator's perspective: in the water at alligator eye level. His work continues today to enhance crocodilian reproduction programs at the St. Augustine Alligator Farm and provide guidance for crocodilian captive management programs throughout North America.

Mark W. J. Ferguson (1981), then a professor of anatomy at The Queen's University of Belfast, documented the embryonic development, egg degradation, and embryology of American Alligators, and astonished scientists by reporting that the sex of crocodilians was not determined by chromosomes, but by the temperature that the crocodilian's eggs were subject to during incubation (Ferguson and Joanen 1982). Also, Ferguson used the palatal development of American Alligator embryos to better understand the problem of cleft palate in humans (Ferguson et al. 1983). From these studies, we now know why crocodilian embryos perished so easily during some stages of development and not during others. Rotating crocodilian eggs during critical developmental periods during incubation may cause the embryo to break loose from its egg membranes and die. The incubating egg must also enjoy a fine balance of moisture and gas exchange if the eggshell is to degrade sufficiently during incubation to allow the fully developed embryo to break out of its shell and hatch.

One of the earliest studies of crocodilian genetics was conducted at the Bronx Zoo by human geneticist Maimon Cohen, director of the Cytogenetics Laboratory of the Greater Baltimore Medical Center, and herpetologist Carl Gans (Cohen and Gans 1970). With the advent of molecular genetics technology, a new generation of scientists emerged to give us a fresh look at the relationships among crocodilian species: George Amato, first at the Zoo and now at the American Museum of Natural History (Amato 1991, 1994; Amato et al. 1998); paleontologist Chris Brochu of the University of Iowa (Brochu 2001; Brochu and Densmore 2001), and Lew Densmore of Texas Tech University (Densmore 1983; Densmore and Dessauer 1984; Densmore and Owen 1989; Densmore and White 1991).

Roland A. Coulson and Thomas Hernandez (Coulson and Hernandez 1964, 1983), of Louisiana State University, pioneered work on crocodilian metabolism working with Ted Joanen and his colleagues at Rockefeller Refuge.

The Right Time and the Right Place for Crocodilians

The United Nations Convention on International Trade in Endangered Species of Wild Fauna Flora (CITES) came into being in 1973 and called attention to the alarming depletion of crocodilians worldwide. The Lacey Act of 1900 was broadened and the Black Bass Act of 1926 and the Endangered Species Act (ESA) (1966) were combined and amended, which gave sweeping protections to crocodilian species throughout the world. The exotic reptile leather trade was itself facing extinction as wild populations plummeted and anticipated profits evaporated, because the demands on the resource outstripped the legal and illegal supply of raw skins. In the United States, the American Alligator, the symbol of America's southland, was endangered. The Wildlife Conservation Society (then the New York Zoological Society) and the reptile department were at the heart of the crocodilian conservation movement. F. Wayne King (1967–1973) had succeeded Dowling as Curator of Reptiles and he soon developed a consuming interest in crocodilian conservation, expanding on the crocodilian work begun by Dowling and Brazaitis (1966). King organized a meeting in 1971 between law enforcement agencies, Louisiana and Florida wildlife authorities concerned with the plight of American alligators, and representatives of the exotic leather trade. The first comprehensive work on species identification of crocodilian hides and products was introduced to facilitate wildlife law enforcement (King and Brazaitis 1971) followed by the species identification of living crocodilians (Brazaitis 1973a). These factors provided a huge incentive to develop captive breeding programs.

In this new era at the Zoo, we still had no accommodations for breeding crocodilians, no conviction that crocodilians could be successfully bred in artificial pools, and no official plan to initiate a crocodilian breeding program at the Bronx Zoo. Then, one day in March 1964, a maintenance truck parked behind the Reptile House as the workers enjoyed a coffee break. In the back of the truck was a discarded wooden tub that had served for many years as a temporary pool for a Pigmy Hippopotamus in the Elephant House. It measured about 2.5 m in length, 2 m in width, and 70 cm deep at its deepest end. The reptile house keepers commandeered the half-rotted tub, installed it in the conservatory behind the west

pools, and immediately populated it with a trio of Chinese Alligators (Figs. 9, 10). The first Bronx Zoo endangered crocodilian species breeding initiative was born (Brazaitis 1968). Something was missing, however, and no breeding occurred.

The west crocodilian pools and the conservatory areas (Fig. 11) were eventually retrofitted in 1981 to include two off-exhibit breeding pools, five nesting areas, and three main exhibit breeding pools. Conspicuous is the exceptionally small size of the complex and its nesting areas, and, in particular, the shallow nature of the pools. The main exhibit breeding pools (1, 2, 3) are less than 65 cm at their deepest point (Table 2).

A number of endangered species in the collection had now reached sexual maturity, and with improved diets and health, began to display reproductive behavior. Because more than one species, following their own intrinsic breeding cycles, would be breeding within a relatively short time period, it was necessary to establish a "breeding calendar," to anticipate having the appropriate accommodations ready at the right time for the right animals. The calendar indicated what species was anticipated to be breeding during what period, and when the females were scheduled to lay eggs. "Musical crocodiles" became the theme, as males and females of one species after another were scheduled in rotation, first to pair and breed in the main or rear breeding pools. Then, females were isolated in secluded rear pools during gestation and later given access to a nesting enclosure to deposit their eggs. Finally, the female crocodile was rotated out to make room for the next gravid female. Eggs would be removed immediately after laying for artificial incubation in the reptile nursery. Hatchlings and growing young, up to a meter in length, were then reared in galvanized cattle troughs on the second floor of the Reptile House, at about 30–35°C, under black light and color-corrected daylight fluorescent lights. In 1983, eggs of three species of crocodilians were under incubation simultaneously.

To date (2008), 10 species of crocodilians have been successfully bred at the Bronx Zoo. Prior to 1980, unanticipated and unrecorded reproduction had taken place with the hatching of single eggs of West African Dwarf Crocodile, *Osteolaemus tetraspis*, and a Smooth-fronted Caiman, *Paleosuchus trigonatus*, found in the pool water. Behler et al. (1987) provided an overview of crocodilian reproduction at the Bronx Zoo.

A Chronology of Crocodilian Reproduction

Initially, the species we bred were the species that were already on hand. As husbandry techniques were refined and new data on the status of wild populations emerged, captive breeding programs focused and gave priority to the most critically endangered species. Programs evolved to include collaborative efforts among consortiums of interested private individuals, zoological institutions, and governments; the Crocodilian Advisory Group of the American Zoo and Aquarium Association, and the IUCN Crocodile Specialist Group. Dedicated space and resources are limited, and priorities changed as some species and wild populations recovered.

Yacare Caiman, *Caiman yacare*

The Yacare Caiman of the grasslands of central South America deserved special interest. Decimated by excessive hide hunting, it
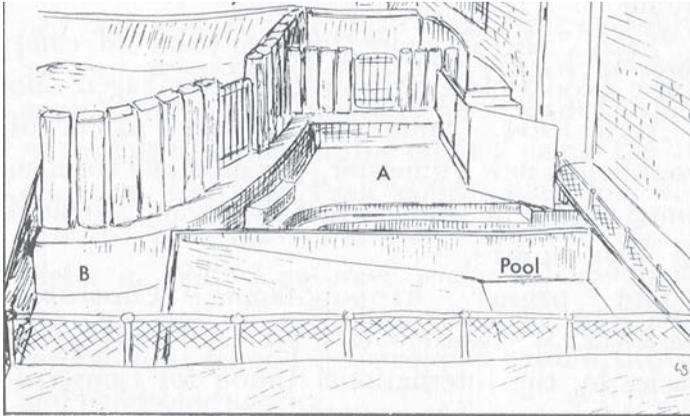
FIG. 9. Chinese Alligator enclosure with old hippo pool, reptile house conservatory, 1964. Illustration by Lloyd Sandford.

FIG. 11. The west crocodilian pools and the conservatory areas as they were retrofitted to provide a multi-species crocodilian reproduction complex. The complex includes: three primary exhibit and breeding pools (1, 2, 3), exhibit basking areas are bare cement and have imbedded heat coils to enhance basking; two off-exhibit breeding pools (4, 5). See Table 4 for dimensions for breeding pools and nesting areas. Connecting doorways and accesses allow for any crocodilian in any pool to be moved without capture to any pool or nesting area throughout the complex. Keeper staff may view all areas from the elevated walkway around the perimeter of the complex or from the public space. Soils nest areas are filled with a soil/sand/mulch substrate ca. 40–60 cm deep. All nest areas have buried temperature-controlled electric heated pads as attractive nest sites (grids). Nest Box 2 contains less than 30 cm deep substrate and measured ca. 80 × 100 cm in size. Illustration by Peter Brazaitis.

was the first crocodilian to be listed as an endangered species under the US ESA on June 2, 1970. Ten hatchling animals, ranging in length from 50–97 cm, were acquired from the U.S. Fish and Wildlife Service in September 1971. An 11-year-old yacare measuring 145 cm in length commenced to lay infertile eggs in 1977 and 1979. Diets prior to 1980 had yet to be improved and consisted largely of frozen saltwater fish and horse and beef meats and Vitamin E supplements. However, with the diet change to fresh-killed small mammals and birds in September 1979, the effect was dramatic. In April 1980, a 137-cm-long female laid four fertile eggs which were successfully incubated and hatched. This was the first of a planned and documented, successful, crocodilian reproduction at the Bronx Zoo (Brazaitis 1986).

Chinese Alligators, *Alligator sinensis*

The odyssey of the Chinese Alligator, a burrowing dwarf species found only in possibly three provinces in southern China (Chen 1990; Huang 1981), beginning with the Bronx Zoo collection, is a global story spanning decades. In 1963, the collection included three Chinese Alligators, which newly developed sexing techniques

FIG. 10. The original pair of Chinese Alligators in the first established breeding pool in 1964. The animal at the rear is the original male estimated to be more than 40 years old at the time. Photo by Peter Brazaitis.

told us were comprised of an adult male and female and a second younger female. It now seemed logical to attempt to breed this small rare species, although the male had been acquired as an adult from Poland in 1956 and was presumed to be at least 40 years old. The trio was established in one of the smaller west pools with a small box of substrate to permit nesting. The older female immediately took over the nest box (Brazaitis 1968). No breeding occurred, although the animals engaged in regular courtship. A second attempt under slightly improved conditions in 1964 also met with failure. The Reptile House effort was abandoned.

In 1975, under the leadership of the late John Behler, who had assumed the curatorship of reptiles in 1973, the program was renewed and expanded to include two animals from the National Zoological Park, in collaboration with the Rockefeller Wildlife Refuge. Two pairs of Chinese Alligators were moved to Rockefeller Refuge in 1976, where a half acre of wetlands and ponds were included in each pair's enclosures. In 1977 the first breeding occurred, resulting in three offspring. The forty-year-old-plus males had sired their first offspring. As in American Alligators, a cold period of hibernation appeared to play a critical role in reproduction. Subsequent breeding occurred in 1978, 1979, and 1980 (Behler and Brazaitis 1982; Brazaitis and Joanen 1984). The program has since produced numerous offspring (Fig. 12), including in a number of satellite zoos, and has evolved into one of the most successful endangered species programs under the Association of Zoos and Aquariums (AZA).

Three Chinese Alligators were sent to China in 2003 to augment the national program to preserve the species. Twelve animals in total, including six males from the Bronx Zoo program

TABLE 2. Dimensions and water depths of the crocodilian breeding complex.

Breeding areas and pools	West pool Area 1	SW pool Area 2	NW pool Area 3	Rear Area 4	Rear Area 5
Pool depth (cm)	49	63.5	43.2	63.5	71.1
Total area (approx m²)	45	11.8	14.6	8.9	4.9
Pool (approx sq m²)	18.2	5.7	7.5	5.1	4.9
Basking area (approx sq m²)	30	5.6	4	na	na
Soil nesting areas (approx. sq m²)	shared (2, 4, 5)	shared (4)	2.67, shared (1, 5)	4.9	2.67, shared (3)

and three females each from St. Augustine and Disney Animal Kingdom, were sent to China in May 2006. The Chinese Alligator breeding centers in China are well funded and emphasize their roles as both tourist attractions and to ensure the survival of the species, at least in captivity (Thorbjarnarson, pers. comm.). Captive individuals now number in the thousands. Field surveys by Watanabe (1982) found, and Thorbjarnarson et al. (2002) confirmed, that the wild population of Chinese Alligators continues to face the prospect of imminent extinction.

Behler officially became the AZA Chinese Alligator studbook keeper in May 1982; this was the first studbook for a reptile breeding program. He was succeeded by Joe Abene, reptile keeper at the Bronx Zoo. The AZA Crocodilian Advisory Group was established in 1986, and the Chinese Alligator program, formally created by Behler in 1980, continues to stand as a model for AZA reptile and amphibian management programs.

Siamese Crocodiles, *Crocodylus siamensis*

Considered virtually extinct in the wild, this species had not been seen in the wild for decades, although older captive animals were the bases of extensive captive breeding for hides and meat in Thailand. The first crocodilians to be seized in 1971 under the new protections (listed as endangered under CITES, 1975; ESA, 1976) were a group of hatchling Siamese Crocodiles without documentation, hidden in an air cargo box at John F. Kennedy International Airport in New York. U.S. Fish and Wildlife Service Special Agents Warren Diffendal and Ed Baker were checking import cargo when they casually tapped on a box labeled machinery and the box began to croak. These 14 youngsters became the first group colony of managed endangered species at the Bronx Zoo, producing offspring almost annually from 1983, at age 12, (Brazaitis and Watanabe 1983) until 1987. They would eventually populate zoos throughout the United States.

Cuban Crocodiles, *Crocodylus rhombifer*

"Fidel" and "Maria" were perhaps two of the most famous crocodilians in US zoos. Fidel (Fig. 16) came to the Bronx Zoo in 1958 from the Tarpon Springs Zoo, Florida, as a juvenile and quickly made his mark by attempting to consume the hand of Brazaitis during a public feeding. The two crocodiles were tightly bonded and remained intolerant of all other crocodiles throughout their lives. Both animals were of immense genetic important to the AZA Cuban Crocodile endangered species propagation program in that they represented pure Cuban Crocodiles from times prior to the commercial hybridization of Cuban and American crocodiles in

Cuban crocodile farms. "Fidel" and "Maria" produced numerous offspring: one in 1983, six in 1984, and 21 in 1985.

Indian Mugger Crocodile, *Crocodylus palustris*

Crocodylus palustris was well represented in the collection between 1969 and 1994, with the arrival of a male and a female in 1969. An additional male and two females were acquired from the U.S. Fish and Wildlife Service in 1971. All of the first eggs produced by these animals were infertile and laid in the water, probably as a result of poor diets of saltwater fish during their pre-reproductive ages, and not having available a nest site with a temperature elevated above the pool water temperature. Typically, pool water temperatures averaged 29°C, while ambient air temperatures might vary from 21 to 26°C during the months from February to April. Prior to the introduction of a heated nesting site in breeding enclosures in 1981, it was not unusual for animals to select for the warmer water as a "nest site" in which to lay their eggs. The pattern of egg production suggests that the reproductive cycle of these animals may well be genetically programmed. In India, *C. palustris* typically lays eggs from February to April in the wild, and averages 28 (10–48 range) eggs per clutch (Lang 1986; Whitaker and Whitaker 1977). Despite having been reared in captivity and subjected to an alien annual photoperiod, lack of natural sunlight, and varying temperatures from the first year throughout maturity, this group of *C. palustris* exhibited a repro-

Fig. 12. Hatching Chinese Alligator, Bronx Zoo, 1984. Photo by Peter Brazaitis.

TABLE 3. Reproductive history of *Crocodylus palustris* at the Bronx Zoo.

C. palustris	69086 female	No. eggs	71098 female	No. eggs	71099 female	No. eggs	71100 male	69503 male
Size on arrival cm	41.5		35.2		33.5		34.6	39.6
Year first breeding	1979		1986		1985		1982	None
First breeding size	219.0		218.44		221.0		193	na
Est. age first breeding	11 yrs		15 yrs		15 yrs		12yrs	na
Eggs laid	Month							
1979	March–May	27						
1980	April	31						
1981								
1982							mounting	
1983	March	27					mounting*	
1984	March	27						
1985	March	28			22	March		
1986			March	28				
1987	March	28			28	March		

* Successful breeding with *Crocodylus rhombifer*

ductive cycle that remained typical for the species in its native homeland (Table 3).

Indian Mugger Crocodile, *Crocodylus palustris* × Cuban Crocodile *Crocodylus rhombifer* hybrid.

In 1983, a male *Crocodylus palustris* successfully bred with an approximately 1.5 m long female *Crocodylus rhombifer.* A number of eggs were laid and artificially incubated on 30 April 1983. One egg successfully hatched on 5 July 1983, producing a healthy hybrid crocodile 249 mm in length and weighing 57.2 g. On 13 August 1984, it was transferred to Florida holding facilities. The animal measured 2.5 m in length and weighed 70 kg (Table 3).

Malayan False Gharial, *Tomistoma schlegelli*

Perhaps one of the most exciting breeding successes took place in July, 1985 (Brazaitis 1999) with the hatching of seven animals. The female, 245 cm long at the time of breeding, had been acquired from the San Jose Zoo, California, in 1974 with an injured upper jaw, which was splinted and wired to stabilize the jaw on arrival. The male, acquired in 1974 from an animal dealer, measured 131 cm on arrival, and was ca. 3.6 m long at the time of breeding in 1985. The female built a nest of hay, bark, and sand, in which she buried and guarded 26 eggs. Breeding took place in a pool shared with a third and smaller animal in breeding complex #4 (Fig. 14), in a pool only slightly longer than the larger male's length and half his width, with a water depth of less than 76 cm. However, breeding was never repeated by these young adult animals for unknown reasons. Their offspring have not, as yet, bred. *Tomistoma* in the care of Bruce Shwedick (pers. comm.), in Florida, where his animals are housed under more natural conditions, also have bred only one time to date.

Broad-snouted Caiman, *Caiman latirostris*

Although a lone male was acquired from the U.S. Fish and Wildlife Service in 1971 as an undocumented importation, it was not until October, 1985, that a group of five male and five female, four-year-old animals, ranging in size from 96 to 185 cm, were obtained from the Atagawa Crocodile Farm in Japan. The animals were captive bred and were to become the nucleus of a US captive breeding program. However, the animals appeared somewhat debilitated and undernourished on arrival, and it was not until April 1987 that the first ones began producing fertile eggs. Eighteen eggs hatched in July of 1987; eight in July, 1988; six in July 1990, seven in August 1994, and one each in July,1995 and August 1996. By that time, commercial farming operations were well underway in Argentina. The species was no longer considered endangered and it was downgraded to lower risk by the International Union for the Conservation of Nature and Natural Resources (IUCN).

Dwarf Caiman, *Paleosuchus palpebrosus*

Crocodilian reproduction continues today with the successful breeding of this prolific, secretive, but common northern and central South American species (Medem 1958). A male was collected in Surinam in 1977 and has since bred with two females acquired from the Paramaribo Zoo in Surinam in 1985 (103 cm and 89 cm, respectively). Since then, these animals have produced numerous eggs and hatchlings (Table 4).

Future History

The history of crocodilian breeding and reproduction has gone full circle over the past 107 years, since Ditmars first put a 12 foot long alligator on exhibit in the new Reptile House at the Bronx Zoo, and ecstatically announced the successful hatching of an American Alligator egg the zoo had acquired from a donor. We no longer put animals together whose species identity and sex are uncertain. Molecular science now allows us to selectively pair those individuals that best typify the species' genetic profile and preserve genetic diversity. Our basic concept of what is a species, and which "species" is more closely related to which and what do

we call it, is in flux.

Forty years ago, we learned that, all good intentions aside, the successful breeding of a single female could provide a stock of more animals than all of the facilities provided by most of the United States' zoos combined could maintain. Yet, other than the most critically endangered species, returning some of those animals to the wild to repopulate decimated populations is often neither possible nor practical. Original habitats, because of recent development and human encroachments, may no longer exist in a condition where they can still support crocodilian populations. In some cases, the countries involved may have implemented national breeding and reintroduction programs. The captive propagation of crocodilians has evolved from asking the question, "Can we breed any species at all?" to "What species do we really want to breed, and how often?" In fact, we have opted to not breed most of the 23-odd species of crocodilians because we have come to realize that, collectively, zoos do not have sufficient accommodations or resources to manage long-term captive breeding programs for any but the most critically endangered species, such as the Chinese Alligator and the Philippine Crocodile, *Crocodylus mindorensis*.

However, the same crocodilian science and technology that allowed the Bronx Zoo to lead the way in captive crocodilian propagation also provided a more lucrative way to save endangered species through commercial propagation. We may yet lose species, not to over-utilization or lack of technology, but to the loss of species identity through the careless breeding of captive animals, disregard for the preservation of the species' genetic integrity, or worse, the large-scale deliberate hybridization of species to produce more prolific crocodilians that are faster growing and have a more valuable skin. The accidental hybridization of *C. palustris* with *C. rhombifer* at the Bronx Zoo in 1983 demonstrates the ease with which crocodilians may interbreed under captive conditions. *C. rhombifer* and American Crocodiles, *C. acutus*, were commercially hybridized for the commercial skin trade in Cuba, and may have compromised the genetic integrity of the Cuban Crocodile. The saltwater Crocodile, *C. porosus*, and the Siamese Crocodile, *C. siamensis*, continue to be hybridized in great numbers for the commercial skin trade in Thailand. In Colombia, commercial caiman skin and meat farms produce millions of skins per year as a product of indiscriminate captive breeding of closely related but distinct *Caiman* species with little regard for population integrity. Non-native crocodilian species continue to be introduced into non-endemic countries to commercially capitalize on a perhaps higher value of skins than those of native species. An example is the commercial introduction of Nile Crocodiles into Brazil for commercial farming. Future zoological historians may yet accuse, and simultaneously congratulate, our generation for developing the skills to produce thousands of individuals of any given species at will in captivity, yet failing to preserve the habitats and wild populations that are our natural wildlife heritage. There may well be tens of thousands of Chinese Alligators in captivity, while the species may yet become extinct in the wild.

TABLE 4. Reproductive success of *Paleosuchus palpebrosus* at the Bronx Zoo.

Female	F Unknown	Hatched	F850075	Hatched	F850076	Hatched
1988	15 eggs	5				
1990			15 eggs	15	13 eggs	12
1991			14 eggs	11		
1992			14 eggs	0	10 eggs	1
1998		2				
1999		7				
2001		3				
2004*		15				

* Breeding curtailed and egg hatching interrupted. Resumed 2007.

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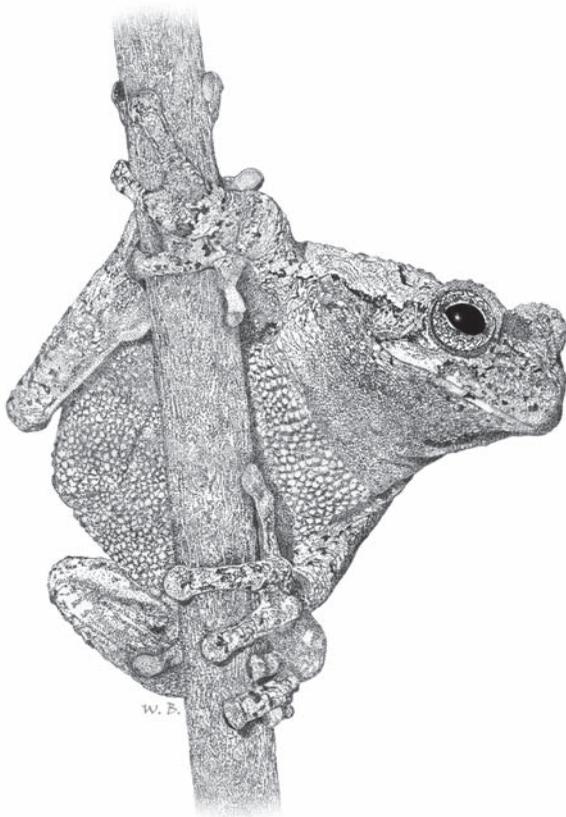
Hyla versicolor (Gray Treefrog). USA: Virginia: Greene Co. Illustration by Will Brown (http://www.blueridgebiological.com/).

POINTS OF VIEW

Toe Clipping of Anurans for Mark-Recapture Studies: Acceptable if Justified

KIRSTEN M. PARRIS*
and
MICHAEL A. MCCARTHY
School of Botany, University of Melbourne VIC 3010, Australia

* *Corresponding author: e-mail: k.parris@unimelb.edu.au*

Individual marking of animals so that they are uniquely identifiable upon recapture is a common practice in ecological field studies (Nietfeld et al. 1994). The return rate observed during a mark-recapture study is a product of the probability of survival (survival rate) and the probability of recapturing an animal that is alive (recapture rate). An ideal marking method will not harm the study organism or change its behavior, and therefore will not affect survival or recapture rates. Toe clipping is a common method of marking anurans, but its use has become controversial (Funk et al. 2005; May 2004) following our study identifying a consistent, negative effect of toe clipping on the return rate of anurans in the wild (McCarthy and Parris 2004).

Phillott et al. (2007) argue that toe clipping is an acceptable method of marking anurans for mark-recapture studies, for three principal reasons. First, because it is unclear whether the observed reduction in the return rate of anurans with increasing numbers of toes clipped is due to changes in survival, changes in recapture rate, or both. Second, because the impacts of alternative marking methods have not been properly assessed; and third, because individual marking of anurans is essential for the conservation management of the group. We would like to respond to some of their points here.

As we state in our earlier papers (McCarthy and Parris 2004; Parris and McCarthy 2001), the negative effect of toe clipping on anuran return rates could be due to an increase in mortality, changes in the behavior of animals leading to a lower recapture rate, or a combination of the two. Phillott et al. (2007), like May (2004) and Funk et al. (2005), focus on the ethical problems associated with reduced survival of toe-clipped animals, implying that behavioral changes following marking are less important. While this distinction is understandable, any impact of toe clipping on anuran behavior also has ethical and scientific consequences. Changes in behavior following toe clipping such as a reduction in calling or foraging activity, or migration from the study area, could have consequences for the fitness of the study animals and the persistence of populations. Furthermore, whether the reduction in return rates is due to the death of the study animals or changes in their behavior, the data arising from a toe-clipping study will be biased. Interestingly, the scientific validity of studies using biased data from toe clipping has received little attention. Some researchers have taken issue with our papers because of subsequent restrictions that could be placed on their use of toe clipping. We are surprised by such reactions, because we had expected that users of a biased research method would want to know the size of the

bias so it could be corrected. Researchers using toe clipping in the future need to ensure that the inherent bias is 1) minimized by careful survey design, and 2) accounted for during data analysis (Parris and McCarthy 2001).

Phillott et al. (2007) propose a number of strategies for minimizing the negative impacts of toe clipping, including removing as few toes as possible and using aseptic handling techniques. We make these same recommendations (Parris and McCarthy 2001), although we propose that care be taken to remove the minimum number of toes from all anurans, not just species that are "heavily reliant on toes". Phillott et al. (2007) suggest that removal of the toe pad only ("toe tipping" rather than toe clipping) may reduce the effects of marking on anurans. While this may be the case, there are no supporting data – in fact, the effect of toe tipping on the return rate of *Hyla labialis* (Lüddecke and Amézquita 1999) is comparable to the effect of toe clipping on the return rate of *Bufo woodhousei* and *Crinia signifera* (Clarke 1972; Lemckert 1996; Williamson and Bull 1996; see McCarthy and Parris (2004), Figs 1 and 2).

It is true that the effects of alternative methods for marking anurans have not been properly assessed in the wild (although Davis and Ovaska (2001) found a 33% lower return rate of salamanders with three toes clipped compared to those implanted with fluorescent elastomer tags). It is likely that other marking methods will affect the recapture and/or survival rates of anurans to some degree, so they, too, must be used with caution. However, the prospect that other methods are just as bad, or worse, than toe clipping does not necessarily make it acceptable. The possible benefits of conducting a mark-recapture study using toe clipping must be weighed objectively against the likely impacts on the study animals, to determine whether toe clipping is justified in a particular circumstance. Phillott et al. (2007) argue that data gained from the individual marking of anurans is essential for their conservation management. For this to be the case, the data must be essential for identifying practical management actions that will improve the viability of a species, and must be of sufficient quality and quantity to achieve this objective. To our knowledge, few mark-recapture studies of anurans meet these criteria, especially studies of threatened species that have small populations. The burden of proof that the value of their research outweighs the harm it may cause lies with researchers who propose a mark-recapture study; the burden of oversight lies with ethics committees.

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Toe Clipping of Anurans for Mark-Recapture Studies: Acceptable if Justified. That's What We Said!

ANDREA D. PHILLOTT*
and
LEE F. SKERRATT
School of Veterinary and Biomedical Sciences
Amphibian Disease Ecology Group, James Cook University
Townsville Qld 4811, Australia

KEITH R. McDONALD
Queensland Parks and Wildlife Service, PO Box 975
Atherton Qld 4883, Australia

FRANK L. LEMCKERT
School of Environmental and Life Sciences, The University of Newcastle
Callaghan NSW 2308, Australia
and
Forest Science Centre, Department of Primary Industries
PO Box 100, Beecroft NSW 2119, Australia

HARRY B. HINES
Queensland Parks and Wildlife Service, PO Box 64
Bellbowrie Qld 4070, Australia

JOHN M. CLARKE
Queensland Parks and Wildlife Service, PO Box 3130
Rockhampton Shopping Fair, Rockhampton Qld 4701, Australia

ROSS A. ALFORD
School of Marine and Tropical Biology, Amphibian Disease Ecology Group
James Cook University, Townsville Qld 4811, Australia

RICK SPEARE
School of Public Health, Tropical Medicine and Rehabilitation Sciences
Amphibian Disease Ecology Group, James Cook University
Townsville Qld 4811, Australia

*Corresponding author: andrea.phillott@jcu.edu.au

Parris and McCarthy (2008) have over-simplified the arguments of Phillott et al. (2007) that toe-clipping is an acceptable method of marking anurans. We discussed six points in defending toe-clipping as a marking method:

1. The absence of unequivocal data to quantify the effect of toe-clipping on return rates. Parris and McCarthy (2001) and McCarthy and Parris (2004) used statistical projections, based on five studies with limited details of search effort to evaluate the likelihood of encountering a marked frog and hygiene procedures that may have influenced survival be-

yond current practices (Clarke 1972, Humphries 1979, Lemckert 1996, Williamson and Bull 1996, Lüddecke and Amézquita 1999).

2. The reasons for reduced return rates after toe-clipping. Mortality after an invasive marking procedure is a real and recognized concern. However, failure to encounter an individual after marking can also be due to behavioral changes that may or may not affect the fitness of the study animals.

3. Current hygiene practices minimise the risk of exposure to pathogens. These are less likely to have been or were not considered in the studies which Parris and McCarthy (2001) and McCarthy and Parris (2004) used as data sources.

4. Ethical concerns raised by May (2004) are unsubstantiated, yet have strongly influenced ethics committees, with some recommending the use of anesthetics that are at times inappropriate or have unknown dosage requirements that are likely to pose a greater threat to the well-being of the animals than toe-clipping.

5. Ethics committees have also favoured the use of other marking techniques, such as pit-tagging, over toe-clipping. The majority of these are still invasive, pit-tagging arguably more than toe-clipping, and their effects are at best no further understood than those of toe-clipping. They have certainly not been shown to pose less of a physiological or physical risk to animals.

6. Some field studies require the recognition of individuals, which for many species requires marking techniques such as toe-clipping. We believe such focused studies with measurable outcomes contributing to understanding and management of a species have value that outweighs the potential impacts on the species.

Parris and McCarthy (2008) responded to points 2, 3, 5, and 6. They are largely in agreement with these points although they do not distinguish between the importance of the effects of toe-clipping on mortality versus behavior. They argue that both are equally important because of the potential effect of changes in behavior on population fitness and study bias. Unfortunately there are no data to test whose opinion is correct. Parris and McCarthy (2008) point out that a minimum number of toes should be removed from all anurans; in general we agree but we stand by the intent of our comment that the function and importance of toes should equally be taken into account when toe-clipping. Parris and McCarthy (2008) also suggest that there is evidence that the effect of toe-clipping is no different from that of toe-tipping although the study they cite is confounded by species. In addition, they argue that toe-clipping may be unacceptable even if it is no worse than other invasive methods of marking animals. The point of our comment was that it is always best to use the most practical, least harmful method of marking, and that toe-clipping should be evaluated on that basis, along with other marking methods.

We believe that mark-recapture studies can contribute to the development of conservation management plans for many anurans in a variety of ways. McCarthy and Parris (2008) argue that the risk of toe-clipping is justifiable only if one is answering questions of direct relevance to management applications. Unfortunately, too little is known about many amphibian populations to know in advance what these questions might be. Correctly con-

ducted population studies can be the only means of identifying risk factors. Potential increases in mortality or emigration rates are generally quite small, but can be accounted for in a study and the need for information must be balanced against those risks.

Parris and McCarthy (2008) are surprised that the scientific validity of potentially biased data from studies using toe-clipping has received little attention. We acknowledge that any field research involving the capture and marking of animals may potentially affect return rates through altered survival and/or behavior, so all techniques violate assumptions related to population estimation models, and bias needs to be considered (Phillott et al. 2007). However, in the absence of evidence-based results that prove a lesser effect on return rates of alternative marking techniques, field researchers will continue with toe-clipping as it is known to have small effects that have been quantified for some species. We hope this discussion has shown that toe-clipping and toe-tipping are acceptable techniques if carried out appropriately, that their use needs to be justified, that their effects on a study need to considered when analysing results, and that they will remain in use until alternative techniques are shown to be superior. We reiterate that controlled studies to evaluate the physical, physiological and behavioural effects of invasive marking techniques on a range of frog species are urgently needed.

Phillott et al. (2007) did not primarily aim to address Parris and McCarthy (2001) and McCarthy and Parris (2004) as we believe the weakness of their arguments was adequately discussed in Funk et al. (2003). Our concern is that animal ethics committees and government agencies have banned the use of toe-clipping as a result of these papers, but have done so without evidence that the procedure has a greater effect than the alternative marking methods. Our paper specifically demonstrated the problems with dismissing toe-clipping in favour of other, less understood invasive marking techniques.

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ARTICLES

Oophagy and Larval Cannibalism without Polyphenism in Tadpoles of the Great Basin Spadefoot (*Spea intermontana*)

SUE FOX
P.O. Box 68, Cedarville, California 96104, USA
e-mail: suefox@hughes.net

Polyphenism associated with cannibalism has been reliably documented in two species of North American spadefoot toads (family Pelobatidae: *Spea bombifrons* and *S. multiplicata*) (Bragg 1956, 1964; Bragg and Bragg 1959; Pfennig 1989; Pomeroy 1981). *Spea* larvae occur as two morphologically distinct phenotypes: 1) carnivores are cannibalistic, have beak-shaped, keratinized mouthparts, and hypertrophied jaw musculature; and 2) omnivores have flat, keratinized mouthparts, and feed primarily on detritus (Bragg 1965; Pfennig 1992; Pomeroy 1981). Pomeroy (1981) noted polymorphism in pools containing *S. multiplicata* 2–4 days after feeding commenced. In *S. multiplicata*, consumption of anostracan shrimps or other tadpoles induces the carnivore morphology and morph determination is reversible based on diet (Pfennig 1990; Pomeroy 1981).

Reports of polyphenism in *Spea intermontana* have been limited to mouthpart characteristics (Acker and Larsen 1979; Black 1973; Orton 1954; Turner 1952). The description provided by Tanner (1939) of the mouthparts of *S. intermontana* collected in Utah has been interpreted as indicative of a carnivore morph (Hall et al. 2002; Pfennig 1992). Subsequent workers have assumed that larvae of *S. intermontana* are potentially morphologically variable (Hall 1993; Hall et al. 1997; Hall et al. 2002). Hall (1998) includes two photographs of the carnivorous and herbivorous morphological types. However, the two types have not been described in detail and there are no reports whether the carnivorous morph is cannibalistic. I report field observations of cannibalism and oophagy by larvae of *S. intermontana* and the lack of polyphenism associated with cannibalism.

Methods.—I conducted this study at permanent, semi-permanent and temporary ponds in Mono County, California, USA (118.965°N, 38.086°W), during the breeding seasons April through June of 1984–1989. Permanent and semi-permanent pools are created by artesian wells. Semi-permanent pools are present year-round, except in drought years. Temporary pools formed from ground water and surface run-off, and were present only during wet years. Study pools varied in size from less than one meter square to several hectares. Additional observations and collections were made from three small pools formed from springs near the south shore of Mono Lake, Mono County, California (119.053°W, 37.940°N).

Tadpoles were observed in the field for 1380 h on 260 days between April 1984 and May 1989. The duration of observations ranged from 3–7 h per day. I identified a tadpole as a cannibal if it was observed eating all or part of a conspecific, while a non-cannibal did not eat a conspecific. For cannibalistic encounters for which an entire sequence was observed I recorded: the length of time it took a cannibal to consume its prey; the number of cannibals feeding on a single tadpole; and the snout–vent length (SVL; tip of the snout to the junction of the posterior body wall and cloaca) and developmental stage (DS, Gosner 1960) of the cannibal(s) and prey.

Tadpoles were collected for morphometric analyses mid-April to mid-June in 1984 through 1987 and during May in 1988 and 1989. Tadpoles were randomly collected with a dip net once a week from the main study pool and less frequently from other pools that contained fewer tadpoles. While phenotypic differences between morphs of *S. bombifrons* and *S. multiplicata* are readily determined by visual inspection (Bragg 1965; Pfennig 1990; Pomeroy 1981; Storz 2004), there were no obvious morphological differences among tadpoles of *S. intermontana* in my study pools. For more detailed morphometric comparisons, cannibals and noncannibals were identified by offering field-collected tadpoles (stages 25–36) at least one pre-feeding stage conspecific for 24 h. Tadpoles were housed individually in 2.4-liter round plastic containers (16.8 cm x 12.5 cm) filled with approximately 1680 ml water to a depth of 8.75 cm. Cannibalism was inferred if a tadpole was missing or its partially consumed remains were present. Tadpoles that did not eat conspecifics were labeled non-cannibals. Cannibals (N = 34) and non-cannibals (N = 36) were preserved for morphometric analysis.

All tadpoles were cold-killed and preserved in 10% formalin. I examined the external morphology of 1089 tadpoles of different sizes and developmental stages. Using dial calipers and a dissecting microscope, three characteristics were measured: SVL, total length (TL; tip of the snout to the tip of the tail), DS, and number of posterior and anterior labial teeth rows (PLT and ALT) using Altig and McDiarmid's (1999) terminology. The criterion for labial tooth row presence was at least three teeth on a tooth ridge. A qualitative description of the keratinized jaw sheaths also was recorded (e.g., serrations on jaw sheaths, thick, thin; see Altig and McDiarmid 1999).

Gut length (GL) and *musculus orbitohyoideus* length (OH) were measured for the 70 experimental tadpoles identified as cannibals and non-cannibals and for 157 tadpoles collected from a single population over the course of their development. These two traits are diagnostic of the carnivore morphotype for *S. multiplicata* (Pfennig 1989; Pomeroy 1981). A dissecting microscope with ocular micrometer was used to measure OH to the nearest 0.1 mm. The relationships of GL and OH to body size were analyzed using analysis of covariance.

I tested whether metamorphs were cannibalized by conspecific larvae by placing metamorphs in the water of ponds 1–2 m from shore. This forced the individual to swim to shore above feeding aggregations of tadpoles. I conducted 35 trials with individual metamorphs in 1984 and 45 metamorphs in 1986.

Results.—Cannibalism was observed on 8 of 260 days of field observations: 6 days in 1984 (April 15–18, 21, 22) and 2 days in 1987 (May 8, 15). A total of 41 occurrences of cannibalism were observed in the 8 days over a period of 27.5 h, in three different ponds. Based on the number of egg clutches recorded in the three ponds and the average number of eggs per clutch (mean = 812, SD = 297), the number of tadpoles present on each day the cannibalism was recorded ranged from 4872 to more than 10,000 tad-

poles (Pond 1 ≥ 10,000, Pond 2 4,872, and Pond 3 5,684).

All cannibalistic encounters occurred in feeding aggregations in the vicinity of a clutch of conspecific eggs that had hatched within the previous two days or were in the process of hatching. Cannibals were in early feeding stages, 25–27, and preyed on tadpoles in stages 20–25. Prey tadpoles with yolk sacs did not struggle while older tadpoles in stages 24–25 lashed their tails, but did not escape. Cannibals seized conspecifics on all body sites, including the head, back, abdomen, and tail. Cannibalistic encounters were initiated by a tadpole butting into another individual with its snout. Butting was a characteristic behavior engaged in by feeding tadpoles. Cannibalistic tadpoles did not pursue their prey if it moved away when butted, nor did they remain in the vicinity of newly hatched tadpoles to selectively hunt and prey on them. Most tadpoles that butted into newly hatched conspecifics did not seize them. These non-cannibals were frequently observed resting alongside or on top of newly hatched tadpoles.

Other tadpoles butted the feeding cannibal and some individuals seized part of the prey. Some individual tadpoles fed on the prey for a few minutes before leaving and being replaced by another tadpole. In 32 instances where the entire cannibalistic encounter from initiation to complete consumption was observed, from 1–7 tadpoles consumed part of a single newly hatched tadpole (mean = 2, SD = 1.5).

Cannibals were behaviorally and morphologically indistinguishable from other tadpoles in the feeding aggregations. However, their cannibalistic feeding behavior was conspicuous because they jerked sharply from side to side as they engulfed their prey. Groups of cannibals feeding on one tadpole tugged in opposing directions and tumbled about in the water, often upside down. In three cases, one individual pulled the prey away from the other tadpoles and rapidly swam away. The other tadpoles pursued a few millimeters before stopping to feed elsewhere.

In 19 timed observations, a cannibal consumed a tadpole in less than 5–2400 sec (mean = 866 sec, SD = 697.7). Large cannibals consumed small prey faster than cannibals that consumed prey close to their size. Some cannibals were the same size (SVL) as their prey, while others were up to 50% larger. The length of time for ten groups of two or more cannibals to completely consume the same prey ranged from 79–1800 sec (mean = 610.6, SD = 554.4).

Cannibalism was not observed experimentally or incidentally on transforming tadpoles, but was recorded on dead and injured tadpoles. In 1985, cattle fed and watered directly in the main study pool. The cows killed some tadpoles and mortally wounded others when they waded in the pond. Dead and injured tadpoles burst open so that their intestines were exposed. Unaffected tadpoles ate the intestines of both dead and live tadpoles as well as other internal organs. The cannibals did not eat the remainder of the tadpoles' bodies (e.g., head, back, tail) until several days later when the carcasses were affected by fungus and algae. The cattle's hooves also created water-filled depressions along the pond's margin. Fluctuations in water levels caused some of the depressions to become separated from the main body of water, trapping tadpoles that died when the water evaporated. When the water level rose again, tadpoles formed feeding aggregations on the dead tadpoles.

Toads appeared to employ a flexible breeding strategy in response to annual hydrologic conditions that appeared to be related to the incidence of oophagy. During dry years (1985, 1986), they were explosive breeders and females deposited their eggs in a period of a few days. In wet years (1984, 1987), they were prolonged breeders and females deposited their eggs over a period of two months. During prolonged breeding seasons, oophagy was observed in all study pools, except in temporary pools in which only one clutch was deposited. In explosive breeding years, few to no feeding stage tadpoles were present that could eat conspecific eggs as there were only a few days of overlap in the time of occurrence of eggs and larvae.

Thirty-eight of 118 egg masses (32%) were completely eaten by conspecifics. Nine of 118 egg masses were destroyed by desiccation (7.6%). Dense aggregations of feeding tadpoles formed on both viable and nonviable clutches of eggs. Nonviable eggs were affected by fungus, and the outer jelly became coated with green algae. Females typically deposited multiple, discrete clumps of eggs. Asynchronous hatching of eggs was recorded in 75.6% of egg clutches (N = 91; range = 1–4 days). Asynchronous development of embryos within clutches provided opportunities for sibling cannibalism as some tadpoles hatched up to four days before their siblings. Sibling cannibalism was observed only once when two Stage 25 tadpoles ate a Stage 20 tadpole. All three tadpoles were from the same discrete clump of eggs.

Female toads appeared to select egg deposition sites away from egg clutches and aggregations of tadpoles (unpubl. data). Due to patterns of egg deposition and oophagy, few situations existed in the field where tadpoles greater than Stage 27 could prey on newly hatched tadpoles. The females' egg laying was not always effective at preventing complete depredation. In 1984, ten clutches of eggs were entirely consumed in less than five days.

Analysis of covariance, with SVL as a covariate, revealed no significant differences in GL or OH length between cannibals (N = 34) and noncannibals (N = 36) for these variables. The use of developmental stage as a covariate in addition to SVL also showed no significant difference between cannibals and noncannibals for either OH (F = 0.32; df = 1, 70; p > 0.05) or GL (F = 0.79; df = 1, 70; p > 0.05). The standardized residuals of OH (mean = 2.68, SD = 8) and GL (mean = 144.3, SD = 113.5) regressed against SVL (mean = 13.8, SD = 8.9) were used to check for bimodality for a subset of tadpoles randomly collected from a single pond (N = 157). The results showed normal curves, which suggest that only one morphotype was present (see Pfennig 1990).

There was a difference in the number of posterior labial teeth rows between cannibals and noncannibals (χ^2 = 13.2, df = 3, p < 0.01) but not anterior teeth rows (χ^2 = 1.5, df = 2, p > 0.05). Cannibals had more rows of posterior teeth (mean = 1.85, SD = 1, range = 0–3) than non-cannibals (mean = 0.9, SD = 1.2, range = 0–3).

The number of labial teeth rows varied among tadpoles sampled from the same pool from 1984–1987. Analysis of variance for homogeneity among samples of tadpoles from four different years revealed that the differences in mean number of posterior and anterior labial teeth rows among the years were significant (posterior: F = 18.4; df = 3, 199; p < 0.001; anterior: F = 7.8; df = 3, 199; p < 0.001). There was also a difference in the mean number of posterior labial teeth rows among samples of tadpoles collected from three different pools (F = 6.5; df = 2, 77; p < 0.01), but not for mean number of anterior labial teeth rows (F = 1.2; df = 2, 77;

Herpetological Review 39(2), 2008

p > 0.05).

The tadpoles' lower jaw sheaths formed a shallow to steep V-shape, while their upper jaw sheaths were medially rounded. No tadpole (N = 1089) had a jaw sheath with the incised morphology indicative of the carnivore morphs of other *Spea*. The jaw sheaths of tadpoles collected from small pools with little organic matter were characterized by reduced pigmentation that was brown in color rather than the typical black pigment. Sharply serrated jaws were present in 93 of 1089 (8.5%) tadpoles examined, but were not present in any of the known cannibals. The serration might wear away with use of the jaws because it was not observed in any tadpoles greater than Stage 30.

Discussion.—Tadpoles exhibited both opportunistic cannibalism in which the prey does not attempt to evade the predator (e.g., oophagy), and cannibalism, in which conspecifics were attacked, killed, and eaten (Crump 1986). Groups of tadpoles feeding on a single prey did not always involve predaceous cannibalism, because in many cases, the prey was already dead from the initial cannibal's feeding activity.

Cannibalism in this population of *S. intermontana* was not associated with poylphenism. Cannibalistic tadpoles did not appear to require specialized oral morphology because the age classes of their prey were vulnerable and easily eaten. The only morphological trait found to differ between cannibals and non-cannibals was the number of rows of posterior labial teeth, which were greater in cannibals. This trait cannot be considered diagnostic of cannibalism or a history of cannibalism because the number of tooth rows also varied by: pool site; year for the same pool; and developmental stage of the tadpole. Reduced number of labial tooth rows, particularly the anterior rows in *S. multiplicata*, is a characteristic trait of *S. hammondii*, *S. bombifrons*, and *S. multiplicata* carnivore morphs (Bragg and Bragg 1959; Bragg 1965; Pomeroy 1981). However, this is only one trait among a suite of morphological and behavioral characters indicative of polymorphism. Moreover, numerous investigators have reported microgeographic variability in labial tooth rows for other species of *Spea* (Bragg and Hayes 1964; Bragg et al. 1964; Hampton and Volpe 1963; Potthoff and Lynch 1986) as well as for *S. intermontana* (Brown 1989; Hall 1993).

Polyphenism in *S. multiplicata* and *S. bombifrons* appears to occur because these species inhabit variable environments where discrete trophic morphs may provide a selective advantage. The carnivore develops faster than the omnivore and survives better in rapidly evaporating ephemeral pools, while the omnivore survives better in long-lasting pools (Pomeroy 1981; Pfennig 1990). The heterogeneous environmental conditions that make polymorphism evolutionarily advantageous for other *Spea* species may be missing in this population of *S. intermontana*. Tadpoles in my study area developed in permanent and long-lasting temporary pools and did not appear to experience any selection pressure to escape evaporation. Use of permanent bodies of water, including human-constructed impoundments, has been noted in other populations of *S. intermontana* (Blair 1956; Brown 1989; Morey and Reznik 2004). Desiccation before metamorphosis was not a source of mortality in this study population (unpubl. data). Morey and Reznik (2004) also reported no risk of evaporation for their study population of *S. intermontana*.

Differences in developmental markers between *S. intermontana*

and other *Spea* suggest that *S. intermontana* might have evolved in long-lived pools. The eggs of *S. intermontana* took an average of 6.5 days to hatch, with a range of 4–9 days. The eggs of other *Spea* species hatch within an average of 48 h (Black 1973; Bragg 1965; Mayhew 1965; Pomeroy 1981). The minimum time to metamorphosis for *S. intermontana* tadpoles in my study area ranged from 36 days in 1985 to 75 days in 1984. Brown (1989) reported 36 days for *S. intermontana* tadpoles to complete development, Nussbaum et al. (1983) reported that *S. intermontana* larvae metamorphose after one or two months of larval development, and Morey and Reznick (2004) reported a range of 36–79 days. Other species of *Spea* have a minimum time to metamorphosis of 13 days (Black 1973; Pomeroy 1981).

It is likely that under natural field conditions, as well as in the laboratory experiment, cannibalism in this population was too limited in scope to produce any effect on morphology. Fairy shrimp (*Brachinecta mackkini*) were not sympatric with tadpoles of *S. intermontana* at my study sites; the fairy shrimp occupied saline water and could not survive in the fresh water inhabited by the tadpoles. Thus, a dietary mechanism that causes differential morph development in *S. mulitplicata* larvae appears to be lacking in this population of *S. intermontana*. The only other report of cannibalism in larvae of *S. intermontana* did not note any morphological differences among the larvae (Durham 1956).

The lack of evidence for a carnivore morph in *S. intermontana* from my study in Mono County, California, compared to specimens from Washington State and Idaho, might not be unexpected for a species that is widely distributed. It is possible that *S. intermontana* has a latent potential for polyphenism that is more readily expressed in other geographic locations and under different conditions. The mechanism by which this occurs warrants further investigation.

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Spring Peepers and Pitcher Plants: A Case of Commensalism?

RONALD W. RUSSELL
Department of Biology, Saint Mary's University
923 Robie Street, Halifax, NS, Canada, B3H 3C3
e-mail: ron.russell@smu.ca

Sarracenia purpurea (Northern Pitcher Plant) is a carnivorous plant found throughout northeastern North America (Schnell 2002). This plant is frequently encountered in nutrient-poor bogs, often associated with *Sphagnum* spp. The water-filled, pitcher-shaped leaves of *S. purpurea* serve as a trap for small invertebrates attracted by extra-floral nectaries near the entrance to the pitcher. Once entry to the pitcher is accomplished, escape is difficult due to downward oriented hairs on the inner surface of the leaf, and captured organisms drown in accumulated rainwater. Nutrients from decomposing invertebrates are absorbed by the plant (Ellison and Gotelli 2001). Capture efficiency of insect prey in Northern Pitcher Plants is low (0.83–0.93%) (Newell and Nastase 1998). A mutualistic relationship is hypothesized to exist between pitcher plants and the inquiline community contained within the pitchers (Bradshaw and Creelman 1984; Ellison and Gotelli 2001). Tiny vertebrates are also known to become entrapped in *Sarracenia* pitchers (Schnell 2002).

There are a number of anecdotal references to amphibian consumption by *Sarracenia* pitchers as well as pitcher use by amphibians in the popular press (The Sentinel 2007). One of the earliest references to *Sarracenia* describes pitchers as insect refugia from amphibian predation (Catesby 1743). Amphibians are known to become entrapped and digested in pitchers (Butler et al. 2006; Schnell 2002), forage for insect prey on pitchers (Jones 1935), and inhabit pitchers (Lim and Ng 1991). In this study, I quantify pitcher use by *Pseudacris crucifer* (Northern Spring Peeper) and elucidate the nature of the frog-pitcher plant interaction.

Twelve adult Northern Spring Peepers (8 females, 4 males) were collected from the field in early May 2004 and placed in a 90-liter glass terrarium extensively planted with *Sphagnum* sp. and four Northern Pitcher Plants with 5–11 pitchers per plant. Pitcher plant density in the laboratory was similar to plant densities observed in the field and peepers had access to non-dessicating roosting sites within the *Sphagnum* mat. All spring peepers were reproductive and ranged in SVL from 18–26 mm. Spring peeper density in the laboratory was much greater than observed in the field. Amphibians were fed wingless fruit flies and juvenile crickets. The artificial habitat was observed at least 3 days per week from May–September for 15 minutes per day. Fruit flies were attracted to extra-floral nectaries on pitchers and spring peepers were frequently observed (at least once per observation period) climbing pitchers to consume these insects. Peepers were routinely observed inside *S. purpurea* pitchers during the day, but were never observed feeding while inside pitchers. Suitably sized pitchers of all plants were occupied and no territorial behavior was observed. Occupancy rates were typically less than 5% (0, 1, or 2 peepers observed in pitchers). Only pitchers large enough to admit peepers were used to

estimate occupancy. The entrance to the smallest pitchers was too small to admit adult frogs, but could potentially accommodate recently metamorphosed spring peepers. This microcosm was maintained for six months, with no amphibian losses resulting from entrapment in pitchers.

Sarracenia purpurea plants located on a coastal barren near Halifax, Nova Scotia, Canada (44°33.246'°N, 63°31.396'W) were surveyed for the presence of spring peepers. In 2004, 163 pitchers were observed and 306 in 2005. Density of Northern Pitcher Plants based on ten random 1 m quadrats was 8.5 ± 4.4 plants/m^2. Quadrats were selected by overlaying a sketch of the study area using approximate distances with a grid, randomly numbering the squares of this grid, then selecting ten squares by a random number generator for density estimates. Spring peeper surveys were conducted over three consecutive days during late May in both years in a large bog dominated by Sphagnum sp., Eriophorum sp., and Sarracenia purpurea where plants grew on a nearly continuous mat of Sphagnum. Observations were limited to a relatively short period at the peak of the spring peeper breeding season since these amphibians disperse back into the forest following reproduction. Additionally, in late May 2005, 50 pitchers were randomly collected from this site, dissected by longitudinal incision with a scalpel in the laboratory, and examined for the presence of amphibian remains. Five pitchers of sufficient size were collected from ten quadrats, randomly selected as described above.

There were no peepers observed in Sarracenia pitchers in 2004, however in 2005, four spring peepers were observed in pitchers during daylight. This corresponds to an incidence of 1.3% of pitchers occupied. When a pitcher was determined to be occupied by a spring peeper, it was marked with a ring of jute twine. Marked pitchers were inspected the following day and it was observed that none was occupied on consecutive days, indicating that amphibians had moved prior to the second survey. Frogs were not trapped within the previously occupied pitchers. Night surveys of 12 wetlands on this same coastal barrens from 2002 to 2006 (at least 8 surveys per year) revealed a large and active spring peeper population based on call surveys. Peepers were occasionally observed calling from pitchers at night and none of the 50 dissected pitchers contained identifiable amphibian remains. Complete digestion for trapped amphibians in S. purpurea pitchers requires at least 10 days (Butler et al. 2006). The sample of dissected pitchers was probably too small to detect amphibian remains with 1% or less.

The combination of laboratory behavior and field observations indicate that spring peepers occasionally use Sarracenia pitchers. Peepers forage for small insects attracted by extra-floral nectaries on the pitcher, intercepting invertebrates that might otherwise become plant food. There is no obvious advantage to the plant from this interaction, thus no mutualistic association, as observed with the pitcher-inquiline community, which assists in decomposition and release of nutrients to the plant. By intercepting nutrition that would normally be routed to the plant and inquiline community, spring peepers may function as parasites; however, only a small fraction of insects attracted to the extra-floral nectaries become entrapped in the pitcher (Newell and Nastase 1998). Parasitism is a minor interaction because of the low incidence of peepers in pitchers. Peepers may function as commensals by harvesting insects attracted to the pitcher.

Spring peepers forage for insect prey mostly during the day (Oplinger 1967), thus exposing these amphibians to potentially desiccating conditions. Peepers avoid desiccation during dry conditions by moving under debris (Wright and Wright 1949). The moist environment of the Sarracenia pitcher provides an ideal refuge from desiccation for amphibians. While refuge in the pitcher may appear to be neutral to the plant, the amphibian partially occludes the entrance to the digestion chamber by taking residence in the pitcher, which may affect pitcher trapping ability. Additionally, the frog is in an ideal position to consume trapped insects. This interaction clearly does not benefit the plant. Use of pitchers as a refuge was a rare event (1.3%) at the study site therefore this was not an important intertaxa interaction at this particular location. The importance of this interaction may increase where pitcher plants are less abundant. While use of Northern Pitcher Plants by spring peepers is not beneficial to the plant, it is a rare event. Consumption of amphibians by pitcher plants is an equally rare event (Butler et al. 2006) which could compensate plants for nutrition usurped by spring peepers.

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Body-flip and Immobility Behavior in Regal Horned Lizards: A Gape-limiting Defense Selectively Displayed Toward One of Two Snake Predators

WADE C. SHERBROOKE
Southwestern Research Station, American Museum of Natural History
Portal, Arizona 85632, USA
e-mail: wcs@amnh.org

and
CLAYTON J. MAY
5814 South Hopdown Lane, Tucson, Arizona 85746, USA

In 1937 Howard K. Gloyd led a herpetological expedition to southern Arizona (Gloyd 1937). Film records show a body-flipping reaction, termed "plays dead," of a Regal Horned Lizard (*Phrynosoma solare*) to prodding with a thin stick and subsequent human handling. An adult lizard repeatedly flipped itself onto its back, nine times within 25 s (immediately righted by Gloyd's hand after each flip). We found only one subsequent mention of the behavior in *P. solare*, without functional explanation (Parker 1971).

Death feigning, letisimulation, or tonic immobility, has been considered an antipredator response across invertebrate and vertebrate taxa without clear identification of its adaptive significance (Carpenter and Ferguson 1977; Greene 1994; Honma et al. 2006; Ruxton 2006; Ruxton et al. 2004), although in some predatory fish the use of death feigning appears to be clearly adaptive during aggressive mimicry (Tobler 2005). Many hypotheses offered to explain immobility responses of prey tacitly assume that prey manipulate predators by sending false information that they are dead and that this information interrupts prey-subjugation behaviors, thus providing opportunities for prey escape (Honma et al. 2006; Ruxton 2006). Honma et al. (2006) proposed that an inducible death-feigning response of a pygmy grasshopper (*Criotettix japonicus*) is a specific antipredator response against a gape-limited anuran predator to avoid being swallowed. The grasshopper's characteristic rigid posture, with body parts physically extended, interferes with prey manipulation and does not mimic death, but directly enhances prey survival.

In the case of *P. solare*, it is difficult to identify an evolutionarily adaptive advantage to body-flipping and re-flipping, to upside-down, by an immobile, death-feigning, animal. This leaves the behavior lacking a clear biological explanation. Our study attempts to place body-flipping and immobility behavior by *P. solare* in the context of adaptive antipredator behaviors that are effective resistance against specific predators that rely on jaw capture of prey which they ingest whole, such as a non-venomous snake.

We report several additional encounters (rare) of body-flipping behavior in *P. solare* in response to human handling. We then describe field trials aimed at elicitation of the body-flipping and immobility response or alternative responses (such as running flight) in specific predator-context encounters involving two snakes, one non-venomous (*Masticophis flagellum*) and one venomous (*Crotalus atrox*). The two snakes present the lizards with two different threats based on their prey-subjugation strategies (Endler 1991; Sherbrooke 2008), 1) *M. flagellum*: search/wait, identify, rapidly pursue, physically jaw-capture, subjugate, and ingest, and 2) *C. atrox*: wait, identify, envenomate (strike), track, and ingest carcass. We use our observations to propose that the lizards distinguish between two categories of predator threat, the two snakes, and respond to each with distinctive antipredator behaviors (flipping or running) that appear appropriate for selectively enhancing survival in response to each predator's subjugation skills. We also use the differences in responses of *P. solare* to the two snakes to propose a hypothesis for the previously unexplained body-flipping and immobility behavior, noting the predator contexts in which it is employed and not employed, and we discuss aspects of body-flipping and immobility that may function as antipredation defenses with *M. flagellum*.

METHODS

Carpenter and Ferguson (1977) reviewed literature reports and numerically catalogued lizard behaviors (termed "act systems") involving body inversion (act system #26, turn over) and letisimulation (act system #150) in various lineages of lepidosaurians. Similarly, Greene (1994) enumerated several categories of antipredator behaviors (#3, catalepsy, letisimulation, death feigning, tonic immobility; #22, invert body). It is difficult to unequivocally assign our observations to a particular category due to the paucity of examples, diversity of descriptions, and frequent lack of meaningful context for the reported behaviors. We simply use descriptive terms, body-flip and immobility behavior. In a body-flip followed by immobility a lizard rapidly raises one side (by extending its legs on that side) to effect a role over along its nose-to-vent axis, landing upside down where it remains motionless (see Figs. 1 and 2).

Following an observation of repeated body-flipping and immobility of a captive *P. solare* in response to human handling (Fig. 1, A–C; 30 June 2006), we reviewed our field notes and summarized additional records of this behavior.

We then studied the behavioral responses of adult *P. solare* during field trials utilizing a known ophidian predator of *P. solare*, the Coachwhip (*M. flagellum*) (Kauffeld 1957), that also preys on other similarly-armored horned lizards (Sherbrooke 1981). The individual *M. flagellum* (SVL 128 cm, tail length [TL] 47 cm; mass 787 g) utilized had previously been observed to capture and eat a *P. solare* (SVL 88 mm, TL 48 mm; mass 36.4 g) on the study area (May, unpubl. data). Our trials involved four *P. solare* fitted with radio-transmitters (Holohil PD-2; approximately 3 g), which were relocated in the field, and six lizards encountered in situ while traversing the study area. Fourteen trials, involving 52 encounters (presentations), occurred between 26 August and 2 September 2006 (Table 1): 0930–1200 h MST (12), and 1730–1900 h MST (2). The study area is immediately adjacent, on the west and northwest sides, to a small volcanic hill in the Altar Valley, Pima Co., Arizona (32°02'11.5"N, 111°23'46.6"W, datum WGS 384).

During trial encounters, the *M. flagellum* was restrained in gloved hands at mid-body, allowing the anterior third or more to move freely as it was held to the ground approximately 1 m from the lizards. It was then allowed/encouraged to approach and contact each lizard (Fig. 2, A). During each trial, an attempt was made to expose the lizard four times to the snake. Contact by the snake

TABLE 1. Summary of behaviors exhibited by ten Regal Horned Lizards (*Phrynosoma solare*) in response to approach of a Coachwhip (*Masticophis flagellum*) in 14 trials involving 52 staged encounters (usually 4/trial). For runs, specific encounter numbers (1–4) are identified. Encounter data are summarized, including number of tilts/trial and the distance (estimated ranges in dm; distance data not complete for lizards #3 26 August, and # 7) of the snake when initiated, occurrence of horn raising by the lizard, and number of encounters in which the snake effected tactile contact, or not, with the lizard. In addition, for encounters of each trial, the mean time and range of the lizard remaining in a flipped position for encounters of each trial are presented.

Lizard # Trial — Date	Sex	SVL (mm)	Lizard body-flip encounters /trial	Lizard run encounters /trial, (#)	Tilt #/s distance (range, dm)	Horns raised (+ / −)	Snake contact (+ / −)	Flip mean/range (s)
1— 26 Aug	F	96	0	1 (1st)	0/—	0/1	0/1	
1— 2 Sept			4	0	4/1–2	0/4	3/1	52/11–106
2— 26 Aug	F	95	4	0	4/3–4	4/0	4/0	33/23–42
2— 2 Sept			4	0	4/0.5–2	0/4	3/1	92/43–123
3— 26 Aug	F	100	4	0	4/3	2/2	4/0	21/15–39
3— 2 Sept			4	0	4/0.5–1	1/3	3/1	36/19–49
4— 26 Aug	M	88	4	0	4/3–4	4/0	3/1	48/35–71
4— 2 Sept			2	1 (3rd)	3/3–4	0/3	2/1	6.5/5–8
5— 28 Aug	F	91	4	0	4/2–5	3/1	4/0	17/6–28
6— 27 Aug	F	109	3	1 (2nd)	4/2–5	3/1	3/1	28/6–51
7— 26 Aug	M	89	4	0	4/0.5–7	1/3	3/1	14/3–19
8— 26 Aug	M	82	4	0	4/2–3	4/0	4/0	21/3–41
9— 31 Aug	M	93	4	0	4/1–5	2/2	4/0	32/12–60
10— 1 Sept	F	97	3	1 (4th)	4/1–3	0/4	3/1	4/2–7
Totals	14		48	4	51/0.5–7	24/28	43/9	n = 46

(present +, or absent −) prior to a lizard response (body-flip or run) was noted. Following a lizard response, the snake was withdrawn and hidden from view behind the experimenter. A subsequent encounter was initiated within about 1 min of the lizard's righting itself. Reactions of the lizards were noted: distance at which body tilting (dorso-ventral flattening of the abdomen while raising one side and lowering the opposite side, as in "dorsal shield;" Sherbrooke 2008) toward the snake occurred, body-flipping, time lizards spent resting on dorsum following flipping before self-righting, eyelids (opened or closed), eyelid bulging (present or absent), horns raised (executed +, or not −; Sherbrooke 1987), color change (effected or not, and resulting color), running escape (if employed, distance). For each trial, a range of the four encounters is given for the distance at which the lizard began exhibiting tilt behavior (except in trials with fewer encounters, Table 1).

On 14 September 2006 we studied, in a similar fashion (Table 2) and at the same field site noted above, the behavioral responses of adult *P. solare* to a known venomous ophidian predator, the Western Diamond-backed Rattlesnake (*C. atrox*) (Vorhies 1948), which also preys on other horned lizards (Sherbrooke 2003, unpubl. data). The snake was collected west of the Tucson Mountains, Avra Valley, Pima Co. Tucson, Arizona (32°11'09.5"N, 111°05'58.9"W). The snake (SVL 82 cm, TL 8 cm; mass 385 g) was placed in a 46 cm long clear plastic tube of 3.5 cm diameter. The snake's head and fore-body extended 15 cm from one end of the tube (Fig. 2C), and the tail extended from the opposite end. The apparatus, with snake, was hand held at the tube base where the posterior extending portion of the snake was duct-taped to the tube rim to ensure a grip of adherence to the snake's body scales without undue constriction, thus preventing forward movement in the tube. The tubed snake, safely and not aggressively restricted in its movements, was held with its head extended during encounters.

Trial encounters were conducted between 0900–1100 h MST, with five lizards (including the four radiotagged lizards) having had previous encounters with *M. flagellum*. The other three lizards (#s 1, 2, 7) had no previous experimental contact with snakes. The radiotagged lizards were located and tested where found in the field. The other four lizards had previously been captured and briefly maintained (3–8 days) in outdoor enclosures (fed and watered) before release back at their field capture sites, where they were subjected to our trial encounters.

The eight lizards were exposed to *C. atrox* in a total of 24 encounters (presentations), which varied between two and six depending on the outcome of encounters. Similar to the *Masticophis* encounters, the rattlesnake's fore-body was placed on the ground near the lizard and moved toward the lizard until it was within attack distance. The anterior portion of the snake extending from the tube moved freely as the snake explored its surroundings. Lizards that ran were followed and the snake was again presented to the lizard, usually within a minute of it having stopped.

RESULTS

Body-flip responses to human stimuli.—Incidental to other studies that involved capture of hundreds of *P. solare* over the years

Lizard #	Sex	SVL (mm)	# encounters	Lizard run encounters #, distance (m)	Lizard body-flip encounters #	Tilt #	Horns raised (+)	Snake contact (+)
1	M	89	6	4 (1–2)	0	0	0	2
2	M	93	3	0	0	3	3	3
3	F	96	2	2 (0.5)	0	0	0	0
4	F	100	2	2 (1–2)	0	0	0	0
5	F	91	2	2 (1–4)	0	2	0	0
6	F	95	2	2 (1–4)	0	0	0	0
7	F	92	3	3 (1–2)	0	0	0	0
8	M	88	4	0	4	3	0	2
totals			24	15	4	8	3	7

1976–2006 in Pima Co., Arizona, we observed and recorded eight instances of body flipping and immobility (5 females, 3 males; SVLs 29, 48, 62, 69, 91 mm, and 61, 91, 96 mm, respectively) in response to human prodding or handling during the months of April (1), June (4), July (2), and September (1); we estimate this was < 1% of captures. All eight lizards repeated flipping of the body in response to being righted (6, 9, 11, and 10–15 times; and four lizards flipped numerous uncounted times), thus repeatedly exposing the lizard's solid-white or white with small black/gray-dots ventral surface, with all legs extended to the sides, tail down on substratum, and the lizard lying on its back (Fig. 1, A–C). Each body flip was accomplished quickly enough so that it was difficult for the human eye/brain to follow the motion (although captured on film, 1/250 s exposure). Lizards remained on their backs for several seconds to many minutes before righting themselves between flips. Four of these lizards had been previously or were subsequently captured without exhibiting body-flipping behavior.

Predator-prey trial encounters with *Phrynosoma solare* and *Masticophis flagellum*.—Of 52 total encounters with *M. flagellum*, 48 (92%) resulted in the lizard doing a body-flip (Fig. 2, A, B) and four (8%) resulted in a run, without a body-flip. All lizards that exhibited a body-flip initially showed some form of body tilting toward the approaching snake, as did three of the four lizards that ran. The snake's distance from the lizard at which this reaction by the lizard was initiated was usually 20–50 cm (Table 1). The raising of horns and lowering of rostral nose/chin areas was seen in approximately half of the encounters (24 of 52; Table 1), but not in the lizards that ran. In the raising of horns response, individual lizards showed variation within a trial from encounter to encounter (Table 1), and individual lizards changed the predominance of their reactions (+ or –) from one trial to another (lizard #s 2–4; Table 1). The snake made contact with the lizard in 43 of 52 encounters; of the nine encounters in which contact by the snake was absent, four resulted in lizard runs and five in body-flips. Most lizard body-flips (90%) were associated with a tactile stimulus by the snake. No runs were initiated by contact with the snake. Of 46 body-flips for which the duration of time spent on its back before the lizard righted itself was recorded, the mean time spent inverted was 34 s, range 2–123 s; encounter data were only recorded twice for lizard # 4 (2 September) and lizard # 6, and were only recorded three times for lizards # 7 and # 10. All body inversions (lateral rollovers) to return to standing posture were executed in a slower and more deliberate fashion than the original instantaneous body-flip, but still quickly. These were accomplished in the visual absence of the snake, in the presence of the experimenter, and with the lizard's eyelids open. In four cases of body-flipping behavior, the time the lizard remained inverted during a flip was not recorded (Table 1). Four encounters in two trials were omitted due to running escapes (lizard # 1 ran down a rodent hole on 26 August, and lizard # 4 ran 41 m, terminating the encounter trials, on 2 September); this reduced total encounters from 56 to 52 (Table 1). With the four radiotagged lizards (#s 1–4), trials of four encounters each were repeated twice, a week apart; all are reported together (Table 1).

During the trial encounters, no lizard exhibited eyelid swelling, engorging the circumorbital sinuses with blood (associated with canid defense; Middendorf and Sherbrooke 1992). In addition, lizards were noted to have their eyelids closed during body-flipping and initial resting upside down, but then to open their eyelids prior to rolling back onto their ventral side. And, frequently, but not always, lizards appeared to exhibit a change in color, usually becoming lighter and more yellow during the predator encounters. No tongue extrusions, that might have enhanced taste or vomeronasal exploration, were seen before or after body-flipping. The snake did not bite any lizard during the trials.

Predator-prey trial encounters with *Phrynosoma solare* and *Crotalus atrox*.—In responses during the 24 encounters with *C. atrox*, the eight lizards ran 15 times (62%), body-flipped four times (17%), and failed to respond five times (21%). Five lizards (#s 3–7; 63%) executed runs in all of their encounters (11), and one lizard (12.5%) ran in four of six encounters. Two lizards (25%) failed to run in any encounter; one was previously exposed to a snake (# 8) and one was not (# 2), and one was radiotagged and one was not. Only one lizard (12.5%) executed body-flips in all four of its encounters. In contrast to other lizards, this radiotagged lizard was found in heavy grass cover under a shrub. Time spent inverted was recorded for two encounters (103 s, 71 s). No changes in lizard color were noted.

Of the three lizards that executed body tilting, one ran, and one raised horns. Body contact by the snake was made with three lizards in non-running encounters. One lizard (#2) was struck and fatally envenomated by the rattlesnake during its third encounter (Sherbrooke and May 2008).

Comparison of *Phrynosoma solare* responses to two snake predators.—Some of the responses of *P. solare* to *M. flagellum* and to *C. atrox* appear to be distinct, in spite of the fact that slightly different designs of the two snake trials do not always provide directly comparative sets of data (Tables 1 and 2; see Discussion). These differences in responses of lizards are seen in the predominance of body-flipping/immobility (48 of 52; 92%) over running (4 of 52; 8%) responses to *M. flagellum* encounters and in the predominance of running (15 of 24; 62%) over body-flipping/immobility (4 of 24; 17%) responses to *C. atrox* encounters (no response, 5 of 24; 21%). Considering only the first encounter response of each lizard (omitting non-responses to *C. atrox*) to the two predator threats (to *M. flagellum* 9 body-flips, 1 run; to *C. atrox* 1 body flip, 6 runs), the lizards' reactions again suggest that *M. flagellum* is more likely to elicit body-flipping than *C. atrox*, which is more likely to elicit running that *M. flagellum*. Also, there appear to be differences in other responses of *P. solare* during each encounter with *M. flagellum* and *C. atrox* (Tables 1 and 2).

DISCUSSION

The differences in defensive body-flipping and running escape reactions exhibited by *P. solare* to *M. flagellum* and *C. atrox* appear to be clear, with some possible errors in animal judgment (potentially influenced in one case with *C. atrox* by obscuring vegetation); *P. solare* tends to body-flip to *M. flagellum* and run from *C. atrox*. The other defense responses (Tables 1 and 2; tilt and horns raised) also suggest a greater tendency to run from *C. atrox*, and stand in place to *M. flagellum*. These data suggest that *P. solare* are able to differentiate between these two predatory snakes, as are *P. cornutum* (Sherbrooke 2008). Similarly, female skinks *Mabuya longicaudata* at their nests have been shown to respond with flight from a lizard-eating snake *Elaphe carinata*, and with nest defense against an intruding snake that is an egg-predator, *Oligodon formosanus* (Huang 2006).

Statistical tests were not run on comparisons of the body-flip versus run responses of *P. solare* to *M. flagellum* and *C. atrox* (first responses 9:1 and 1:6, respectively) due to a number of issues, including low number of experimental animals, involvement of some lizards in more than one encounter or trial, differences in pretrial treatment of lizards (radiotagged or not, field encountered or not), differences in methods of restraining snakes, and diversity of conditions at individual field sites. Nevertheless, we feel that the distinctly different responses of the lizards to the two forms of predatory snakes represent real differences in categorization of predators by the lizards during the execution of antipredator tactics exhibited in body-flipping and immobility, and in running flight. Supporting this view, we note that similar and statistically supported response differences were seen under controlled trials in non-field conditions with the same two predatory snakes and *P. cornutum* (Sherbrooke 2008).

The ten rare instances of body-flipping and immobility behavior in response to human handling (< 1%; versus 92 % to *M. fla-*
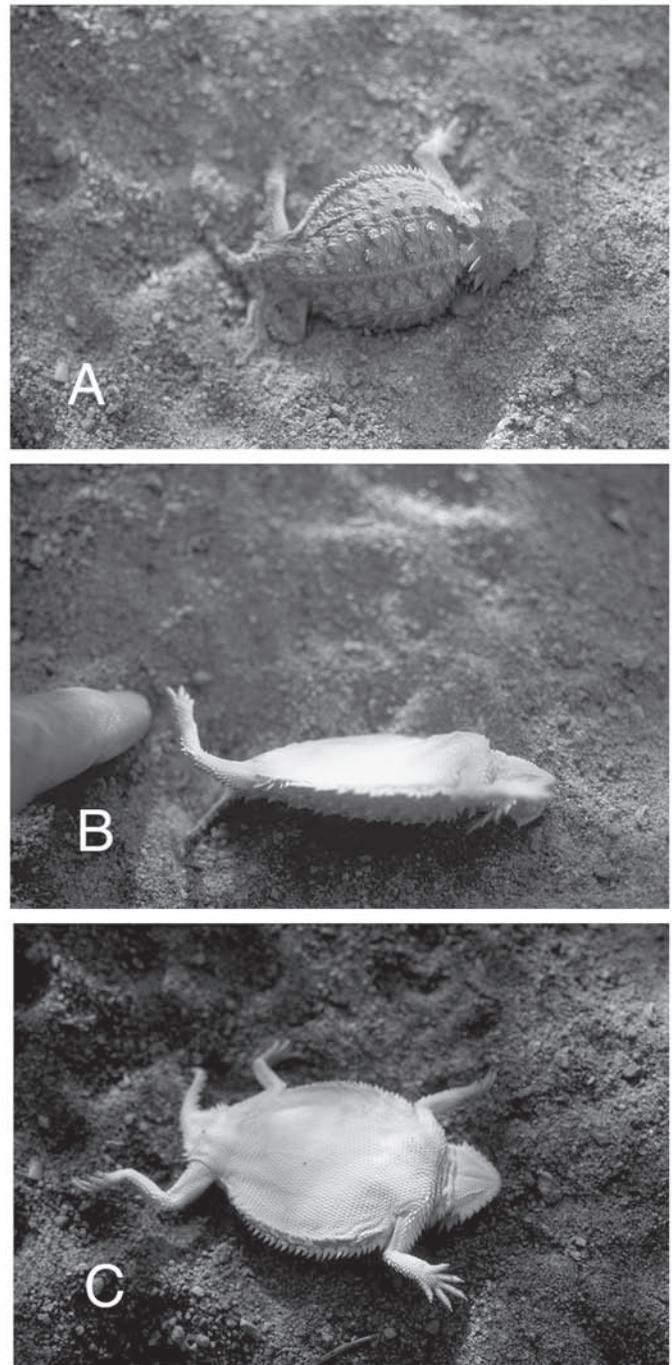
FIG. 1. Adult female (SVL 69 mm) Regal Horned Lizard (*Phrynosoma solare*) exhibiting body-flipping behaviors on 30 June 2006 in response to human handling and righting of body orientation. A) initial upward-thrust of one side in body-flipping. B) mid-flip position (immediately following tactile stimulation by a human finger, left); note closed eyelids. C) inverted posture held following flip, illustrating wide and white ventral surface (not inflated), spread legs, and tail depressed toward substratum. Eyelids were closed.

gellum) that we recorded may be cases of prey error in categorization of predator threat. These responses to humans might be similar to blood squirting at humans in *P. solare*, which occurs in only 4.6% of encounters (Parker 1971), whereas with dogs it occurs in 60% of encounters (Sherbrooke and Middendorf 2001); in *P. cornutum* it occurs in 5.9% of human encounters, 70–100% of
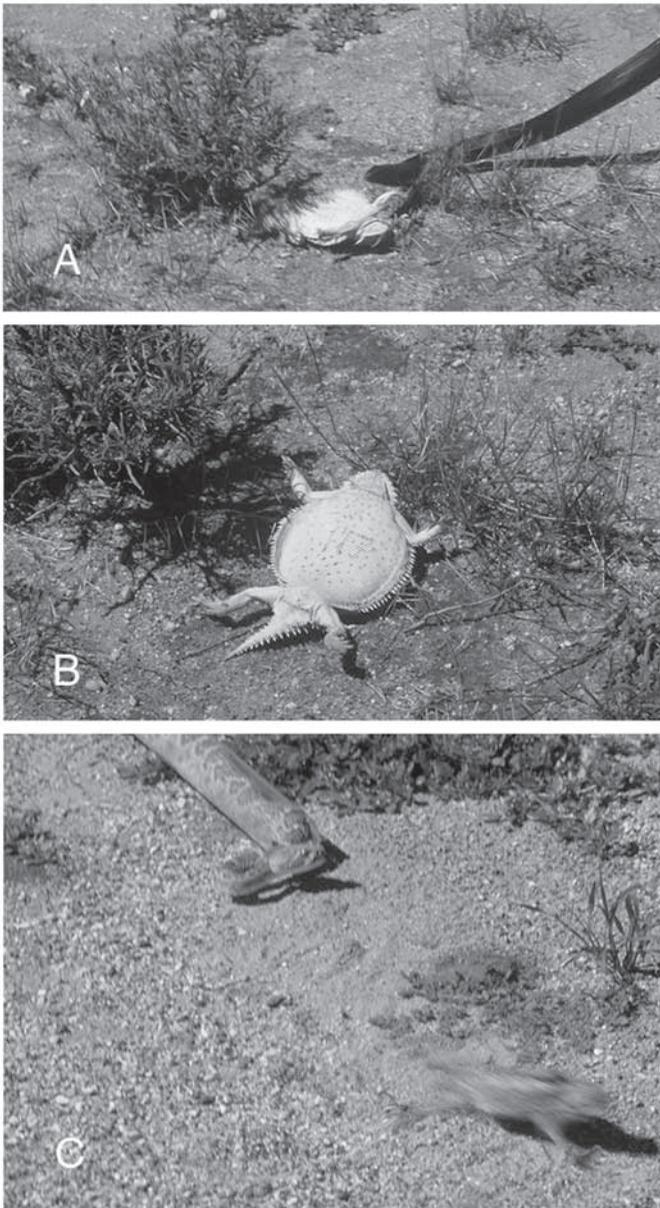
FIG. 2. Responses of adult Regal Horned Lizards (*Phrynosoma solare*) to presentation of encounters with ophidian predators. A) body-flip response to an approaching Coachwhip (*Masticophis flagellum*). B) continued holding of a body-flip response to a *M. flagellum* following retraction and hiding of the snake. C) running response (lower right) to a tubed Western Diamond-backed Rattlesnake (*Crotalus atrox*) (upper left/center).

dog encounters, and 75% of encounters with a native canid (Sherbrooke and Middendorf 2001, 2004). Assuming humans were not a selective force in the evolution of blood squirting (nor in the evolution of body-flipping/immobility behavior in *P. solare*), these significant differences in frequency of horned lizards employing antipredator defenses at humans versus at predators suggest that humans present confounding stimuli that may sometimes erroneously elicit defensive behaviors evolved as defenses against other categories of organisms.

Ingestion of horned lizards by gape-limited predators such as snakes involves significant risk of death to the predator (Holte and Houck 2000; Sherbrooke 1981, 2003; Vorhies 1948). Because

of this, features of the *P. solare* body-flip and immobility display may inhibit the likelihood of further attack, depending on the relative size of the snake and the lizard, the experience of the snake, and the snake's level of hunger (Aubret et al. 2007). And, if a snake initiates an attack, the flipped and immobile lizard is in a position for maintaining a stance that maximizes the effectiveness of its physical defenses against such a predator. Rattlesnakes possess similar size-related ingestion limitations as do whipsnakes, but envenomation may reduce some features of resistance to capture and ingestion, such as leg rigidity, but not others, such as horn erection (Sherbrooke and May 2008). A body-flip and immobile response offers little defense against envenomation by a rattlesnake, but a running response distances the lizard from a strike by this predator that does not rapidly pursue fleeing prey.

Phrynosoma solare responses to *M. flagellum* were initiated at a distance of 5–70 cm, suggesting a visual identification of the predator as a precursor to subsequent reactions. Tilting was the most common response (98%). This was followed by body-flipping (92%) and horn raising (54%). We suggest that following visual identification of predator type (as non-venomous rather than venomous; breadth and characteristics of these predator categories have not yet been determined), the lizard adjusts its body defensively with a tilting of its dorsal surface toward the predator, with a raising of the horns in many cases, and then, or even before these reactions, it executes a body-flip.

Once body-flipping behavior has instantaneously inverted a *P. solare*, still located at the site of its encounter with a *M. flagellum*, its appearance has been visually altered. This may startle (Edmund 1974; Ruxton et al. 2004) a non-venomous snake enough to prevent an immediate jaw-grasping attack. During body-flipping the lizard's cryptically-colored and disruptively-patterned dorsal surface (visually fragmented) is replaced by a nearly pure white (sometimes with small gray spots; Fig. 2, B) ventral surface. This surface is broadly oval with a row of lateral fringe scales (jagged in appearance) along each side of the abdomen, four laterally-splayed limbs, and an extended tail. This suddenly appearing new vision may advertise to the snake that its potential prey possesses a broad dimension and extended sharp structures, which present potential difficulties for ingestion (Inbar and Lev-Yadun 2005; Speed and Ruxton 2005). The wide-taxonomic occurrence of uniformly-white ventral surfaces in iguanid lizards suggests that this character is plesiomorphic in the clade. Therefore the uniform-white color of ventral surfaces exposed during body-flip/immobility displays of *P. solare* may have evolved as an exaptation.

If body-flip and immobility displays do not successfully thwart subjugation and consumption by a relatively large *M. flagellum*, it may be unlikely that an attempted running escape would enhance survival. Limb length is short and sprint speed is low in *Phrynosoma* (Bonine and Garland 1999; Pianka and Parker 1975), virtually assuring capture by a pursuing *M. flagellum*. Fleeing prey often elicit chase and capture responses by predators (Cyr 1972), and running horned lizards 1) may not easily visually monitor the movements of a pursuing snake, 2) may provide a horizontally-flattened target for the vertically-grasping jaws of whipsnakes (Sherbrooke 2008), and 3) may be unable to display their morphological features that are threats to whole-prey ingestion.

The best defense of a *P. solare* against a *M. flagellum* appears to be remaining stationary (flipped and immobile), thus visually in-

timidating its adversary with potentially life-threatening defenses (horns), broad-body/appendage circumference and pseudo-defenses (pointed lateral-fringe scales). Unlike the "dorsal shield" response of *P. cornutum* to *Masticophis* spp. (Sherbrooke 2008), the body-flipping response of *P. solare*, once assumed, does not allow continuous adjustments of defensive positioning by the inverted lizard. Nevertheless, we noted increased rigidity of limbs and further raising of horns, possible antipredator adjustments, during our simulations of snake biting by pinching (dorso-ventrally) the edge of inverted lizards' bodies (unpubl. data, Sherbrooke and May). As a defense against ingestion by gape-limited snakes, body-flipping and immobility in *P. solare* resembles defenses in some anguid and cordylid lizards. When threatened by colubrid snakes, they effect body conformation changes by grasping their tail in their jaws to create a broad circular body form that is difficult or impossible for snakes to ingest (Arnold 1993; Fitch 1935; Mouton et al. 1999).

The apparent visual monitoring for the continued presence of *M. flagellum* by the lizards (by opening their eyelids), and the short duration of the time lizards spent resting in an inverted position once the snake was removed (usually < 1 min) suggests that the lizards, once flipped, remained open to subsequent running escapes from the snake encounter site. The duration of immobility may be influenced by access to escape routes and absence of predator threat (Burghardt and Greene 1988; Hennig et al 1976; O'Brien and Dunlap 1975). Repeated body-flips by *P. solare* during multiple-interrupted encounters of the trials (Table 1) illustrate the significance of the presence or absence of the predator threat to the lizard assuming the flipped and immobile posture.

In contrast to *M. flagellum*, *C. atrox* do not rapidly pursue prey, but strike nearby prey with a venomous injection from their fangs, from which a horned lizard has no chance of survival (Sherbrooke 2008; Sherbrooke and May 2008). Prevention of envenomation may be best accomplished by avoidance, which *P. solare* accomplishes by running to quickly remove itself from the vicinity of *C. atrox*. *Crotalus atrox* is unlikely to pursue an unenvenomated lizard. In contrast to this appropriate escape behavior, assumption of a body-flip and immobility stance by *P. solare* to a *C. atrox* threat would only facilitate prey capture and subjugation (envenomation). Thus, in response to two predator threats, *P. solare* appears to identify the category of snake predator involved and responds to each with a distinct defensive behavior that may enhance its potential for survival in each of two distinctly-different predation scenarios, non-venomous and venomous snakes.

We consider body-flipping behavior by *P. solare* to be an adaptive survival response involving honest presentation and amplification (Taylor et al. 2000) of prey resistance abilities to subjugation and consumption by a gape-limited predator. This is in contrast to the death-feigning hypothesis (untested) that prey death-feigning (tonic immobility, etc.) might have intrinsic survival value, without a clear explanation of how it functions in enhancing prey survival (Honma et al. 2006; Ruxton 2006; Ruxton et al. 2004). Although we see no support from our study for the death-feigning hypothesis, we note that the two hypotheses are not mutually exclusive: both display of features of morphological resistance and immobility per se may contribute to prey survival.

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Predation on Caecilians (*Caecilia orientalis*) by Barred Hawks (*Leucopternis princeps*) Depends on Rainfall

HAROLD F. GREENEY
and
RUDY A. GELIS
Yanayacu Biological Station, Cosanga, Napo, Ecuador

and

W. CHRIS FUNK
Department of Biology, Colorado State University
Fort Collin, Colorado 80523-1878, USA
e-mail: Chris.Funk@colostate.edu

Caecilians are limbless, subterranean or aquatic amphibians found throughout much of the tropics (Duellman and Trueb 1994; Himstedt 1996). Although amphibians are declining dramatically (Stuart et al. 2004), the conservation status of caecilians is largely unknown due to lack of information on their ecology and natural history (Gower and Wilkinson 2005). A handful of studies have documented caecilian life histories (e.g., Funk et al. 2004; Gans 1961; Kupfer et al. 2005; Malonza and Measey 2005; Parker 1936, 1958; Sanderson 1937; Sarasin and Sarasin 1887–1890; Taylor 1968; Wake 1980). Nevertheless, 114 out of 172 species (66%) of caecilians remain too poorly known for an accurate status assess-

ment, and thus are listed as "Data Deficient" by the IUCN (2006). Perhaps because of their elusive nature, there is an increasing interest in the biology of caecilians (Kupfer et al. 2006; Measey and Herrel 2006).

Predator-prey interactions are widely recognized to have important effects on population dynamics (e.g., Krebs et al. 1995; Lotka 1925; Volterra 1926), but in the case of caecilians, little is even known about which taxa act as predators. Snakes are considered the main predators of caecilians (Duellman and Trueb 1994; Kupfer et al. 2003), although some other predators such as turtles (Zamprogno and Zamprogno 1998), spiders (Boistel and Pauwels 2002), and ants (Measey 2004) have been documented preying on caecilians. Identifying predators of amphibians is important in the context of amphibian declines, because predation may tip already declining populations over the edge toward extinction (Corn 1993; Parker et al. 2000). Here we show that a tropical hawk acts as an important predator of the caecilian *Caecilia orientalis* and that this unexpected ecological interaction depends strongly on weather.

Methods.—We filmed a Barred Hawk (*Leucopternis princeps*) nest using a hidden camera from 15 February–8 May 2004 and 7–28 January 2005 for a total of 599 h in the private reserve of Cabañas San Isidro, next to Yanayacu Biological Station (00°35'S, 77°53'W; 1950 m elev.). During most days of filming, the nest was filmed continuously during daylight hours (from morning to evening) when the hawks were active. The Barred Hawk is a rare, large hawk (total length = 52–61 cm) found from northern Peru to Costa Rica (700–2200 m; Ridgely and Greenfield 2001). The 1700 ha reserve comprises a mosaic of primary and secondary growth in humid, montane, evergreen forest about 3 km W of the town of Cosanga in the Napo Province of northeastern Ecuador (for a more complete site description, see Greeney et al. 2006).

Each year, the same Barred Hawk pair raised a single chick in the same nest. The nest was located on a rocky ledge 5 m from a rushing waterfall. The blind was installed 3.5 m above and 10 m from the nest, on the opposite side of a stream. All videos were transcribed at a later date. In addition to recording prey brought to the nest, we recorded whether it rained during each hour-long time interval. Since video quality was excellent, most taxa were clearly identifiable, but seven unknown taxa were excluded from the analysis. Because caecilians surface primarily during heavy rains and snakes are active at Yanayacu when it is clear and sunny, we hypothesized that Barred Hawks would bring more caecilians to the nest, but fewer snakes, when it was raining. We tested this in 2004 using a Fisher's exact test. This was the second Barred Hawk nest ever documented (Muela and Valdez 2003) and the first closely monitored to document feeding behavior. Details of the breeding ecology of these Barred Hawks are being prepared separately for an ornithological journal (R. A. Gelis and H. F. Greeney, unpubl. ms.).

Results.—To our surprise, a caecilian species (*Caecilia orientalis*) was the main prey item brought to the nest by two Barred Hawk parents to feed a single chick brooded each year (Fig. 1; videos available upon request). *Caecilia orientalis* is a large caecilian (total length = 31–62.5 cm) found in the Andes of Ecuador and Colombia and is the only caecilian known from this site (Funk et al. 2004; IUCN 2006). Prey items delivered to nestlings included 50 caecilians (48.1% of diet), 36 snakes (34.6%; *Atractus occipitoalbus* and two unidentified colubrid species), five giant
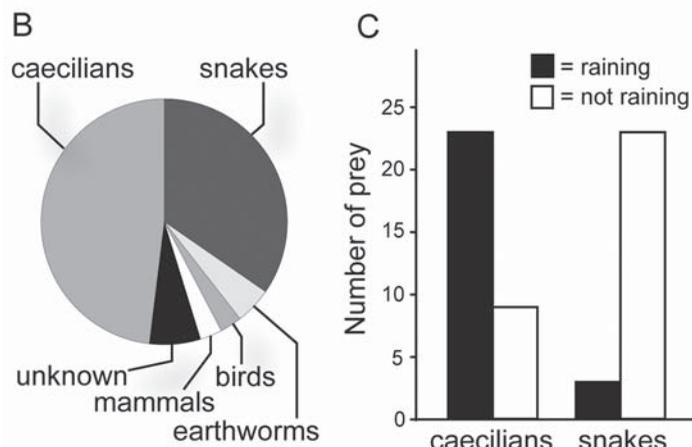
FIG. 1. (A) Barred Hawk (*Leucopternis princeps*) with caecilian (*Caecilia orientalis*) in talons (left). The white chick is seen in background (upper right). A color version of this photo is available upon request. (B) Proportion of Barred Hawk diet in 2004 and 2005 composed of different taxa. (C) Barred Hawks bring significantly more caecilians than snakes to the nest when it is raining ($P < 0.00001$, N = 58).

earthworms (4.8%), three young birds (2.9%), three small mammals (2.9%), and seven unknown animals (6.7%) (Fig. 1B). *Caecilia orientalis* vouchers from this site are available in the Museo de Zoología at the Pontificia Universidad Católica del Ecuador (QCAZ 21417–21419).

As predicted, we found that Barred Hawks brought significantly more caecilians than snakes to the nest during hour-long time intervals when it was raining (Fisher's exact test, $P < 0.00001$, N = 58; Fig. 1C).

Discussion.—It is surprising that an aerial predator, the Barred Hawk, was able to find subterranean prey such as caecilians. A previous report states that birds may occasionally prey on caecilians (Wake 1983), but this report did not provide specific bird species names or details of this predator-prey interaction. During several years of research at Yanayacu, caecilians were rarely encountered on the surface in the day even when it was raining (Funk et al. 2004). Thus it is unknown how Barred Hawks are able to

consistently find these elusive amphibians. These results suggest that *Caecilia orientalis* may actually be fairly common, as has been found for some other caecilian species (Measey 2004), yet *C. orientalis* is reported as "uncommon in Ecuador" by the Global Amphibian Assessment (IUCN 2006). Because of the rarity and huge ranges of Barred Hawks, we were only able to find and intensively monitor one pair over two years. It will likely take several years of intensive searching to find additional Barred Hawk nests. Nonetheless, the dominance of caecilians in this pair's diet and consistent use of these amphibians over two years suggests that caecilian predation by Barred Hawks will likely be widespread at sites with abundant caecilian populations.

Rainfall has increased at some sites in Ecuador over the last 40 years (Haylock et al. 2006), although rainfall trends at Yanayacu are unknown. If predation on caecilians is typical for Barred Hawks, changes in rainfall could alter this predator-prey interaction and potentially impact populations of both species. Climate change has already been implicated in amphibian declines in Ecuador and elsewhere in the Neotropics (Blaustein and Dobson 2006; Pounds et al. 2006). Predicting the ecological impacts of climate change, however, will require a better understanding of trophic interactions and the influence of weather on these interactions as documented here.

Determining the effect of predators on caecilian populations will also require a much better understanding of caecilian population dynamics. Studying the population ecology of these fossorial amphibians has proven difficult in the past due to low detectability, a paucity of methods for individually marking caecilians, and the rareness of some caecilians species. However, at Yanayacu Biological Station and some other sites (Bustamante 2005; Measey 2004; Péfaur et al. 1987), caecilians can be abundant and thus potentially amenable to study. New methods have also recently been developed for marking caecilians for capture-recapture estimation of vital rates and demographic parameters (Gower et al. 2006; Measey et al. 2001, 2003). Use of these methods in combination with population modeling (Biek et al. 2002) and molecular genetic markers (Beebee 2005; Funk et al. 2005) should help illuminate the demography, ecology, and conservation status of these fascinating animals.

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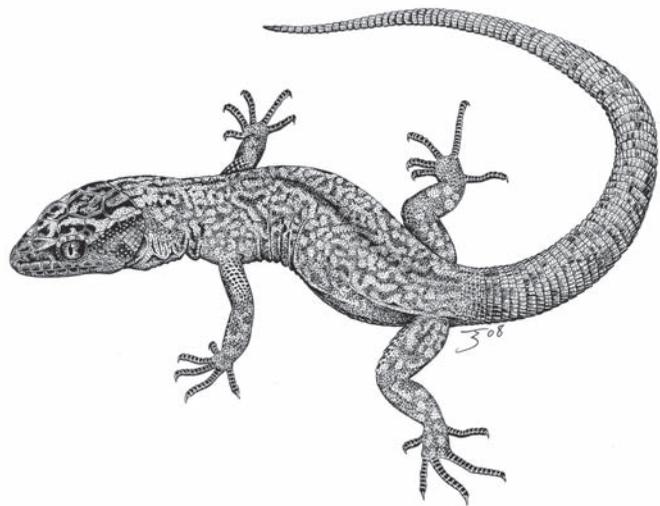
Xantusia sierrae (Sierra Night Lizard): USA: California: Kern Co., foothills of Greenhorn Mountains. Illustration by Jackson Shedd.

Ecology and Behavior of *Polypedates leucomystax* (Anura: Rhacophoridae) in Northeast Thailand

JENNIFER A. SHERIDAN

Section of Ecology, Behavior, and Evolution
Division of Biological Sciences,University of California, San Diego
La Jolla, California 92093-0116, USA
e-mail: jsherida@biomail.ucsd.edu

Polypedates leucomystax (Rhacophoridae) is among the most common of the nearly 800 species of anurans in southeast Asia (Iskandar and Colijn 2000), and among the most widespread, ranging from southern China south to Indonesia, and from India to the Philippines. Compared to most anurans of tropical southeast Asia, there are several reports on its habitat (Garcia-Rutledge and Narins 2001; Inger and Steubing 1997; Malkmus et al. 2002; Narins et al. 1998), calls (e.g., Christensen-Dalsgaard et al. 2002; Sheridan 2008) and reproductive habits (Feng and Narins 1991; Malkmus et al. 2002; Yorke 1983). Despite this, relatively little is known of its population size, sex ratio, and variation in reproduction. In this paper, I present a detailed study of reproduction (clutch size and variation therein), time to metamorphosis, adult body size, and male site fidelity at a seasonal site (Sakaerat, Thailand) to allow for an evaluation of variation in these traits across the broad range of *P. leucomystax*. My observations permit the exploration of the adaptations seen in other tropical anurans that range from aseasonal to seasonal environments.

Polypedates leucomystax is a medium-sized tree frog (male SVL 37–64 mm, female SVL 57–89 mm) common in disturbed areas. It breeds in standing water such as natural ponds, cattle tanks, cisterns, and flower pots. Males form calling groups around standing water and females create foam nests above water in emergent vegetation or other suitable substrate (e.g., cistern wall). In some cases, multiple males will clasp a single female during a given breeding event (Feng and Narins 1991; pers. obs.). In Singapore, eggs have been found in January, February, April, August, and September, and females had enlarged oviducts in all months in which they were captured (all months except May, July, and November, Berry 1964). Zeller (1960) reported that they can breed throughout the year but are inhibited by dry conditions in western Java. Yorke (1983) noted that near Kuala Lumpur, Malaysia, the females deposit 100–400 eggs in foam masses measuring about 10 cm in length on vegetation above ephemeral ponds. In Sabah, Malaysia, Malkmus et al. (2002) found larger clutch sizes, 150–900 eggs. Time to metamorphosis was reported as 4 weeks at Sakaerat, northeast Thailand (Heyer 1973), and 7 weeks in Kuala Lumpur (Yorke 1983).

Polypedates leucomystax is not a well-defined species and is probably a complex of cryptic sympatric and allopatric taxa. Narins et al. (1998) reported significant differences in calling habits of two genetically distinct sympatric morphotypes of *P. leucomystax* near Kuala Lumpur, but did not propose new nomenclature. Within the Sakaerat, Thailand, population, Sheridan (2008) found no significant differences in calls, and analysis of 500 bp of the 16S gene indicated variation of less than 1%. Thus, all individuals encountered at Sakaerat are likely conspecific, but further studies of
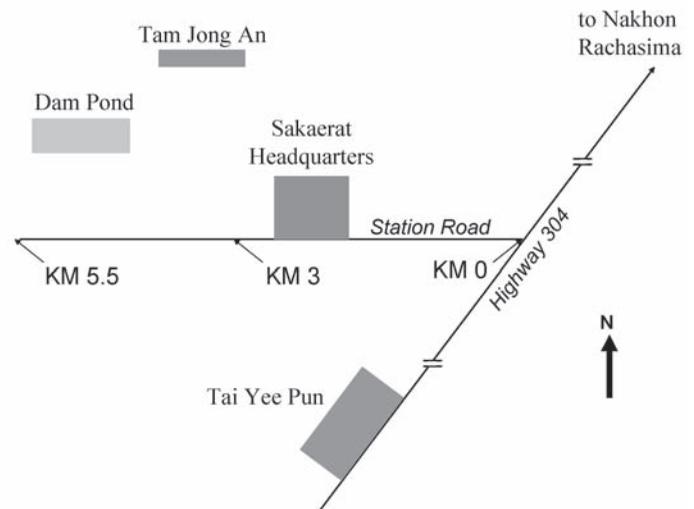

Fig. 1. Schematic diagram of study areas of *Polypedates leucomystax* breeding at Sakaerat, Thailand. Image not to scale. Tai Yee Pun is 7 km south of Sakaerat headquarters.

call, genetic, and morphological variation are necessary to determine how this population of *P. leucomystax* is related to others.

Methods.—I conducted this study from April to September 2005 (except for call recordings as noted below) at Sakaerat Environmental Research Station (14.5°N, 101.92°E), Thailand. This forested region is 60 km S of Nakhon Ratchasima and 250 km NE of Bangkok on the northeastern slope of the central highlands at the edge of the Korat Plateau. I monitored five areas during the rainy season between 25 April and 4 September 2005. Annual mean rainfall is 1240 mm and there is a marked dry season from November through March. The 78 km^2 area is 70% dry dipterocarp and dry evergreen forest, with the remaining area comprised of grasslands, bamboo, and plantation forests (Heyer 1973; Lynam et al. 2006). Elevation ranges between 280 and 762 m above sea level at the site, but all study areas were below 600 m. I selected areas in different habitat types, including dry dipterocarp forest, dry evergreen forest, two types of pond systems, and a cleared area (Fig. 1). For logisitical reasons, two areas (Tam Jong An and Tai Yee Pun) were added to the study at 3 and 5 weeks, respectively. For a full description of each study area, see Appendix 1.

Each area was surveyed 1–3 times per week between 1900 h and 000 h. Frogs were detected by eye-shine and vocalizations. All adult *P. leucomystax* encountered were measured for snout-vent length (SVL) using a ruler, individually marked according to Hero (1989), and released at point of capture. Sex was determined by size, calling behavior, or presence of male nuptial pads. In this species, females are larger than males, so any individual between 35 and 60 mm, heard calling, or with nuptial pads was assumed to be a male. All individuals above 70 mm were assumed to be female (no individuals measuring 65–70 mm SVL were found). Voucher specimens were deposited in the Natural History Museum of Chulalongkorn University, Bangkok.

Areas were searched in the morning at least every other day for foam-covered egg masses. Within 36 hours of discovery, eggs were staged (Gosner 1960) and counted. If eggs were at or below stage 13, diameter of ten eggs was measured under a dissecting scope to
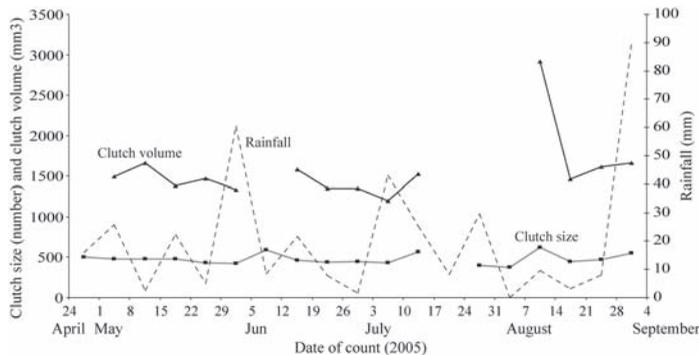
Fig. 3. Mean clutch size (number of eggs, solid line and squares) and mean clutch volume (mm^3, solid line and triangles) of *Polypedates leucomystax*, and rainfall (mm, dashed line and diamonds) at Sakaerat Environmental Research Station, Thailand.

the nearest 0.01 mm with digital calipers, averaged to give a mean egg size per clutch, and used to calculate clutch volume ((2/3*3.14*(radius of egg)^3)*clutch size). Eggs of this species lack jelly capsules, making it easy to obtain ovum size.

Time to metamorphosis for *P. leucomystax* was determined in 7 L round plastic basins, 35 cm in diameter. A single clutch was divided among eleven basins with thirteen tadpoles each when tadpoles were at developmental stage 25 (Gosner 1960). Tadpoles were given algae water once a week and fed commercial aquarium fish food (flakes and pellets). Basins were kept in a shade house with plastic roofing to prevent exposure to rainfall and direct sunlight. Nighttime water temperatures in cement basins in the forests of Sakaerat were 26.0 ± 0.2°C during the study period and that of the experimental basins was assumed to be similar. Mean daytime air temperature fell from 35.4°C in April to 30.0°C in September.

Calls were recorded between 5 July and 30 September 2006 using a Sony WM D6C Professional Walkman Cassette Recorder and an Audio-technica condenser. Calls were digitized using Windows Sound Recorder at 44.1 kHz. Audiospectrograms and oscillograms were produced and quantified by Raven Software 1.2.

Results.—I marked 225 *P. leucomystax* (174 males, 31 females, and 20 juveniles) over 150 search nights. Males were commonly
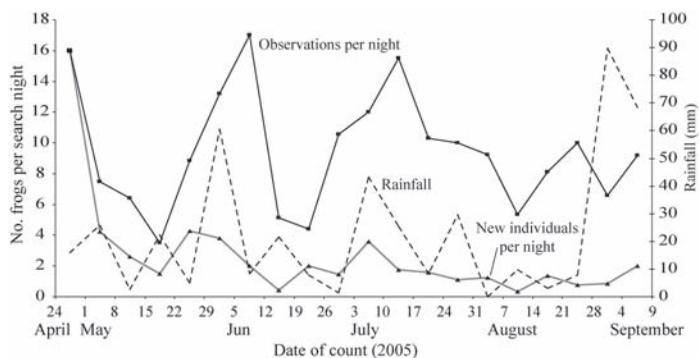

Fig. 2. Number of individual *Polypedates leucomystax* observed per search night (solid line and squares) and number of new individuals per search night (solid line and triangles) at Sakaerat, Thailand. Rainfall (mm, dashed line and diamonds) is also shown.
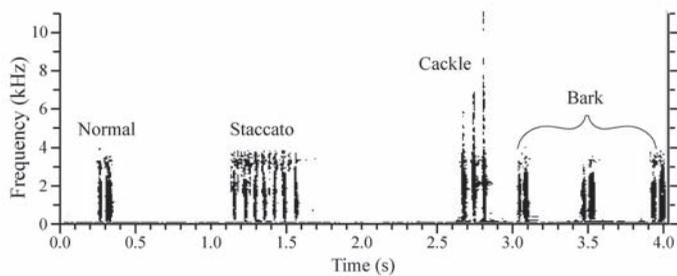

Fig. 4. Spectrogram of calls made by *Polypedates leucomystax* at Sakaerat, Thailand. Call elements are from a single individual but did not occur consecutively; call elements were cut and pasted from a 5 minute recording.

encountered and were heard calling even when no females were observed. Across weeks, the mean ± SE number of observations per night was 9.35 ± 0.87 (range = 3.5–17, N = 19). Mean ± SE male SVL was 55.05 ± 0.24 mm (range = 43–65 mm) and that for females was 79.0 ± 0.69 mm (range = 71–89 mm). Overall recapture rate during the study period was 75% for males and 29% for females (Table 1). Most of the locations where males were encountered were spaced such that determining site fidelity to an accuracy of 20 m was possible for 98 of the 130 recaptured males. Of these 98, 72 (73 %) were only ever encountered within 20 m of their original capture point, and 26 (27%) were encountered at least one time more than 20 m from their original capture point. Rainfall did not influence total observations or new individuals per search night (regression R^2 < 0.01 for both; see Fig. 2). After the first week of surveys, the number of new individuals per search night each week was 1.94 ± 0.28 (N = 19) which represented 23.3 ± 3.7% of the total observations per search night each week.

I counted eggs of 76 *P. leucomystax* clutches. Number of clutches found per week ranged between 1–15 (mean ± SE = 3.07 ± 0.76) and differed between weeks (χ^2 = 52.9, P < 0.01). However, this variation between weeks is due to a single week in which 15 clutches were found, and was the week in which an additional area (Tai Yee Pun) was added to my searches. Number of clutches found in a given week did not change predictably over the study period and was not dependent on rainfall (regression R^2 = 0.01). An additional 10 clutches were not included in the analyses because ova could not be counted accurately due to their late stage of development or the presence of insect larvae which appeared to have eaten a large number of eggs. Mean ± SE clutch size for the entire study period was 454.45 ± 12.41 (range = 230–804; N = 76), mean ± SE egg diameter was 1.81 ± 0.02 mm (N = 37), and mean ± SE clutch volume was 1494.79 ± 75.11 mm^3 (N = 37). Not all clutches were used to calculate clutch volume because some clutches were found after eggs had passed developmental stage 13 (Gosner 1960). Dissections of preserved females and from females collected immediately after oviposition indicated that females contain eggs at different stages of development at any given time, but that all eggs of a given size class were oviposited at once (Sheridan 2008).

There was no difference in clutch size (ANOVA F-value = 0.76, P > 0.70) or clutch volume (ANOVA F-value = 0.60, P > 0.85) between weeks (Fig. 3). Clutch size and clutch volume were unrelated to rainfall in a given week (regression R^2 = 0.01 and 0.02,

TABLE 1. Overall recapture rate for adult *Polypedates leucomystax* at Sakaerat, Thailand, between 25 April and 4 September 2005.

| | Number of recaptures | | | | |
	0	1–2	3–5	6–10	11+
Males	44	52	39	27	12
Females	22	8	0	1	0

respectively). Time to metamorphosis for tadpoles in basins with constant water levels was 41.66 ± 0.35 days and size (SVL) at metamorphosis was 19.40 ± 0.16 mm (mean ± SE).

I recorded several different call types. The most common was a single note ("normal") followed by 0–3 lower notes. Males also produced a "wreh-eh-eh" akin to a drawn out croak ("staccato"), a cackling sound ("cackle"), and a chuckle or laughing sound ("bark"; Fig. 4). These corresponded to call elements recorded in western Thailand (Christensen-Dalsgaard et al. 2002). All call elements were heard to be combined in various ways to create a complex call repertoire (Fig. 4). I analyzed call parameters of only the most common type of call, as this is believed to be the mating call (Christensen-Dalsgaard et al. 2002). Dominant frequency was 1197.1 ± 183.5 Hz, call duration was 58.5 ± 5.4 ms, pulse number (pulses/call) was 4.2 ± 0.3, and pulse rate (pulses/second) was 72.8 ± 4.2.

Discussion.—I report several new findings regarding the reproductive demography and behavior of *P. leucomystax* from Sakaerat, Thailand. First, both the mean and the maximum SVL of *P. leucomystax* at Sakaerat were larger than the maximum SVL of *P. leucomystax* in Borneo (Inger and Stuebing 1997: male maximum SVL, 50 mm; female maximum SVL, 75mm). The larger body size at higher latitudes is not surprising since many amphibians have been shown to follow Bergmann's Rule (Ashton 2002). Second, recapture rate for males was high, as was site fidelity (percentage of males only encountered within 20 m of their original capture point). This could indicate that males of this population are territorial. Christensen-Dalsgaard et al. (2002) frequently observed vocal interactions between males, in one case leading to wrestling between males. Although I never observed such interactions in the Sakaerat population, such interactions may also be indicative of territoriality. Although the number of new individuals found per search night was relatively low, it represented nearly a quarter of the total observations per search night. One possibility is that these individuals were present but not found during previous searches, but it is also possible that new individuals were constantly entering the local population.

Geographic variation in clutch size across the range of this species is uncertain. Although most reports on clutch size of *P. leucomystax* give only ranges and not mean values, Berry (1964) reported a mean clutch size of 315 (range 270–373) in Singapore, which is smaller than that found at Sakaerat (454). However, the range of clutch sizes at Sakaerat (230–804) overlapped with clutch size ranges from Borneo (150–900, Malkmus et al. 2002) and the Philippines (150–900, Alcala 1962; Taylor 1921; Villadolid and del Rosario 1930), indicating that within-site variation may swamp variation between sites.

Lack of variation in clutch size over time is surprising, as other frogs in seasonal tropical environments have shown decreasing clutch sizes over the course of the rainy season (Lampert and Linsenmair 2002; Lips 2001; Spieler and Linsenmair 1997; Williamson and Bull 1995). This could be due to the different variabilities, durations, or severities of the rainy seasons of each study location. For studies showing a decrease in clutch size as the rainy season progresses, rainfall generally decreases over the course of the season. At Sakaerat, the rainy season typically has five months of consistent rainfall (about 100 mm/month April–August) and then one to two months of extremely heavy rain (400 mm/month in September–October). Given the relatively short time to metamorphosis (about 42 d in basins kept in a shade house at ambient temperature), this 5–6 month rainy season might allow tadpoles to reach metamorphosis before larval habitat dries, even if eggs are laid in September or October. Temporal variation in breeding times of *P. leucomystax* at this site may reduce competition for resources among tadpoles and increase survivorship to metamorphosis.

Time to metamorphosis (42 d) was one and a half times longer than the 28 d previously recorded at Sakaerat (Heyer 1973) but nearly the same as the 49 d in Kuala Lumpur, Malaysia (Yorke 1983). It is important to note that Heyer's (1973) values are from non-experimental settings, and differences may be due to water temperature, food availability, and food type. Time to metamorphosis in my study was faster than the 70 to 119+ days reported for Philippine populations (Alcala and Brown 1956), and size at metamorphosis was slightly larger than the 14–17.5 mm reported for Philippine frogs (Alcala and Brown 1956). As with body size and reproductive measures, these differences in time to metamorphosis and size at metamorphosis could be due to temperature and rainfall differences between study sites, or could reflect the unrecognized taxonomic differences within this species.

Call types and diversity are similar to those reported from western Thailand (Christensen-Dalsgaard et al. 2002). Multiple call types also have been reported from northern Thailand (Garcia-Rutledge and Narins 2001) and Vietnam (Trepanier et al. 1999) but calls of *P. leucomystax* in Peninsular Malaysia, Borneo, and Bali appear to be less diverse (Marquez and Eekhout 2006; Matsui et al. 1986; Sanchez-Herriaz et al. 1995). A detailed summary of known call parameters from across the range of this species is given by Sheridan (2008).

Differences in life history variables between central Thailand and other populations of *P. leucomystax* are not surprising. Several studies on temperate amphibians show variation in clutch size, egg size, time to metamorphosis, and size at metamorphosis across a species' range (Berven 1982; Bury and Adams 1999; Kaplan 1980; Meeks and Nagel 1973; Riha and Berven 1991). However, no consistent trends of increases or decreases in these traits across latitude emerge from published data on temperate species and in general, we are still unable to predict variation in reproduction across latitudes for tropical species. Detailed studies on the reproductive ecology and behavior of tropical species such as *P. leucomystax* illustrate variation in reproduction across the range of a tropical species, and provide a baseline against which future changes can be measured.

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APPENDIX I

Detailed Description of Study Areas

Dry dipterocarp forest.—This area consisted of 20 cement cisterns located 1–5 m from the main road in the deciduous dipterocarp forest at Sakaerat. These cisterns are round, 0.75 m in diameter, 0.32 m deep, and held water at depths of 0.1–0.3 m during the study period. This area occurs between km 1 and km 2.7 of the station road, with km 0 located at the junction of Highway 304 and the station road (Fig. 1).

Dry evergreen forest.—This area consisted of 34 cement cisterns, 0.75 m in diameter, in the evergreen forest at Sakaerat. Water depths were not less than 0.25 m. Cisterns were 1–5 m from the main road, except for two cisterns located 10 and 20 m from the road. The evergreen forest extends west from km 3 along the station road (Fig. 1).

Tam Jong An (Cobra Cave Pond) .—This area comprised 70 m of an ephemeral stream that runs parallel to the main road through Sakaerat, about 700 m to the north of the main road in the evergreen forest. The western end of the area was a semi-permanent pool of water at the base of a 3 m waterfall. As the two years prior to the study year were drier than normal, rainfall was quickly absorbed by the ground, the stream was not flowing during the study period, and the pool shrank from 4 x 20 m, to 3.5 x 12 m. Water in the remaining 65 m of stream bed was restricted to small ephemeral pools in rock crevices. The stream was bounded on the north and south by steep banks about 6 m apart. Note that the first date this area was sampled was 9 May 2005.

Dam Pond.—This area was an ephemeral pond covering approximately 75 m^2 created by a 5 m dam located approximately 100 m north of the main road near the km 5 marker (distance measured from Highway 304 along the main road through Sakaerat) in evergreen forest. The bottom of the pond was covered with herbaceous vegetation during this study period and contained standing water on only 2 survey nights. No eggs were

ever found on this transect, but amplectant pairs were found twice. This is not the same area as the "dam stream pond" referred to in Heyer (1973).

Tai Yee Pun (Thai Japanese ReAfforestation Project) .—This area was separated from those detailed above by ca. 7 km, and was a cleared area used as a plant nursery, ca. 120 m on a side. There were 20 cement cisterns 0.8 m in diameter along the road, and four 15 x 25 m nurseries covered by shade cloth. Two nurseries contained 6 rectangular 0.8 x 2 m cisterns 1m deep, with variable volumes of water. Depth of water in these cisterns varied between 0.1–1 m. A third nursery had four of these cisterns and the fourth nursery had four standard 0.75 m round cisterns. Note that the first day this area was sampled was 25 May 2005.

High Densities of a "Rare" Skink

HAROLD HEATWOLE
Department of Zoology, North Carolina State University
Raleigh, North Carolina 27695-7617, USA
e-mail: harold_heatwole@ncsu.edu

and

BRYAN L. STUART
The Field Museum, Department of Zoology
1400 S. Lake Shore Drive, Chicago, Illinois 60605-2496, USA
and
Museum of Vertebrate Zoology, 3101 Valley Life Sciences Bldg.
University of California, Berkeley, California 94720-3160, USA:

"Rarity" and "commonness" is more of a perception than a reality for some species. If one were to conduct a visual sampling of a cryptically colored species and compare it with that of a more conspicuous, non-camouflaged species of the same general size, the results might be very different, even if both species had the same absolute population density. In the same way, quiescent sit-and-wait predators may be more easily overlooked than similarly colored species of the same size that actively forage and attract attention because of their movement. This property of human visual perception can lead to erroneous assessments of densities, assemblage structure, and community dynamics by underestimating the relative importance of cryptic or secretive components of the fauna. General hand-collecting is especially prone to this source of error. Some other methods, such as pitfall traps that discount human visual acuity and discrimination, are more accurate by not being influenced by visual properties, but are biased in favor of selectively capturing the more active species and underestimating secretive ones. Even plot sampling can be highly inaccurate and numbers underestimated if the plots are small or unfenced and unless special measures are taken to prevent escapes or immigration (Heatwole 2008). Heatwole and Sexton (1966) devised a method of fenced plots, subsequently refined by Rodda et al.

(2001a) and Heatwole (2008), that improves on other plot methods by completely censusing animals of all ages, including eggs, i.e., all individuals are found.

The present paper reports on a census of a small, Southeast Asian, forest-floor skink, *Sphenomorphus tridigitus* (Bourret 1939), using this method of fenced plots. This "rare" species was previously known from only four specimens. It was originally described on the basis of a single specimen in a poor state of preservation found dead on a road at Bach Ma, Thua Thien-Hue Province, Vietnam (Bourret 1939). Greer et al. (2006) redescribed the species from a second specimen found "at day, hidden inside a log lying on grass near a small creek in an open forest" at 1200–1250 m elevation on the Bolaven Plateau (="Boloven Highlands") in Champasak Province, Laos. Bain et al. (2007) reported on two additional specimens that were collected in pitfall traps, one at 940 m elevation and one at 1470 m elevation, on Mt. Ngoc Linh, Tra Don Commune, Tra My District, Quang Nam Province, Vietnam.

The present study took place at three sites (15°02'48"N 106°10'45"E, 400 m elev.; 15°04'37"N 106°08'15"E, 1000 m elev.; 15°03'55"N 106°13'03"E, 1200 m elev.) on the Bolaven Plateau in the Dong Hua Sao National Protected Area (formerly National Biodiversity Conservation Area), Pakxong District, Champasak Province, Laos during 10–25 September 1999. Eight plots, each 10 m x 10 m, were fenced by mosquito netting 1 m high with the bottom edge buried in a trench, and then the low vegetation, litter and wood removed down to mineral soil by Heatwole's (2008) method. Specimens of *S. tridigtus* collected in the study were deposited at The Field Museum (FMNH 258772–98, 258824–40, 258843–63, 258914–18, 258929–38). These specimens fully agree with the detailed redescription of the species by Greer et al. (2006), including discrepancies from the type. Like the specimens of Greer et al. (2006) and Bain et al. (2007), ours have a frontonasal scale with two separated prefrontals and the nasal and first supralabial are fused (erroneously called the "first infralabial" by Greer et al. [2006] and repeated by Bain et al. [2007]), and the loreal and the

TABLE 1. Abundance of *Sphenomorphus tridigitus* in the forest floor of Wet Evergreen Forest, Bolaven Plateau, Laos, September 1999.

Elevation/ Plot No.	Number of individuals	Number of eggs	Density (no./m²) of individuals	Density (no./m²) of eggs
400 m				
Plot 3	0	0	0	0
Plot 4	0	0	0	0
1000 m				
Plot 1	19	6	0.19	0.06
Plot 2	19	5	0.19	0.05
Mean: 1000 m	19	5.5	0.19	0.055
1200 m				
Plot 5	18	0	0.18	0
Plot 6	14	2	0.14	0.02
Plot 7	2	2	0.02	0.02
Plot 8	1	0	0.01	0
Mean: 1200 m	8.8	1	0.09	0.01

preocular are not fused. The specimens in our series have snout-vent length from 16.5 mm (hatchling) to 43.6 mm (largest adult). The eggs, collected from under leaf litter in the plots (see Table 1), are creamy-white to yellow, oval, and leathery and average 8.2 mm long by 4.8 mm wide (after preservation in 10% formalin). Most have a small, purplish-black spot visible through the egg-shell. A fully developed skink is visible through the eggshell of two eggs (FMNH 258918). A baby skink hatched from one egg (FMNH 258917) immediately upon immersion of the egg in formalin in the field, making identification unambiguous. Animals with regenerating tails accounted 5.5% of the specimens captured.

The plot results for *S. tridigitus* are summarized in Table 1. All individuals and eggs from the census plots were found under leaf litter. Six of the eight plots (75%) contained this species and it was clear that abundance was related to elevation. Intensive searching over 16 days (10–25 September 1999) at these sites by the authors and two camp assistants (and others sporadically) in the conventional way yielded only two individuals of this species, one under leaf litter when clearing a campsite and the other inside a rotten log. Thus, by the standard methods of expeditionary field surveys, this species would have been considered rare at the study site. In fact, it was the most abundant reptile in the area. Without the plot method the small numbers of individuals otherwise obtained would not have revealed this. No animals were found at low elevations but they were relatively abundant at 1000 m. Population density was lower again at 1200 m. Hence, this species is most abundant at mid-elevations.

At 1000 m on average there was one egg for every 3.5 adults, whereas at 1200 this value dropped to one egg for every 8.75 adults suggesting either that reproductive rate was much lower at the higher elevation, or that the reproductive season differed between the two sites.

This species, rather than being an insignificant rarity, is abundant at higher elevations on the Bolaven Plateau, where it accounted for 86% of the total individuals of the forest-floor lizards and frogs (6 species; snakes inadequately sampled) at 1000 m and 57% of the individuals of forest-floor lizards and frogs (8 species) at 1200 m. At a lower elevation on the plateau where *S. tridigitatus* was not present, it was replaced by a similarly small skink in the *Scincella reevesi* complex (mean density: 0.05/m^2; 64% of total individuals of the forest-floor frogs and lizards; four species). These two skinks probably play an important role in the dynamics of the forest floor community as significant predators upon small invertebrates and as food for various snakes.

Rodda et al. (2001a,b), using a censusing technique similar to the present one, also found unexpectedly high densities of some small reptiles and it is likely that many small forest-floor lizards are far more abundant than they appear to be. Estimates of density are used in studies of population biology and structure of assemblages and often play an important role in decisions about conservation. Much of the previous literature, even that based on fenced plots, probably contains serious underestimates and needs to be reassessed by research using more refined, fenced-plot techniques.

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TECHNIQUES

Bromeliad Patch Sampling Technique for Canopy Herpetofauna in Neotropical Forests

SHAWN F. McCRACKEN*
Department of Biology, Texas State University
601 University Drive, San Marcos, Texas 78666, USA

TADPOLE Organization
2214 South First, Austin, Texas 78704, USA

and
MICHAEL R. J. FORSTNER
Department of Biology, Texas State University
601 University Drive, San Marcos, Texas 78666, USA

*Corresponding author; e-mail: smccracken@txstate.edu

The canopy strata of tropical forests are one of the remaining unexplored biotic frontiers. Canopy research is a relatively new discipline facilitated by recent methodological advances in canopy access techniques (Basset et al. 2003b). Forest canopies are among the most species-rich terrestrial habitats on earth, supporting approximately 40% of known extant species and estimated to hold up to 50% of the earth's biodiversity (Basset et al. 2003b; Mitchell et al. 2002). The ecological role of amphibians and reptiles in forest canopies is mostly unknown. Thus far the research focus has been on arthropods, birds, mammals, plants and ecological processes; investigations of canopy herpetofauna have only recently been documented (De Vries et al. 1997; Guayasamin et al. 2006;

Schiesari et al. 2003). Kays and Allison (2001) reviewed published ecology and study methods for arboreal tropical forest vertebrates and found amphibians and reptiles to be grossly understudied compared to mammals, primarily due to their cryptic habits and sampling difficulties. Of 752 articles on tropical forest arboreal vertebrates published between 1988 and 1998 only 4% focused on reptiles and amphibians, with the majority of those covering reptiles (Kays and Allison 2001). While many studies report arboreal occupancy by an extensive number of amphibian species, few have documented ecological characteristics besides presence/absence data based on calling males and new species descriptions (Duellman and Trueb 1986; Guayasamin et al. 2006; Schiesari et al. 2003). Most data for arboreal amphibians were obtained through collection and observation during reproduction of those species that descend from the canopy to breed in water bodies at the forest floor level (Duellman 1978; Duellman 2005; Ron and Pramuk 1999). Standard survey techniques for amphibians, such as those at breeding sites, only encompass a small stratum (~2 m vertical height) of forest diversity (McCracken et al. 2007). Amphibians that specialize within the upper canopy remain mostly unaccounted for as a result of this limited vertical sampling bias (Guayasamin et al. 2006). More practical methods for studying canopy amphibians and reptiles is a high priority to facilitate the need for more survey and natural history work (Kays and Allison 2001).

A component of neotropical rainforest canopies that provide rich fauna microhabitats are the phytotelmata, defined as plants or parts of plants which hold rainwater (e.g. bromeliads, fruits, inflorescences, palm fronds and tree holes). In some tropical locations the availability of this habitat for aquatic organisms is up to 50,000 liters per hectare, literally a "wetland in the sky" (Kitching 2000; McCracken and Forstner 2006). In particular, epiphytic tank bromeliads are capable of holding relatively large amounts of water and play a principal role as a "keystone resource" and microhabitat for invertebrates, vertebrates and other plants (Nadkarni 1994). Canopy bromeliad arthropod surveys have reported them as reservoirs of incredibly high biodiversity (Basset et al. 2003a; Kitching 2000). Typically, tank bromeliads occur in the upper canopy and overstory trees of lowland rainforest at vertical heights between 5–45 m. Bromeliads normally range in number of individuals from ~5 to >150 on a single tree. Herein, we describe a technique for canopy bromeliad patch sampling of herpetofauna in lowland neotropical forests which is similar to those used in other canopy research disciplines but has not been documented for herpetofaunal investigations.

Methods.—Bromeliad patch sampling was conducted during 2004 and 2006 at the Tiputini Biodiversity Station (TBS)–Universidad San Franciso de Quito (USFQ), Orellana Province, Ecuador (00.63847°S, 076.14908°W, 217 m elev.). The vegetation type of the site has been defined as Amazonian Evergreen Lowland Forest (Palacios et al. 1999). Sampling units consisted of five bromeliads from each of 16 trees for a total of 80 bromeliads sampled. A tree was not sampled if less than 15 bromeliads of any species to be sampled were present to ensure continued persistence of the bromeliad community. Host trees were measured for diameter at 1.5 m above ground, height using a clinometer, and canopy cover using hemispherical photography with the Gap Light Analyzer (GLA) software. A leader line was positioned in the tree using a large slingshot (Sherrill™ Big Shot) which en-
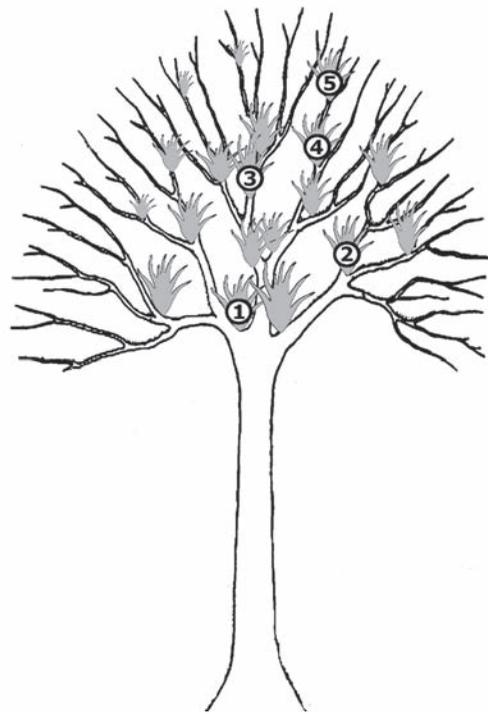

FIG. 1. Schematic of tree with bromeliads illustrating distribution strategy for sampling units (bromeliads), numbers denote bromeliads sampled.

ables setting lines at 30+ m. The canopy was accessed using single-rope technique, which should only be performed by trained and experienced individuals (Fig. 2d). The lowest and highest elevation bromeliads were sampled with the remaining three sampled at estimated even intervals in between (Fig. 1). Before removal of each bromeliad a wide-angle photograph was taken and the following variables collected: elevation, ambient air temperature, relative humidity, barometric pressure, water temperature and pH are measured inside one of the outer leaf bracts, and a 50 ml water sample is collected by siphon. Ambient air temperature, relative humidity and barometric pressure were also collected at 1.5 m elevation. The bromeliad was removed by holding several leaves at the tips in one hand and cutting its base support stem with a pruning saw. The response of most animals is to retreat into the bromeliad bracts and therefore alleviates loss of specimens due to escape. The bromeliad was placed in a 55 gal. plastic bag with minimal disturbance, sealed, and placed in a tarp connected to a rope that is threaded through a carabiner on the climbers harness and the other end held by a ground support person. It was then gently lowered to the forest floor by the ground support person. Another photograph was taken of the site where the bromeliad was removed. After removal of the five bromeliads, a herbarium sample was collected from the tree to confirm identification and deposit in a herbarium. Bromeliads were processed at camp in a screen tent to prevent escape of animals (Fig. 2c). Bromeliad water was strained through a 1 mm mesh screen to separate arthropods, leaf litter, and detritus. Water volume was measured with a graduated cylinder. Bromeliads were measured, number of leaves counted, and photographed including a meter stick for scale reference (Fig. 2a, b). Individual leaves were removed to facilitate collection of herpetofauna, which were temporarily stored in bags

Fig. 2A) Side view photo of *Aechmea zebrina* bromeliad with meter stick in background. Bar = 20 cm. 2B) Top view of *A. zebrina* bromeliad with meter stick below. Bar = 20 cm. 2C) Senior author in screened tent with sampled bromeliad to prevent escape of herpetofauna. 2D) Senior author ascending into canopy to access bromeliads for sampling using single-rope technique (SRT) to climb.

for further processing. Herpetofauna species were photographed, measured and weighed. Blood or tissue samples were collected and stored in blood storage buffer or 95% ethanol, respectively. Animals were euthanized in 10% ethyl alcohol or by ventral application of 20% benzocaine (Orajel®) and preserved using 10% formalin before being transferred to 70% ethyl alcohol for storage.

Results.—In 2004, eight trees were surveyed for a total of 40 bromeliads sampled. Three species of bromeliads were sampled: 20 individuals of *Aechmea zebrina*, 17 of *Aechmea* sp., and three of an unidentified tankless bromeliad. In 2006, eight trees were surveyed for a total of 40 *A. zebrina* bromeliads sampled as part of a current study. Bromeliads were collected at elevations of 5.7–38.0 m (mean 27.0 ± 6.2 m) above ground. *Aechmea zebrina* bromeliads were 58.5–125.0 cm (mean 79.9 ± 13.9 cm, N = 40) tall and 54.0–147.5 cm (mean 89.5 ± 22.2 cm, N = 40) in diameter, *A* sp. bromeliads were 32.0–58.0 cm (mean 47.2 ± 9.7 cm, N = 17) and 54.0–94.0 cm (mean 66.8 ± 12.6 cm, N = 17) in diameter, and the unknown tankless bromeliads were 41.0–47.0 cm (mean 43.8 ± 3.1 cm, N = 3) and 33.0–43.0 cm (mean 37.3 ± 5.1 cm, N = 3) in diameter.

Thirty-four adults, 10 juveniles, 15 tadpoles, and 17 eggs of anurans representing at least four species were collected during the two survey periods. The identified adult and juvenile species included *Dendrobates* (*Ranitomeya*) *ventrimaculatus*, *Eleutherodactylus* (*Pristimantis*) *aureolineatus*, *Eleutherodactylus* (*Pristimantis*) *waoranii*, and *Osteocephalus taurinus*. Eight of the tadpole specimens were easily identified as *D. ventrimaculatus* due to their advanced stages of development. The remaining tadpole specimens are to be identified using morphological and/or molecular techniques. One gecko, *Thecadactylus rapicauda*, was collected in an *A. zebrina* in 2006. Only one anuran was observed jumping from a bromeliad during removal and was visually identified when it landed on a nearby bromeliad before retreating into the leaf bracts.

Of the three bromeliad species, no anurans were found in the three tankless bromeliads, nine tadpoles of *D. ventrimaculatus* and three adult *E. waoranii* in five *Aechmea* sp., and the remainder in 26 *A. zebrina* (65% of *A. zebrina* sampled had anurans). All anurans were collected in bromeliads between 20.0–36.0 m (mean 28.3 ± 5.3 m) above ground.

Discussion.—Visual encounter surveys, focal point observations, and inspection of individual bromeliads along a 100 m-long canopy walkway and two ~40 m high observation towers built around emergent trees at TBS–USFQ revealed 13 species of anurans; these surveys were conducted 3–4 times a year from 1998 to 2001 dur-

ing the morning, afternoon, and night for 4–5 days duration (Cisneros-Heredia 2003; D. F. Cisneros-Heredia, pers. comm.). During one week in May 2002 canopy searches targeted at calling anurans were conducted using tree-climbing spurs at the Yasuni Scientific Research Station–Universidad Católica del Ecuador and resulted in the discovery of six anuran species occupying canopy habitat (S. Ron, pers. comm.). Canopy bromeliad patch sampling revealed a minimum of four species and the additional species *E. waoranii* (McCracken et al. 2007). Results from our surveys contributed significantly to the new species description for *E. aureolineatus* and a manuscript on the reproductive ecology and behavior; they are wholly responsible for the new species description of *E. waoranii* (Guayasamin et al. 2006; McCracken and Forstner 2006; McCracken et al. 2007). Three other species found during these canopy surveys are newly described since 1999, demonstrating the value of such research techniques (Guayasamin et al. 2006). The potential for the discovery of additional new species and collection of detailed ecological data at other sites is evident in the fact that our surveys and the previous canopy surveys represent a limited sampling effort at two sites within close geographic proximity (~28 km) and similar habitat structure.

The technique provides a labor intensive, but successful, method for surveying the otherwise inaccessible microhabitats of the upper forest canopy strata herpetofauna. While our bromeliad patch sampling technique recovered less than a third of the number of species collected during the canopy walkway/tower surveys it represents a much less intensive sampling effort. Our sampling focused on the specific microhabitat provided by bromeliads, of which we only investigated three species. Our results indicate that the largest tank bromeliad in our surveys, *A. zebrina*, had the greatest occurrence rate, with 65% of those sampled having anurans present. The use of canopy bromeliad patch sampling is also supported by the limited availability of canopy walkways and towers for research in Amazonia, and the financially prohibitive construction costs of such infrastructure for most research projects. Canopy bromeliad patch sampling can be employed anywhere the forest is accessible and facilitates the collection of independent replicate sampling units with associated biotic and abiotic factors for the analysis of ecological correlates of species diversity and abundance in a robust sampling design. Our current study targets a species specific (*A. zebrina*) tank bromeliad microhabitat, but the technique may be applied to other species and microhabitats (e.g. tree holes/cavities) within the canopy. The technique may also be used to survey other forest canopies and their specific microhabitats.

Fauna of forest canopy habitats are at risk due to high rates of deforestation and habitat fragmentation, which are primary reasons for the rapid decline in amphibian populations worldwide with nearly one-third of all amphibians being threatened and at least 43% declining in population size (IUCN et al. 2006). The rapid exploitation of natural resources is having a profound effect on the rainforests and its inhabitants of the Ecuadorian Amazon. Yet, little is known about the effects of canopy biota loss. Epiphytes are considered hypersensitive to climatic conditions, requiring the very conditions they promote for existence (Benzing 1998, 2000; Hietz 1998). This hypersensitivity makes them particularly susceptible to forest microclimate changes as a result of anthropogenic disturbance, making epiphytes suitable as a bioindicator of diversity and forest ecosystem functions (Benzing 1998; Brighigna et al. 2002; Hietz 1998). Loss of epiphyte diversity will degrade all biodiversity within inclusive ecosystems by causing shifts in faunal resource availability, nutrient budgets and cycling, system energetics, and hydrology (Benzing 1998). Amphibians may be considered a vertebrate counterpart to epiphytes as bioindicator species and their utilization of epiphytic tank bromeliad habitat provides the researcher with a unique system for monitoring anthropogenic disturbance in forest canopies. Bromeliad patch sampling surveys are essential to documentation of the faunal diversity in neotropical forest canopies and promoting the conservation of these important "wetlands in the sky" (McCracken and Forstner 2006).

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Efficacy of PIT Tags for Tracking the Terrestrial Anurans *Rana pipiens* and *Rana sylvatica*

SEAN M. BLOMQUIST
Department of Wildlife Ecology, 5755 Nutting Hall
University of Maine, Orono, Maine 04469-5755, USA
e-mail: sean.blomquist@umit.maine.edu

JOSEPH D. ZYDLEWSKI
US Geological Survey, Maine Cooperative Fish and Wildlife Research Unit
5755 Nutting Hall, University of Maine, Orono, Maine 04469-5755, USA

and
MALCOLM L. HUNTER, JR.
Department of Wildlife Ecology, 5755 Nutting Hall
University of Maine, Orono, Maine 04469-5755, USA

The terrestrial ecology of many amphibians is poorly known compared with the aquatic stages (e.g., Regosin et al. 2003). Although advances have employed radiotelemetry on terrestrial adults (e.g., Hodgkison and Hero 2001; Watson et al. 2003), the size and battery life of transmitters are limitations on the use of radiotelemetry for smaller amphibian species and life stages. Other approaches for following small amphibians have included powder tracking, radioactive tags, and harmonic radar diodes, but each of these techniques has significant limitations (Heyer et al. 1994; Langkilde and Alford 2002).

Passive integrated transponders (PIT tags) overcome many limitations of these other techniques. PIT tags are small, glass-encased electromagnetic coils with a microchip containing a 10-space unique alphanumeric code that is emitted at a radio frequency (typically 134.2 kHz) when the coil is activated. PIT tags are easily applied and relatively benign to the tagged animal, provide a unique and essentially permanent mark, and can be cost-effective (Arntzen et al. 2004; Gibbons and Andrews 2004; Ott and Scott 1999). As a result, PIT tags have been increasingly used for marking fish, amphibians, reptiles, and other animals for demographic and behavioral studies (e.g., Camper and Dixon 1988; Kurth et al. 2007; Reaser 2000; Rowe and Kelly 2005; Sinsch 1992). Usually, PIT tag detection relies on the physical recapture of the tagged organism because the tag needs to be within range (usually ~ 0.3 m) of an antenna to transmit the alphanumeric identification code to the transceiver (see review by Gibbons and Andrews 2004). Portable antenna and transceiver systems (PIT-packs) are a new approach to locating and identifying a tagged organism without physical recapture, thereby minimizing associated disturbances (Hill et al. 2006; Kurth et al. 2007; Zydlewski et al. 2001).

We evaluated a PIT-pack as a tool to locate and identify confined individuals of two pond-breeding amphibian species, recently metamorphosed *Rana pipiens* (Northern Leopard Frogs) and adult *R. sylvatica* (Wood Frogs). We evaluated the detection range of the PIT-pack using PIT tags alone and the detection probability of frogs implanted with PIT tags and held in terrestrial enclosures. We used the PIT-pack to identify breeding pairs in a small vernal pool and collect information on the breeding ecology of *R. sylvatica*. In addition, we evaluated three surgical implant locations and PIT-tag retention in recently metamorphosed *R. pipiens*.

Methods.—The PIT-pack consisted of a battery-powered Destron-Fearing transceiver (Model FS 2001A-ISO; Digital Angel Co., St. Paul, Minnesota, USA) and custom-built antenna. The antenna head was constructed in an airtight oval (0.20 × 0.25 m) with 1.27-cm schedule 40 PVC. The antenna consisted of 20-gauge multi-strand wire wrapped 26 times through the PVC frame until an inductance of approximately 425 µH was reached. Capacitors were attached to the antenna lead cable and enclosed in the PVC, fixing the capacitance at ~ 3300 pF. Fine-scale tuning was achieved with a 400–1600 pF variable capacitor. The head of the antenna was mounted on an adjustable 1.5-m long handle at an angle of ~ 120° (Fig. 1). The instrument was tuned in water or air immediately prior to use at each site to maximize current at 3.0 to 3.3 Amps. In theory, changes in soil or water density and chemistry can affect the electromagnetic field generated by the antenna, and consequently it is necessary to tune the antenna prior to use in the

FIG. 1. Using a PIT-pack to search for PIT-tagged, recently metamorphosed *Rana pipiens* in a terrestrial enclosure in a three-year old clearcut in Maine, USA. We held the transceiver in a shoulder bag, and constructed the antenna using a modified forearm crutch for ergonomics. We varied the angle of the antenna to increase the detection probability as we searched for concealed frogs, and an audible beep from the transceiver alerted us to detection of a tag. Photograph by Valerie Moreau.

medium (i.e., air or water) in which it will be used to achieve the maximum detection range. The PIT-pack is light (3.1 kg) and portable in the terrestrial environment (Fig. 1), but the transceiver is small and low-powered. Heavier equipment with a larger antenna head size (e.g., 0.55 × 0.40 m and 19.3 kg in Hill et al. 2006) would probably have greater detection ranges but would sacrifice the convenience of the smaller unit (Kurth et al. 2007; Zydlewski et al. 2001). We used 12-mm PIT tags (134.2 kHz ISO tag; Model TX1411SST, Digital Angel Co., St. Paul, Minnesota, USA) in all experiments because the small size of our study frogs. Tag size may contribute to performance, and larger tags may increase the detection range for other applications (Hill et al. 2006; Roussel et al. 2000).

Prior research with larger 23-mm tags and more powerful readers reported detection ranges of 30–38 cm in air and 60–91 cm in water (Cucherousset et al. 2005; Hill et al. 2006). With a blind observer, we evaluated the PIT-pack detection range for 30 PIT tags in 30 mL polyethylene vials in each of two soil types commonly found in Maine, USA, forests (N = 60 total tags). We visually evaluated each area and assessed one to be predominantly glaciomarine hydric soils found in wetlands and the second to be predominantly well-drained till soils found in uplands (Natural Resources Conservation Service, 1963). One observer dispersed PIT tags in a 16 m^2 area (4 × 4 m) at depths ranging from the soil surface to 76 cm by driving a measured metal rod to the desired depths in the soil. A second observer, naive to the location and number of tags, searched the area with the PIT-pack by walking in a systematic zig-zag pattern through the area and making three passes through the area to find the tags. The first observer, who placed the tags, recorded the number and identity of the tags found on each pass. The first, informed observer then made one pass though the area and attempted to detect tags that were missed using the PIT-pack.

We collected recently metamorphosed *R. pipiens* and adult *R. sylvatica* from the University of Maine's Dwight B. Demeritt and Penobscot Experimental Forests (Penobscot County, Maine, USA, 44°50'N, 68°35'W) with hand capture and pitfall traps in August 2006. We housed all frogs in 125 L plastic tanks or 38 L glass aquaria in small groups (20 metamorphs and 5 adults) for 1–16 days prior to experiments (described below). Each container had leaf litter for cover, holes in the top, and a wet paper towel on the bottom to maintain moisture. We fed captive frogs crickets *ad libitum*. We measured (snout–vent length [SVL], mass) and marked each animal individually with a PIT tag.

We surgically implanted PIT tags sub-dermally as recommended for small amphibians (Ott and Scott 1999). We anesthetized all frogs using 0.5 g/L MS-222 (tricaine methanesulfonate; Sigma Aldrich, St. Louis, Missouri, USA) in well water prior to surgery. We lightly anesthetized the frogs to minimize mortality associated with small frogs (e.g., Cecala et al. 2007), and held frogs in anesthesia only until they lost their righting response but remained responsive to touch (< 15 min in most cases). We made a 2-mm long incision with a sterile, single-use blood lancet (Propper Mfg. Co., Long Island City, New York, USA). To cut only the skin, we placed the blood lancet at an acute angle to the body of the frog and lightly pressed it into the skin until the skin began to fold upwards. We continued to apply pressure until we pierced the skin. After making the incision, we slipped a sterile PIT tag through the

incision, and placed one drop of Bactine (Bayer Co., Pittsburgh, Pennsylvania, USA) on the wound to sterilize the incision and promote healing. Frogs recovered from surgery for 6 hours before release, and we assessed tag retention and the condition of the wound after the frog recovered.

We conducted a two-week laboratory trial to determine the best position for PIT tag placement in small ranids. Three positions (scapula insertion, pubis insertion, ilium insertion) were tested in recently metamorphosed *R. pipiens* (N = 20 for each position). For scapula insertion, a longitudinal incision on the dorsum was made above the scapula ~ 3 mm posterior to the eye and ~ 2 mm medial to the tympanum. For pubis insertion, a lateral incision was made ~ 2 mm anterior to the posterior end of the urostyle. For ilium insertion, a longitudinal incision was made ~ 1 mm anterior to the anterior end of the ilium and centered on the dorsum. The frogs used in the experiment were 34 ± 1 mm (mean ± SE; range 31–38) SVL and weighed 4.0 ± 0.3 g (range 2.8–6.1). Frogs were checked twice daily for tag retention and healing of the surgical wound.

Based on the results of the retention study, we PIT tagged (scapula insertion) 50 adult *R. sylvatica* (26 males, 24 females; 46 ± 1 mm SVL, range 41–55 mm; 14.5 ± 0.5 g, range 10.1–24.9 g) and 52 recently metamorphosed *R. pipiens* (37 ± 1 mm SVL, range 31–48; 4.5 ± 0.2 g, range 1.0–8.7 g) in August 2006. Tagged frogs were placed into uninhabited 3.8 × 3.8 m (14.4 m²) terrestrial enclosures constructed 15 months prior to data collection in an unharvested forest (unharvested), a forest partially harvested to 50% crown closure (partial), and a 3-year old clearcut with coarse woody debris removed (removed) on the Dwight B. Demeritt and Penobscot Experimental Forests (see Patrick et al. 2006 for a description of the sites). Enclosure walls were 1.2 m tall galvanized steel hardware cloth (3.2 mm square mesh; TWP Inc., Berkeley, California, USA) supported with wooden garden stakes. Enclosure walls were buried 20–30 cm in the ground and bent 10 cm at the top toward the inside of the pen to prevent escape of animals.

We stocked terrestrial enclosures with *R. pipiens* metamorphs and *R. sylvatica* adults. *Rana pipiens* metamorphs were stocked to three enclosures: one enclosure in the removed treatment at a density of 12 per enclosure (0.83 m⁻²), one in the removed treatment at a density of 20 per enclosure (1.39 m⁻²), and one in the unharvested treatment at a density of 20 per enclosure (1.39 m⁻²). We were unable to capture enough *R. pipiens* metamorphs at our study sites to replicate each density and treatment combination. For *R. sylvatica* adults, we stocked each of 10 enclosures at a density of five per enclosure (0.35 m⁻²): five enclosures in the partial treatment and five in the unharvested treatment. We located *R. pipiens* metamorphs every three days during 23 August – 7 September 2006 and once weekly thereafter through 11 October (the end of the growing season in central Maine). We located *R. sylvatica* adults once weekly from 26 August to 27 September 2006. We removed dead frogs and did not include them in subsequent detection probability calculations.

Lastly, we captured (drift fences and by hand) 139 adult *R. sylvatica* (61 females, 78 males) returning to breed at a single, ~ 80-m² vernal pool on the University of Maine's Dwight B. Demeritt Experimental Forest in April 2007. Each frog was PIT tagged (scapula insertion), and held in captivity for < 9 h prior to release at ~ 1 h before sunset. Nightly during 22 April – 2 May we located

pairs in amplexus with a spotlight and by scanning the surface of the water with the PIT-pack. We attempted to identify both members of each located pair with the PIT-pack without disturbing the frogs. We relocated the pair visually and with the PIT-pack until the female oviposited. Each morning we counted the number of fresh egg masses in the pond. We conducted all statistical analyses in SAS (SAS Institute, Cary, North Carolina, USA) with α = 0.05.

Results and Discussion.—Our mean detection probability was 0.65 ± 0.14 (± 95% confidence interval), and we detected 100 ± 0% of the tags at 13 cm and 33 ± 7% of PIT tags at 43 cm in the soil (Fig. 2). The informed observer (i.e., who knew the location of the tags) detected a higher proportion of tags in a single pass (0.76) than the blind observer (0.61 ± 0.03; range 0.57–0.67) did in three passes. This higher success in detecting tags is probably due to increased effort in an area known to have a tag versus the systematic pattern employed by the blind observer. Subtle changes in antenna orientation associated with concentrated effort in one area can change detection success without a change in detection range. The antenna is most effective at detecting a tag if the tag is perpendicular to the face of the antennae (Cucherousset et al. 2005).

No frogs died during the two-week tag retention experiment. Tag retention after two weeks was highest with the scapula insertion technique; all *R. pipiens* retained their tags. Retention also was high with ilium insertion (90%), but retention with pubis insertion was poor (55%). All tag loss occurred before the incision healed, generally in < 6 days during these laboratory trials. The scapula and ilium insertion techniques will probably result in high tag retention rates in other similar sized frogs, although retention rates are important to quantify for any field study.

The proportion of recently metamorphosed *R. pipiens* detected with a PIT-pack was not affected by harvesting treatment or density, and the proportion detected in the three terrestrial enclosures remained at 1.00 throughout the study (Fig. 3). The proportion of adult *R. sylvatica* detected remained high (> 0.90) until the first time the minimum daily temperature (MDT) was < 0°C, but declined over subsequent surveys. Because the proportion detected
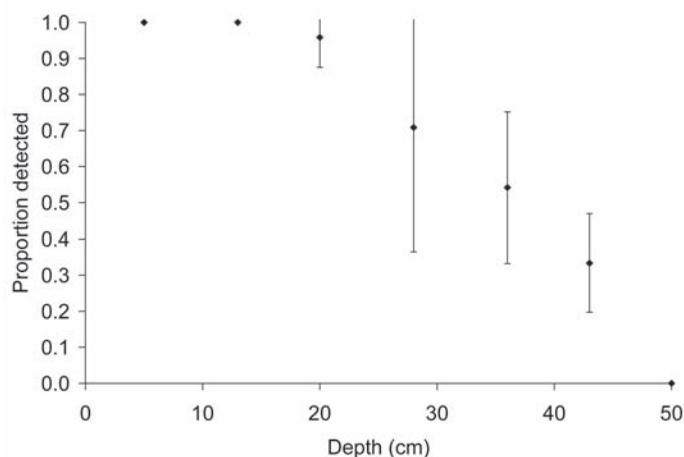

FIG. 2. Mean (± 95% confidence interval) proportion of PIT tags detected per depth in the soil using a PIT-pack in two 16 m² areas. Each depth had six tags available for detection and means were calculated from all four passes with the PIT-pack. All depths 50 cm were lumped.

Herpetological Review 39(2), 2008
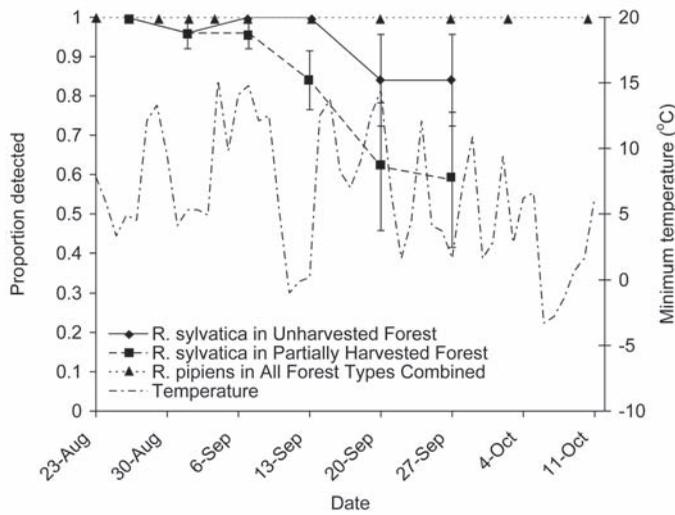
FIG. 3. Mean (± SE) proportion of PIT-tagged frogs detected with a PIT-pack in 14.4-m² terrestrial enclosures in unharvested forest (recently metamorphosed *Rana pipiens*: one enclosure with 20 frogs; adult *R. sylvatica*: five enclosures with five frogs each), a forest partially harvested to 50% crown closure (adult *R. sylvatica*: five enclosures with five frogs each), and a 3-year old clearcut (recently metamorphosed *Rana pipiens*: one enclosure with 20 frogs and one enclosure with 12 frogs) in Maine, USA, in 2006. Data for the three enclosures containing *R. pipiens* are presented together because the proportion of frogs detected was always 100%. Proportion of frogs detected dropped for *R. sylvatica* after the minimum daily temperature fell below 0°C for the first time.

remained high until 11 October 2006 for the aquatic hibernator *R. pipiens* (Rorabaugh 2005), we speculate that adult *R. sylvatica* began to enter subterranean hibernacula (Redmer and Trauth 2005) in refugia below our detection range with the PIT-pack, and thereby reduced the proportion of frogs detected. We are confident that the enclosures were escape proof (only one of 1600 *R. sylvatica*

and *Ambystoma maculatum* stocked into 64 enclosures in 2005 escaped; SMB and MLH, unpubl. data). Although the steel walls reduce detection range when the antenna is nearby, we detected adult *R. sylvatica* within ~ 5 cm of the fences at depths of 16 cm deep on 27 September.

A PIT-pack is a non-invasive method for locating tagged individuals, and this technique can make multiple recapture studies in confined areas more feasible. Most studies using terrestrial enclosures use destructive sampling (e.g., Rodda et al. 2001) or pitfall trapping to sample or census animals in enclosures (e.g., Bailey et al. 2004). With a PIT-pack, a user can repeatedly search an enclosure with minimal disturbance. Advantages of this technique for sampling enclosures are that it is relatively noninvasive, the user can search until all animals are detected, and detection probability should remain at 1.00 unless the study animal is likely to move below a depth of 13 cm (detection range of the PIT-pack; Fig. 2). The effectiveness of the PIT-pack would be limited for species that burrow deeper than 13 cm. For example, *Ambystoma maculatum* burrows up to 1.3 m in winter (Semlitsch 1983). In addition, some species may not be detected during some seasons. For example, *Spea multiplicata* burrows 1.3–10 cm deep in summer and up to 90 cm in winter (Rubial et al. 1969).

Two potential future applications for this technology are tracking in subterranean environments and tracking juvenile anurans. Anurans, especially bufonids (e.g., Eggert 2002), are known to use the subterranean environment as a refuge from thermal extremes and to conserve water (Duellman and Trueb 1986). Ranid frogs can dig their own burrows (Parris 1998), and many species use burrows excavated by other animals (e.g., Blomquist and Tull 2002; Lips 1991). However, the duration of time spent in the subterranean environment is not well studied, and PIT-tag telemetry could be used to non-invasively monitor amphibians in shallow subterranean habitats (see the study design of Quintella et al. 2005 for a possible method). A PIT-pack would be an effective technique for tracking burrowing species that use shallow burrows <

TABLE 1. Number of pairs of adult *Rana sylvatica* identified and observed ovipositing at a breeding pond in Maine, USA, in 2007; number of pairs disturbed with a PIT-pack prior to laying or identification of both individuals; additional pairs observed and not disturbed but both individuals were not identified or the pair was not observed ovipositing; and new egg masses observed the next morning. Males began calling on 16 April 2007, but females were not present until 22 April at which time we began nightly observations at this vernal pool.

Date	Pairs identified and observed ovipositing	Pairs disturbed	Additional pairs observed	New egg masses observed
22 April	0	0	0	0
23 April	0	0	0	0
24 April	16	4	3	17
25 April	2	0	0	2
26 April	4	2	2	4
27 April	0	0	0	0
28 April	3	1	2	3
29 April	0	0	1	0
30 April	0	0	0	0
1 May	0	0	0	0
2 May	0	0	0	0
Total	25	7	8	26

13 cm deep (e.g., *Spea hammondii*; Morey 2005).

Juvenile survival and movement can be important factors in population persistence (e.g., Red-legged Frogs in Biek et al. 2002; Conroy and Brook 2003). For example, dispersal in most amphibian species probably occurs as juveniles (e.g., Berven and Grudzen 1990; Dole 1971). Survival and movement probably are quite different in many anuran species, and PIT-based telemetry could be used to improve knowledge about the ecology of juvenile and small adult amphibians. However, the applicability of PIT-tag telemetry to free-ranging individuals could be limited. The technique will probably work best with animals that have small home range sizes and are not likely to use the subterranean habitat deeper than 13 cm during the period of study. Searching the terrestrial habitat for moving individuals (e.g., dispersing juveniles) could be labor-intensive and thus costly and only generate low recaptures of marked animals (see Arntzen et al. 2004 for a detailed analysis of the use of PIT tags and associated costs of a capture-mark-recapture studies). For example, searching the 14.4-m^2 enclosures took 6 ± 4 ($\pm$ SD) minutes with the 0.20×0.25 m head antenna across all forest types. In addition, dispersing or migrating animals can move relatively long distances in a short period when environmental conditions are conducive to movement (e.g., a warm, rainy night for pond-breeding amphibians in Maine, USA), which would necessitate more frequent relocation in these conditions.

We used a PIT-pack to non-invasively identify 40 pairs of PIT-tagged *R. sylvatica* in amplexus (Table 1), and relocate and monitor 25 of these pairs until the female oviposited. The number of pairs we identified and monitored until the female oviposited each night was highly correlated with the number of new egg masses in the pond the following morning (Pearson's correlation r = 0.983, p < 0.0001). This result indicates that we identified most of the frogs that successfully bred in the pond and the other 59 frogs we captured entering the pond did not successfully breed. In most instances where both male and female were identified, we were able to position the antenna underwater below the pair to read the female's tag. In seven instances, we were able to identify only the male because his PIT tag interfered with detection of the female's tag (Table 1, additional pairs observed column). We lost track of one pair prior to observing oviposition. The male stopped amplexus by releasing the female (Table 1, pairs disturbed column) when we placed the antennae near seven pairs. This disturbance typically occurred after we identified the male and moved the water and vegetation while moving toward the pair with the antenna to identify the female. We speculate that using a PIT-pack to identify breeding pairs of *R. sylvatica* was much less invasive than would be required using other techniques. Identifying animals marked with visual implant elastomer or toe clipping usually requires handling, and externally attached radio-transmitters can interfere with swimming and amplexus in some frogs (e.g., Muths 2003).

In summary, we successfully used PIT-tag telemetry to track recently metamorphosed and adult ranids in the terrestrial and aquatic environments, and this technique has potential for many more applications in anurans and other small animals, such as monitoring of animals in the shallow subterranean environment. Limitations for PIT tag and PIT-pack use are tag size and limited detection range. We successfully implanted 12-mm tags into ranids > 30 mm SVL. Currently available, 8-mm tags should be suitable for frogs > ~ 20 mm SVL and ~ 0.7 g, but use with smaller animals is not possible due to tag size. Also, additional work is needed to assess the long-term affects of tagging on animals of this size. A PIT-pack can detect 100% of tags in the terrestrial environment to a depth of 13 cm and > 90% of tags to a depth of 20 cm.

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A Minimally Invasive Method for Obtaining Venom from Helodermatid Lizards

HANG FAI KWOK*
Univesity of Ulster, School of Biomedical Sciences
Coleraine, Northern Ireland, U.K. BT52 1SA

and
CRAIG IVANYI
Arizona-Sonora Desert Museum, 2021 North Kinney Road
Tucson, Arizona 85743, USA

*Current address: Fusion Antibodies Ltd., Belfast, Northern Ireland, UK
e-mail: h.f.kwok@qub.ac.uk

Biomedical researchers are examining the venoms of several reptiles in their search for bioactive peptides that may be beneficial to human medicine (Chen et al. 2002; Raufman 1996). Acquiring venom for research can be problematic. Some venoms are commercially available from biochemical supply companies, while others, such as Beaded Lizard *(Heloderma horridum)* and Gila Monster *(H. suspectum)* venoms, may only be periodically available (in our experience), may be of suspect origin, and are expensive. Therefore, researchers may have to collect venom from live or recently killed animals they have direct access to. In the past, proteomic and genomic research on helodermatid venom toxins often resulted in animal sacrifice or surgical removal of the lizard's venom glands (Chen and Drucker 1997; Pohl and Wank 1998).

Sacrificing animals for such research may be deemed objectionable on moral and ethical grounds or present conservation concerns. Thus, researchers may need to collect venom from live lizards, but this, too, can be problematic.

Helodermatid lizards are protected, either federally (in Mexico) or by state governments (in the U.S.), and all helodermatids are listed under CITES (Levell 1997). Thus, it can be difficult to acquire these animals. Venom collection from helodermatids may prove difficult due to the nature of the helodermatid venom apparatus (Strimple et al. 1997). Additionally, work with live venomous lizards presents safety risks, both to the researchers and the lizards, and necessitates special training and equipment to manipulate them safely (Poulin and Ivanyi 2003). Surprisingly, helodermatid bites are not uncommon and, at a minimum, these bites can be extremely painful. The only fatalities reported from Gila Monster bites are suspect (Beck 2005; Brown and Carmony 1999), but its venom and that of *H. horridum* can have systemic effects that can be life-threatening to humans, including a rapid drop in blood pressure (which can result in hypotensive shock) (Burnett et al. 1985; Preston 1989), severe angioedema (Piacentine et al. 1986), coagulopathy and renal failure (Preston 1989), acute myocardial infarction (Bou-Abboud and Kardassakis 1988), and anaphylaxis (Cantrell 2003).

We explored several published methods of helodermatid venom collection wherein the investigators forced the lizard to bite the edge of a saucer, which it was inclined to do (and, once the animal had seized the saucer, it was hard to remove); or offering a sponge material for the lizard to bite, with the venom collected from the sponge after the animal released it (Arrington 1930; Mitchell and

Fig. 1. Medicine dropper (60 ml) with rubber bulb, over plastic tube. Note: that only the squeeze bulb with plastic tube is used with this technique.

Reichert 1883; Russell and Bogert 1981). In addition, Stuart et al. (1998) demonstrated the toxic effects that anesthesia and parasympathetic stimulation can have on *Heloderma* while collecting venom. These techniques were found to be impractical, or injurious to the lizards, and/or ineffective. However, modifying the technique of offering a rubber-covered object to bite (Russell and Bogert 1981) worked extremely well.

Materials and Methods.—After the lizard was safely restrained (Poulin and Ivanyi 2003), had opened its mouth and the mouth cavity had been rinsed with water or saline, we presented it with a plastic-reinforced rubber squeeze bulb (14.5 mm diameter) from a Nalgene® 60 ml medicine dropper (Fig. 1). As soon as the bulb contacted the lizard's mouth, the lizard would voluntarily bite down on the bulb. Care was taken to ensure that the posterior teeth (toward the angle of the jaw) engaged the bulb. The lizard was then held with its head at a 30–45° angle (below horizontal) and its mouth was suspended above a glass or plastic vessel (Fig. 2).

Results and Discussion.—After a lizard bites the squeeze bulb, released and compressed its jaws several times, drops of venom would be produced and the venom would drop into the vessel from along the gums of the lower jaw (Fig. 2). Initially, 40 drops (~ 2 ml) of venom were obtained from a several adult specimens. Subsequent trials suggest that this volume of venom can frequently be obtained using this technique but the quantity of venom varies with animal size and vigor (range of 1–4 ml), and it is important to note that the venom may be mixed with saliva and blood. Though the amount of venom per bite diminished after several jaw compressions, generally enough venom was collected in two minutes, allowing us to stop the trial. After each trial, the animal was placed back in its enclosure. In every case, as soon as the lizard was re-

leased, it would release the medicine dropper, making it easy to retrieve.

This method was used on six each of *H. horridum* and *H. suspectum* during late morning to early afternoon hours in spring, summer, and autumn. The lizards ranged from subadults (2–3 yrs. old) to large adults (up to 21+ yrs. old), and in both species, males and females were used for venom collection. All of the animals had been in captivity for a minimum of 2 years and a maximum of 21 years. Each lizard would bite and release (but not let go of) the bulb in a rhythmic pattern (i.e., bite and hold down for 4 seconds, bite and hold for 6 seconds, etc.). Though the defensive attitude of animals varied, only the oldest animal (an adult male Gila Monster), displayed less vigor in biting frequency (quantity of bite compressions).

Collected venoms (pooled by species/collection event) were stored at 4°C and immediately transported to a facility for lyophilization and then kept at -80°C. After CITES permits were obtained, lyophilized venoms were shipped to the research laboratory for genomic and proteomic analysis. The lyophilized venoms from *H. suspectum* and *H. horridum* were separately analyzed by gel permeation chromatography, reverse-phase HPLC, and mass spectrometry for the isolation and structural characterization of bioactive peptides. The typical and novel helodermatid venom peptides, exendins and helokinestatin respectively, were both isolated and characterized from the lyophilized venoms collected by this method (Chen et al. 2006; Kwok et al. 2008). The precursor cDNAs of exendin-4 and exendin-3 were also cloned where the lyophilized venoms used as the material for reverse transcriptase PCR (Chen et al. 2006).

Data published by Chen et al. (2006) and Kwok et al. (2008) showed that this technique for helodermatid venom collection worked extremely well. The advantages of this method are that 1) generally it is non-injurious to the lizard; 2) reduces animal stress and the amount of blood from breaking teeth that might be inadvertently collected using other methods (Mitchell and Reichert 1883); and 3) maximizes the quantity of venom that can be safely collected.

Fig. 2. Restrained Gila monster biting down on rubber bulb. The animal's head is held at a 30-45° angle (below horizontal). Note drop of venom hanging from lower jaw of lizard.

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Analysis and Comparison of Three Capture Methods for the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)

ROBIN L. FOSTER[1]
AMY M. McMILLAN[1*]
ALVIN R. BREISCH[2]
KENNETH J. ROBLEE[3]
and
DAWN SCHRANZ[1]

[1]*Department of Biology, Buffalo State College
Buffalo, New York, 14222, USA*

[2] *Endangered Species Unit
New York State Department of Environmental Conservation
Albany, New York 12233, USA*

[3] *Region 9, New York State Department of Environmental Conservation
Buffalo, New York 14203, USA*

Corresponding author; e-mail: mcmillam@buffalostate.edu

The Hellbender (*Cryptobranchus alleganiensis* Daudin) is North America's only member of the Cryptobranchidae, and one of the world's largest salamanders. Hellbenders are elusive animals; they are nocturnal, cryptically-colored, and spend most of their time beneath large rocks on the bottoms of swift-flowing streams. These characteristics make them difficult to locate and capture. A variety of capture methods have been tested and evaluated, but even the most widely accepted of these are still questionable in terms of their impact on breeding habitat and reproductive behavior. In addition, no effective technique has been reported to consistently locate and capture larvae or juveniles.

A common method of searching for Hellbenders involves lifting the upstream ends of rocks greater than 30 cm diameter, and capturing any Hellbender below it by hand or net with or without the aid of a mask and snorkel. Whereas this method is inexpensive and relatively quick (Nickerson and Krysko 2003), turning rocks during the breeding season may disrupt nest sites and result in mortality of eggs or larvae (Williams et al. 1981). Although appropriate for locating large adults, it may be ineffective for locating smaller size classes, especially larvae and juveniles less than 20 cm total length (Peterson et al. 1983). Nickerson and Krysko (2003) speculated that turning small rocks and other objects in shallow water might yield more larval Hellbenders. Additional disadvantages to rock turning include injury to the researcher due to heavy lifting, difficulty seeing Hellbenders because of stream surface glare, possibility of Hellbenders escaping unnoticed by researchers, inability to locate Hellbenders in deep water, and time required for silt to clear after a rock is lifted (Nickerson and Krysko 2003; Pauley et al. 2003).

Electroshocking has been used extensively with high capture success reported (Williams et al. 1981). Bothner and Gottlieb (1991) reported that Hellbenders were completely unaffected by the electrode unless directly touched with it, and even then appeared only mildly disturbed. Regardless of capture success, electroshocking equipment is heavy and expensive, and risk to

researchers and Hellbenders, especially eggs and larvae, is potentially significant (Nickerson et al. 2002; Nickerson and Krysko 2003).

Searching the stream bottom at night using spotlights is another technique that has been used to locate Hellbenders (Humphries and Pauley 2000). Hellbenders observed in the open are captured by hand or net, and rocks are lifted when Hellbender heads are observed protruding out from underneath. Nighttime searches may be useful for determining the presence/absence of Hellbenders during periods of peak nocturnal activity (Humphries and Pauley 2000). Humphries (2007) reported on an apparently unique population in North Carolina that seasonally exhibits a high degree of diurnal activity which made daytime visual searches very productive.

Several attempts have been made to capture Hellbenders using baited traps. Hellbenders are believed to forage at least partially by chemoreception, and have been documented responding to dead bait from a considerable distance (Nickerson and Mays 1973). Wire mesh traps baited with chicken liver proved unsuccessful (Soule and Lindberg 1994), but hoop traps baited with sucker fish did successfully capture Hellbenders (Kern 1984). Despite the mixed success with which traps have been used, they allow researchers to investigate deeper areas, and are not affected by turbidity.

Nickerson et al. (2003) effectively used snorkeling and SCUBA to capture Hellbenders, including larvae, in deep water areas. In their study more than 20 Hellbenders under 20 cm total length were located and 16 of these were gilled larvae. Most were located under small rocks, or in the interstices of small accumulations of gravel or gravel mixed with twigs near the stream banks, but some were located under large rocks in deeper water, or in deep gravel beds. Petokas (pers. comm.) has captured Hellbenders in water as deep as 6 m in the Susquehanna River in Pennsylvania using SCUBA techniques.

The objective of this study was to examine three methods of searching for Hellbenders in terms of efficiency and effectiveness: turning rocks, trapping, and searching along stream banks. Advantages, disadvantages, and limitations also were assessed in order to recommend a capture protocol for Hellbender population studies that will minimize disturbance and increase the likelihood of locating individuals of a variety of size classes.

Materials and Methods

Study Sites

This study was conducted at eight sites in three streams of the Allegheny River drainage in Cattaraugus County, New York, USA. Extant populations of Hellbenders were documented in these sites by a previous study (Bothner and Gottleib 1991). Substrate composition and embeddedness were visually estimated along transects at each site. Percent composition was visually estimated across the entire transect. Embeddedness was estimated at each bank, and at $^1/_4$, $^1/_2$, and $^3/_4$ of the stream width. Three independent estimations were averaged for each transect.

Capture Methods

Rock Turning.—As part of a mark-recapture study, rock turning

searches were conducted between late August and October of 2004 and 2005, and generally involved two to four active searchers. Hellbenders were located by slowly lifting the upstream ends of suitable rocks in each study site. A peavey or cant hook was used to provide leverage when needed. Suitable rocks were defined as those measuring at least 30 cm in diameter that did not require the use of multiple leverage devices for lifting. Before lifting a rock, a net was placed against the downstream edge to catch Hellbenders escaping with the silt plume. Hellbenders remaining in place or moving upstream were captured by grasping them behind the head and maneuvering them into a trout net. Rocks deemed likely to be nest sites were not turned in 2005. This is because during the 2004 survey, several nests were discovered and later found to be destroyed, possibly as a result of being disturbed.

Bank Searches.—Bank searches were conducted at all sites during the summer of 2005, between late May and late August, in an effort to locate smaller size classes. This technique was performed by two searchers. Habitable stretches of bank area, defined as having substrate larger than 7 cm in diameter, within the study site were divided into sections 1 m wide and extending 4 m into the stream. Five percent of these sections were randomly selected for search in each site (see Foster 2006 for site descriptions). Searching involved turning or agitating all substrate particles in the section. Aquarium nets with flat bottoms were held downstream to capture any juvenile hellbenders that were observed. Hellbenders were located by feel and captured by hand when visibility was poor.

Trapping.—The traps were a rectangular box design made of 1.3 cm plastic-coated hardware cloth. The traps measured 61 × 46 × 23 cm with a funnel on one end 7.5 cm high and 10 cm wide. A hinged door on the end opposite the funnel, held closed with a bungee cord, could be opened to add bait or remove any captured animals (Fig. 1). During the summer of 2004 we conducted a preliminary trapping test at Site No. 5 to aid in protocol development. We informally tested two baits: previously frozen venison (*Odocoileus virginianus*) and White Sucker (*Catostomus commersonii*). Both baits were selected for their availability, and
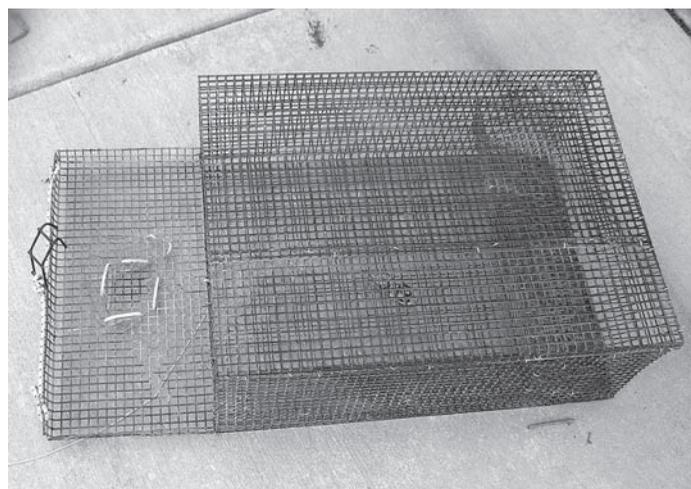

Fig. 1. Trap used to capture Hellbenders in Allegheny River drainage during the summers of 2004 and 2005. Bait (White Sucker) was attached to the inside of the hinged door in a wire mesh cage (later the cage was removed and replaced with plastic zip ties, see text).

sucker fish has been used successfully to capture Hellbenders in hoop traps (Kern 1984). Based on the preliminary data generated, we selected White Sucker as the bait for our future trapping efforts.

Trapping was conducted in all sites during the summer of 2005, between late May and late July. Trapping was performed at one site in May, two sites in June, and five sites in July. We performed four consecutive nights of trapping in each site. The number of traps used varied with site size. Traps were set approximately 20 m apart in potentially habitable areas with sufficient water depth to cover the entire trap (0.25 m minimum). These areas included sections of stream bed covered with large rocks, wood, or decaying vegetation, and areas with rock ledges at the banks. Traps also were set in areas that lacked large cover rocks, but were adjacent to habitable areas. In areas that contained habitat not accessible by turning rocks, such as rock ledges or large, unliftable rocks, and in areas too deep to be searched by hand, traps were set more densely (up to every 5 m). Traps were baited with pieces of White Sucker placed in a wire mesh cage on the trap door (Fig. 1) and set with the entrance facing downstream. In shallow water, traps were set flat against the stream bottom. In deep water, this often was not possible to ensure. Traps were tied to sturdy vegetation and weighted down with rocks. They were checked and bait was changed daily, except for site No. 8, at which bait was only changed every other day. Baiting and setting traps was completed by 1500 h each day, and traps were checked the following morning.

Evaluation of Capture Methods

Efficiency.—Capture efficiency was calculated for each method as the number of Hellbender captures per unit of effort. For the two manual search methods, effort was measured in person hours. Person hours included all time spent actively searching for and processing Hellbenders. Hellbenders were processed as they were found and processing time averaged 8 min/Hellbender. For the trapping method, effort was measured in trap nights. Trap nights were calculated by multiplying the number of traps set by the number of nights deployed. One trap night required 0.5 person hours


FIG. 2. Relative success of three capture methods in locating various size classes of Hellbenders (Rock Turning, N = 123; Bank Searches, N = 14; Trapping, N = 22; recaptures are not included in these numbers).

(it took two people approximately 15 min to bait, set, and check a trap). All Hellbender captures, including recaptures, were included in this analysis.

Effectiveness.—Each of the three methods was evaluated in terms of its effectiveness at locating Hellbenders of different sizes. Hellbenders were grouped into seven size classes, and the percentage of Hellbenders in each size class was determined for each method. Each animal was only counted once for this analysis, regardless of how many times it was captured. Each technique also was assessed in terms of its ability to capture Hellbenders at different water depths.

RESULTS

Study Sites.—Site areas ranged from 2355 to 15,741 m². Substrate in all sites included rocks > 30 cm diameter covering 4–8% of the stream bed, and fine particles (sand and silt) and gravel were prevalent. Site No. 8 also contained large areas of exposed

TABLE 1. Capture efficiency, measured as catch per unit effort, for three methods used to locate Hellbenders in the Allegheny River drainage in New York State. For rock turning and bank searches, effort was measured in person hours. For the trapping method, effort was measured in trap nights. One trap night is roughly equivalent to 0.5 person hours since it takes two people approximately 15 minutes to set a trap. Site No. 3 is excluded because no Hellbenders were observed.

| Site	Rock Turning (No. of captures)[1]	Rock Turning (Captures / person hour)	Bank Searches (No. of captures)	Bank Searches (Captures / person hour)	Trapping (No. of captures)	Trapping (Captures / trap night)
1	5	0.21	2	0.50	1	0.03
2	19	0.35	7	0.47	2	0.03
4	33	0.49	0	0.00	4	0.05
5	32	0.55	0	0.00	4	0.03
6	12	0.32	0	0.00	2	0.02
7	33	0.83	5	1.00	1	0.01
8	23	0.64	0	0.00	8	0.10
total	157		14		22	

[1]These numbers include recaptures.

FIG. 3. Relative success of traps placed at different depth ranges. N = number of traps placed at each depth.

bedrock. Substrate embeddedness was greater than 50% at all sites. The study streams were all relatively shallow (< 1 m deep in most places) and very clear during the study period.

Efficiency.—Capture efficiency varied by site for both manual search methods (Table 1). A total of 317 person hours were spent on rock turning and 55 person hours were spent on bank searching. A total of 157 captures (including recaptures) resulted from rock turning searches. Rock turning yielded 0.2 to 0.8 captures/person hour. Bank searches resulted in a total of 14 captures. In four of the seven sites, no Hellbenders were captured using the bank searching method. In the remaining three sites, capture efficiency was higher for bank searching than for rock turning, ranging from 0.47 to 1.0 captures/person hour. Traps were set for a total of 627 trap nights among all seven sites, resulting in 22 captures. Capture efficiency was highly variable between sites, ranging from 0.01 to 0.10 captures/trap night (Table 1). Only rock turning resulted in recaptures.

Effectiveness.—Each of the three methods was successful at locating both adult and juvenile Hellbenders, but only the two manual search methods resulted in the capture of gilled larvae. The smallest animal, less than 11 cm total length, was captured using the rock turning method. Captures of very large Hellbenders, greater than 60 cm total length, resulted only from the use of traps. No method was capable of locating all size classes equally (Fig. 2). Rock turning searches were biased toward middle-sized adults, between 41 and 50 cm total length. Of 123 individual Hellbenders captured using this method, 48% were in this size class. Bank searches were biased toward immature animals. Of the 14 Hellbenders captured in bank searches, 53.8% were between 11 and 20 cm total length. An additional 30.8% were between 21 and 30 cm total length. Trapping was most successful in capturing large adults. More than 80% of the 22 Hellbenders captured in traps were greater than 40 cm total length.

Each method was capable of locating Hellbenders at a range of depths, although manual search methods were limited to water <1 m deep. Bank searches were successful within the narrowest depth range, from 0.145 to 0.540 m. Rock turning captures ranged in depth from 0.155 to 0.85 m. Trapping had the greatest successful depth range, with Hellbenders captured from 0.28 to 1.25 m depth.

TABLE 2. Summary of advantages, disadvantages, and limitations associated with three Hellbender capture methods used in the Allegheny drainage in 2004 and 2005.

Method	Advantages	Disadvantages	Limitations
Rock Turning	- High capture efficiency - Locates some juveniles - Risk of injury to Hellbender - May reduce reproductive success (if done during breeding season)	- Labor intensive - May damage habitat - High turbidity - Low light - Rock size and mobility - Depth - Minimum of five person hours per site recommended	- Wind - Rain
Bank Searches	- Effective for finding juveniles - High capture efficiency where successful - Potential impacts to reproduction of other stream organisms - May fail to detect presence	- Does not result in high capture rate for larvae - Habitat disturbance	- High turbidity - Rock density - High flow
Trapping	- Little habitat disturbance - Useful for water slightly exceeding maximum depth of other methods - Useful for areas with unliftable rocks or ledges - Captures largest size class - Only method that detected Hellbenders at all sites	- Labor intensive - Low capture success - Requires large supply of bait - Risk of injury to Hellbender - Incidental catch may result in mortality of turtles - Cannot use during breeding season - Did not detect larvae	- Shallow water (< 0.25 m deep) - Deep water (> 1 m deep) - Minimum of 100 trap nights / site recommended

Trapping appeared to be most successful in deep water, between 0.76 and 1.0 m (Fig. 3). Of 27 traps set at this depth range, 18.5% resulted in captures. Less than 15% of traps set in shallower areas resulted in captures, and fewer than 4% of traps set in water >1 meter were successful in capturing Hellbenders.

<center>DISCUSSION</center>

Of the three methods examined, rock turning was the most efficient when viewed in terms of overall catch per unit effort. However, in some streams, bank searches were also highly efficient. Capture efficiency for trapping was lower than for rock turning in all sites, and was lowest in terms of overall catch per unit effort.

Bank searches were notable in the "all or nothing" type of capture success seen between sites. At all three sites where the method was successful, it exceeded the capture efficiency of rock turning. In the remaining four sites, it yielded no captures. This disparity is most likely due to differences in habitat between the sites. Bank searches were successful where stream margins included deep cobble piles interspersed with larger rocks. These areas presumably provide refuge from predation and an abundant food supply.

Sites at which bank searches were unsuccessful fell into two categories: those at which bank habitat was poor, and those at which bank habitat was exceptionally good. Poor bank habitat was characterized by silt and sparse rock cover. Exceptionally good bank habitat was characterized by dense piles of various-sized cobble and boulder along the stream edges. These areas were difficult to search thoroughly. It is possible that employing seines, buried into the substrate on either end of the search area, might increase the success of this method in areas with good habitat.

The capture rate for rock turning can be impacted by water and weather conditions. Hellbenders are difficult to see when the surface of the water is choppy. When turbidity is high, Hellbenders are often lost in the silt plume that is generated by lifting the rock. Under certain circumstances, a mask and snorkel might help alleviate these problems (Nickerson and Krysko 2003). Early in our study we tried using a mask and snorkel for both rock turning and bank searches, but because our streams were extremely shallow and clear this method did not prove useful. Even in our streams, SCUBA may have been useful for turning rocks in deep pools. However, we did not attempt this method and thus could not manually search for Hellbenders in areas deeper than ca. 1 m.

The usefulness of trapping may be limited by the nature of Hellbenders as predators. Hellbenders often lie in wait for prey, with only their noses protruding from rocks (Humphries and Pauley 2000), utilizing a powerful type of suction feeding enabled by unique jaw asymmetries and hyoid movements (Lorenz Elwood and Cundall 1994). This may limit their need to move about in search for food (Nickerson and Krysko 2003), reducing the likelihood of their capture using traps. On the other hand, Humphries and Pauley (2000) suggest that during times of high metabolic demand Hellbenders may forage more actively. This may increase trapping success at some times of the year, especially prior to the breeding season.

Prey availability may influence Hellbender foraging. Large numbers of crayfish were observed in our sites throughout the study period, which may have minimized trapping success. Bait choice also may affect trapping success. Although White Sucker was successful in capturing Hellbenders in our study, other baits may prove more enticing. For example, Hellbenders may be attracted to bait with fresh blood (Bishop 1941).

Traps appeared to be most successful when set at depths between 0.75 and 1.0 m. Few Hellbenders were trapped at depths >1 m, possibly due to difficulty in setting traps flat against the stream bottom at these depths. This problem could be corrected by diving to the bottom using a mask and snorkel or SCUBA equipment and properly setting the trap. Diving to set deep-water traps may be useful if rock ledges or unliftable rocks are present.

Each of these methods has associated advantages and disadvantages that affect their usefulness in various situations (Table 2). Rock turning may be the most efficient method for capturing Hellbenders, but may have serious repercussions during the breeding season. Hellbenders tend to select nest rocks that are mostly embedded in smaller substrate and have only a single opening, which the male defends (Bishop 1941). Once the nest is disturbed, several openings may exist, exposing the eggs or larvae to a variety of predators. In addition, overturning potential nest rocks may render them unsuitable as nest sites because they will no longer be sealed by small particles.

Bank searches are extremely useful for locating juvenile Hellbenders, but may be highly disturbing to the habitat. Many organisms may be affected, including crayfish, small fish, mudpuppies, tadpoles, and macroinvertebrates. While not impacting Hellbender reproduction, bank searches during the summer may affect the reproduction of some other organisms.

Trapping was the only method that did not cause substantial disturbance to the stream habitat. It also worked in situations where other methods failed, such as in habitat areas with very large rocks or rock ledges. Of the 22 Hellbenders trapped in 2005, 16 were not located using any other method. Of these, one was trapped near a rock ledge, seven were trapped near unliftable rocks, and five were trapped in deep water.

Trapping also has some disadvantages. Traps are heavy, bulky, and take a considerable amount of time to set. There is risk of injury to Hellbenders. Several Hellbenders sustained minor injuries on the original wire bait holder. As a result we removed the holders and used plastic zip ties to hold bait for the remainder of the study. There is also a risk to other animals that may become caught in the trap, particularly turtles. Trapping should not be conducted during the breeding season, since females captured in traps overnight could become stressed and drop their eggs, and captured males would be prevented from returning to their nests rocks, possibly exposing eggs to predation.

When determining which capture method to use for studying a particular group of Hellbenders, it is important to consider the attributes of the site and the advantages versus the disadvantages of each method. Our results suggest that no single method for Hellbender capture is capable of providing access to all portions of the population. Based on its high catch efficiency and ability to locate some juveniles, rock turning is most likely the best method for studies aimed at determining population size. The inclusion of rocks smaller than 30 cm diameter in bank areas may increase the ability of this method to provide information on age structure. However, the main advantage of rock turning in the breeding season, gathering sex ratio data, is outweighed by the potential negative impacts to reproductive success. To provide the most complete

data on Hellbender population structure, including age structure and habitat usage, we recommend a combined approach using extensive summer rock turning, bank searches focused on appropriate cobble piles adjacent to large rock areas, and limited trapping in areas of deeper water, or where unliftable substrate renders other search methods impossible.

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Relative Efficacy of Three Different Baits for Trapping Pond-dwelling Turtles in East-central Kansas

R. BRENT THOMAS*
IAN M. NALL
and
WILLIAM J. HOUSE
Department of Biological Sciences, Emporia State University
Emporia, Kansas 66801-5087, USA

*Corresponding author; e-mail: rthomas2@emporia.edu

The diverse array of collection methods used to sample freshwater turtles (e.g., Gibbons 1990; Glorioso and Niemiller 2006; Plummer 1979; Vogt 1980) do not necessarily provide equivocal results in ecological studies of freshwater turtles. Using different methods may significantly influence estimates of abundance, sex ratio, and population/community structure (Frazer et al. 1990; Gamble 2006; Ream and Ream 1966; Thomas et al. 1999). Frazer et al. (1990) argued that studies designed to compare different methods of capturing turtles were needed to ensure that the results of ecological studies accurately reflect reality.

Baited funnel traps of various designs are commonly used to sample freshwater turtle populations/communities, using a variety of baits (see Gibbons 1990; Kennett 1992; Plummer 1979). We are aware of three published studies that attempt to quantitatively compare the effectiveness of different baits on the capture rate of freshwater turtles (Ernst 1965; Jensen 1998; Voorhees et al. 1991). We experimentally examined the effectiveness of three types of bait in funnel traps to capture *Trachemys scripta elegans* and *Chrysemys picta bellii*. The baits selected were canned creamed corn (*Zea mays*), canned Jack Mackerel (*Trachurus symmetricus*), and frozen fish (*Pomoxis annularis* or *Lepomis cyanellus*); these baits were selected because they were commonly used in previous studies.

Methods.—Rectangular frame nets (65 × 90 cm frame covered with 3.8 cm treated nylon mesh; Nichols Net & Twine Inc.) were used to capture Red-eared Sliders (*T. s. elegans*) and Western Painted Turtles (*C. p. bellii*) in a complex of eight manmade ponds (pond sizes ranged from 0.2–9.6 ha) located on or within 2.5 km of Emporia State University's Ross Natural History Reservation (RNHR; Spencer 1988) near Americus, Kansas, USA (38.49491°N, 96.33540°W; NADS 1983). Three frame nets were set in each of the eight ponds (total = 24 frame nets). Baits were placed in perforated PVC tubes so that turtles could detect but not consume baits. The three frame nets within each of the eight study ponds were baited either with canned creamed corn, canned jack mackerel, or frozen fish (i.e., each of the three frame nets within a single pond were baited with a different bait). The initial assignment of bait

type to the three frame nets within a pond was random. Thereafter, frame nets were checked daily and the position of the PVC tubes containing the different baits systematically rotated daily among the three frame nets. The purpose of systematically rotating the baits among the three traps within each pond was to equally distribute the possible influence of differences in capture rates between specific trap locations within a given pond. Baits were removed from the perforated PVC tubes and replenished with fresh bait every other day.

Frame nets were set in 1–3 ponds/day over the 5 d period that began 14 May 2007. We reversed this staggered schedule for removal of frame nets at the end of the 13 d study period to maintain an approximately equal number of trap hours in all ponds. Thus, all ponds were sampled continuously for a total of 13 d with substantial temporal overlap of the trapping schedules (i.e., all trapping conducted from mid- to late May). There were 3 traps/pond for 13 d in eight ponds (overall, 7488 trap hours summed across all three baits, 2496 trap hours/ bait, 936 trap hours/pond, and 312 trap hours/pond/bait).

All *C. p. bellii* and *T. s. elegans* captured were uniquely marked using the system described by Cagle (1939). We considered all captures (original captures and recaptures) as independent in statistical analyses.

Trap success may have been influenced by inherent site-specific variation among the eight ponds and/or the temporal variation that may have resulted from slight differences in the precise trapping schedules among sites. Because of possible site-specific variation, we used Analysis of Variance (ANOVA) within a randomized block design to compare the mean number of turtles (of each species) captured with each of the baits during the 13 d study period. Blocking designs are desirable in such situations because they increase the precision of the model by removing one source of known (or suspected) variation (e.g., inherent site-specific variation in capture rates among ponds) from experimental error (Peterson 1985; Sokal and Rohlf 1995). The eight study ponds were considered as blocks, the different baits were the treatments, and mean number of turtles (i.e., either *C. p. bellii* or *T. s. elegans*) captured/pond with each of the three baits served as the response variable. Separation of means was accomplished using Fisher's Protected Least Significant Difference (LSD; Peterson 1985) and alpha was set at 0.05 in all statistical tests.

Results.—We captured 93 (69 original captures + 24 recaptures) *C. p. bellii* and 81 (50 original captures + 31 recaptures) *T. s. elegans* during the 13 d study period. We captured *C. p. bellii* in all ponds and caught *T. s. elegans* with one or more of the baits in all but one pond. Therefore, we excluded this pond from the analyses for *T. s. elegans*. We observed a significant bait effect for both species (*T. s. elegans*: F = 5.25; d.f. = 2, 12; P = 0.023; R^2 = 0.69; *C. p. bellii*: F = 4.73; d.f. = 2, 14; P = 0.027; R^2 = 0.75). We captured significantly more *T. s. elegans* in frame nets baited with frozen fish than with creamed corn, but observed no significant difference between frozen fish and canned mackerel or between canned mackerel and creamed corn (Fig. 1A). Mean separation procedures for *C. p. bellii* revealed that both canned mackerel and frozen fish were significantly more effective than creamed corn but canned mackerel and frozen fish were not significantly different from each other (Fig. 1B).

*Discussion.*—We concluded that both canned mackerel and fro-
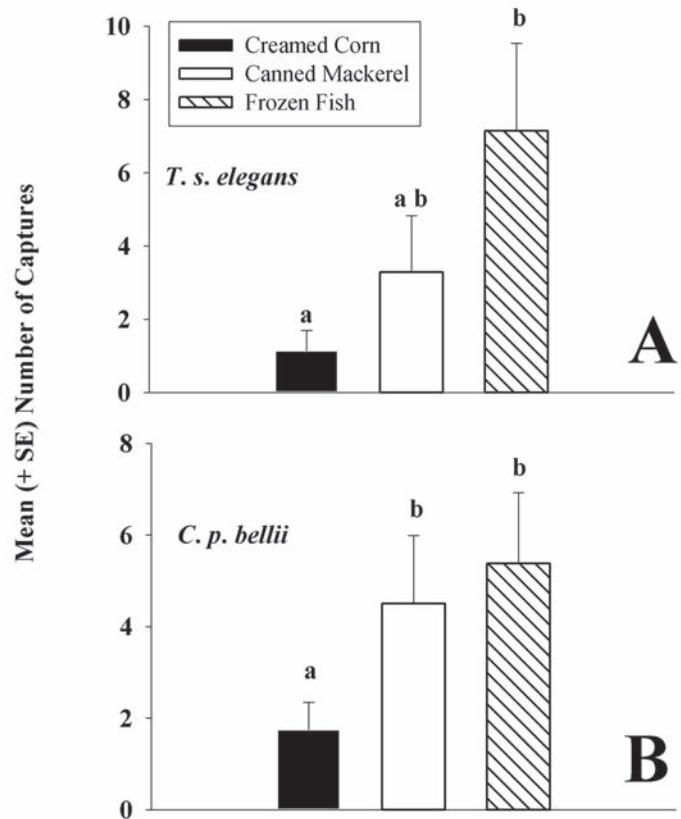
Fig. 1. Mean (+ SE) number of turtles captured/pond during 13 days of trapping (A = *Trachemys scripta elegans*; N = 7 ponds; B = *Chrysemys picta bellii*; N = 8 ponds) with canned creamed corn, canned mackerel, and frozen fish. Means sharing the same lower case letter were not significantly different (Fisher's Protected LSD; α = 0.05).

zen fish were significantly "better" than creamed corn for attracting these two species to frame nets. First, we discuss several potentially confounding factors that are known to influence capture rates. For example, captured females may serve as an additional enticement for males to enter nets (Frazer et al. 1990; Jensen 1998; Thomas et al. 1999). However, we did not observe unusually large numbers of males within traps containing females (see Jensen 1998), and we see no reason to expect that the particular food bait within a trap would alter the attractiveness of a female within that trap. Therefore, the influence of this factor should have been equal across all three baits. Likewise, individual turtles sometimes exhibit so-called "trap-happy" or "trap-shy" behaviors (Deforce et al. 2004; Koper and Brooks 1998). But, we do not think that the observed differences were an artifact of such behaviors. First, because of the short duration of our study period many individuals were never recaptured (i.e., captured only once) and most of those that were recaptured were recaptured only once. Second, turtles were not rewarded for entering a trap (i.e., not allowed to consume the baits) and the bait tubes were systematically rotated every day among the three traps within each pond. Therefore, we have no reason to expect the propensity for "trap-happiness" or "trap-shyness" to have differed among the three baits. Therefore, the influence of such behaviors (if any) should have been equal across all three baits.

Consistent with previous studies, we found that using different

baits sometimes resulted in differences in capture rates. But various factors limit our ability to directly compare our results with those of previous studies. For example, the three published studies (Ernst 1965; Jensen 1998; Voorhees et al. 1991) were conducted in different geographic locations and/or habitats, sometimes used different baits, and/or involved different species. Our study was conducted in manmade ponds located within a small portion of east-central Kansas and we cannot necessarily assume that our results are applicable across the relatively large geographic distributions of these species. We examined three commonly used baits but there are a large number of baits that have been used as bait in funnel traps. Currently, nothing is known with respect to the relative effectiveness of most of these baits. Likewise, the potential for seasonal, sexual, and ontogenetic variation in the effectiveness of particular baits deserves further consideration.

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A Simple Pitfall Trap for Sampling Nesting Diamondback Terrapins

JOEL A. BORDEN*
Department of Biology, University of South Alabama
Mobile, Alabama 36688, USA

and
GABRIEL J. LANGFORD
School of Biological Sciences, University of Nebraska at Lincoln
Lincoln, Nebraska 68588, USA

*Corresponding author; e-mail: jab315@jaguar1.usouthal.edu

The Diamondback Terrapin *(Malaclemys terrapin)* is an estuarine turtle inhabiting coastal salt marshes from Massachusetts to Texas (Ernst et. al. 1994). Previous data on nesting terrapins have primarily been collected via visual searches during peak nesting activity (Feinberg and Burke 2003; Roosenberg 1996; Roosenberg and Dunham 1997). Although effective, this method is time consuming, requires a reasonably large population, and sometimes requires numerous volunteers. Many of these studies occurred along the Atlantic Coast where nesting beaches are located on the mainland. This has allowed researches to easily access nesting beaches to conduct visual searches for terrapins. Nesting beaches in the Northern Gulf of Mexico, however, are located almost exclusively on islands (D. H. Nelson, pers. comm.), making nesting beaches accessible only by boat. Boat travel results in increased travel time and thus decreased searching time for nesting terrapins. To complicate matters, nesting beaches in the northern Gulf Coast are usually small and widely distributed, making typical nesting surveys almost impossible to conduct (Nelson et. al. 2005). Unlike Atlantic coast nesting beaches, beaches in Alabama are largely composed of oyster shells, which prevents locating turtles and their nests via female crawls (a method used in Feinberg and Burke 2003). Given these atypical nesting conditions, we decided that a passive trapping method would be more appropriate for capturing terrapins on local nesting beaches.

Initial efforts with pitfall traps constructed from Christiansen and Vandewalle (2000) fell short of our expectations. These traps did not hold up to the demands of the estuarine environment (e.g., saltwater, winds). Specifically, the wooden lid and metal rod degraded quickly, rendering the trap non-functional. Furthermore, 5-gallon buckets did not seem to provide suitable space for trapped terrapins to maneuver. We used the Christiansen and Vandewalle (2000) design as a starting point and began experimenting with various modifications of their design. Herein, we describe the

modified design that best addressed the specific problems described above.

We erected four, 90-m long drift fences on shell middens (composed of oyster shell) at Barton Island (30°23'N, 88°22'W), Mon Luis Island (30°20'N, 88°11'W), and Cedar Point (30°19'N, 88°08'W) in southern Mobile County, Alabama, USA. Pre-staked construction silt fencing, 90 cm in height, was used for several reasons including, low cost, ease of handling, and durability. Fences were buried to a depth of 30 cm leaving 60 cm above ground. Two pitfall traps were installed along each fence 30 m from the ends and 30 m apart. Pitfalls had a self-righting lid that was placed over the pitfall (Fig. 1). This type of lid was chosen for two reasons: 1) to increase the numbers of turtles that were captured, since turtles seemed wary of uncovered pitfalls (Christiansen and Vandewalle, 2000), and 2) to provide shelter from thermal stress. Temperature was monitored in the month of June (tropical storms prevented sampling temperature in July) using HBE International Inc. Minimum-Maximum thermometers. One thermometer was secured with cable-ties midway inside a pitfall trap, while another thermometer was staked on exposed shell adjacent (outside) to the same pitfall trap. Thermometers were reset everyday to acquire daily temperature extremes. Minimum temperature inside the pitfall ranged from 18°C to 23°C and a maximum temperature ranged from 25°C to 29°C. Temperatures outside the pitfall had a minimum range of 24°C to 30°C and a maximum range from 40°C to 47°C (N = 20 days).

Each trap consisted of a single 68.1 L (19 gal) plastic storage container. The rigid construction of the Sterilite® brand worked better than other available styles, as shifting sand and shells of nesting beaches tended to warp and distort other plastic containers. To prevent water accumulation from rain and/or over wash caused by storm events, holes were drilled through the bottom of the containers. The lid was designed to rotate when a large or heavy animal walked across one side or the other. The lid returned to its original, horizontal position after a turtle fell into the trap via a pendulum. Construction of the rotating lid assembly began by drilling holes in the handles where 15.2 cm (6 inch) steel I-bolts were mounted on each handle with 3/8 inch washers and nuts to create a mount for the rotating lid. Next, the outer edges of the lids were cut to fit inside the container, which allowed the lids to rotate freely inside the pitfall trap. The lid was very flimsy, so 1/2 inch PVC tubing was used as a framework for the rotating lid and attached to the lid with 20.4 cm (8 inch) cable ties. The PVC was cut to fit through the I-bolts and capped to prevent sliding of the lid assembly. A hole was cut at the center of the lid for a pendulum to pass through into the pitfall. The pendulum consisted of a 15.2 cm (6 inch) section of 1/2 inch PVC, filled with lead fishing weights, attached to the central rib at the T-joint. The pendulum allowed the rotating lid to remain level even during high winds and right itself after a turtle was captured.

The labor and construction cost involved in erecting the fences and burying the pitfalls was minimal compared to hourly monitoring of nesting beaches. Total cost of one 90 m fence with two pitfall assemblies was US $90, and each array required 2 person-hours for construction and instillation. No part of the traps needed to be replaced throughout the nesting season, which included two tropical storm events.

From 13 May to 19 August 2005, we successfully captured 14 gravid female terrapins 16 times in 310 trap days (one trap day = one pitfall open for one night) for a catch per unit effort of 0.05 terrapins per trap day. Capture rates were greater than those of modified crab traps (similar traps used by Wood 1997) sampled near the nesting beaches, 21 captures over 2048 trap days (0.01; Borden, unpubl. data). Although catch per unit effort was low, terrapin populations in Alabama appear to be uncommon to rare and highly isolated (Nelson and Marion 2004). During the nesting season, the plastic pitfalls did not degrade. However, it was necessary from time to time to adjust the fit of the lid with a utility knife to ensure unobstructed rotation. We opened traps on Mondays and closed them on Fridays. Traps were checked daily. When not in use, we covered traps with a 60 × 80 cm piece of rubber-coated chicken wire and staked the wire at each corner, to prevent the inadvertent capture of terrapins. We observed no apparent predation on terrapins within the traps, although Raccoons *(Procyon lotor)* and River Otters *(Lontra canadensis)* were observed on the nesting beaches. Although nesting beaches are used by humans, there was no evidence of trap disturbance during this study.

We found this technique to work well for terrapins inhabiting estuaries with minimal nesting habitat. However, it may be less effective than visual searches in habitats with expansive or readily accessible nesting beaches. Longer drift fences with more pitfalls will need to be tested to determine their effectiveness at large nesting areas. Possible disadvantages of this technique are that nesting females may be forced to alter nesting behavior when they encounter the fence. In our experience, however, turtles nested along and even beneath drift fences with no adverse impacts.

In conclusion, although pitfall traps have been used to capture turtles for many years (Congdon et. al. 1987; Gibbons et. al. 1983; Tucker 2000), our trap is the first to incorporate a pendulum and the first designed for harsh, estuarine environments. This trapping system will be appreciated by terrapin researchers along the northern Gulf Coast where typical capture methods (e.g., visual transects, locating signs of nesting females) are not effective. Overall, this
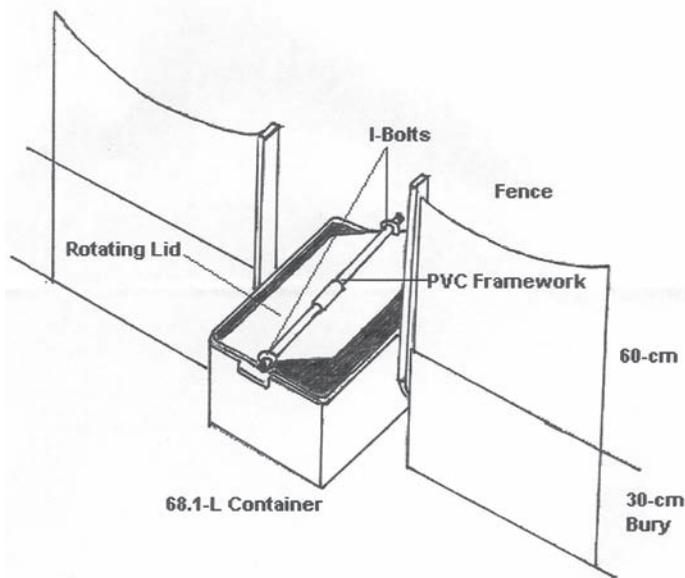

FIG. 1. Diagram for 68.1 L (19 gal) pitfall trap with self-righting lid, shown attached to a drift fence. (Illustration provided by B. Gill)

trapping system seems to be a relatively inexpensive and time saving technique for sampling terrapins in an undersampled portion of their range.

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Use of Traditional Turtle Marking to Obtain DNA for Population Studies

PATRICK J. DAWES
COLLEEN S. SINCLAIR*
and
RICHARD A. SEIGEL
Department of Biological Sciences, Towson University
8000 York Road, Towson, Maryland 21252, USA

*Corresponding author; e-mail: csinclair@towson.edu

Genetic analysis has been applied extensively to studies of wildlife populations to examine population diversity, gene flow, inbreeding depression, source-sink dynamics, and extinction-recolonization frequencies (Hedrick and Kalinowski 2000; Jehle and Arntzen 2002). Blood or tissue samples and buccal swabs are the common source of DNA for most genetic studies. In chelonians, blood samples are acquired by drawing blood from the tail, leg, or neck (Avery and Vitt 1984; Jacobson et al. 1992; Rosskopf 1982). Although effective, obtaining blood samples is invasive, sometimes difficult to accomplish, and possibly stressful to the turtle. However, alternative methods have also had serious drawbacks, including a protocol using shell samples that required such large amounts of bone that either a deceased animal was needed or the animal had to be sacrificed (Hsieh et al. 2006).

In this paper, we describe a method of obtaining tissue for genetic studies that makes use of the traditional marking techniques for turtles, i.e., drilling or notching the marginal scutes (Cagle 1939; Ernst et al. 1974; Mockford et al. 1999). The drill shavings produced during marking are used as the source of DNA for genetic analysis instead of being thrown away thereby eliminating the invasive and stressful procedure of blood extraction and increasing the speed with which the samples can be taken.

Materials and Methods.—All samples collected came from gopher tortoises at the Kennedy Space Center (Brevard and Volusia Counties, Florida, USA) where mark-recapture studies have been conducted for over 30 years (Pike et al. 2005). Tortoises collected were examined for previous marks and mass and length measurements were recorded (Pike et al. 2005). While wearing sterile gloves, 100% ethanol was used to swab the scute area to be drilled in order minimize contamination of the sample. A 1/8th inch (3.17 mm) drill bit was used to drill holes in scutes of unmarked tortoises, while a larger bit was used to drill holes in scutes of previously marked individuals. Filter paper was placed under the scute area where the hole was drilled to catch the drill shavings during the marking process. Drill shavings from one or two holes were enough to facilitate genomic DNA extraction. After drilling, the shavings were placed in a sterile 15 ml polypropylene tube, and stored at ambient temperature. After a tortoise was marked, the drill bit was cleaned by brushing with a firm toothbrush dipped in 100% ethanol. The drill bit was then dipped in 100% ethanol and flamed to sterilize. (Note: Isopropyl alcohol could be substituted for ethanol.)

The extraction process used two 5/8th inch (15.88 mm) hex bolts

and a matching nut. Prior to use, the threaded end of the bolts were ground flat to provide an even grinding surface to maximize the pulverization of the drill shavings (Thomas and Moore 1997). The nuts and bolts were then wrapped in aluminum foil and sterilized in an autoclave. The nut was partially threaded on to one bolt creating a small cup that was then filled with approximately 0.1 g of drill shavings. The second bolt was added to make a sealed chamber encapsulating the drill shavings (Thomas and Moore 1997). The bolt assembly was placed in liquid nitrogen for 30 seconds to one minute (Thomas and Moore 1997). Upon removal from the liquid nitrogen, the sample was pulverized by simultaneously twisting both bolts together. The bolt assembly was tightened and loosened several times and tapped on the hard surface to assure the sample was uniformly pulverized (Thomas and Moore 1997). The bolt assembly was then carefully dismantled over a piece of filter paper to collect the powder and facilitate transfer to a 1.5 ml microcentrifuge tube.

The powdered drill shavings were decalcified in 500 µl of 0.5 M pH 8.0 EDTA at 37ºC while shaking at 225 rpm until the pellets had broken down, (approximately three to five days) following a modified protocol for the Qiagen DNeasy Blood and Tissue kit (Qiagen, Valencia, California) (Qiagen 2006). The decalcification step is critical since the cells containing DNA must be freed from the calcified matrix in order for the extraction to be successful. The samples were centrifuged at 13,000 rpm to pellet and washed three times with sterile deionized water to remove ions that had accumulated during the decalcification process. Decalcified samples were then processed using a Qiagen DNeasy Blood and Tissue kit following the modified protocol above.

Results.—A total of 0.1 g of drill shavings yielded enough DNA for multiple genetic analyses. Total DNA yields ranged from 110 to 4650 ng. The high molecular weight DNA produced with this method has been verified by ultraviolet spectrophotometry and PCR. Ratios of A260/A280 measurements ranged from 1.6 to 2.0. PCR amplifications with seven species-specific microsatellite primers produced strong, clear bands in >91% of the samples tested.

Discussion.—Our results show that DNA can be obtained from a standard method of marking turtles. By refining and combining existing techniques, we have developed a protocol that requires lesser amounts of shell material and minimizes the invasive procedures when compared to currently published techniques. The drilling or filing of the marginal scutes has been observed to show no signs of physical pain in the animals (Gibbons 1968). Pike et al. (2005) also noted that handling and drilling stress wore off quickly enough to have no discernable effect on recapture rates, demonstrating that drill marking has little detrimental effect on tortoises. Mockford et al. (1999) described a similar protocol for DNA extraction from freshwater turtle hatchlings; however it is important to note that the shell material was not ossified at the time of removal making the DNA extraction process less problematic.

Our technique provides the basis to easily gather and process genetic material from ossified shell to examine chelonian genetic diversity and long-term viability. A better understanding of the population structure and effective populations of these long-lived and slow reproducing animals is necessary to properly formulate management strategies for these animals (Gibbons et al. 2000; Scott and Seigel 1992). Our protocol uses a waste product of a common

marking technique to obtain high-quality DNA allowing for the addition of genetic analysis to ongoing mark-recapture studies. Our technique enables non-invasive sampling of a population to get DNA samples of comparable quality to those obtained with more invasive methods.

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AMPHIBIAN CHYTRIDIOMYCOSIS GEOGRAPHIC DISTRIBUTION

Amphibian Chytridiomycosis in Captive *Acris crepitans blanchardi* (Blanchard's Cricket Frog) Collected from Ohio, Missouri, and Michigan, USA

KEVIN C. ZIPPEL
Detroit Zoo, Royal Oak, Michigan 48068, USA
Current address: Amphibian Ark, 12101 Johnny Cake Ridge Road
Apple Valley, Minnesota 55124, USA
e-mail: KevinZ@AmphibianArk.org

and
CHRIS TABAKA
Detroit Zoo, Royal Oak, Michigan 48068, USA
Current address: Binder Park Zoo, 7400 Division Drive
Battle Creek, Michigan 49014, USA
e-mail: tortvet@gmail.com

Amphibian chytridiomycosis, a disease caused by the fungus *Batrachochytrium dendrobatidis* (*Bd*), has been documented in numerous wild populations in North America (Ouellet et al. 2005), including an Illinois population of Blanchard's Cricket Frog (*Acris crepitans blanchardi*) (Pessier et al. 1999). Herein we document the possible occurrence of *Bd* in this species in Ohio in 1999 and the likely occurrence of *Bd* in populations from Missouri in 2001 and Michigan in 2004.

On 16 September 1999, 10 Blanchard's Cricket Frogs were collected at St. Mary's Fish Hatchery in Auglaize County, Ohio, and transferred to the Toledo Zoo where they spent 10 days in isolation before being sent to the Detroit Zoo, Michigan. By 20 September 2000, eight frogs had been moved from their quarantine enclosure to a native-Michigan, mixed-species amphibian exhibit. The other two frogs were missing from their quarantine enclosure and presumed dead; it is not unusual for small amphibians to decompose completely before their death has been detected, particularly in naturalistic enclosures. The first two confirmed deaths were over a year after their arrival in Detroit and within months of their addition to the mixed exhibit (10 December 2000, 7 February 2001); these two frogs tested positive histologically for *Bd*. As the *Bd* treatment protocol had only recently been published (Nichols and Lamirande 2000) and was not yet known by zoo staff, nothing was done for the animals remaining in the exhibit. Three more frogs died between 27 February 2001 and 10 July 2003: histopathology results were inconclusive for two, and *Bd* was not detected histologically in the third. Two additional frogs were missing and presumed dead at that time also. On 30 March 2003, an American Toad (*Anaxyrus americanus*) in that exhibit died; this animal tested positive histologically for *Bd*. Medication with the established protocol (Nichols and Lamirande 2000) was begun for the other amphibians in that enclosure in late July 2003. The last cricket frog died on 22 July 2003 while under treatment for *Bd*; there was no histologic evidence of active *Bd* infection, but there was mild multifocal epidermal hyperplasia likely from previous *Bd* infection. There are two scenarios that could explain the presence of *Bd* in this group of cricket frogs from Ohio. The wild population could be infected and these frogs could have entered the collection asymptomatically carrying *Bd* and gradually succumbed over nearly four years. Although some species susceptible to *Bd* tend to die within a few weeks of infection, others can carry light infections of the disease with no clinical symptoms and only succumb under duress. In this case, the last cricket frog survived over two and half years after the first *Bd*-positive death in the enclosure. The other possibility is that, since the two positive cases were not detected until after the group was moved into the mixed-species exhibit, the cricket frogs could have been infected by the other amphibians in that exhibit, which could have been asymptomatic. Two of the three other taxa (*Anaxyrus americanus*, *Notophthalmus viridescens*, but not *Lithobates pipiens*) eventually tested positive.

On 22 October 2001, 10 Blanchard's Cricket Frogs were collected from Franklin County, Missouri, and transferred to the Detroit Zoo. All were dead within four months. Four frogs died in quarantine throughout December 2001; histopathology results were inconclusive. The remaining six frogs were moved on 2 January 2002 into a general holding room with other species but were maintained in isolation in their own enclosure. Two more frogs were dead by 10 January 2002; histopathology results on these frogs were also inconclusive. The seventh frog died on 29 January 2002; this frog tested positive histologically for *Bd*. The remaining three frogs were dead by 18 February 2002 before we learned the results from the seventh frog and had a chance to medicate them using the established protocol; histopathology results were inconclusive. The *Bd* in these animals could have come from poor husbandry (transmission from other isolated asymptomatic animals), but because these frogs were in an isolated enclosure with dedicated tools during their entire time in captivity, more likely they came infected from the wild.

From 4 August through 7 October 2004, 835 Blanchard's Cricket Frog adults and 176 tadpoles were collected from a wetland in Ypsilanti, Washtenaw County, Michigan, where their native habitat was slated for development. These frogs were held temporarily in isolated quarantine at the Detroit Zoo, then released into three newly constructed local wetland sites from 24 August to 7 October 2004 (Rickard et al. 2004). Histopathology results from three frogs and four tadpoles collected and sacrificed a month prior to translocation revealed no *Bd* or other diseases. While they were in captivity, 181 frogs died. Of those, eight were submitted for histopathology and the last two tested positive for *Bd*. Because these animals were kept in isolated quarantine in a new building with no other amphibians, it is likely that they came infected from the wild.

In all three cases, there is a possibility that the *Bd* in the captive cricket frogs originated from other animals in the captive collection. However, we feel that this is rather unlikely, at least in the two cases where the animals were kept isolated from others in the collection. In the future, we recommend testing for *Bd* in all amphibians arriving into captive collections. Not only will this benefit the health of the captive collection, it can also provide valuable data on the distribution of *Bd* in the wild. *Bd* is not something most zoos test for in quarantine, although a simple PCR test is now available (Annis et al. 2004) and might someday be afford-

able for such routine testing. Sampling a subset of the animals is cheaper, but as in the case of the cricket frogs from Michigan, it can lead to oversight.

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Occurrence of the Amphibian Pathogen *Batrachochytrium dendrobatidis* in Blanchard's Cricket Frog (*Acris crepitans blanchardi*) in the U.S. Midwest

SHELDON L. STEINER
and
RICHARD M. LEHTINEN*
The College of Wooster, Department of Biology
931 College Mall, Wooster, Ohio, 44691 USA
corresponding author e-mail: rlehtinen@wooster.edu

Batrachochytrium dendrobatidis is a chytrid fungal pathogen of amphibians that has been implicated in a number of amphibian declines (Berger et al. 1998; Lips et al. 2006). However, despite the importance of *B. dendrobatidis* as a potential causative agent of population declines and biodiversity loss in amphibians, many questions remain regarding this pathogen and its impact. Most importantly, we still have relatively few data on which species are infected by *B. dendrobatidis*, if infection is commonly associated with declines, and the geographic scope of its occurrence. Even in North America, where the amphibian fauna is relatively well-known, only a small number of studies have examined infection and distribution patterns of *B. dendrobatidis*.

Blanchard's Cricket Frog (*Acris crepitans blanchardi)* is a small North American hylid that was formerly one of the most common frogs in North America (Gray et al. 2005). Recently, serious declines have been reported in Blanchard's Cricket Frog populations throughout much of the midwestern United States, particularly the northern and western parts of its range (Brodman and Kilmurry 1998; Hay 1998; Lannoo et al. 1994; Lehtinen 2002; Lehtinen

and Skinner 2006; Mierzwa 1998; Mossman et al. 1998). A number of hypotheses have been proposed to account for the asymmetric decline of Blanchard's Cricket Frog including: habitat loss and fragmentation, drought and climate change, contaminants, competition and/or predation by fish or other amphibians, and changes in local and regional successional patterns (Beasley et al. 2005; Gray and Brown 2005; Hammerson and Livo 1999; Hay 1998; Irwin 2005; Jung 1993; Lannoo 1998; Lehtinen 2002; Lehtinen and Skinner 2006; Reeder et al. 2005; Russell et al. 2002). The potential involvement of *B. dendrobatidis* in the decline of this species is clearly another hypothesis in need of investigation. Here we report on tests for the presence of *B. dendrobatidis* in Blanchard's Cricket Frog.

Methods.—Skin swabs or tissue samples from 205 Blanchard's Cricket Frogs were collected from 21 haphazardly chosen ponds in six states in the midwestern United States (Fig. 1). Most samples (N = 197) were collected between June and October of 2006 from live frogs in the field. A small number of samples (N = 8) came from venter skin sections of alcohol-preserved museum specimens collected in April 2002 and June 2003. Most samples were from juveniles or adults but a small number of larvae were also sampled. Skin swabs were obtained by running a sterile cotton swab along the skin of the captured frog for approximately 30 seconds, focusing on the hands, feet and pelvic region. For larvae, swabbing was concentrated around the oral apparatus. Tissue samples were either toe clips or skin sections. Toe clips were removed from live frogs using sharp, sterilized scissors. Both skin swabs and tissue samples were preserved in 70% ethanol in 2.0 ml screw-capped microcentrifuge tubes. In a few cases, voucher specimens were retained for reference purposes (deposited at the Illinois Natural History Survey and the James Ford Bell Museum of Natural History), otherwise frogs were released at the site of capture. All
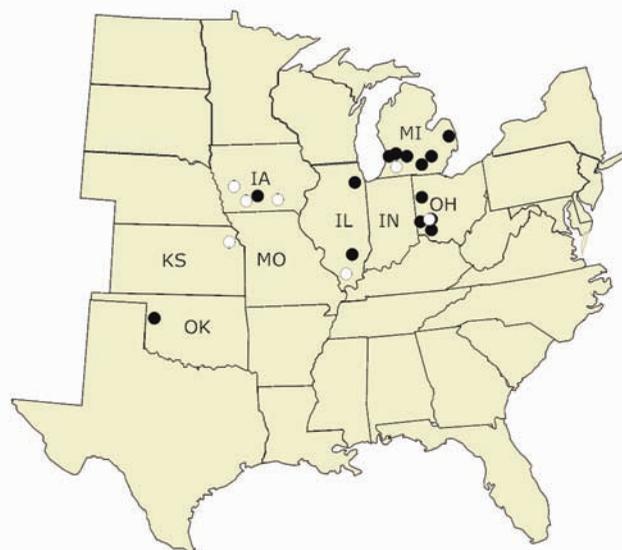

Fig. 1. Geographic distribution of sites where Blanchard's Cricket Frogs were sampled in the U.S. Midwest. Filled dots indicate sites where *B. dendrobatidis* was detected with the PCR assay. U.S. States: IL = Illiniois; IN = Indiana; IA = Iowa; KS = Kansas; MI = Michigan; MO = Missouri; OH = Ohio; OK = Oklahoma.

TABLE 1. Prevalence of *B. dendrobatidis* infection of Blanchard's Cricket Frog (*Acris crepitans blanchardi*) samples from the midwestern U.S., as determined by standard PCR assay.

State	County	Locality	Latitude	Longitude	No. infected / total sampled	Prevalence of infection
Ohio	Auglaize	St. Marys Fish Hatchery	40.526°N	84.418°W	6 / 42	0.14
Ohio	Preble	Woodland Trails W.A.	39.750°N	84.633°W	3 / 19	0.16
Ohio	Greene	Caesar Creek St. Park	39.748°N	83.816°W	0 / 1	0.00
Ohio	Greene	Fish & Game Club	39.856°N	83.943°W	2 / 9	0.11
Ohio	Clinton	Unspecified pond	39.667°N	83.964°W	3 / 10	0.30
Michigan	Kalamazoo	Harrison Lake	42.149°N	85.680°W	0 / 1	0.00
Michigan	Barry	Lux Arbor Reserve	42.613°N	85.228°W	2 / 8	0.25
Michigan	Lenawee	Ives Road gravel pit	42.180°N	84.156°W	2 / 10	0.20
Michigan	Washtenaw	Ypsilanti	42.207°N	83.578°W	1 / 10	0.10
Michigan	St. Clair	Port Huron	42.970°N	82.425°W	1 / 10	0.10
Michigan	Ottawa	Grand Rapids gravel pit	42.941°N	85.820°W	1 / 9	0.11
Michigan	Kent	Unspecified pond	42.989°N	85.509°W	2 / 6	0.33
Illinois	Jackson	Unspecified pond	37.727°N	89.209°W	0 / 9	0.00
Illinois	Effingham	Unspecified pond	38.995°N	88.621°W	5 / 16	0.31
Illinois	Will	Unspecified pond	41.570°N	88.072°W	1 / 14	0.07
Iowa	Madison	Unspecified pond	41.300°N	93.744°W	1 / 3	0.33
Iowa	Guthrie	Unspecified pond	41.686°N	94.359°W	0 / 1	0.00
Iowa	Lucas	Unspecified pond	41.016°N	93.115°W	0 / 8	0.00
Iowa	Ringgold	Unspecified pond	40.741°N	94.241°W	0 / 5	0.00
Kansas	Jefferson	Unspecified pond	39.082°N	95.546°W	0 / 5	0.00
Oklahoma	Ellis	Packsaddle Wildlife Area	35.846°N	99.616°W	1 / 9	0.11

samples were transported to the College of Wooster (Wooster, Ohio) for processing with a PCR-based assay.

All DNA from tissue samples were extracted according to the animal tissues protocol provided by the manufacturer (Qiagen, Valencia, CA; DNeasy Blood and Tissue Handbook, 07/2006). Skin swab samples were agitated for thirty seconds in a vortex and the swab was removed and squeezed along the side of the tube to remove the maximum amount of solution. An aliquot of 300 µl was removed from the tube and centrifuged in a 2.5 ml tube for five minutes. The supernatant was subsequently removed and the remaining pellet was used for the remainder of the extraction procedure. Following the extraction procedure, all samples were concentrated to approximately 20 µl by centrifugal evaporation.

Amplification of the extracted samples was completed with standard polymerase chain reactions (PCR) using the primers reported in Annis et al. (2004). Amplification reactions consisted of 13 µl of deionized water, 5.0 µl of template (containing approximately 10–30 µg of DNA), 2.5 µl 10x PCR buffer (Qiagen, Valencia, CA), 2.5 µl dNTPs (10 uM of each), 1.0 mM $MgCl_2$, 0.5 µl of each primer at a concentration of 50 pmol/µl, and 0.25 µl *Taq* polymerase (5 units/mL) in a volume of 24 µl. The amplification of the mixture took place according to the following steps: an initial denaturation at 94°C for 10 minutes, followed by 30 cycles of 45 seconds at 93°C and 45 seconds at 60°C, and then a final extension at 72°C for 10 minutes to complete the amplification. Products were then viewed on ethidium bromide stained 1.0% agarose gel dissolved in TAE (40 mM Tris [pH 8.0], 20 mM acetic acid, 1 mM EDTA) alongside a 1 kb ladder. A band approximately 300 base-pairs in length indicated the presence of *B. dendrobatidis* infection.

A positive control of *B. dendrobatidis* broth culture and zoospores was used to optimize and determine the sensitivity of the PCR assay. A dilution series of the positive control was run and successful amplification took place in 1/5, 1/10, 1/50, 1/100, and 1/500 dilutions. All PCRs were run twice for each sample. Amplification in both replicates was considered a true positive signal of infection, while no amplification in both replicates was considered a true negative signal. Templates that amplified once were subject to a third replicate, in which a successful amplification was taken as indicating infection. To avoid false-positive and false-negative results, negative and positive controls were used with all samples analyzed.

Available information suggests that declines in Blanchard's cricket frogs may be moving from north to south, and inward from both the western and eastern range boundaries (Lannoo and Grundel 2004; Lehtinen and Skinner 2006). Based on where declines have been reported, we used chi-squared analyses to test for differences in infection prevalence north and south of three latitudes (38°N, 40°N, and 42°N) and east and west of two longitudes (88°W and 90°W). Also, the difference in prevalence of infection between skin swab samples and tissue samples was tested using a chi-square test. All statistical analyses were performed using SPSS (version 13.0, SPSS Inc., Chicago).

Results.—*Batrachochytrium dendrobatidis* was detected in 15.1% (31 of 205) of samples from Blanchard's Cricket Frogs (Table 1). Within infected sites, prevalence of infection was generally low (18.8 ± 9.8%; Table 1). We did not detect *B. dendrobatidis* at seven sites but all of these localities had relatively small sample sizes. In all sites where more than ten frogs were sampled, *B. dendrobatidis* was detected (Table 1). No dead, dying or obviously diseased frogs were found at any of the investigated sites.

Infected frogs were found in Ohio, Michigan, Iowa, Illinois, and Oklahoma (but not in any of the five samples from Kansas; Table 1). There was no obvious geographic pattern in infection. Infection rates did not differ significantly at longitudes greater and less than 90°W or 88°W ($\chi^2 = 1.281$, df = 1, P = 0.258; $\chi^2 = 1.130$, df = 1, P = 0.288, respectively). Prevalence of infection also did not differ significantly at latitudes greater and less than 38° N ($\chi^2 = 1.407$, df = 1, P = 0.236), 40°N ($\chi^2 = 0.784$, df = 1, P = 0.376), or 42°N ($\chi^2 = 0.136$, df = 1, P = 0.712). The prevalence of infection did not differ significantly between samples obtained by skin swabbing and those from tissue samples ($\chi^2 = .273$, df = 1, P = .0602).

Discussion.—We document the widespread presence of *B. dendrobatidis* in populations of Blanchard's Cricket Frogs in the midwestern United States. Although *B. dendrobatidis* is now known from captive situations (Zippel and Tabaka 2008), to our knowledge, this is the first documented case of *B. dendrobatidis* infection in cricket frogs from wild populations. However, no mortality was found or reported in these infected, yet seemingly healthy cricket frogs. Additionally, we have mark-recapture data from one of these populations since 2004 (St. Marys Fish Hatchery, Ohio; R. Lehtinen, unpubl. data). This population has maintained a large and relatively stable population size over the last four years (2004–2007), despite *B. dendrobatidis* infection. In this respect, our results parallel Ouellet et al. (2005) who found *B. dendrobatidis* to be enzootic in Quebec with no symptoms associated with infection. It is possible that Blanchard's Cricket Frogs utilize antimicrobial skin peptides (Woodhams et al. 2006) or behavioral thermoregulation (Woodhams et al. 2003) as defenses against *B. dendrobatidis*, but these possibilities have yet to be investigated. While preliminary, our data suggest that Blanchard's Cricket Frog populations are able to persist in the face of ongoing *B. dendrobatidis* infection (e.g., Daszak et al. 2005; Retallick et al. 2004).

We found *B. dendrobatidis* to have no obvious geographic pattern of occurrence. In fact, *B. dendrobatidis* was present at every site where ten or more samples were available. These data reinforce the observations of others that *B. dendrobatidis* appears to be widespread in North America (Longcore et al. 2007; Ouellet et al. 2005; Pearl et al. 2007). Importantly, we detected *B. dendrobatidis* both in areas where Blanchard's Cricket Frog declines have occurred (Ohio, Michigan, northern Illinois) as well as where declines have not been reported (Oklahoma, southern Illinois). The apparent absence of declines in more southerly parts of the range suggests that *B. dendrobatidis* may not be solely responsible for recent population declines in Blanchard's Cricket Frogs further north. However, more northerly populations could be more vulnerable to infection since *B. dendrobatidis* grows best in cooler temperatures (Longcore et al. 1999) and the amphibian immune system functions most effectively at higher temperatures (Maniero and Carey 1997). The declines in the northern portions of the range could also have resulted from earlier declines caused by *B. dendrobatidis* that have now stabilized. Similar patterns of persistence with *B. dendrobatidis* after initial declines are known (Retallick et al. 2004; Woodhams and Alford 2005). More work is clearly needed to assess what threat (if any) *B. dendrobatidis* infection poses to Blanchard's Cricket Frogs.

Many records of *B. dendrobatidis* infection in North American anurans are from ranid and bufonid frogs (e.g., Ouellet et al. 2005; Pearl et al. 2007). Fewer hylid species have been reported to be infected. Using histological techniques, Ouellet et al. (2005) reported *B. dendrobatidis* infection in *Pseudacris triseriata* (54 out of 143 individuals) and *Hyla versicolor* (1 out of 16). However, Longcore et al. (2007) found no infection in *Hyla versicolor* (0 out of 50), or *Pseudacris crucifer* (0 out of 21). Pearl et al. (2007) also found no infections in *Pseudacris regilla* (0 out of 28) in the Pacific Northwest. Our results with *Acris crepitans* (31 out of 205) suggest that *B. dendrobatidis* may be more widely distributed in North American hylids than previously suspected.

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Low Prevalence of *Batrachochytrium dendrobatidis* Across *Rana sylvatica* Populations in Southeastern Michigan, USA

AMANDA J. ZELLMER[*]
CORINNE L. RICHARDS
and
LISA M. MARTENS
University of Michigan, Department of Ecology and Evolutionary Biology and Museum of Zoology, 1109 Geddes Avenue Ann Arbor, Michigan 48109-1079, USA

[*]*Corresponding author; e-mail: azellmer@umich.edu*

The emerging infectious disease chytridiomycosis has been implicated in the decline and extinction of numerous amphibian species worldwide (Berger et al. 1998; Lips et al. 2006; Skerratt et al. 2007). The fungus causing this disease, *Batrachochytrium dendrobatidis* (*Bd*), has been present in North American amphibian populations since at least the 1960s (Ouellet et al. 2005); however, in many areas of North America, there is little evidence of negative effects of the disease on amphibian population persistence. Understanding how environmental factors affect infection prevalence is thus important for determining under what conditions chytridiomycosis is likely to have a devastating impact on populations.

We conducted a preliminary assessment of the role of season and habitat quality on chytridiomycosis infection prevalence in populations of the Wood Frog, *Rana sylvatica*, in southeastern Michigan, USA. In laboratory studies, *Bd* appears to be limited by temperatures outside the range of 4–25°C (Piotrowski et al. 2004). Several studies also have noted that the prevalence and severity of infections in wild populations tend to vary seasonally (Berger et al. 2004; Kriger and Hero 2006, 2007; Retallick et al. 2004; Woodhams and Alford 2005). Given this, we predicted that levels of infection would be higher in the spring as opposed to the summer because the warmer temperatures experienced during the summer months in southeastern Michigan should limit *Bd* infection rates (Berger et al. 2004; Kriger and Hero 2006, 2007; Ouellet et al. 2005; Retallick et al. 2004; Woodhams and Alford 2005; Woodhams et al. 2003). Additionally, habitat quality may affect

infection rates because the higher stress levels associated with low quality habitats may make individuals more susceptible to infection (Carey and Bryant 1995). Ponds that are exposed to high levels of agricultural and urban runoff may be particularly stressful for amphibians. For example, both pesticides (Relyea 2005) and road de-icing salt (Sanzo and Hecnar 2006) affect larval Wood Frog survivorship. Thus, we predicted that Wood Frog (*Rana sylvatica*) populations in ponds surrounded by agricultural or urban areas would show higher levels of infection than populations surrounded by intact, forested habitat.

Methods.—To assess whether season affects infection prevalence, breeding adults and metamorphs were tested for the presence of *Bd* DNA, since breeding adults often experience colder temperatures than metamorphs. Adults were sampled from eight populations in March 2007 and metamorphs were sampled from five populations in June 2007. All adults and metamorphs were sampled from populations on the University of Michigan's Edwin S. George Reserve (Fig. 1). Temperatures during the 30 days prior to sampling ranged from -16–23°C (mean temperature = 2°C) for the adults and 5–33°C (mean temperature = 20°C) for the metamorphs. The dorsum, venter, and feet of adults and metamorphs were swabbed with a sterile cotton swab. Swabs were stored in 95% ethanol until extraction.

In addition, to assess the relationship between habitat quality and *Bd* distribution, we collected larvae of *R. sylvatica* from 16 populations across southeastern Michigan (Fig. 1) during June 2005 and 2006. Aerial images (Michigan Department of Natural Resources 1998) were used to select ponds with varying degrees of surrounding forest and wetland fragmentation. Larvae were stored in 95% ethanol until extraction. The oral discs of six individuals from each population were excised in the lab using sterilized razor blades and forceps.

Extraction of *Bd* DNA was completed following the methodology of Hyatt et al. (2007). DNA from larval samples was extracted from the oral discs, whereas DNA from the metamorphs and adults was extracted from the swabs. DNA extracted from larvae was pooled in groups of three for each population. The pooled-larval samples and both the adult and metamorph samples were then diluted 1:10 with double deionized water. Taqman diagnostic quantitative PCR (Boyle et al. 2004) was used to detect the presence of *Bd* DNA. Quantitative Taqman PCR assays were performed in triplicate using an Applied Biosystems Prism 7700 Sequence Detection System following the protocol of Boyle et al. (2004). VIC$_{TM}$ Exogenous Internal Positive Control reagents were used for the detection of PCR inhibitors (Applied Biosystems following Hyatt et al. 2007). Inhibitors did not appear to be present in any of the samples. A sample was only considered positive for *Bd* if all three replicates indicated the presence of the fungus. Samples testing positive in one or two replicates were re-assayed once. If the second assay produced a consistent negative or positive result for all three replicates the sample was considered negative or positive, respectively. Samples testing positive in one or two replicates of the second assay were considered "suspicious." Prevalence rates were calculated by dividing the number of infected individuals by the total number of sampled individuals, and 95% confidence intervals were calculated based on a binomial distribution (Stata Intercooled v. 10.0).

The percentage of combined agricultural and urban land cover
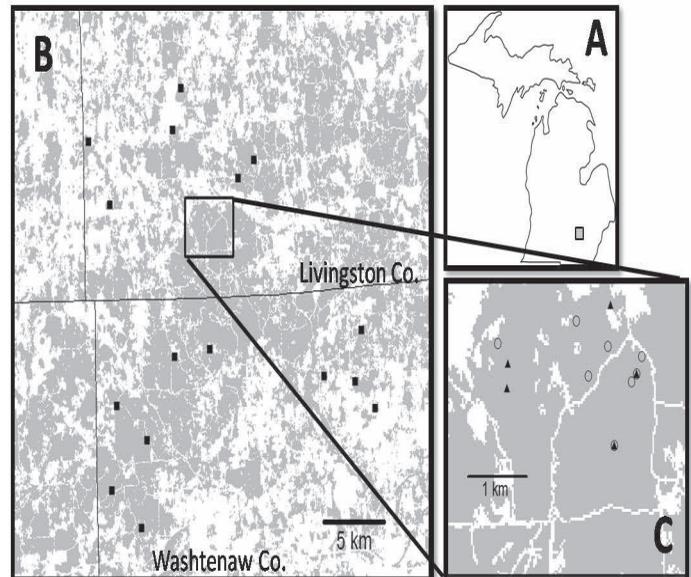
Fig. 1. Wood Frog (*Rana sylvatica*) sampling locations in southeastern Michigan, USA, showing areas sampled for *Batrachochytrium dendrobatidis* in adults (open circles), metamorphs (triangles), and larvae (squares). Agricultural and urban areas are white. Forests, wetlands, rivers, and lakes are gray.

within 1 km (estimated genetic neighborhood size of *R. sylvatica*: Berven and Grudzien 1990) of each of the 16 ponds sampled for larvae was calculated in ArcGIS v. 9.2 using the 2001 National Land-Cover Database (Homer et al. 2004). This percentage ranged from 6.18 to 78.55 (Table 1).

Results.—Two of 239 (prevalence = 0.83%; 95% confidence interval = 0.1–3.0%) samples tested positive for the presence of *Bd*. One of 70 (1.4%) adults, zero of 73 metamorphs, and 1–3 of 96 (1.0–3.1%) larvae tested positive in each of three replicates. The range surrounding the number of infected larvae arises from pooling the larvae into groups of three for the analyses. As a result, a positive sample indicates that at least one of the three individuals was positive for *Bd*. In addition, one of 70 (1.4%) adults tested positive in two out of three replicates and thus was classified as suspicious.

Discussion.—We found a very low level of *Bd* infection in populations of *R. sylvatica* in southeastern Michigan (0.83%). Other studies of North American *R. sylvatica* populations have found much higher rates of infection (15.5%, Longcore et al. 2007; 6.6%, Ouellet et al. 2005). We calculated 95% confidence intervals for each of these studies to assess the extent to which our results differed from these previous studies and found that our confidence intervals did not overlap (Longcore et al. 2007: 6.4–29.4%; Ouellet et al. 2005: 3.4–11.1%). Our results are consistent with the idea that the quality of the habitat and the season may be important predictors of infection rates. For the effects of season, we found one adult that tested positive for *Bd*, while no metamorphs tested positive. Temperatures during the adult breeding period remained at or below the optimal temperature range for *Bd*, whereas during the metamorph sampling period, temperatures exceeded the maximum temperature at which *Bd* can survive in the laboratory (Piotrowski et al. 2004). Similarly, we detected *Bd* in larvae in a pond exposed to one of the largest areas of anthropogenic distur-

TABLE 1. Wood Frog (*Rana sylvatica*) larval infection rates in relation to amount of agricultural and urban habitat surrounding ponds in southeastern Michigan, USA.

Percent Agricultural/ Urban Land Cover	Number Infected/ Sample Size
6.18	0/6
8.73	0/6
14.61	0/6
15.35	0/6
17.06	0/6
17.09	0/6
18.09	0/6
25.42	0/6
35.28	0/6
54.07	0/6
55.49	0/6
57.57	0/6
59.24	0/6
62.82	0/6
65.39	(1–3)/6
78.55	0/6

bance in this study (Table 1). However, the low level of infection we found prevents us from testing our hypotheses statistically. Future research on the effects of habitat quality and seasonality on *Bd* infection prevalence remains a priority.

Two hypotheses may explain the low infection levels detected in this study, given the high prevalence of *Bd* both worldwide and in other areas of the Wood Frog's range. First, the more terrestrial life-history of *R. sylvatica* may help prevent infection in this species (Longcore et al. 2007). *Rana sylvatica* is an explosive breeder that breeds in early spring. Larvae develop and metamorphose in approximately 6 weeks, and juveniles then move into the terrestrial habitat for foraging (Regosin et al. 2003). In comparison to other co-occurring species, wood frogs are in the ponds for a shorter amount of time. These results are consistent with Lips et al. (2003) hypothesis that the probability of decline as a result of *Bd* infection is positively related to the amount of time the species spends in aquatic habitats. However, while rates of infection in *R. sylvatica* are typically lower than in other co-occurring species (Longcore et al. 2007; Ouellet et al. 2005), the levels of infection in *R. sylvatica* seen in this study are much lower than in other studies, suggesting that other factors may have contributed to the low prevalence of *Bd* across southeastern Michigan.

Second, it is possible that habitat differences between southeastern Michigan and other parts of *R. sylvatica*'s range could account for the low infection prevalence seen in our study, as compared with other studies. Differences in climate, for instance, in temperature or the amount of rainfall, are associated with differences in infection rates (Kriger and Hero 2007), and thus may dictate the range over which *Bd* is viable. However, this seems unlikely, because projections from an ecological niche model (Ron 2005) suggest that the habitat of southeastern Michigan is more climatically suitable for *Bd* than other areas where *Bd* prevalence

in wood frogs has been found to be higher (Longcore et al. 2007). Similarly, differences in the structure of the landscape separating populations may contribute to the variation in infection prevalence across *R. sylvatica*'s range. A fragmented landscape, resulting in reduced connectivity among amphibian populations, may hinder the spread of *Bd* and thus keep regional infection rates low. Further research at a broader geographic scale will be necessary for evaluating whether such habitat differences contribute to the observed patterns of infection in *R. sylvatica*.

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Occurrence of *Batrachochytrium dendrobatidis* in Amphibian Populations in Denmark

RICCARDO SCALERA*
Via Torcegno 49 V1 A2, Rome 00124, Italy

MICHAEL J. ADAMS
and
STEPHANIE K. GALVAN
U. S. Geological Survey, Forest and Rangeland Ecosystem Science Center
3200 SW Jefferson Way, Corvallis, Oregon 97331, USA

*Corresponding author: Riccardo.Scalera@alice.it

Amphibian decline is a global phenomenon with multiple causes (Stuart et al. 2004). Some declines have been attributed to the disease chytridiomycosis that affects the skin of amphibians (Skerratt et al. 2007). The agent responsible for chytridiomycosis is the fungus *Batrachochytrium dendrobatidis* (Berger et al. 1998). There is evidence that the spread of *B. dendrobatidis* around the world occurred in the last half century (Ouellet et al. 2005), and there is a need for detailed information on its current spatial extent. In Europe, *B. dendrobatidis* has been reported in several amphibian species in multiple countries, such as Spain, Portugal, Italy, Switzerland, France, Germany and the UK (Cunningham et al. 2005; Garner et al. 2005, 2006; Mutschmann et al. 2000; Simoncelli et al. 2005; Stagni et al. 2004). No comprehensive surveys have occurred in Denmark but a single record of *B. dendrobatidis* for *Rana* kl. *esculenta* on the island of Bornholm is reported (www.spatialepidemiology.net) and confirmed by Trent Garner

(pers. comm. to R. Scalera, 2007). Here, we report the results of surveys carried out at four sites in Denmark (Fig. 1) on two native amphibians: *Rana temporaria* and *Rana* kl. *esculenta*.

In summer 2007, we hand captured individual amphibians and sampled them for *B. dendrobatidis* by rubbing a cotton-tipped swab over the body of each individual. Frogs were held separately prior to swabbing and technicians wore a new pair of gloves for each individual handled. The sampling is harmless and was carried out *in-situ* so as to release the sampled animals within just a few minutes at the location where they were captured. As the frog was restrained, the swab was firmly rubbed back and forth 25–30 times, targeting the drink patch, the mouth, and the webbing between each toe. The swab was immediately inserted, cotton side down, into a 2 ml screw-cap tube containing 1 ml of 70% ethanol and stored upright. Vials were shipped to the laboratory for analysis, and each swab was analyzed individually for the presence of *B. dendrobatidis*. Swabs were qualitatively analyzed using a PCR assay (45 amplification cycles). Presence of *B. dendrobatidis* was determined by presence of PCR product visualized on agarose gels (30–90 minute electrophoresis) containing positive controls. Fragments were sized using a molecular weight marker (Pisces Molecular LLC, Boulder, Colorado, USA (Annis et al. 2004; J. Wood, pers. comm.). All field gear was cleaned with a brush and water and then sterilized using a dilute bleach solution between each sampling location.

Two of the 13 amphibians we swabbed were positive for *B. dendrobatidis* (Table 1). We found *B. dendrobatidis* on individuals from both species and at 2 of the 4 study areas we examined. One of the positive results was for an adult of *Rana* kl. *esculenta* captured in Vestamager. The other positive result was for a juvenile of *Rana temporaria* captured in Egense. We did not find any frogs that were dead or that appeared to be sick.

Fig. 1. Locations of study areas in Denmark where amphibians were sampled for the presence of *Batrachochytrium dendrobatidis* in 2007. Circles are filled at locations where we found *B. dendrobatidis*. The square symbol indicates the location of the positive record reported by Trent Garner (see text). Vestamager is located on the island of Zealand, close to Copenhagen, Egense is on Fyn Island, and both Amtoft and Klosterheden are on the Jutland Peninsula.

TABLE 1. Anurans that tested positive or negative for the presence of *Batrachochytrium dendrobatidis* in Denmark in 2007. See Fig. 1 for the locations of the study areas referenced in the table. The species examined were *Rana* kl. *esculenta* (RANESC), and *Rana temporaria* (RANTEM).

Study Area	Latitude	Longitude	Species	Stage	Sex	No. Positive	No. Negative
Egense	55.044167	10.519444	RANTEM	adult	unknown	1	3
Amtoft	57.007500	8.939722	RANTEM	adult	male	0	1
Klosterheden	56.485278	8.362500	RANTEM	juvenile	unknown	0	1
Vestamager	55.614722	12.577222	RANESC	adult	male	0	3
Vestamager	55.614722	12.577222	RANESC	adult	female	0	1
Vestamager	55.614722	12.577222	RANESC	juvenile	unknown	1	2

Further surveys should be undertaken to determine the extent of the pathogen in Denmark. In the meantime, proper sanitizing of equipment would be prudent for anyone entering amphibian habitats. Particular care should be used around sensitive species such as *Bombina bombina*, which is actively managed in Denmark (Pihl et al. 2001), however the threat posed by *B. dendrobatidis* to this and other Danish species is currently unknown.

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Batrachochytrium dendrobatidis Not Detected in *Oophaga pumilio* on Bastimentos Island, Panama

CORINNE L. RICHARDS*
AMANDA J. ZELLMER
and
LISA M. MARTENS
Department of Ecology and Evolutionary Biology
and
Museum of Zoology, University of Michigan, 1109 Geddes Avenue
Ann Arbor, Michigan 48109-1079, USA

Corresponding author; e-mail: clrichar@umich.edu

Amphibian chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*), has been implicated in the decline and extinction of many populations worldwide (Berger et al. 1998; Lips et al. 2006; Skerratt et al. 2007), and has led to massive die-offs in Latin America over the past few decades (Lips et al. 2006). However, not all populations that carry *Bd* have experienced such declines (e.g., American Bullfrog: Garner et al. 2006; African Clawed Frog: Weldon et al. 2004). Some species have been shown to have physiological (Woodhams et al. 2007a), behavioral (C.L. Richards, pers. comm.), or bacterial (Woodhams et al. 2007b) defenses that may allow them to cope with *Bd*. For many species that have not experienced declines, it is unknown

whether they have lower susceptibility, due to such defenses, or if they have not been exposed to the disease. Evaluation of these alternatives is necessary for distinguishing between species that may be at risk of population declines and those that may be *Bd* carriers.

Despite the fact that an epidemic wave of *Bd* has apparently swept through Costa Rica and western Panama since the late 1980s (Lips et al. 2006), populations of the Strawberry Dart Frog, *Oophaga pumilio*, remain relatively stable. *Oophaga pumilio* is a dendrobatid frog found in rainforests of the Caribbean coast from Nicaragua to Panama. They are found across a range of elevations, from sea level to about 1000 m (Walls 1994). Populations of *O. pumilio* in the Bocas del Toro archipelago in Panama remain abundant and apparently healthy, and we are unaware of any chytrid-related die-offs in other areas of their range or any studies that have assessed *Bd* prevalence in this species. The stability of the Bocas del Toro populations suggests that either *O. pumilio* is able to physiologically or behaviorally cope with the disease or else *Bd* is not present in this region. To distinguish between these alternative hypotheses, we tested for the presence of *Bd* in *O. pumilio* across Bastimentos Island in the Bocas del Toro archipelago, Panama.

Methods.—We captured adults from the leaf-litter at 17 transect points across Bastimentos Island (Fig. 1) during July 2007. Sampling locations were chosen to ensure all areas of the island (approximately every 2 km) were assessed for the presence of *Bd*. The dorsum, venter, and feet of five adults from each location were swabbed with a sterile cotton swab for a total of 85 individuals. Swabs were stored in dry microcentrifuge tubes and upon returning to the lab were refrigerated at 4°C until extraction. Individuals were released at the site of capture.

Extraction of *Bd* DNA was accomplished using the methodology of Hyatt et al. (2007). Taqman diagnostic quantitative PCR (Boyle et al. 2004) was used to detect presence of *Bd* DNA. Quantitative Taqman PCR assays were performed in triplicate using an Applied Biosystems Prism 7700 Sequence Detection System following the protocol of Boyle et al. (2004). VIC$_{TM}$ Exogenous Internal Positive Control reagents were used for the detection of PCR inhibitors (Applied Biosystems following Hyatt et al. 2007). A sample was only considered positive for *Bd* if all three replicates indicated a presence of the fungus. Prevalence rates were calculated by dividing the number of infected individuals by the total number of sampled individuals, and 95% confidence intervals were calculated based on a binomial distribution (Stata Intercooled v. 10.0).

Results and Discussion.—None of the 85 individuals sampled tested positive for the presence of *Bd* in any of the three replicates (95% confidence interval = 0–4.2%). Inhibitors did not appear to be present in any of the samples. Our results suggest that there is
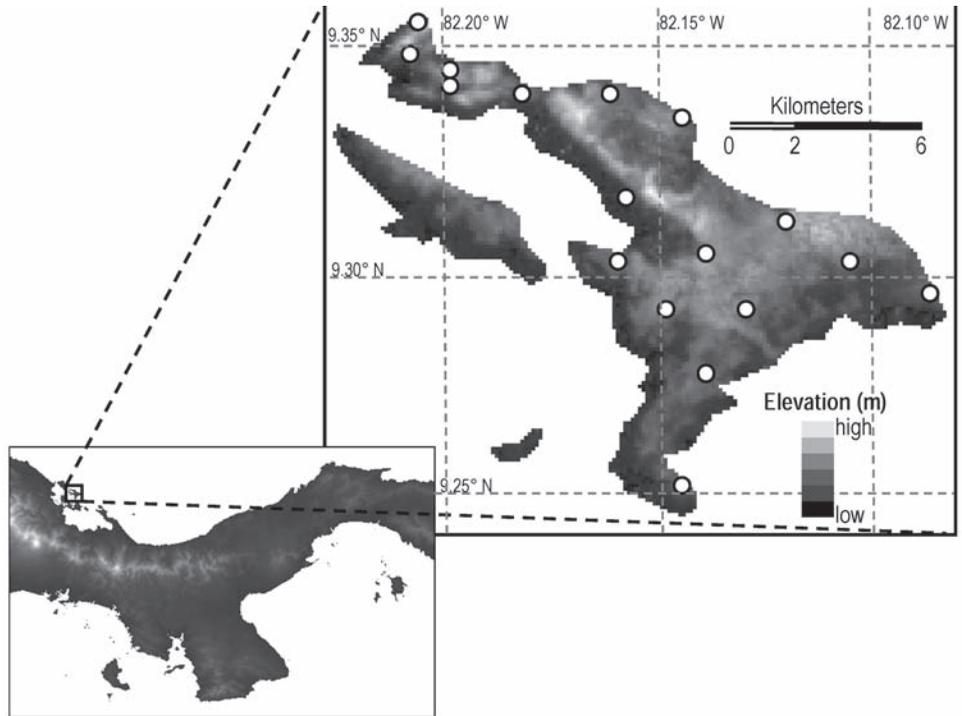

Fig. 1. Sampling locations for *Batrochochytrium dendrobatidis* in *Oophaga pumilio* frogs across Bastimentos Island, Panama.

either a very low level of *Bd* prevalence or that *Bd* is absent from the Island of Bastimentos. We have two hypotheses as to why *Bd* was not detected in our study. First, *Bd* may not yet have reached Bastimentos Island. The geographic isolation of Bastimentos *O. pumilio* populations from mainland populations may have impeded the spread of the disease. The island is, however, heavily traveled by tourists, implying that populations on these islands may be more connected to mainland populations than expected by geography alone.

Alternatively, the apparent absence of *Bd* on Bastimentos could be due to unsuitable environmental conditions. *Bd* is limited by temperatures outside the range of 4–25°C under laboratory conditions (Piotrowski et al. 2004), and the distribution and severity of infections appear to be correlated with rainfall and temperature patterns in wild populations (Kriger et al. 2007). However, *Bd* has been detected in at least one population of Panamanian frogs that

TABLE 1. Climate data for Bastimentos Island, Panama (Hijmans et al. 2005).

Climate Variable	Value
Annual Mean Temperature	25.8°C
Maximum Temperature of the Warmest Month (April)	30.0°C
Minimum Temperature of the Coldest Month (February)	21.0°C
Annual Temperature Range	9.0°C
Annual Precipitation	3109 mm
Precipitation of the Wettest Month (July)	398 mm
Precipitation of the Driest Month (March)	146 mm

is, on average, exposed to slightly hotter conditions than are *O. pumilio* populations on Bastimentos Island (C. L. Richards, pers. comm.). In addition, the average temperature and precipitation on Bastimentos Island (Hijmans et al. 2005; Table 1) is within the range of values for a number of infected sites in Central America (Ron 2005). It is therefore predicted that if *Bd* was introduced to these populations that it would be able to survive.

Identification of areas where *Bd* is absent is crucial for determining the physiological limits of the pathogen and for establishing areas of priority for conservation. Further research on the distribution of *Bd* will provide necessary information for predicting the patterns of spread, potentially assisting managers in preventing outbreaks of the disease.

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Results of Amphibian Chytrid (*Batrachochytrium dendrobatidis*) Sampling in Denali National Park, Alaska, USA

TARA CHESTNUT*
Washington State Department of Transportation, Olympic Region Environmental and Hydraulic Services, Tumwater, Washington 98504, USA

JAMES E. JOHNSON
and
R. STEVEN WAGNER
Department of Biological Sciences, Central Washington University Ellensburg, Washington 98925 USA

*Corresponding author: tarachestnut@gmail.com

The amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) has been detected in amphibian populations along the northwest coast of North America from Vancouver Island, British Columbia (Adams et al. 2008) north to the Kenai Peninsula (Reeves and Green 2006). However, *Bd* has not been detected in interior Alaska in the Innoko or Tetlin National Wildlife Refuges (Reeves 2008). The Wood Frog (*Rana sylvatica*) is the only amphibian species that occurs in interior Alaska (Wright and Wright 1995) and is susceptible to *Bd* infection (Reeves and Green 2006; Ouellet et al. 2005). In 2006, we sought to determine if *Bd* occurred in Wood Frogs in Denali National Park.

Methods.—Denali National Park (DNP) is located in central Alaska, approximately 183 km S of Fairbanks and 317 km N of Anchorage in Denali Borough (63.97°N, 149.13°W), and covers 2.4 million ha (Fig. 1). Three areas were surveyed for Wood Frogs within the park boundary: Wonder Lake vicinity roadside and backcountry, Teklanika River vicinity roadside, and along the roadside between the park entrance and the Savage River.

Known Wood Frog pond sites were surveyed in the Wonder Lake area (Hokit and Brown 2006), and seven additional ponds with no Wood Frog survey history were selected along the roadside in the Teklanika River vicinity and between the park entrance and the Savage River for their high traffic location. Surveys took place during a two-week period in August 2006 using standard techniques (Olson et al. 1997). Non-invasive techniques were used to

recover skin cells (Boyle et al. 2004; Retallick et al. 2006); each frog was stroked 20 to 30 times on the abdomen, pelvic patch, inner thighs and in between toes or, in the case of larvae, the oral disk was rubbed 5 times in a circular motion with a sterile cotton swab. The swab was then placed individually in a 1.5 ml microfuge tube containing a DNA extraction buffer (Zolan and Pukkila 1986) and stored at ambient temperature. All samples were processed twice by JEJ using polymerase chain reaction (PCR) assay to detect *Bd* (Boyle et al. 2004; Annis et al. 2004). Individual animals were handled with clean latex gloves or a plastic bag inverted over the observers hand. Equipment was sprayed with a concentrated sodium hypochlorite solution between each site. Malformed metamorphs were collected, preserved in a 95% ethanol solution at ambient temperature and x-rayed by a veterinarian to determine if malformations were due to injury or amputation (Summit Industries, Innovet Classic, Model LX125V).

Results.—We found Wood Frogs at 20 of 26 known sites near Wonder Lake (Fig. 1). Frogs were not found at additional sites searched between the Park entrance and the Savage River or in the Teklanika vicinity, although they were not previously known to be present and may not occur at these sites. Thirty frogs were swabbed, 12 at roadside
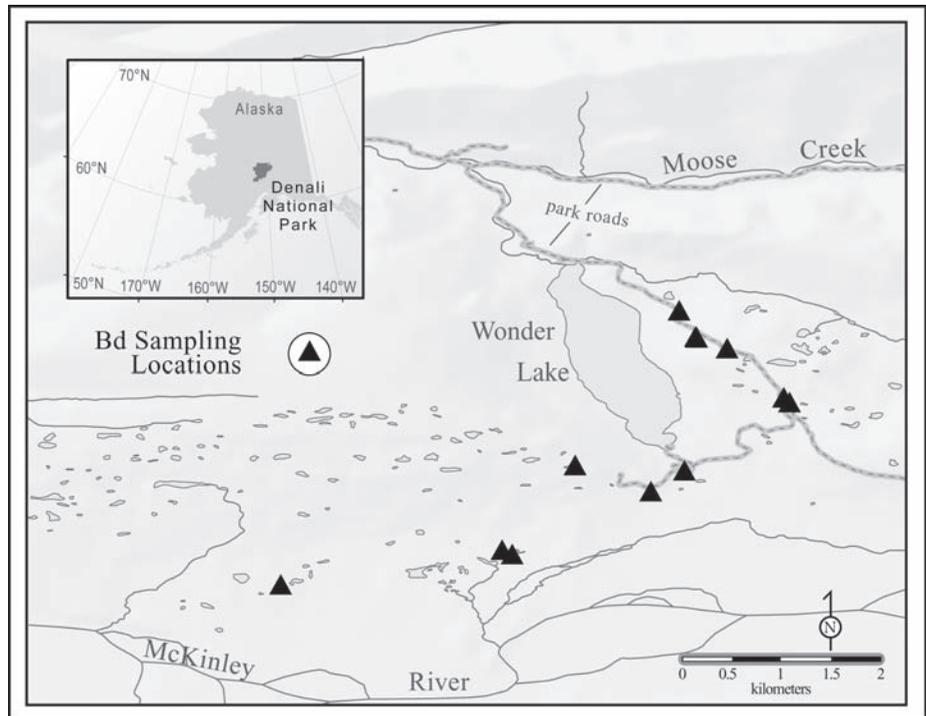

Fig. 1. Denali National Park (DNP), Alaska, USA, and Wood Frog (*Rana sylvatica*) *Bd* sampling locations in the Wonder Lake vicinity.

sites and 18 at backcountry sites up to 4.5 km from the road (Table 1). No *Bd* was detected. Nearly 87% of the animals sampled were newly metamorphosed. At one backcountry site, five (16%) metamorphs were malformed and had missing limbs, and three

Table 1. *Bd* was not detected in 30 wood frogs (*Rana sylvatica*) at Denali National Park, Alaska, USA, in 2006.

Date	Latitude	Longitude	Number Observed	Life Stage	Condition of Animal(s)	*Bd* Detected?
8 Aug 06	N63 26.960	W 150 52.169	1	Metamorph	Normal	No
8 Aug 06	N63 26.248	W 150 53.979	7	Metamorph	4 Missing Limb, 3 Dead	No
9 Aug 06	N63 25.826	W 150 56.670	1	Metamorph	Normal	No
10 Aug 06	N63 26.196	W 150 53.856	2	Adult	Normal	No
10 Aug 06	N63 26.197	W 150 53.857	1	Metamorph	Normal	No
11 Aug 06	N63 27.212	W 150 51.760	1	Metamorph	Normal	No
12 Aug 06	N63 28.041	W 150 50.481	2	Metamorph	Normal	No
14 Aug 06	N63 28.103	W 150 50.551	1	Metamorph	Normal	No
14 Aug 06	N63 28.694	W 150 51.241	3	2 Metamorph, 1 Larvae	Normal	No
14 Aug 06	N63 28.834	W 150 51.621	1	Metamorph	Normal	No
14 Aug 06	N63 28.824	W 150 51.612	2	Metamorph	Normal	No
14 Aug 06	N63 29.151	W 150 51.828	1	Metamorph	Normal	No
14 Aug 06	N63 27.280	W 150 53.086	1	Adult	Missing Limb	No
15 Aug 06	N63 27.279	W 150 51.806	1	Metamorph	Normal	No
15 Aug 06	N63 27.371	W 150 53.327	1	Metamorph	Normal	No
15 Aug 06	N63 27.485	W 150 53.706	1	Metamorph	Normal	No
15 Aug 06	N63 27.652	W 150 53.528	1	Metamorph	Normal	No
15 Aug 06	N63 27.646	W 150 53.402	2	Metamorph	Normal	No

(10%) were dead but not obviously malformed. The mechanism of malformation or death is unknown and could not be determined from the x-rays. In addition, one adult frog recovered from a site more than 4 km NNW of the metamorph malformation site was missing a hind limb.

Discussion.—The lack of *Bd* detection does not demonstrate absence from DNP. The low sample size at each site, between 1 and 7 animals, greatly reduces the probability and confidence level of *Bd* detection at each site. *Bd* prevalence varies with a number of abiotic (Berger et al. 2004; Drew et al. 2006) and biotic (Carey et al. 2003) factors. The effect of season (Berger et al. 2004), altitude (Young et al. 2001; Collins et al. 2003), rainfall (Collins et al. 2003), and temperature (Collins et al. 2003) are implicated in *Bd* outbreaks. Amphibians also exhibit differential sensitivity to *Bd* infection depending on life stage (Blaustein et al. 2005; Garcia et al. 2006). *Bd* may be less detectable in newly metamorphosed frogs (J. E. Johnson, unpublished), and may not be reliably detected in some species until two to three weeks after metamorphosis (C. Carey, pers. comm.). Pearl et al. (2007) reported a comparable sample size of juvenile frogs (N = 29) and detected *Bd* in 34.5% of their samples. However, they report fewer *Bd* detections in the summer months (6.15%) compared to the winter months (38.6%) which suggests sampling during the breeding season may improve the likelihood of *Bd* detection. An assay of a greater sample size of Wood Frogs across all life stages in DNP will better assess *Bd* prevalence.

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NATURAL HISTORY NOTES

Instructions for contributors to Natural History Notes appear in Volume 39, Number 1 (March 2008).

CAUDATA — SALAMANDERS

LISSOTRITON VULGARIS (Smooth Newt). **PREY.** *Lissotriton vulgaris* is a widespread species in Europe and western Asia. Because of their nectonic lifestyle (Dolmen 1983. J. Herpetol. 17:23–31), adult *L. vulgaris* feed primarily on planktonic Crustacea (Dolmen and Koksvik 1983. Amph.-Rept. 6:133–136). The following observations were made on 5 May 2007 between 1500 and 1545 h at an artificial pond in northern Hesse, Germany (51.2069444°N, 9.0722222°E; elev. 330 m). An adult female *L. vulgaris* (ca. 95 mm TL) was observed to capture a large dragonfly nymph (total length about 50 mm, family Aeshnidae). The nymph, which was sitting on a floating leaf, had recently moulted and the chitin armor appeared to be soft. The newt approached the leaf from beneath and captured the insect with a quick bite into its anterior portion. Another female *L. vulgaris* appeared and snapped several times at the legs of the nymph. The intruder took the prey from the other female and disappeared into deeper water, holding the nymph between its jaws. Whether the newt succeeded in swallowing its prey remains unknown. Because of their size and usually protective exoskeleton such large dragonfly nymphs may not form a regular part of the diet of *L. vulgaris* (Avery 1986. Oikos 19:408–412).

Submitted by **ANDREAS HERTZ**, Forschungsinstitut Senckenberg, Senckenberganlage 25, 60325 Frankfurt am Main, Germany; e-mail: ahertz@senckenberg.de.

NECTURUS MACULOSUS (Red River Mudpuppy). **HOST.** Several species of leeches have been known to prey upon amphibian species (Briggler et al. 2001. J. Freshwater Ecol. 16:105–111; Moser et al. 2005. J. North Carolina Acad. Sci. 121:36–40; Sawyer 1972. Illinois Biol. Monogr. 46:1–46). The leech, *Placobdella cryptobranchii* (Ozark Hellbender Leech) was described in 1977 (Johnson and Klemm 1977. Trans. Amer. Micros. Soc. 96:327–331). To date, the only known host for *P. cryptobranchii* is the Ozark Hellbender, *Cryptobranchus alleganiensis bishopi* (Moser et al. 2006. J. Arkansas Acad. Sci. 60:84–95). Herein, we provide information on the first report of *P. cryptobranchii* on *Necturus maculosus*.

On 1 Sept 2005, four juvenile *P. cryptobranchii* were found attached to a *N. maculosus* captured on the Eleven Point River, Oregon County, Missouri, USA. The *N. maculosus* appeared healthy (mass 105 g; SVL 16.5 cm; TL 25.5 cm). While attached to the *N. maculosus*, all four leeches exhibited a reddish colored crop area that indicated blood feeding upon the host. Two leeches were collected and deposited at the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM 1100749) where blood-feeding was further confirmed by full crops in each leech (WEM, pers. obs.). This account is the first report of *P. cryptobranchii* feeding on *N. maculosus*, and the second known host for *P. cryptobranchii*. More information should be collected on *P. cryptobranchii* to determine if its presence on *N. maculosus* is a common occurrence or an isolated event. Since 2005, surveyors have captured 6 *N. maculosus* from the Eleven Point River in Missouri and this is the only instance when *P. cryptobranchii* was observed. With the continued decline of the main host, *C. a. bishopi*, this leech may need to rely increasingly upon *N. maculosus*.

Submitted by **JEFFREY T. BRIGGLER**, Missouri Department of Conservation, 2901 W. Truman Blvd, Jefferson City, Missouri 65109, USA (e-mail: jeff.briggler@mdc.mo.gov); and **WILLIAM E. MOSER**, Department Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20013-7012, USA (e-mail: moserw@si.edu).

NOTOPHTHALMUS VIRIDESCENS LOUISIANENSIS (Central Newt). **LEECH INFESTATION**. Glossiphoniid leeches (*Placobdella picta*) have previously been reported to infest Redspotted Newts, *Notophthalmus v. viridescens* in Maryland (Mock 1987. J. Parasitol. 73:730–737), New York (Barrow 1953. Trans. Amer. Microsc. Soc. 72:197–216; Pough 1971. Science 174:1144–1146), Pennsylvania (Raffel et al. 2006. J. Parasitol. 92:1256–1264), and Virginia (Gill 1978. Ecol. Monogr. 48:145–166). To our knowledge, *P. picta* has not been reported from *N. v. louisianensis*.

On 22 March 2007, D.J. visited a fishless pond with rooted aquatic vegetation situated in an oak-hickory forest of mountainous terrain, 1 km W St. Hwy. 23, Carroll County, Arkansas. Sixtythree *N. v. louisianensis* were collected and examined for leeches; 18 (29%) had *P. picta* firmly attached to their integument, the majority under their lip, while others had leeches attached to the tail and lower abdomen. On several occasions, newts were observed trying to physically remove leeches by biting at their tails and shaking their heads vigorously, unusual behavior previously reported in *N. v. viridescens* by Gill (*op. cit.*). The same site was revisited about 2 months later on 19 May 2007 and 49 *N. v. louisianensis* were examined; only three (6%) possessed leeches. This observation further supports the understanding that *P. picta* is a temporary ectoparasite on amphibians and may be an important regulator of certain populations (Brockleman 1969. Ecology 50:632–644; Berven and Boltz 2001. Copeia 2001:907–915).

We document herein the first report of *P. picta* infesting *N. v. louisianensis*. Interestingly, this leech has previously been reported on other amphibians in northern Arkansas (McAllister et al. 1995. J. Helminthol. Soc. Washington 62:143–149; Briggler et al. 2001. J. Freshwater Ecol. 16:105–111; Turbeville and Briggler. 2003. J. Freshwater Ecol. 18:155–159; Moser et al. 2006. J. Arkansas Acad. Sci. 60:84–95).

Voucher specimens of *P. picta* are deposited in the American Museum of Natural History (AMNH 5427); a voucher of *N. v. louisianensis* is deposited in the Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 30705).

Submitted by **CHRIS T. McALLISTER**, Dept. Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: cmcallister@csc.edu); **DAVID JAMIESON**, Biological Sciences, Northwest Arkansas Community College, One College Drive, Bentonville, Arkansas 72712, USA (e-mail: djamieson@nwacc.edu); and **MARK E. SIDDALL**, Division of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024, USA (e-mail: siddall@amnh.org).

PSEUDOEURYCEA LEPROSA (Leprous False Brook Salamander). **REPRODUCTION**. There are ca. 26 species in the genus *Pseudoeurycea* that occur in Mexico, but data on reproduction exist only for eight of those species. *Pseudoeurycea leprosa* is one of the most abundant and broadly distributed species in Mexico, inhabiting the mountains of the central part and east of Eje Neovolcánico, from Pico de Orizaba to Serranía del Ajusco (Vega and Alvarez 1992. Act. Zool. Mex. 15:1–25). The habitat of *P. leprosa* is mainly pine forest, under decomposing logs, piles of dead vegetation, or under rocks. Reproduction in this species is mostly unknown. On 14 March 2005, at Parque Nacional Zoquiapan y Anexas, where the vegetation is dominated *Pinus hartwegii*, ALV observed a mature female *P. leprosa*, (19°27'4"N, 98°41'5"W; 3433 m elev.) under a log. The female (78 mm TL) was wrapped around a ball-shaped clutch of 10 eggs. The eggs were slightly oval, with a maximum diameter of 5 mm and the minimum of 4.9 mm. Nine eggs were attacked by fungus and only one egg hatched a month later (15 April), the hatchling measured 25 mm TL.

We thank the authorities of the Parque Nacional Zoquiapan who allowed us access to their facilities. Xóchitl Aguilar-Miguel verified identification of the salamander.

Submitted by **ANGELICA LIZARRAGA-VALENCIA,** Laboratorio de Herpetología, Instituto de Biología, Universidad Nacional Autónoma de México, A.P. 70-153, México D.F. 04510 (e-mail: alizarraga@ibiologia.unam.mx); **GUSTAVO CASAS-ANDREU**, Laboratorio de Herpetología, Instituto de Biología, Universidad Nacional Autónoma de México, A.P. 70-153, México D. F. 04510; and **XOCHITL AGUILAR-MIGUEL**, Centro de Investigación en Recursos Bióticos, Facultad de Ciencias, Universidad Autónoma del Estado de México, Instituto Literario #100, 50000, Toluca, Estado de México, México.

ANURA — FROGS

CRAUGASTOR BERKENBUSCHII (Berkenbusch's Robber Frog). **MICROHABITAT USE**. *Craugastor berkenbuschii* has been reported as a common nocturnal species in the Los Tuxtlas rainforest (Vogt et al. 1997. *In* Gonzáles-Soriano et al. [eds.], Historia Natural de Los Tuxtlas*,* pp. 507–522. UNAM México). Some changes have recently been reported in Los Tuxtlas' concerning the herpetofaunal species abundance (Urbina-Cardona et al. 2005. *In* Halffter et al. [eds.], Sobre Diversidad Biológica: El significado de las Diversidades Alfa, Beta y Gamma, pp. 191–207. Vol. 4. Editorial Monografías Tercer Milenio, Zaragoza, España). To date there is little natural history information for *C. berkenbuschii*.

During six sampling seasons, between June 2003 and April 2005, I surveyed 108, 50 m permanent transects across the tropical rainforest at Los Tuxtlas, Veracruz, Mexico (18°32'N, 95°6'W). During 1007 person-hours of effort I recorded only a single adult *C. berkenbuschii* (80 mm SLV) in the tropical rainforest interior (100 m from the forest edge) on 31 July 2003 at 2350 h. This individual was located in the biggest forest fragment (472 ha), at 200 m elevation. Microhabitat characteristics were: in a hole in the soil 38 cm deep, 25°C soil temperature, 88% relative humidity, 62% leaf litter cover, 7 cm leaf litter depth, 40% herbaceous cover, 6.2% understory density, and 44.7% canopy cover. On 23 April 2005 at 2030 h in the second biggest forest fragment in the region (177 ha), and during the last survey night of the last field season I found a small congregation of *C. berkenbuschii* with 3 adults (72 mm average SVL) and 10 juveniles (22 mm average SVL). These individuals were in a 2 m² area surrounding an almost dried stream in the forest interior (200 m from the forest edge). Microhabitat characteristics at this site were: 25°C air temperature, 83% relative humidity, 90.5% leaf litter cover, 8.25 cm leaf litter depth, 30% herbaceous cover, 4.4% understory density, and 46.9% canopy cover.

This is the first report on habitat use by this species, which has been listed as Near Threatened (Santos-Barrera and Flores-Villela 2004. *In* 2006 IUCN Red List of Threatened Species. <www.iucnredlist.org>. 10 August 2007). *Craugastor berkenbuschii* should be placed on the "Los Tuxtlas forest interior species list" reported by Urbina-Cardona et al. (2006. Biol. Cons. 132:61–75). This population has been identified as fragile and may experience regional extinction. Thus, the extinction risk ranking of this species should be reconsidered because of its endemism, small range, and natural rarity. It is of special concern in the Los Tuxtlas region because of the increase in anthropogenic activities and habitat loss that continuously threaten the persistence of amphibians in the forest.

I thank Adriana González-Hernández for the species identification and help with my dissertation fieldwork. I thank Victor Hugo Reynoso for advice and support during the project, and Georgina Santos-Barrera for review of this note.

Submitted by **J. NICOLÁS URBINA-CARDONA,** Departamento de Biología Evolutiva, Facultad de Ciencias – Universidad Nacional Autónoma de México, A.P. 70-399, C.P. 04510, México, D.F.; e-mail*:* nurbina@yahoo.com.

HYPSIBOAS FABER (Smith Frog). **DIET.** *Hypsiboas faber* is a large hylid frog allocated to the *H. faber* group (Faivovich et al. 2005. Bull. Amer. Mus. Nat. Hist. 294:1–240) that occurs from northern Argentina to eastern Brazil, in permanent ponds in the Atlantic Forest Domain (Ab'Saber 1977. Geomorfologica 52:1–21; Martins 1993. Herpetol. J. 3:31–34). Published studies regarding the diet of *H. faber* are restricted to two papers that reported the major prey items are opilionids and arboreal hylid frogs (*Scinax granulatus* in Solé et al. 2005. Stud. Neotrop. Fauna Environ. 40[1]:23–28 and *S. granulatus* and *Aplastodiscus perviridis* in Solé et al. 2004. Herpetol. Rev. 35:159).

On 24 Jan 2007 at ca. 2100 h a gravid female *H. faber* (SVL 85 mm) was found preying on a juvenile *Eleutherodactylus binotatus* (SVL 29 mm) in a forest fragment at the municipality of Mariana,

state of Minas Gerais, Brazil (UTM:23K 0656671/7760247; ca. 1190 m elev.). The individual was encountered 2 m above ground and away from any pond or stream with the *E. binotatus* in its mouth. Both specimens were collected and the stomach contents of the female *H. faber* were examined and contained only plant material, likely ingested incidentally. Voucher specimens of the *H. faber* (LZV 855) and *E. binotatus* (LZV 856) were deposited in Laboratório de Zoologia dos Vertebrados of Universidade Federal de Ouro Preto (LZV/UFOP).

Eleutherodactylus binotatus is a medium-sized frog of the family Brachycephalidae occurring in Atlantic forests from Bahia to southeastern Brazil (Ribeiro et al. 2005. Biota Neotrop. 5[2]:1–15) and is found usually on the leaf litter and in low vegetation (Heyer 1990. Arq. Zool. 31[4]:237–410). This is the first record of a brachycephalid and of a terrestrial anuran being predated by *H. faber*.

Submitted by **FELIPE SÁ FORTES LEITE,** Classe Construções e Meio Ambiente, Rua Almirante Tamandaré, 438, CEP 30430-120, Belo Horizonte, MG, Brazil; **TIAGO LEITE PEZZUTI** and **LEANDRO DE OLIVEIRA DRUMMOND**, Laboratório de Zoologia dos Vertebrados, Universidade Federal de Ouro Preto, CEP 35400-000, Ouro Preto, MG, Brazil (e-mail: pjandaia@yahoo.com.br).

HYPSIBOAS FABER (Smith Frog). **PREDATION**. Predation is a major cause of mortality among tadpoles (Calef 1973. Ecology 54:741–758), and aquatic invertebrates often are cited as tadpole predators (Eterovick and Sazima 2000. Amphibia-Reptilia 21:439–461). Herein, we report predation by the belostomatid *Lethocerus melloleitaoi* on a *Hypsiboas faber* tadpole.

On 18 April 2006 at 2100 h (air temp. 12° C, water temp. 20°C) we found a *H. faber* tadpole (Gosner Stage 25; 34 mm TL) (Gosner 1960. Herpetologica 16:183–190) on the edge of permanent pond in Botucatu, State of São Paulo, Brazil (22°50'S, 48°25'W), being preyed upon by the water bug, *L. melloleitaoi* (68.1 mm body length; 25 mm width). The water bug was holding the tadpole on the anterodorsal region of the body (Fig. 1). The animals were

FIG. 1. *Hypsiboas faber* tadpole predated by *Lethocerus melloleitaoi*.

captured and preserved. The tadpole had a cut on the side of its spiracle, caused by the belostomatid proboscis. The water bug is deposited in the entomological collection of the Museu de Zoologia of the Universidade de São Paulo, Brazil, and the tadpole is deposited at the Jorge Jim Collection, Departamento de Zoologia, Universidade Estadual Paulista, Botucatu, São Paulo State, Brazil (without numbers).

Submitted by **SILVIO CÉSAR DE ALMEIDA** (e-mail: scesar@ibb.unesp.br), **DANIEL CONTIERI ROLIM**, **DOMINGOS GERALDO SCARPELLINI JÚNIOR**, and **JORGE JIM**, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, 18618-000, Botucatu, SP, Brazil.

ISCHNOCNEMA HOEHNEI (Hoehnei's Robber Frog). **ADVERTISEMENT CALL**. *Ischnocnema hoehnei* was described from Paranapiacaba, in the coastal Atlantic Forest of the state of São Paulo, southeastern Brazil (Lutz 1958. Mem. Oswaldo Cruz, Rio de Janeiro, 56:378). It has also been observed at Boracéia, (Heyer et al. 1990. Arq. Zool., São Paulo, 31:231–410) and Teresópolis, ca. 400 km NE of the type locality in the state of Rio de Janeiro (http://www.globalamphibians.org/servlet/GAA).

On 29 Nov 1997 AAG observed the species at its type locality. Two males were heard calling, although only the call of a single individual was recorded. This call was recorded with a UHER 4200 (19 cm/s) tape recorder and a UHER M518A Microphone. The call was digitized and audio spectrogram prepared with the Spectrogram software (Horne 1994. Spectrogram. www.visualizationsoftware.com/gram.html). Sample rate was set at 22050 Hz, with 16-bit resolution. The call was analyzed and oscillogram and spectrogram derived with the SoundRuler software (Griddi-Papp 2007. Sound Ruler. V0.9.6.0. http://soundruler.sourceforge.net), using a Fast Fourier Transformation at 1024 data points, frequency resolution at 21.5 Hz, and low and high band limit at 50 and 7500 Hz. The individual recorded was calling on the ground in an open area, among tuffs of grass-like plants (40 cm tall) about 8 m from the forest border. The other calling individual was about 10 m away in similar habitat. Calls were released sporadically. The recorded call (Fig. 1) presented 50 pulses and lasted 1.3 s; pulses lasted 0.025–0.035 s; pulse rate was 2123/s. Call frequency and intensity modulated, beginning low and quiet, rising in frequency and intensity to about mid-call, then maintaining relatively constant frequency and intensity to the end; 4th to 13th note frequency ranging from 1591 to 1980 Hz; second half of call with frequencies between 720 to 2900 Hz; side bands evident. *Ischnocnema hoehnei* has traditionally been allocated to the *E. binotatus* species group (Lynch and Duellman 1997. Nat. Hist. Mus., Univ. Kansas Spec. Publ. 23:1–236), although Heinicke et al. (2007. PNAS. 104[24]:10092–10097) reported *E. binotatus* only distantly related to the other eleutherodactylines of southeastern Brazil. Acoustic data, such as presented here, might help resolve the species group relationships among the eleutherodactyline frogs of southeastern Brazil.
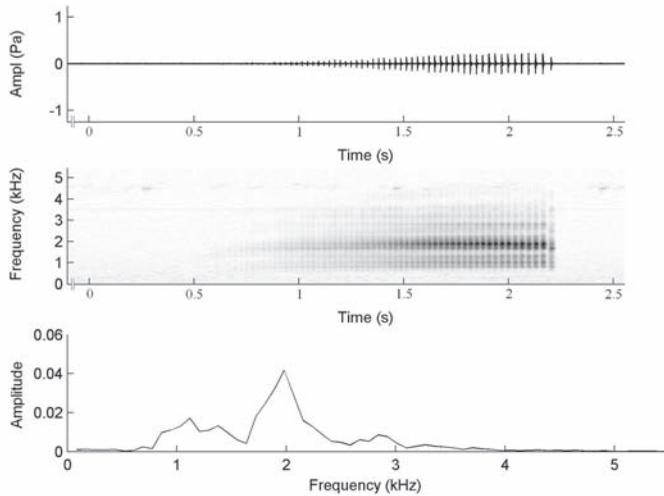
FIG. 1. Oscillogram, spectrogram, and power spectrum of the call of *Ischnocnema hoehnei*, Paranapiacaba, São Paulo, Brazil, air 16.5°C. Voucher: AmphibiaWeb photo (CalPhotos ID: 0000 0000 0504 0973); call also available in the AmphibiaWeb (unnumbered MP3 sound file).

Submitted by **LUCIANO ELIAS OLIVEIRA** (e-mail: luc.deoliveira@gmail.com), **RENATA MIGLIORINI CARDOSO OLIVEIRA** (e-mail: remigliorini@hotmail.com), and **ARIOVALDO ANTONIO GIARETTA** (e-mail: thoropa@inbio.ufu.br), Laboratório de Taxonomia, Comportamento e Sistemática de Anuros Neotropicais, Universidade Federal de Uberlândia, Uberlândia, Minas Gerais, Brasil.

KALOULA PULCHRA (Painted Burrowing Frog). **ANTIPREDATOR BEHAVIOR**. *Kaloula pulchra* is known from northern India (Meghalaya) east into Vietnam (IUCN, Conservation International, and NatureServe 2006. Global Amphibian Assessment. <www.globalamphibians.org>. Accessed 15 June 2006). *Kaloula pulchra* occurs throughout Thailand (Nabhitabhata et al. "2000" 2004. Checklist of Amphibians and Reptiles in Thailand. Office of Environmental Policy and Planning. 152 pp.) and is often used for human consumption. To our knowledge, antipredator behavior in *K. pulchra* is poorly known and no antipredator behavior has been described from Thailand. On 29 March 2003 during our visit to Sam Pran Protected Unit, Khao Ang Rui Ni Wildlife Sanctuary, Tha Takhieb District, Chachoengsao Province (southeastern Thailand), we had an opportunity to photograph frogs that had been collected for food. While being handled during the daytime, an individual frog displayed an antipredator behavior when touched. The frog inflated its lungs and outstretched the limbs. It presented a large color pattern image on its dorsum. The inflation of the lungs did not lift the body. When we overturned the frog the lungs remained inflated and the individual remained rigid and immobile for several seconds (Fig. 1). Anurans frequently employ posture as a defensive mechanism, and in species of *Scaphiopus*, *Limnodynastes*, *Leptodactylus*, and *Bufo*, inflation of the lungs is usually accompanied by elevation of the body from the substrate (Duellman and Trueb 1986. Biology of Amphibians. McGraw-Hill Book Company, New York. 670 pp.).
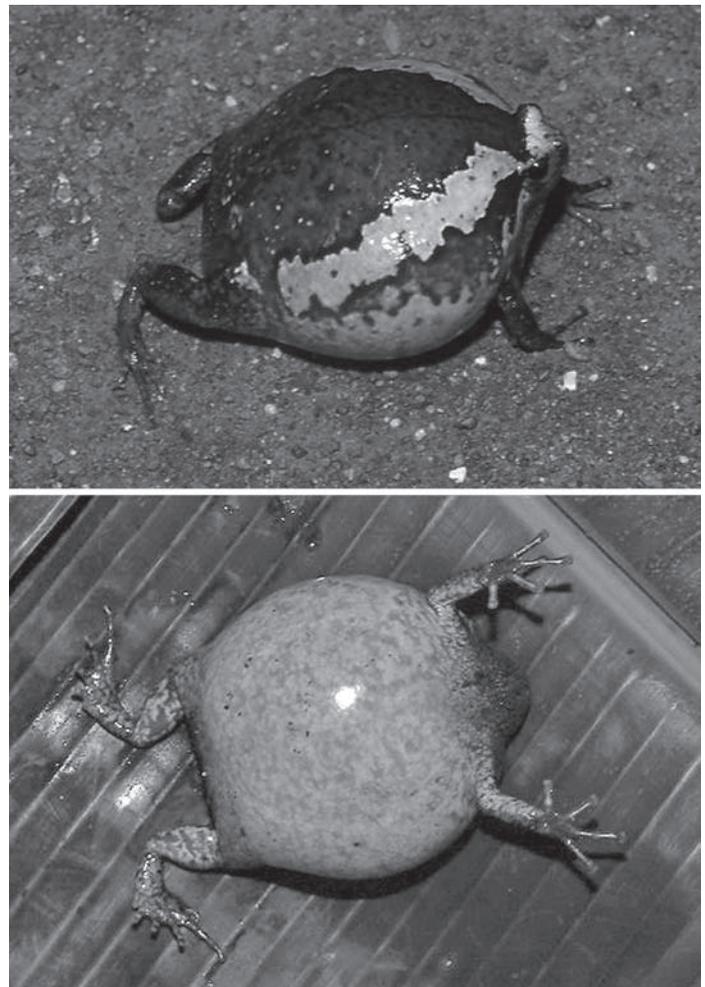
FIG. 1. Top: Dorsolateral view of *Kaloula pulchra*, showing antipredator behavior. Lower: Ventral view.

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Submitted by **YODCHAIY CHUAYNKERN**, Muséum national d'histoire naturelle, Laboratoire des reptiles et amphibiens, 25 rue Cuvier, F-75005 Paris, France; Thailand Natural History Museum, Technopolis, Khlong 5, Khlong Luang, Pathum Thani, 12120 Thailand (e-mail: ychuaynkern@yahoo.com); **CHANTIP INTHARA**, Muséum national d'Histoire naturelle, Laboratoire des reptiles et amphibiens, 25 rue Cuvier, F-75005 Paris, France; Khon Kaen University, Department of Biology, Faculty of Science, Muang, Khon Kaen, 40002 Thailand (e-mail: ichant@kku.ac.th); and **PONNARIN KUMTONG**, Phu Si Than Wildlife Sanctuary, P.O. Box 2, Huay Mueng, Kuchinarai, Kalasin, Thailand.

NECTOPHRYNE BATESII (Bates' Tree Toad). **JUVENILE COLORATION.** Marked differences in the coloration and pattern between juvenile (i.e., recently metamorphosed) and adult anurans are seldom noted in the literature. In most cases, this is because there are few remarkable differences between different age classes. *Nectophryne* comprises two species found in Central African forests extending from the coast of Cameroon, Equatorial

Guinea, and Gabon across to northeastern Democratic Republic of Congo (IUCN et al. 2006. <www.globalamphibians.org>). Recently metamorphosed juveniles of *N. afra* are velvet black with thin bluish white lines that cover much of the dorsal surface and form loops or even rings (Scheel 1970. Rev. Zool. Bot. Afr. 81:225–236). In contrast, adult *N. afra* are black or brown with dorsolateral bands that extend posteriorly from the eyes to the inguinal region and are lighter shades of brown or yellow. There are no reports of similar ontogenetic changes in color or pattern in *N. batesii* or the closely related Cameroonian toad genus *Wolterstorffina*.

In June 2006, juvenile *Nectophryne* specimens, MCZ A-138204 (SUL 5.6 mm) and 138144 (SUL 6.9 mm), were collected by VD from leaves and branches surrounding orchids in moist, tropical, submontane forest near Bidjouka (3.1430556°N, 10.4775°E) and Akom 2 (2.7444444°N, 10.5305556°E), in Sud Province, Republic of Cameroon. These specimens exhibit a color pattern similar to each other but different from *N. afra* juveniles. The specimens are identifiable as *Nectophryne* because both exhibit lamellae on the hands and feet, which are a unique, derived characteristic of this genus. To determine the species identity of these specimens, a genomic region consisting of 2365 base pairs of the mitochondrial 12S and 16S ribosomal RNA, and intervening Valine tRNA, was amplified from MCZ A-138144 (Genbank [GB] No. EU394537) and compared to sequence data from the same genomic region of adults of both *N. afra* (MVZ 234685, GB EU394535; MVZ 234686, GB EU394533; CAS 207832, GB EU394534; GB DQ283360) and *N. batesii* (MVZ 234687, GB EU394536; GB DQ283169). Sequences were aligned in Clustal X v.1.83.1 using default parameters and uncorrected pairwise sequence divergences calculated using PAUP v.4.0b10. The mean pairwise divergence found within *N. afra* is 0.83% (range: 0.17–1.59%; N = 6 pairwise comparisons) and the pairwise divergence between the two *N. batesii* specimens is 6.67%. The mean divergence between *N. afra* and *N. batesii* is 10.80% (range: 10.08–11.23%; N = 8 pairwise comparisons). The mean pairwise divergence between the juvenile specimen (MCZ A-138144) and *N. afra* is 10.25% (range: 10.05–10.81%), whereas it is only 4.32% and 4.67% from the two *N. batesii* specimens. Because the latter are less than the divergence between the two *N. batesii* adults and fall within the range of intraspecific divergence in 16S rRNA documented in other anurans (i.e., Vences et al. 2005. Front. Zool. 2:1–12), it is reasonable to assign these juvenile specimens to *N. batesii*. Similar results were obtained by local BLAST searches in BioEdit v.7.0.5.

The juvenile specimens were compared to adults of both *N. afra* (MCZ A-2607, A-101156–59; MVZ 234685–86) and *N. batesii* (MCZ A-46621, A-101155; MVZ 234687). In dorsal view, juvenile *N. batesii* are black with four prominent and solid transverse stripes that are distributed at roughly equal intervals across the rostrocaudal axis. In life, these stripes are pale light green and change to either gray or white in preservative. In addition to the dorsal stripes, there is a white stripe extending proximodistally on the posterodorsal surface of the femur, a small transverse stripe at both the proximal and distal ends of the tibiofibula, and a spot at the most proximal part of the tarsus. The throat is somewhat darkened but the belly exhibits little, if any, pigmentation. Only one of the adult *N. batesii* examined (MCZ A-101155) exhibits any mark-
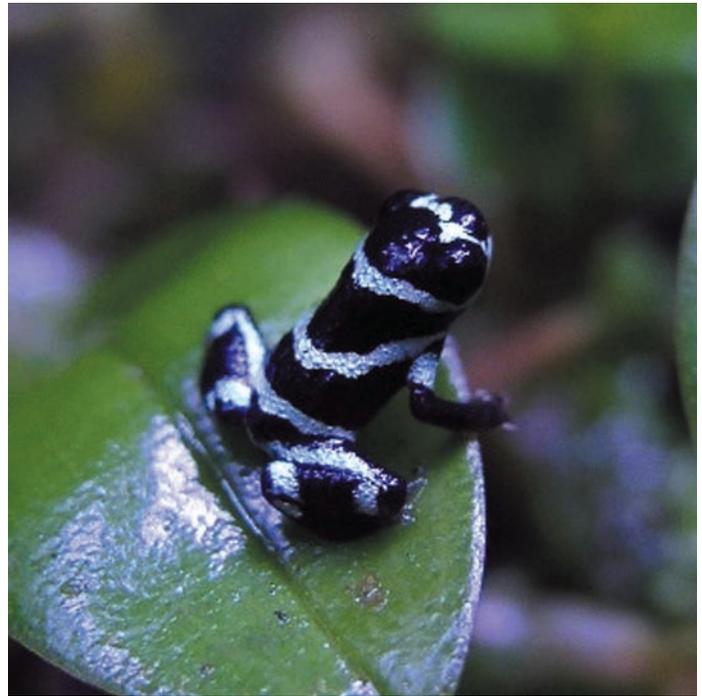
Fig. 1. Juvenile *Nectophryne batesii* (MCZ A-138144), photographed in life, exhibit coloration and pattern that differ remarkably from adults.

ings that can be interpreted as similar to the juveniles. However, these are only apparent as very poorly defined lighter regions on the dorsal surface in the approximate position of the four transverse stripes. Relatively little is known of the natural history of *Nectophryne* (Scheel 1970, *op. cit.*). The function, if any, of the strikingly different coloration and pattern of juveniles and adults remains enigmatic. Future study should focus on whether this distinctive juvenile coloration plays a role in crypsis, mimicry, or possibly aposematism.

Submitted by **DAVID C. BLACKBURN**, Department of Organismic and Evolutionary Biology, Harvard University, 26 Oxford Street, Museum of Comparative Zoology, Cambridge, Massachusetts 02138, USA (e-mail: dblackb@fas.harvard.edu); and **VINCENT DROISSART**, Laboratoire de Botanique systématique et de Phytosociologie, Université Libre de Bruxelles, CP 169 Av F. Roosevelt 50 B – 1050, Brussels, Belgium (e-mail: vincent.droissart@ulb.ac.be).

PHYSALAEMUS CUVIERI (Barker Frog). **PREDATION.** Although anuran amphibians are often preyed upon by invertebrates, including spiders of the family Ctenidae (Toledo 2005. Herpetol. Rev. 36:395–400; Menin et al. 2005. Phyllomedusa 4:39–47), the taxonomic extent and size aspects of that relationship remain poorly documented. We observed a relatively small ctenid spider preying on a *Physalaemus cuvieri* at 2152 h, 1 Jan 2007, on the property of Escola Evangelica Buriti (5.4066667°S; 55.8030556°W), ca. 7 km W of Chapada dos Guimarães on Hwy MT251, Mato Grosso State, Brazil. The female spider (0.8 g) was obliquely head-up on a lichen- and moss-covered sapling (dbh 3 cm), ca. 1.2 m above the ground near a small stream, with the male *P. cuvieri* (SVL 29 mm; mass 1.8 g; CFBH 14277, Coleção de Anuros, UNESP Rio

Fig. 1. Adult *Physalaemus cuvieri* restrained in the chelicerae of an unknown species of ctenid spider. The *P. cuvieri* was more than two times the weight of the spider.

Claro, São Paulo, Brazil) restrained in its chelicerae. The frog was immobile but not limp, bleeding slightly from its wounds, and responded to human handling with faint leg movements. The impressively high prey/predator mass ratio (2.25) was likely facilitated by venom injection, a specialized predation tactic (Toledo et al. 2007. J. Zool. 271:170–177). *Physalaemus cuvieri* is typically terrestrial so perhaps the spider captured the frog on the ground and then carried it up the tree, after immobilizing it with venom. The ctenid is likely an undescribed species in an as yet undetermined genus of Cteninae (Daniele Polotow, pers comm.), and is deposited in the arachnology collection of Insituto Butantan, São Paulo, Brazil (IBSP 85314).

Submitted by **MARY C. DURYEA** (e-mail: mcd33@cornell.edu), **KELLY R. ZAMUDIO, HARRY W. GREENE,** Department of Ecology and Evolutionary Biology, Cornell University, Corson Hall, Ithaca, New York 14853-2701, USA ; and **FERNANDO J. ZARA**, UNESP - Campus do Litoral Paulista, Unidade de São Vicente, Praça Infante Don Henrique, s/n, CEP 11330-205, Parque Bitaru, São Vicente, São Paulo, Brazil.

PHYSALAEMUS CUVIERI (NCN). **PREDATION**. On 26 Dec 2006 at 2145 h in Eldorado City (26°24'32"S, 54°34'56"W), Misiones Province, Argentina, we found a dead adult male *Physalaemus cuvieri* (26.7 mm TL) caught by a giant water bug *Lethocerus annulipes* (Belostomatidae: Lethocerinae) (67.0 mm TL) (Fig. 1) in a shallow temporary pond surrounded by tall grasses. There were several calling males on the edge of the pond, and a foam nest was observed, indicating reproductive activity of *P. cuvieri*. Predation of adult anurans by Belostomatinae giant water bugs was previously reported by Oda (2006. Herpetol. Rev. 37:4) and Toledo (Phyllomedusa 2:105–108). To our knowledge, this is the first report of a Lethocerinae giant water bug predating an adult *P. cuvieri*.

Fig. 1. *Physalaemus cuvieri* predated by *Lethocerus annulipes* in Eldorado city, Misiones, Argentina.

We thank G. C. Küppers for her comments on the manuscript and for assistance in the field, and to J. Muzón for help identifying the giant water bug.

Submitted by **SANTIAGO J. NENDA,** División Herpetología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia," Ángel Gallardo 470, (CP 1405) Ciudad Autónoma de Buenos Aires, Argentin (e-mail: santiagojnenda@yahoo.com.ar); **DIEGO A. BARRASSO,** Centro de Investigaciones del Medio Ambiente, Departamento de Química, Facultad de Ciencias Exactas, UNLP, 47 y 115 (CP 1900), La Plata, Bs. As., Argentina; and **RODRIGO CAJADE,** Centro de Ecología Aplicada del Litoral (CECOAL-CONICET), Ruta 5 Km 2,5 (CP 3400), Corrientes, Argentina.

***PROCERATOPHRYS* SP.** (NCN). **PREDATION.** An undescribed Cerrado species of the genus *Proceratophrys* belongs to the *cristiceps* group, and is found in open grasslands and in gallery forests (R. Brandão, pers. comm.). On 12 March 2002, at Fazenda Água Limpa, Distrito Federal, Brazil four adult White-eared Puffbirds (*Nystalus chacuru*) were captured on mist nets in a "campo cerrado" area. One of them was holding a *Proceratophrys* sp. in its beak (Fig. 1). This puffbird is known to dig in ground or banks to construct a gallery as an entrance for the nest chamber, and could have captured the frog in its diurnal retreat. The White-eared Puffbird is a common Cerrado species that is considered mostly insectivorous, although other food items, including lizards and vegetable matter, have been reported (Del Hoyo et al. 2002. Handbook of the Birds of the World. Cotingas to Pipits and Wagtails. Lynx Edicions, Barcelona). This is the first record of *Proceratophrys* being preyed upon by a White-eared Puffbird.

Submitted by **MIEKO F. KANEGAE,** Laboratory of Ornithology, Department of Ecology, São Paulo University, São Paulo, Brazil (e-mail: miekok@terra.com.br); and **THAÍS M. AGUILAR**, Biology Course, Instituto de Educação Superior de

Fig. 1. White-eared Puffbird captured in a mist net while carrying an individual *Proceratophrys* sp.

Manhuaçu, Minas Gerais, Brazil (e-mail: thais_maya@yahoo.com.br.

SCINAX RUBER (Red-Snouted Treefrog). **PREDATION.** It has long been known that invertebrates are predators of adult frogs (Duellman and Trueb 1986. Biology of Amphibians. McGraw-Hill, New York. 670 pp.; Hayes 1983. Biotropica 15:74–76). Recently, Brasileiro and Oyamaguchi (2006. Herpetol. Rev. 37:451) reported a male *Scinax alcatraz* being preyed upon by an immature Wandering Spider, *Oligoctenus medius*. Here, we report the predation of adult *Scinax ruber* by a water bug, *Belostoma* sp. (Hemiptera: Belostomidae).

On 30 March 2007, between 1900 and 2200 h, in a small temporal pond close to the Coello River in Tolima, Colombia (4.25°N, 75.32°W), we observed three *Belostoma* sp. grasping frogs in the inguinal region to kill them (Fig. 1). This observation of high predation in a short time coincides with the beginning of the rainy season and the explosive reproductive behavior of *S. ruber*.

Submitted by **EVER EDREY HERNÁNDEZ-CUADRADO** (e-mail: ecuadra@ut.edu.co), Laboratorio de Herpetología and Eco-Fisiología, Universidad del Tolima; and **MANUEL HERNANDO BERNAL** (e-mail: mhbernal@ut.edu.co), Grupo de Investigación en Zoología, Laboratorio de Herpetología and Eco-Fisiología, Universidad del Tolima, Ibagué, Colombia, and Universidad Nacional de Colombia, Bogotá, Colombia.

SPHAENORHYNCHUS DORISAE (Spotted Hatchet-faced Treefrog). **OCULAR ANOMALY**. There are no reports in the literature regarding ocular anomaly in *Sphaenorhynchus dorisae*. On 18 May 2006 at 1050 h we observed an adult female *S. dorisae* (INPA-H 17704; SVL 28.3 mm, mass 2.8 g), without the visual organs, in the Reserva Extrativista do Baixo Juruá (03.60194°S, 066.06711°W), Amazonas, Brazil. We found the specimen in the margin of flooded forest near a branch 1.5 m above ground, at Igarapé Central. The ocular cavities were covered only with a fine membrane (Fig. 1).

Submitted by **VINICIUS T. CARVALHO** (e-mail: viniciustc@ig.com.br)**, SOLEDAD M. H. NOVELLE, LUIZA P. C. LOPES, RICHARD C. VOGT,** Coleção de Anfíbios e

Fig. 1. Predation of *Scinax ruber* by *Belostoma* sp.

Fig. 1. Adult female *Sphaenorhynchus dorisae* with ocular anomaly found at Reserva Extrativista do Baixo Jurua, Brazil. Photograph by Vinicius T. de Carvalho.

Répteis, Instituto Nacional de Pesquisas da Amazônia - INPA, CP 428, CEP 69.083-000 Manaus, Amazonas, Brazil; **RAFAEL ARRUDA**, Coordenação de Pesquisas em Ecologia, INPA, CP 478, CEP 69.011-970, Manaus, Amazonas, Brazil; and **MARIA ERMELINDA E. S. OLIVEIRA**, Departamento de Parasitologia, Universidade Federal do Amazonas - UFAM, CEP 69.070-000, Manaus, Amazonas, Brazil.

TESTUDINES — TURTLES

APALONE SPINIFERA (Spiny Softshell Turtle). **DIET**. *Apalone spinifera* is a generalist carnivore known to consume a variety of invertebrates and vertebrates; vegetation is also occasionally eaten, but nuts (= a single seeded fruit with a woody pericarp, partially or wholly encased in a husk) have only rarely been reported in the diet (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 578 pp.). On 22 July 2007 we captured two large (carapace length = 380 and 405 mm) female *A. spinifera* in a baited (canned sardines) hoopnet set in Bayou Duplantier, ca. 1 km downstream from the Louisiana State University Campus in Baton Rouge, East Baton Rouge Parish, Louisiana, USA. Bayou Duplantier is a turbid, low gradient stream draining an extensive urban watershed. We returned these turtles to the lab and each was placed in a water-filled plastic tub (capacity ca. 75 L) for 48 h, and then permanently marked and released at the capture site. Both turtles defecated within 24 h of capture and we passed the contents of each tub over a sieve (2-mm mesh) to recover food items. Numerous acorn (*Quercus* spp.) fragments were found in the feces of both turtles, and pieces of at least one pecan (*Carya illinoensis*) were recovered from the smaller female; other food items included cicadas (Cicadidae), crawfish (*Procambarus* sp.), grasshoppers (Caelifera), and an unidentified fish. The number of acorn fragments indicated that each turtle had consumed 5–6 of these fruits. We were unable to identify the acorns to species owing to the small size of the fragments; however, Water (*Quercus nigra*) and Live (*Q. virginiana*) Oaks are common along the bayou and produce small acorns that could be readily swallowed by turtles. Viable nuts rapidly sink (Schopmeyer 1974. Seeds of Woody Plants in the United States. USDA Forest Service, Agriculture Handbook No. 450, Washington, D.C. 883 pp.) and the fragments we recovered were darkly stained suggesting the nuts had been buried in sediments since the previous autumn and probably consumed as turtles foraged among the benthos. Our observation compliments an earlier report from Iowa (Williams and Christiansen 1981. J. Herpetol. 15:303–308) where 61% of *A. spinifera* stomachs contained plant material, including "acorns, leaves, and vegetable matter" (specific breakdown not provided). To our knowledge, these are the only two reports of *A. spinifera* consuming acorns. We are unaware of any previous report documenting pecan consumption by *A. spinifera*. *Apalone spinifera* are known to forage extensively among benthic debris (*op. cit.*) and consumption of nuts is therefore not unexpected. Acorns and pecans represent a concentrated source of carbohydrates and fat and also contain relatively high levels of protein, calcium, and phosphorus (Goodrum et al. 1971. J. Wildl. Manage. 35:520–532). Sloan et al. (1996. Chelon. Conserv. Biol. 2:96–99) found intact acorns and pecans in the stomachs of *Macrochelys temminckii* and raise the possibility that these turtles function as seed dispersal agents in riparian ecosystems. However, our observations, albeit limited, indicate that *A. spinifera* are seed predators rather than seed dispersers because nuts are digested instead of being passed intact through the digestive tract.

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Submitted by **STEVEN G. PLATT**, Department of Biology, P.O. Box C-64, Sul Ross State University, Alpine, Texas, 79832, USA (e-mail: splatt@sulross.edu); **JOHN D. McVAY**, Museum of Natural Science, 119 Foster Hall, Louisiana State University, Baton Rouge, Louisiana, 70803, USA (e-mail: jmcvay@lsu.edu); and **THOMAS R. RAINWATER**, The Institute of Environmental and Human Health, Department of Environmental Toxicology, P.O. Box 764, Jefferson, Texas, 75657, USA (e-mail: trrainwater@gmail.com).

APALONE SPINIFERA ASPERA (Gulf Coast Spiny Softshell). **PREDATION.** The Flathead Catfish, *Pylodictis olivaris*, is an obligate omnivore; adults are primarily piscivorous and young consume invertebrate prey. Native to the Rio Grande, Mississippi, and Mobile River drainages, *P. olivaris* has been introduced to other drainages beyond their native ranges in North America. Where introduced, they are considered an invasive species due to their heavy predation on native fish species and associated population declines (Pine 2005. Trans. Am. Fish. Soc.134: 901–909). During the summer of 2007, *P.olivaris* were captured on Ichawaynochaway Creek at the J.W. Jones Ecological Research Center (31.367°N, 84.800°W, Newton, Georgia) for a study examining the impacts of this species on native aquatic fauna. Stomach contents were examined and in one male *P. olivaris* (1016 mm TL; 13.3 kg) a partially digested *A. spinifera* was found. Much of the turtle was intact, enabling identification and measurements (carapace length 130 mm; width 128 mm; plastron length 109 mm; width 123 mm). Flathead Catfish at this size predominately feed on live fishes such as Centrarchidae (sunfish) and Percidae (perches and darters) in addition to decapods (crayfish). Known predators of *A. spinifera* include fishes, other turtles, snakes, alligators, wading birds, and small mammals (Webb 1962. Univ. Kansas Publ. Mus. Nat. Hist. 13:429–611). To our knowledge, this is the first record of turtles in the diet of *P. olivaris* in the southeastern U.S.

Submitted by **TARA K. MUENZ** (e-mail: tmuenz@jonesctr.org), **DAVID A. STEEN, BOBBY E. BASS**, J.W.Jones Ecological Research Center, Newton, Georgia 39870, USA; and **ADAM KAESER**, Department of Natural Resources, Region 5 Fisheries Management, Albany, Georgia 31701, USA.

CHELODINA LONGICOLLIS (Eastern Long-necked Turtle). **DRINKING BEHAVIOR**. Most species of freshwater turtles use terrestrial habitats at several points in their annual and life cycles, including nesting, movements between water bodies, and, in some species, for over-wintering and aestivation. Some of these behaviors require an extended time out of water (i.e., weeks, months, or even years) and thus present a challenge for the maintenance of water balance. During a radio-telemetric study of *C. longicollis* in

Booderee National Park, Jervis Bay Territory, Australia, I observed one obvious and two apparent instances of terrestrial drinking behavior during a rainfall event (44.2 mm) on 20 February 2005 in the austral summer. All three turtles (2 male, 1 female; carapace lengths 170.0–215.5) had been inactive and completely buried under leaf litter in the forest near a wetland that had been dry for 93 days, but between 1649–1655 h during heavy rainfall at 20°C, all three were observed on the surface within one meter of their refuge sites. Two turtles were in a sprawled posture with legs and neck fully extended, while the third was actively drinking water that had pooled in a shallow natural depression in the litter. The turtles were buried in their previous refuge sites the following day. During drought, terrestrial tortoises are well known for their ability to drink pooled water during rainstorms (Medica et al. 1980. Herpetologica 36:301–304), but this is apparently the first report for drinking in a freshwater turtle while in natural terrestrial aestivation. Such behavior may in part replace respiratory and evaporative water losses incurred throughout aestivation and allow for more extended periods of survival out of water.

Submitted by **JOHN H. ROE**, Institute for Applied Ecology, University of Canberra, Bruce, Australian Capitol Territory 2601, Austrália; e-mail: roe@aerg.canberra.edu.au.

CHELONIA MYDAS (Green Sea Turtle). **HABITAT AND OCCURRENCE.** Of the seven recognized sea turtle species, five are known to visit the coastline of Brazil to feed and nest (Marcovaldi 1999. Marine Turtles of Brazil: The History and Structure of Projeto TAMAR-IBAMA. Biological Conservation. 35 pp.). The region of Cananéia, at the southernmost part of the state of São Paulo, southeastern Brazil, is a complex of conservational units visited by marine turtles year round, particularly the *Chelonia mydas*, which uses this region to feed and grow (Bondioli et al. 2005. *In* II Jornada de Conservação de Pesquisa de Tartarugas Marinhas do Atlântico Sul Ocidental, Praia do Cassino, Rio Grande do Sul. Livro de Resumos. 53 pp.). In this area, there are artisanal fishing traps called "cerco-fixo" or permanent fencing. These traps incidently capture the turtles, maintaining them alive. Since 2003, monitoring of the region's beaches, as well as the "cerco-fixo" distributed along the entire estuary, has allowed us to register the occurrence of 222 marine turtles. Of these, 216 were Green Sea Turtles (1% adults, with a curvilinear length of the top shell > 70 cm, and 99% juveniles), one subadult Leatherback Turtle (*Dermochelys coriacea*), two subadult Hawksbills (*Eretmochelys imbricata*), five Loggerhead Sea Turtles (*Caretta caretta*, two subadults and three adults), and the carcass of an adult Olive Ridley Sea Turtle (*Lepidochelys olivacea*). Of the 222 turtles, 177 (all juvenile Green Turtles) were collected in the "cerco-vivo," therefore, alive. Remaining turtles were found dead along the beaches in the region. Aside from these data, informal reports as well as shells displayed in homes, museums, and local restaurants (in approximately the same proportions registered in this study) confirm the presence of these species in this region. Based on these data, we can conclude that, besides being characterized as a feeding area for Green Sea Turtles, the Estuarine Complex Lagoon of Cananéia is visited by all the species of marine turtles which visit the Brazilian coastline. Because this region is characterized by different conservation units, its preservation also helps assure the preservation of the marine turtles that spend at least one phase of their lives in the region.

Submitted by **ANA CRISTINA VIGLIAR BONDIOLI** (e-mail: anabondioli@yahoo.com.br), **SHANY MAYUMI NAGAOKA** (e-mail: shanynagaoka@yahoo.com.br), and **EMYGDIO LEITE DE ARAÚJO MONTEIRO-FILHO** (e-mail: kamonteiro@uol.com.br), Instituto de Pesquisas Cananéia-IPeC, CEP11990-000, Cananéia, São Paulo, Brazil.

DERMOCHELYS CORIACEA (Atlantic Leatherback Sea Turtle). **REPRODUCTION**. *Dermochelys coriacea* is reported to nest along the entire eastern coast of Florida, with highest concentrations in southern Florida (Meylan et al. 1995. Sea Turtle Nesting Activity in the State of Florida. Florida Marine Research, Pub. No. 52). Herein, we provide support for these findings along with a first county record voucher. At ca. 1645 h on 26 June 2007, a female (ca. 340 kg) *D. coriacea* (UF photographic voucher 151367) came ashore on Vilano Beach ca. 4 km N of the St Augustine Inlet, St. Johns County, Florida (29.950575°N, 81.3034694°W, datum WGS84, elev. <1 m). This turtle created a disturbed area (combined nest and adjacent sand displacement) of about 4.5 × 6.1 m. The entire act was captured on film, and nesting lasted from 1645–1811 h when the turtle returned to the Atlantic Ocean. There are currently three other known nestings of *D. coriacea* in St. Johns County, all to the north of this documented nest. Only five *D. coriacea* nests have been recorded in northeastern Florida since 2004.

Submitted by **JOSEPH BURGESS** (e-mail: Joseph.Burgess@dep.state.fl.us) and **CATHERINE EASTMAN**, Florida Department of Environmental Protection, GTM NERR, Ponte Vedra, Florida 32082, USA.

ERETMOCHELYS IMBRICATA (Hawksbill Sea Turtle). **PREDATION.** Predation on hatchling sea turtles by fire ants, crabs, fish, birds, and mammals is widely acknowledged, however, there are relatively few accounts of reptiles as hatchling sea turtle predators. To our knowledge, only varanid lizards and a few snakes have been reported as reptilian predators of hatchling sea turtles (Blamires 2004. Copeia 2004:370–377; Brattstrom 1955. Am. Midl. Nat. 54:219–229; Crother 1986. Herpetol. Rev. 17:47). Here we report neonate sea turtle predation by a teiid lizard, *Ameiva fuscata*, on the island of Dominica, West Indies.

At 1200 h on 6 September 2007, while walking the boardwalk at the Soufriere Scott's Head Marine Reserve at Champagne Bay we observed an adult *A. fuscata* scrambling up the coastal slope with a hatchling *Eretmochelys imbricata* in its mouth. The lizard had the dead hatchling sea turtle grasped by the head and dropped it as we followed to investigate further. We searched beneath the 1.5 m high boardwalk that runs parallel to the ocean and the coastal slope and found an *E. imbricata* nest. The nest was in a small sandy opening (ca. 20 cm diameter) among beach stones 5– 15 cm diameter. A minimum of six other *A. fuscata* were within 1 m of the nest but fled as we approached. Five live hatchlings were exposed in the ca. 12 cm wide exit burrow and after excavation we

discovered 145 live hatchlings and 36 eggs that were undeveloped or in different stages of decay. Whether the lizards were waiting for the hatchlings to emerge or digging them from the sand is unknown.

To our knowledge, this is the first reported observation of a neotropical lizard preying on hatchling sea turtles. Species of *Ameiva* are among the largest terrestrial carnivorous lizards in the Lesser Antilles and *A. fuscata* can reach mean densities of 379 individuals/ha on Dominica (Bullock and Evans 1990. J. Zool. Lond. 222:421–443). The consequences of high population densities and active foraging behavior of *A. fuscata* may have significant effects on hatchling sea turtle survival on Dominica and warrants further study wherever coastal populations of *Ameiva* are sympatric with nesting sea turtles.

We thank Alan Bolten and Karen Bjorndal for confirming the identification of the sea turtle hatchings and for providing comments on this note. This observation was made while conducting *Iguana delicatissima* research on Dominica, funded through the center for Conservation and Research for Endangered Species (CRES) at the Zoological Society of San Diego.

Submitted by **CHARLES R. KNAPP**, Conservation and Research for Endangered Species, Zoological Society of San Diego, 15600 San Pasqual Valley Road, Escondido, California 92027, USA (e-mail: cknapp@ufl.edu); and **LYNDON PRINCE**, Salisbury Village, Commonwealth of Dominica, West Indies.

GOPHERUS AGASSIZII (Desert Tortoise). **PREDATION**. Predation events on *Gopherus agassizii* are rarely observed and documented. Thus, most predators of the Desert Tortoise have been inferred by the presence of tortoise parts in scats, pellets, and/or carcasses deposited at nests or denning sites. Boarman (2002. *In* Boarman and Beaman [eds.], The Sensitive Plant and Animal Species of the Western Mojave Desert. U.S. Geological Survey, Western Ecological Research Center, Sacramento, California) records several native predators that are known to prey on Desert Tortoise eggs, hatchlings, juveniles, and adults, including Coyotes (*Canis latrans*), Kit Foxes (*Vulpes macrotis*), Badgers (*Taxidea taxus*), Skunks (*Spilogale putorius*), Common Ravens (*Corvus corax*), Golden Eagles (*Aquila chrysaetos*), and Gila Monsters (*Heloderma suspectum*).

During a four year study (2003–2006) of Desert Tortoises at a site ca. 40 km NE of Barstow, California, in San Bernardino Co. (Walde et al. 2007. Southwest. Nat. 52:147–149; Walde et al. 2007. West. N. Am. Nat. 67:147–149), we observed many Burrowing Owls (*Athene cunicularia*). Examination of owl pellets that are ejected close to burrows and perches revealed that they often contain insect remains (Lepidoptera and Coleoptera), and less frequently remains of small rodents. On 10 May 2006, a Burrowing Owl pellet was found close to a perch that had several parts of a beetle, *Cerenopus concolor* (Coleoptera: Tenebrionidae) in it, a species which frequently comprised 100% of pellets. This particular pellet, however, also contained vertebral and marginal scute material and bones of the Desert Tortoise. One vertebral scute was entirely intact and had growth annuli suggesting that the Desert Tortoise was at least one year old. The disarticulated pellet was deposited in the Natural History Museum of Los Angeles County, Los Angeles, California (LACM 168081). To our knowledge, this is the first documentation of predation by *A. cunicularia* on the Desert Tortoise.

We thank Rolf Aalbu for identification of the Tenebrionidae in the owl pellet and Rick Feeney of the Natural History Museum of Los Angeles County for his assistance with the specimen.

Submitted by **ANDREW D. WALDE,** ITS Corporation, 7686 SVL Box, Victorville, California 92395, USA (e-mail: awalde@hotmail.com); **ANGELA M. WALDE**, Walde Research & Environmental Consulting, 12127 Mall Blvd., Suite A156, Victorville, California 92392, USA; and **DAVID K. DELANEY**, USACERL, P.O. Box 9005, Champaign, Illinois 61826, USA.

GOPHERUS POLYPHEMUS (Gopher Tortoise). **RECORD SIZE**. To our knowledge, the largest *Gopherus polyphemus* reported to date had a straight-line carapace length of 38.7 cm (Timmerman and Roberts 1994. Herpetol. Rev. 25:64). Here we report a specimen that exceeds this size. In March 2007, one of us (AE) received for rehabilitation a large, injured Gopher Tortoise. The cause of injury was unknown, but its wounds, which proved fatal, were consistent with damage from a backhoe shovel. The tortoise originated from Lee County, Florida, west of Interstate Highway 75, within the city limits of Fort Myers. The exact point of collection was withheld, due to the potentially illegal action which led to the discovery and death of this tortoise. Ultrasound evaluation (by O. Diaz, DVM, of Orlando, Florida) revealed testes, showing the tortoise to be male. However, the posterior plastron has an unpronounced indentation, and the anal scute is single, flat, extends toward the tail, and is not divided or curved as is normal in male *G. polyphemus*. Post mortem weight was 12.2 kg. The straight-line carapace length was 41.6 cm, and the plastron length was 40.6 cm. The specimen is preserved in the Chelonian Research Institute collection (PCHP 12633).

Submitted by **RAY E. ASHTON, JR.,** Ashton Biodiversity Research and Preservation Institute, Inc., 14260-331 W. Newberry Rd., Newberry, Florida 32669, USA (e-mail: Tortfarm2@aol.com); and **AMANDA EBENHACK**, 2005 NW 392nd St., Okeechobee, Florida 34972, USA.

GRAPTEMYS FLAVIMACULATA (Yellow-blotched Map Turtle). **INTERSPECIFIC BASKING SITE COMPETITION.** *Graptemys flavimaculata* is a highly aquatic, riverine turtle endemic to the Pascagoula River and its tributaries of southern Mississippi, USA (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, D.C. 578 pp.). It is common to see multiple turtles of different species occupying the same snag within the Pascagoula River system, but there have been no reports concerning interspecific competition among turtles for basking locations in this area. Here we report observations of interspecific aggression and competitor avoidance behavior by *G. flavimaculata* when trying to secure a desired basking location.

On 17 April 2007 (1410 h), on the Leaf River (Forrest County, Mississippi), WS observed from a distance of 30 m a small *G. flavimaculata* female basking partly submerged on a low-angled tree crown snag, while a slightly smaller *Apalone mutica* was basking directly above her. The female *G. flavimaculata* extended her

forelimb and pushed the *A. mutica* off of the basking snag, then climbed to the location that the *A. mutica* had vacated. Shortly thereafter (ca. 30–45 sec), presumably the same *A. mutica* re-emerged on the same snag below the *G. flavimaculata*. Soon after the *A. mutica* emerged, a second small *G. flavimaculata* female, similar in size to the first, emerged from the bank side of the snag. While she was climbing onto the snag, she placed her right fore-limb on the carapace of the *A. mutica*, apparently prompting it to move to another emergence point on the same snag (ca. 0.5 m away). After several minutes, the second *G. flavimaculata* vacated the log and then quickly reemerged and oriented itself behind the first *G. flavimaculata*.

Also on 17 April 2007 (1530 h), an alternative strategy, avoid-ance of a much larger interspecific, was observed by several *G. flavimaculata*. Upon approaching a 1.5 m long horizontal branch-sized snag, several emydid turtles were observed by WS vacating their basking locations before they could be identified. The snag was watched (via spotting scope) from a distance to see if the turtles would reemerge. Within minutes, a large female *G. flavimaculata* (>15 cm CL) emerged from the lowest angle of the snag/water interface and climbed approximately 15 cm up the snag. A large *Pseudemys concinna* (>20 cm CL) emerged behind the *G. flavimaculata* female and occupied the lowest emerged portion of the snag. After the emergence and 'roadblock' of the snag by the *P. concinna*, several more *G. flavimaculata* were observed swim-ming around the snag (heads emerged from the water). A second large *G. flavimaculata* female climbed vertically up the channel side of the snag to a basking location about 0.75 m away from the first *G. flavimaculata* female. A third *G. flavimaculata* female exhibited the same vertical climbing behavior, except approach-ing from the bank side of the snag and choosing a position be-tween the first and second *G. flavimaculata*. It appeared that the second and third *G. flavimaculata* females used this technique, climbing a steeper, vertical angle, to get to a desired basking loca-tion while avoiding encounters with the previous two occupants of the snag.

In the first observation, aggression appeared to be advantageous for the larger *G. flavimaculata* females in order to obtain a favor-able basking location. However, in the second observation, the two female *G. flavimaculata* 'climbers' were smaller than the *P. concinna*, and therefore, may not have had the option of using aggression to advance themselves to a favorable basking locality. These observations are supported by previous research that exam-ined aggressive interactions among four emydids: *Trachemys scripta*, *Pseudemys concinna*, *Graptemys pseudogeographica*, and *Graptemys oauchitensis* (Lindeman 1999. J. Herpetol. 33:214–219). Lindeman noted that aggressive interactions were "won" 70% of the time by larger turtles, which is consistent with our observations and interpretations of *G. flavimaculata* behavior.

Submitted by **WILL SELMAN** and **CARL QUALLS**, Depart-ment of Biological Sciences, Box 5018, University of Southern Mississippi, Hattiesburg, Mississippi 39401, USA (e-mail: will.selman@usm.edu).

GRAPTEMYS FLAVIMACULATA (Yellow-blotched Map Turtle). **FORAGING BEHAVIOR.** The *Graptemys flavimaculata* is a freshwater aquatic turtle that is endemic to the Pascagoula River system of southern Mississippi, USA (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, D.C. 578 pp.). R. J. Brauman and R. A. Seigel (unpubl. report) suggest that the primary food items of *G. flavimaculata* are insects, sponges, mollusks, and algae. They con-cluded that the presence of algae was due to secondary ingestion, rather than being a primary food item. However, very little is known about the foraging behavior of this species. Here we report two separate observations of female *G. flavimaculata* foraging on al-gae-covered submerged logs.

On 2 June 2006 (1650 h), a female *G. flavimaculata* was ob-served (by WS) ca. 0.3 m deep in a swift-flowing riffle section of the Leaf River (Forrest County, Mississippi) foraging on an algae-covered log. The female was grasping the downstream side of the log with her forelimbs as she appeared to "graze" on the periphy-ton. After brief observation, the female was captured with a dip net for marking and measurement (16.7 cm straight-line carapace length, 740 g); she had some filamentous algae in her mouth at the time of capture.

The second observation (also by WS) occurred on 30 August 2006 in the Lower Pascagoula River (Jackson County, Mississippi) at 1340 h. An adult female *G. flavimaculata* was observed from 2–2.5 m away (the presence of the boat did not appear to affect her behavior) "grazing" on the periphyton of a submerged log, in the same manner as noted before on the Leaf River. Her forelimbs were gripping the log as she foraged on the bank side. While feed-ing, she would quickly protrude her head, bite, and pull with her jaws, sometimes doing a "pushup" motion with her forelimbs to assist in tearing the algae off the submerged log. Feeding appeared at random without a side-to-side or a top-to-bottom order. This foraging behavior occurred in water ca. 20–80 cm deep and con-tinued as the turtle moved ca. 1.5 m along the log, sometimes holding onto the log with all four legs. After continuously feeding for ca. 15 minutes, the turtle surfaced (apparently for air), noticed its observer and quickly swam away. Inspection of the log showed little evidence of aquatic insects, but it was covered by a very thick layer of short growth filamentous algae. Also, while watch-ing the adult female, a juvenile female *G. flavimaculata* was also seen foraging in a similar manner for the first 3–5 minutes of the observation.

During both of these observations it could not be ascertained if the turtles were feeding directly on algae or on macroinvertebrates within the algae. Lahanas (1982. Unpubl. M.Sc. thesis, Auburn University) found that the diet of a closely related species, *G. nigrinoda*, had 28% and 41% average volume plant material for females and males, respectively. Similar behavior hás been noted in *G. oculifera*, another closely related species (R. L. Jones, pers. comm.). Thus, based on the above observations, it is plausible that *G. flavimaculata* is omnivorous and supplements its diet with plant material. More study is needed to determine if this species consumes algae as a primary component of the diet, or if algae is secondarily ingested during foraging for macroinvertebrates.

Submitted by **WILL SELMAN** and **CARL QUALLS**, Depart-ment of Biological Sciences, Box 5018, University of Southern Mississippi, Hattiesburg, Mississippi 39401, USA (e-mail: will.selman@usm.edu).

GRAPTEMYS GIBBONSI (Pascagoula Map Turtle). **BASKING AND PARASITE REMOVAL**. The primary physiological role of basking by turtles is presumed to be for thermoregulation (Boyer 1965. Ecology 46:99–118), to increase metabolism and digestion rates (Moll and Legler 1971. Bull. Los Angeles Co. Mus. Nat. Hist. Sci. 11:1–102). However, additional basking hypotheses and secondary roles of basking have been proposed including to aid in vitamin D synthesis (Pritchard and Greenhood 1968. Int. Turtle Tortoise Soc. J. 2:20–25, 34) and to rid turtles of ectoparasites (Cagle 1950. Ecol. Monogr. 20:31–54; Neill and Allen 1954. Ecology 35:581–584; Vogt 1979. Auk 96:608–609). Here we provide evidence to support the hypothesis that basking aids turtles in parasite removal as a secondary role and (to our knowledge) the first documented observation of basking-induced release of a parasite from a turtle while basking.

On 17 May 2007 (1125 h), WS and DS observed a large female *Graptemys gibbonsi* (>20 cm, ca. 1500 g) emerge on a large log-sized snag to bask (Leaf River, Forrest Co., Mississippi). The female emerged facing the observers and a large leech (*Placobdella* sp.) was noted on the anterior left pleural scute of the carapace. At this time, the leech was in an elongated position. After 10 minutes (1135 h), the leech was observed shortening into a ball-shaped posture; it is presumed that this posture was used by the leech for water conservation. After 35 minutes of basking (1200 h), the turtle began to exhibit 'gaping' behavior while basking, evidently reaching a high internal body temperature. Soon after at 1212 h (47 minutes after turtle emergence), the leech terminated the ball-shape and moved slowly toward the left margin of the turtle near the bridge of the shell. At 1214 h (after 49 minutes), the leech removed one end of its body from the margin of the turtle and began to 'search' below toward the log, while the other end was still attached at the margin of the carapace. The leech attached the free end of its body to the log and the attached end on the carapace followed, thus removing itself from the turtle. At 1215 h (after 50 minutes), the leech reentered the water at the edge of the basking log.

During this time, a *G. flavimaculata* female was basking on the same log as the female *G. gibbonsi*. The surface temperature of the *G. flavimaculata* female was being monitored via a carapace mounted temperature sensitive transmitter (AVM Instruments). The carapace temperature of the *G. flavimaculata* female during this observation of the *G. gibbonsi* female was 40–42°C. Therefore, the carapace temperature of the *G. gibbonsi* female was probably comparable to the carapace temperature of the *G. flavimaculata*, and thus, likely hot enough to induce the leech to voluntarily release itself from its host organism. To our knowledge, this is the first documented observation of voluntary parasite release during basking, and supports the secondary hypothesis of basking as a means for parasite removal.

Submitted by **WILL SELMAN, DUSTIN STRONG,** and **CARL QUALLS**, Department of Biological Sciences, Box 5018, University of Southern Mississippi, Hattiesburg, Mississippi 39401, USA (e-mail: will.selman@usm.edu).

GRAPTEMYS GIBBONSI (Pascagoula Map Turtle). **INTERSPECIFIC COMPETITION FOR BASKING SITES**. *Graptemys* gibbonsi is a highly aquatic freshwater turtle that inhabits the Pearl and Pascagoula rivers and tributaries of Mississippi and Louisiana, USA (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, D.C. 578 pp.). Very little is known concerning the life history and ecology of *G. gibbonsi*, and previous research within the Pearl and Pascagoula Rivers has focused predominantly on the two federally threatened species (*G. flavimaculata* within the Pascagoula River and *G. oculifera* within the Pearl River) that occur sympatrically with *G. gibbonsi*. These observations of *G. gibbonsi* basking behavior were made within the Pascagoula River system.

On 14 June 2006 (1200 h), on the Chickasawhay River (Greene County, Mississippi), WS observed a male *G. gibbonsi* emerge from the water and position himself above the water's surface on a low-angled, branch-sized snag. After several minutes, a slightly larger *Apalone* sp. approached and climbed onto the submerged portion of the same snag. The *Apalone* remained partially above the surface of the water, but was apparently not in an optimal basking location; it then extended its head forward and proceeded to nudge or bite (unknown due to the observation distance) the posterior of the male *G. gibbonsi*. The *G. gibbonsi* reacted by climbing up the snag. This sequence occurred again until the *G. gibbonsi* moved far enough up the snag to allow the *Apalone* to emerge fully from the water, presumably achieving a more optimal basking site.

On 11 April 2007 (1250 h), WS observed a male *G. gibbonsi*, ca. 9 cm in carapace length, climb vertically 19.5 cm to get to a desired basking location on a low-angled snag (Leaf River, Forrest County, Mississippi). No other turtles occupied the log at this time. This chosen basking location was 1.5–1.8 m from the lowest angle at the air/water interface where most turtles would emerge onto the snag. It could have chosen this "easier" location to emerge and only climb a 10–15° angle rather than the chosen vertical climb. It is unclear why the *G. gibbonsi* male chose this more difficult route to get to a desired basking location. However, it is possible that he took this route to avoid larger turtles that may emerge to bask from the lower angle at the air/water interface.

Submitted by **WILL SELMAN** and **CARL QUALLS**, Department of Biological Sciences, Box 5018, University of Southern Mississippi, Hattiesburg, Mississippi 39401, USA (e-mail: will.selman@usm.edu).

GRAPTEMYS GIBBONSI (Pascagoula Map Turtle). **INTERACTIONS WITH DUCKS.** *Graptemys gibbonsi* is an aquatic turtle that inhabits the Pearl and Pascagoula rivers and tributaries of Mississippi and Louisiana, USA (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, D.C. 578 pp.). Very little is known about the life history of *G. gibbonsi* following its description as a species in 1992 (Lovich and McCoy 1992. Ann. Carnegie Mus. 61:293–315). Observations were made on two occasions of interactions between adult female *G. gibbonsi* and Wood Ducks (*Aix sponsa*).

On 11 May 2006 (1500 h), on Oakohay Creek (Covington County, Mississippi), WS observed a basking adult female *G. gibbonsi* on a horizontal log-sized snag, along with a pair of Wood Ducks. The two Wood Ducks were startled by the approaching boat, but the female *G. gibbonsi* was not startled off the log when they flew away. However, the turtle vacated the log ca. 30 seconds

after the ducks flew away, apparently in response to the boat's approach. On 16 April 2007 (1450 h), on the Leaf River (Forrest County, Mississippi) WS observed from shore via spotting scope a female *G. gibbonsi* basking on a large log-sized snag with three *Pseudemys concinna*. A female Wood Duck was also perched above the four turtles on the same log. Upon noticing their observer, the female Wood Duck, and a male Wood Duck (that was previously unnoticed nearby on the water), flew away but none of the turtles were startled by this event. The turtles remained on the log and were only startled once they were approached by boat ca. 5 minutes later. From these observations, it appears that Wood Ducks are not viewed as a potential predator by these turtles and further, do not serve in any 'sentinel' capacity to alert turtles of danger while these turtle species are basking.

Submitted by **WILL SELMAN** and **CARL QUALLS**, Department of Biological Sciences, Box 5018, University of Southern Mississippi, Hattiesburg, Mississippi 39401, USA (e-mail: will.selman@usm.edu).

KINOSTERNON SCORPIOIDES ABAXILLARE (Central Chiapas Mud Turtle). **SIZE, GROWTH, AND REPRODUCTION**. Since its description (Baur, in Stejneger 1925. J. Washington Acad. Sci. 15[20]:462–463) the only published growth or reproductive data for *Kinosternon scorpioides abaxillare* were those of Alvarez del Toro (1983. Los Reptiles de Chiapas. Tercera Edición, Corregida, y Aumentada. Instituto Historia Natural, Los Tuxtlas, Chiapas. 248 pp.), who reported that 6–12 eggs are laid in March or April, and they hatch after three months. The present report is based on 23 specimens trapped between 1700 h 30 April and 0800 h 1 May 1981 (15 in the first two hours) near the Rio Cintalapa bridge on Hwy 190 in Chiapas, Mexico, as well as 52 examined museum specimens of this subspecies (see acknowledgments).

Males did not differ significantly from females in carapace length (CL: males, 122.4 ± 15.7 mm, 88–149, N = 21 versus females, 118.6 ± 14.6 mm, 84–153, N = 36; t = 0.93, P = 0.35) or plastron length (PL: males, 116.1 ± 15.6 mm, 83–143, N = 20 versus females,115.8 ± 14.8 mm, 81–149, N = 36; t = 0.8, P = 0.94), but differed significantly for the ratio PL/CL (males, 0.95 ± 0.02, 0.91–0.99, versus females, 0.98 ± 0.02, 0.93–1.01; t = 3.6, P = 0.0007). Females outnumbered males in the field collection (12:7) and the museum collections (24:14). Body mass (in grams) for the field-collected animals was related to CL (in mm) by the equation BM = $0.000506 CL^{2.727}$ (r = 0.994; P < 0.0001; N = 23), and the equations for males and females were nearly identical. A single neonate (CU 48847) was available, collected 25 June 1971, and measured 29.6 mm CL and 24.1 mm PL.

Although *K. s. abaxillare* was originally diagnosed as lacking an axillary scute, of 66 specimens examined for the trait, 8 had partial medial axillary seams, and 6 had complete axillary seams. In addition, I have observed the absence of axillary scutes in occasional specimens of *K. s. cruentatum* from Veracruz (BCB-SM 7852) and Cozumel (UF 24135, 24138).

The largest immature (no eggs, corpora lutea, or ovarian follicles > 3 mm), field-collected females were 99, 102, 110, 110, 121, and 126 mm CL. The smallest mature females were 124 mm CL (two 9 mm follicles), and 130 mm (one 8 mm follicle). Other mature females were 130 mm CL (follicles, 15, 15, 10, 10 mm), 130 mm CL (9, 9, 8, 8, 8, 8, 8 mm), 131 mm CL (9, 9, 8, 8 mm), and 133 mm CL (8, 8, 8, 7). These data suggest sexual maturity at 120–130 mm CL. Another 132 mm CL female (UIMNH 39373; 27 December 1955) bore 5 partially shelled oviducal eggs (3 crushed, the others 32.3 × 16.5 mm, and 28.75 × 17.5 mm), and follicles of 14, 13, 13, 9, and 8 mm, but counts of corpora lutea were not possible because of preservative effects. These preliminary dissection data suggest that clutch sizes might range from one to five eggs, and that the clutch sizes reported by Alvarez del Toro (*op. cit.*) may be exaggerated. The presence of preovulatory and enlarged follicles in females at the beginning of May suggest that the production of clutches might be possible in May and June, in addition to March and April as suggested by Alvarez del Toro (*op. cit.*). Furthermore, the ovaries of the UIMNH female suggest that eggs could also be laid in January. Whether *K. s. abaxillare* exhibits as long a reproductive season as captive *K. scorpioides* from Honduras (Goode 1994. *In* Murphy and Adler [eds.], Captive Management and Conservation of Amphibians and Reptiles, pp. 275–295. Soc. Study Amphib. Rept., Lawrence, Kansas) or *K. s. cruentatum* on the Yucatan Peninsula (Iverson, unpubl.) remains to be determined. In addition, whether *K. s. abaxillare* also exhibits delayed embryonic development, with hatching synchronized to the onset of the summer rainy season, like other populations of Mexican and Central American *K. scorpioides* (Ewert 1991. *In* Deeming and Ferguson [eds.], Egg Incubation: Its Effect on Embryonic Development in Birds and Reptiles, pp. 173–191. Cambridge Univ. Press, Cambridge, UK), also deserves attention.

Measurements of right abdominal scute annuli were used to estimate previous plastral lengths following the method of Ernst et al. (1973. Herpetologica 29:247–250). Three estimates of PL for age one year were 34.2, 40.9, and 39.3 mm; four estimates for two years were 45.2, 52.1, 62.0, and 66.4 mm; one for three years was 64.2 mm; and one for four years was 70.7 mm. A crude extrapolation of those data suggests that 8–10 years would be required to approach maturity at 120 mm PL (ca. 122 mm CL).

College, and the Joseph Moore Museum of Natural History.

Submitted by **JOHN B. IVERSON**, Department of Biology, Earlham College, Richmond, Indiana 47374, USA; e-mail: johni@earlham.edu.

KINOSTERNON SUBRUBRUM (Eastern Mud Turtle). **DIET.** *Kinosternon subrubrum* is an ubiquitous turtle found in wetlands throughout the eastern U.S. Food items taken by this turtle were listed in Ernst et al. (1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington, D.C.), and include invertebrates, vertebrates, and plant material. On 27 July 2007, we discovered the carcass of an adult *K. subrubrum* on the substrate of a large drying beaver pond in Tuskegee National Forest, Macon County, Alabama (UTM 16S 0627179N 3588804E). The turtle measured 97 mm in carapace length and 82 mm in plastron length, and is believed to be a male due to its deep posterior plastral notch (AUMO 37608). Upon dissection, the specimen was found to contain 190 seeds of the aquatic plant *Nuphar luteum* (spatterdock or yellow pond-lily) and one chelicera of a crayfish (*Cambarus* sp.). This represents the first record of *K. subrubrum* feeding on the seeds of *N. luteum*. The seeds appeared to be ripe and at a later stage of development than seeds found on the *N. luteum* at the time of collection, suggesting that the turtle may have been foraging on the seeds in the mud on the bottom of the pond. Finally, it is possible that this species may play a role in the seed dispersal of this plant, although seed viability experiments would need to be performed to confirm this.

Submitted by **SEAN P. GRAHAM** (e-mail: grahasp@auburn.edu) and **GEOFFREY G. SORRELL**, Auburn University Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36830, USA.

TERRAPENE CAROLINA TRIUNGUIS (Three-toed Box Turtle). **CARRION FEEDING.** *Terrapene carolina triunguis* is common throughout Arkansas and is reported to have a broad-based omnivorous diet (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas, Univ. Arkansas Press, Fayetteville, 421 pp.). Carrion is commonly reported in the diet of box turtles (Dodd 2001. North American Box Turtles: A Natural History, Univ. of Oklahoma Press, Norman, 231 pp.). Dead birds, including ducks (*Anas* spp.) and Green Herons (*Butorides striatus*) have been recorded in the diet of *T. carolina* (Ernst et al. 1994. Turtles of the United States and Canada, Smithsonian Institution Press, Washington, 578 pp.). The literature appears to lack mention of smaller birds, such as songbirds (passerines) being consumed as carrion. Here we report the consumption of a Brown-headed Cowbird (*Molothrus ater*) as carrion by a *T. c. triunguis*.

As part of a study estimating scavenging rates of avian carcasses, we distributed eight female Brown-headed Cowbird carcasses throughout an open field in Greene Co., Arkansas on 10 September 2007. On 13 September 2007 at 0735 h, one of us (IG) observed a male *T. c. triunguis* (113.6 mm CL, 87.5 mm CW, 308 g)

feeding on one of the cowbird carcasses (UTM 15N 0701128, 3975567). The turtle was measured, sexed, and then released. Because small birds inevitably share habitat with box turtles, their consumption as carrion by the turtles is not unexpected and may occur fairly frequently.

Submitted by **IDUN GUENTHER, MATTHEW B. CONNIOR,** and **ERIN MACCHIA**, Department of Biological Sciences, Arkansas State University, State University, Arkansas, 72467 USA (e-mail: erin.macchia@smail.astate.edu).

TRACHEMYS GAIGEAE GAIGEAE (Big Bend Slider). **KYPHOSIS.** The term kyphosis has been used, often incorrectly, to describe a variety of spinal deformities seen in turtles, ranging from true kyphosis to lordosis (Rhodin et al. 1984. British J. Herpetol. 6:369–373). During studies of *Trachemys g. gaigeae* in the Rio Grande Valley of Socorro and Sierra counties, New Mexico in 1994–1998, we captured a small adult male that was distinctly kyphotic or possibly kyphoscoliotic (*sensu* Rhodin et al., *op. cit.*). The turtle (Fig. 1) was captured in May 1998 in Elephant Butte Reservoir near Nogal Canyon, Sierra Co. and had the following measurements: straight-line carapace length at midline (CL) = 135 mm; straight-line plastron length at midline (PL) = 123.5 mm; maximal shell width = 111 mm; maximal shell height (at hump) = 61.5 mm; mass = 346 g. The hump was centered slightly to the right of the carapace midline at the second vertebral scute, suggesting kyphoscoliosis. All five vertebral scutes (V1–V5) were irregular in shape and asymmetrical. No melanistic disruption of the shell and skin color pattern, a common feature of older and larger male *T. g. gaigeae*, was evident. The slider appeared healthy when captured, but later died in captivity.

Four other specimens (all adults that were marked and released) were examined from our study area that exhibited varying degrees of kyphosis or kyphoscoliosis, although none as pronounced as the illustrated example. These included: 1) a female (258.5 mm CL; 238 mm PL) with a slight, localized hump to the right of the midline of V2 and V3; 2) a female (245 mm CL; 233 mm PL) with a slight, localized hump to the left of the midline of V2 and V3; 3) a female (268 mm CL, 239 mm PL) with a highly domed carapace

Fig. 1. Kyphotic male *Trachemys g. gaigeae* from Sierra Co., New Mexico.

centered to the left of the midline; and 4) a male (114 mm CL; 105 mm PL) with a hump between V1 and V2; spine laterally curved at hump; scutes V1–V5 were deformed.

Only 5 of the 235 (2.1%) adult and subadult specimens examined in our study exhibited noticeable kyphosis or kyphoscoliosis, and only one (0.4%) was markedly abnormal. We observed no spinal deformities in any hatchlings (N = 123) obtained from gravid females captured in the study area (Stuart and Painter 2006. Herpetol. Rev. 37:79).

Within the genus, kyphosis or related spinal deformities have been reported in *T. scripta scripta* (Carr 1952. Handbook of Turtles: The Turtles of the United States, Canada, and Baja California. Cornell Univ. Press, Ithaca, New York), *T. s. elegans* (Tucker et al. 2007. Herpetol. Rev. 38:337–338), *T. s. troostii* (Cagle 1950. Ecol. Monog. 20:31–54), and *T. yaquia* (Plymale et al. 1978. Southwest. Nat. 23:457–462). Tucker et al. (*op. cit.*) found kyphosis in only 0.06% of all *T. s. elegans* (N = 21,786) they captured in Illinois but noted that higher rates of occurrence (< 2.6%) have been reported in other turtle species based on much smaller sample sizes. Our report is the first for spinal deformities in *T. gaigeae* and suggests that its occurrence is also uncommon in this species.

We thank C. Travis Darwin for help in the field.

Submitted by **JAMES N. STUART** (e-mail: James.Stuart@state.nm.us) and **CHARLES W. PAINTER** (e-mail: Charles.Painter@state.nm.us), New Mexico Department of Game and Fish, Conservation Services Division, P.O. Box 25112, Santa Fe, New Mexico 87504, USA.

SQUAMATA — LIZARDS

ABRONIA TAENIATA (Bromeliad Arboreal Alligator Lizard). **MICROHABITAT.** Lizards of the genus *Abronia* (Anguidae) display both morphology and behavior specialized for arboreality (Campbell and Frost 1993. Bull. Am. Mus. Nat. Hist. 216:1–121). The genus also appears to be among the most endangered of Neotropical squamate lineages, and several species are known from only one or a few specimens (Campbell and Frost, *op. cit.*). In addition, species of *Abronia* are secretive (Formanowicz et al. 1990. Biotropica 22:391–396), and probably exhibit naturally low densities, though detailed information on population size is difficult to obtain in their arboreal habitats. Consequently, observations of *Abronia* are rare, and few reports describe activity in terrestrial environments (Martin 1955. Copeia 1955:173–180; Campbell and Frost, *op. cit.*). *Abronia taeniata* is a relatively widespread Mexican species that occurs in the pine-oak forests of the Sierra Madre Oriental between 1000–3000 m (Martin 1958. Misc. Publ. Mus. Zool. Univ. Michigan 101:1–102). Terrestrial habitat use in this taxon has been infrequently reported, with little information available on associated behavior (Martin 1955, *op. cit.*). Here, we provide two additional observations of terrestrial activity in this species from the state of Hidalgo.

At 1545 h on 1 July 2006, BPS, ELMV, and NI found an adult female *A. taeniata* (83.9 mm SVL, 116.5 mm tail, 10.7 g) in the crevice of a large limestone boulder (20.8778°N, 99.2299°W, datum: WGS84; elev. 2464 m) under pine (*P. greggii/P. patula*)-oak (*Q. crassipes*) forest canopy near the community of La Manzana, in Parque Nacional Los Mármoles (PNLM). The observation was made following strong morning rains. On our approach, the *A.*

taeniata retreated into the boulder, but we captured it at 1645 h after it reappeared at the edge of the same crevice. The nearest tree (a mature pine, probably *P. greggii)* was ca. 1.5 m away.

Elsewhere in the range of *A. taeniata*, the species has been collected in trees (Martin 1958, *op. cit.*). Other species of *Abronia* have been collected on tree trunks, and in epiphytic bromeliads and mosses (Campbell and Frost, *op. cit.*). In the Los Mármoles region, however, mature trees support few large epiphytes (BPS, pers. observ.), so *A. taeniata* may use terrestrial refugia in this area with greater frequency, at least during inclement weather. The specimen (BPS-CIB 24) was deposited in the vertebrate collections of the Centro de Investigaciones Biológicas (CIB) at the Universidad Autónoma del Estado de Hidalgo.

At 1030 h on 29 March 2007, IECS also found an adult female *A. taeniata* (106.8 mm SVL, 143.0 mm tail, 19.0 g) on leaf litter in a pine (*P. rudis*)-oak (*Q. rugosa*) forest at Campamento Conejo in Parque Nacional El Chico (20.1877°N, 98.7097°W, datum: WGS84; elev. 2915 m). The lizard was found in a patch of forest floor illuminated by morning sunlight; the nearest trees were 2–3 m away. IECS observed it for ca. 15 min, then captured it for deposition into the CIB vertebrate collection (specimen: ARP-00109).

Submitted by **BARRY P. STEPHENSON**, Department of Biology, University of Miami, Coral Gables, Florida 33124, USA (e-mail: barry@bio.miami.edu); **URIEL HERNÁNDEZ SALINAS**, Centro de Investigaciones Biológicas (CIB), Universidad Autónoma del Estado de Hidalgo, A.P. 1-69 Plaza Juárez, C.P. 42001, Pachuca, Hidalgo, México (e-mail: hu128613@uaeh.reduaeh.mx); **IGNACIO E. CASTELLANOS STUREMARK** (e-mail: ignacioe@uaeh.edu.mx), **ERIKA L. MENDOZA VARELA** (e-mail: litzahaya@gmail.com), **NIKOLETT IHÁSZ** (e-mail: ihaszniki@yahoo.com), and **AURELIO RAMÍREZ BAUTISTA** (e-mail: aurelior@uaeh.edu.mx).

AMEIVA EXSUL (Puerto Rican Ground Lizard). **DIET**. *Ameiva exul* has a diverse diet that includes invertebrates (earthworms, snails, insects, crabs), vertebrates (frogs, lizards), vegetable matter (banana, apple, cactus fruits), dog food, and even certain types of garbage (Joglar [ed.] 2005. Biodiversidad de Puerto Rico–Vertebrados Terrestres y Ecosistemas. Editorial del Instituto de Cultura Puertorriqueña, San Juan. 563 pp.; Lewis 1989. J. Herpetol. 23:164–170; Rivero. 1998. Los Anfibios y Reptiles de Puerto Rico. Editorial de la Universidad de Puerto Rico, San Juan. 510 pp.). Here, we add observations of several unreported food items to its already broad diet.

At 1247 h on 3 November 2005, we observed an adult *A. exsul* (ca. 13 cm) capture and eat an adult male of the Puerto Rico ground tarantula spider (*Cyrthopholis portoricae*; ca. 30 mm cephalotho-

FIG. 1. Common Ground Lizard (*Ameiva exsul*) ingesting a Puerto Rico Ground Tarantula (*Cyrthopholis portoricae*).

rax–abdominal length)) at Gurabo Abajo, Juncos, Puerto Rico (18.2519°N, 65.8964°W; datum: WGS84; elev. 171 m). The lizard, which located the male tarantula from a distance of ca. 3 m, rushed the spider, grabbed it (Fig. 1), and broke it into pieces by striking it on the substrate before eating it. Additional photos of the episode were deposited in the collection at the University of Puerto Rico-Humacao (UPR-H -Ameiva 1,2,3 – 2007).

During February 2007 (dry season), RAPR twice observed a female *A. exsul* (ca. 15 cm) eating insect larvae on drying dog feces at Bairoa Park, Caguas (18.2594°N, 66.0439°W; elev. 82 m). This lizard also ingested 3–4 mm fragments of fecal material that broke off of the fecal bolus.

On 15 September 2007, also in Caguas (18.2353°N, 66.0278°W; elev. 79 m), RAPR observed a Greater Antillean Grackle (*Quiscalus niger*) eating the crust and the insides of a piece of a recently discarded cheese pie. This attracted an adult (ca. 13 cm) *A. exsul* that came to investigate, which induced the grackle to leave. The lizard began eating the coagulated melted cheese almost immediately. A little later, a larger (ca. 15 cm) *A. exsul* supplanted the first, and after examining the remains, also consumed cheese. Additionally, AMO has often observed *A. exsul* in Juncos consume discarded human food as cooked beans, boiled rice, and pieces of boiled squash.

Our observations represent the first report of predation on tarantula spiders and the ingestion of cheese and fecal material by *A. exsul*. Tarantulas such as *Cyrthopholis* may be atypical prey for diurnal lizards. Nevertheless, during the breeding season the males emerge from their holes and start wander in search of females even during light day hours (Torres and Pérez–Rivera 1976. Science-Ciencia 3/4:104–108). Ingestion of feces may also be atypical. Drought reducing the typical prey base for *Ameiva* may explain this rare behavior. Our observations may support the notion that *A. exsul* is and opportunistic generalist, but the possibility also remains that great variation in food selection by individuals in this lizard may exist.

Submitted by **RAUL A. PEREZ–RIVERA** and **ALBERTO MOLINA-OPIO**, Department of Biology, University of Puerto Rico-Humacao, CUH Station, Humacao, Puerto Rico 00791 (e-mail [RAPR]: raperezrivera@yahoo.com).

ANOLIS UNIFORMIS (Lesser Scaly Anole). **DIET.** *Anolis uniformis* is a small lizard widely distributed in wet tropical rain forests from southern Tamaulipas, México through northern Guatemala and Belize to northern Honduras. It occurs in forest understory from near sea level to about 900 m (Campbell 1998. Amphibians and Reptiles of Nothern Guatemala, the Yucatán, and Belize. University of Oklahoma Press, Norman. 380 pp.; Campbell et al. 1989. Biotropica 21:237–243; Lee 1996. The Amphibians and Reptiles of the Yucatan Peninsula. Cornell University Press. Ithaca, New York. 500 pp.). The most observable lizard at Los Tuxtlas tropical rain forest, Veracruz, México, *A. uniformis* is thought to be a diurnal insectivore across its geographic range (Duellman 1963. Univ. Kansas Publ. Mus. Nat. Hist. 15:205–249; Villarreal 1997. *In* González et al. [eds.], Historia Natural de los Tuxtlas. Universidad Nacional Autónoma de México. 647 pp.; Villarreal and Heras 1997. *In* González et al., *op. cit.*). Here we report predation by *A. uniformis* on an anuran.

At 2315 h on 3 September 2003 during a nocturnal herpetofaunal survey, we observed a young *A. uniformis* male (29 mm SVL) swallowing a very small (ca. 9 mm SVL) leaf litter frog (*Craugastor* sp.). The event occurred on a leaf of a medium-sized plant in a small bamboo and tropical rain forest remnant in the Los Tuxtlas region, Veracruz, México (18.6072°N, 95.1437°W, datum: WGS84; elev. 650 m). The anole was collected and deposited in Colección Nacional de Anfibios y Reptiles, Instituto de Biología, Universidad Nacional Autónoma de México (CNAR IBH 21138).

From September 2006 to July 2007, we also collected and dissected 30 *A. uniformis* adults at the Laguna Escondida rainforest remnant at Los Tuxtlas region (18.5909°N, 95.0883°W; elev. 150 m) as a part of a parasitological study. Examination of stomach and intestinal contents revealed only arthropod remains, mostly terrestrial and flying insects (flying Diptera, Hymenoptera, Hemiptera; terrestrial Orthoptera) and a few spiders. We found no amphibian remains in this sample.

Previous diet records for *Anolis uniformis* (Stuart 1948. Misc. Publ. Mus. Zool. Univ. Michigan 69:1–109; Villarreal, *op. cit.*; Villarreal and Heras, *op. cit.*) indicate that it preys on insects and litter-dwelling invertebrates, especially soft-bodied arthropods. Our 2003 observation indicates that *A. uniformis* can prey on small amphibians and that it may sometimes feed at night

Submitted by **ELISA CABRERA GUZMÁN** and **VÍCTOR HUGO REYNOSO,** Colección Nacional de Anfibios y Reptiles. Instituto de Biología, Departamento de Zoología, Universidad Nacional Autónoma de México, Circuito exterior, Ciudad Universitaria, México D.F. C.P. 04510; e-mail: anfisbenido@yahoo.com.

ASPIDOSCELIS VELOX (Plateau Striped Whiptail). **PREDATOR EVASION.** Successful attempts form the basis of most predation reports in the herpetological literature. In contrast, failed attempts are rarely reported even though they are essential to understanding of behavior, natural history, and selection pressures of predators and their prey. Here I report an observation of *Aspidoscelis velox* successfully avoiding a predation attempt by a

Long-tailed Weasel (*Mustela frenata*) in southeastern Utah.

At 1051 h on 19 August 2007, in the valley of Indian Creek, San Juan Co., Utah, USA (38.0523°N, 109.5587°W, datum: WGS84; elev. 1697 m), I observed a *M. frenata* moving from an open area of compacted sand to the cover of a Greasewood (*Sarcobatus vermiculatus*) shrub, ca. 40 m W of the intermittent stream channel of Indian Creek. Air temperature was ca. 27°C and cloud cover was 60%. Vegetation was dominated by Big Sagebrush (*Artemisia tridentata*), Greasewood, and Four–wing Saltbush (*Atriplex canescens*). I observed the weasel through 10× binoculars from a distance of ca. 3 m. The weasel seemed aware of my presence as its gaze was fixed in my direction. After ca. 1 min of observation, the weasel darted from the shrub in pursuit of an adult (ca. 7 cm SVL) *A. velox* that I had not previously noticed. The lizard maneuvered in a series of rapid zigzag movements up–slope and away from where the weasel had appeared, making at least four abrupt (ca. 90°) turns over a distance of ca. 4 m. The weasel seemed to follow closely, tracing each abrupt turn of the lizard, but the speed of the pursuit made it impossible to ascertain from my position whether the weasel was gaining on the lizard or the lizard was gaining distance from the weasel. The weasel gave up chase after ca. 4 m and returned rapidly to the shrub from which it had emerged, where it apparently entered a burrow and disappeared from sight. As the weasel gave up the chase, the lizard crested a small rise in the slope, leaving my field of view. Based on the recording times of photographs taken during the chase, the chase lasted ca. 26 sec.

Because the weasel was aware of my presence prior to chasing the lizard it may have been motivated to terminate the chase earlier than it would have otherwise. However, Long-tailed Weasels have been reported to continue apparently normal foraging behavior even in front of large groups of people (e.g., Hamilton 1933. Am. Midl. Nat. 14:289–344). Long-tailed Weasels are regarded as generalist predators even though they eat primarily small rodents, and only rarely take lizards (Sheffield and Thomas 1997. Mamm. Species 570:1–9). Predation attempts, successful or otherwise, by *M. frenata* on *A. velox* have not been previously reported. Whiptail lizards are known for their speed and evasive abilities, and being notoriously difficult for humans to capture is the origin for the species name "*velox*" (Springer 1928. Copeia 169:100–104; Stuart 1998. Cat. Am. Amphib. Rept. 656:1–6). This observation suggests that the rapid zigzag escape strategy of *A. velox* is effective in avoiding capture by other mammalian predators as well.

Submitted by **RYAN P. O'DONNELL**, Department of Biology and the Ecology Center, 5305 Old Main Hill, Utah State University, Logan, Utah 84322–5305, USA; e-mail: Ryan@biology.usu.edu.

COLEODACTYLUS NATALENSIS (NCN). **CLUTCH SIZE; HATCHLING SIZE.** *Coleodactylus natalensis* is a small lizard endemic to the Atlantic Forest of Rio Grande do Norte, Brazil (Freire 1999. Bol. Mus. Nac. 399:1–14). Clutch size is not known, but its geographically proximate congener, *C. meridionalis*, has a one-egg clutch (Vanzolini et al. 1980. Répteis das Caatingas. Acad. Bras. de Ciênc. Rio de Janeiro, Brazil. 161 pp.). Here, we provide an observation of clutch size and hatchling size in *C. natalensis*.

At 1630 on 24 January 2006, PAGS collected two eggs of *C. natalensis* ca. 1 m apart among leaf litter in a 30-cm deep cavity in a large rock (ca. 1 m²) at the Estação Experimental Rommel Mesquita de Faria (Mata do Jiquí; 5.9305°S, 35.1814°W; datum: WGS84; elev. 40 m), an Atlantic Forest fragment on an EMPARN (Empresa de Pesquisas Agropecuárias do Rio Grande do Norte) farm of 79 ha in the of municipality Parnamirim. These data and field observations of females carrying one egg (CMCAL, pers. obs.) indicates that this species likely has a fixed clutch size of a single egg.

The eggs were placed in a terrarium (20 cm × 12 cm × 20 cm) with a substrate of sand and leaf-litter, and maintained at Laboratório de Herpetologia, in the Departamento de Botânica, Ecologia e Zoologia in Universidade Federal do Rio Grande do Norte) at an ambient temperature averaging about 25°C, but which varied between 24°C and 32°C over the incubation period. On 6 March 2006 (41 days after collection), one juvenile emerged. Measurements were SVL: 11 mm; tail length: 0.8 mm; foreleg length: 3.1 mm; fourth finger: 0.4 mm; hindleg length: 3.6 mm; fourth toe: 0.7 mm; head length: 2.9 mm; head width: 2.0 mm; jaw length: 1.6 mm; head height: 1.1 mm; body width: 2.2 mm; pelvis width; 1.3 mm; axilla–groin length: 4.4 mm; and mass: 0.024 g. This is the first record of hatchling size in *C. natalensis*.

Submitted by **CAROLINA M. C. A. LISBOA**[1,2], **PABLO AUGUSTO GURGEL DE SOUSA**[2], **LEONARDO B. RIBEIRO**[3], and **ELIZA M. X. FREIRE**[2]; [1]Programa de Pós–Graduação em Ciências Biológicas, Centro de Biociências, Universidade Federal do Rio Grande do Norte, 59072–970, Natal, RN, Brazil; [2]Departamento de Botânica, Ecologia e Zoologia, Centro de Biociências, Universidade Federal do Rio Grande do Norte, 59072–970, Natal, RN, Brazil; [3]Programa de Pós–Graduação em Psicobiologia, Universidade Federal do Rio Grande do Norte, Centro de Biociências, Departamento de Fisiologia, Caixa Postal 1511, 59078–970, Natal, RN, Brazil; e-mail (CMCAL): carolisboabio@yahoo.com.br; (PAGS): pabloguitar2@hotmail.com; (LBR): ribeiro.lb@gmail.com; (EMXF): elizajuju@ufrnet.br.

CYCLURA CYCHLURA CYCHLURA (Andros Iguana). **ATTEMPED PREDATION.** Shifts in prey size may reflect several processes including limitations on gape (Shine and Sun 2003. Funct. Ecol. 17:340–348). Alternatively, rather than the ability to physically ingest prey, limitations may reflect a predator's ability to capture, kill, or digest prey of different sizes. Few field accounts exist demonstrating a snake's ability to dispatch but not ingest prey (but see Sabo and Ku 2004. Herpetol. Rev. 35:396–397). The few reports of failed predation attempts may reflect a combination of the inability to record them without direct observation and bias against reporting unsuccessful predation events even though such events can inform aspects of species-specific predation be-

havior unavailable elsewhere. Here we report three failed predation attempts by snakes on hatchling *Cyclura cychlura cychlura* from two island localities over an eight-day period in September 2003.

In coordination with a hatchling dispersal study of the Andros Iguana, we affixed 2.7 g radio-transmitters (model PD-2, Holohil Systems, Ltd., Ontario, Canada) to 41 hatchling iguanas (Knapp and Owens 2005. Herpetol. Rev. 36:264–266) on Sandy and Mangrove Cays of Andros Island, Bahamas (see Knapp and Owens 2004. Caribb. J. Sci 40:265–270 for site descriptions). We attempted to locate telemetered hatchlings daily after release at their respective nests. On 3 September 2003 (20 days after release), we found a dead hatchling *C. c. cychlura* (102 mm SVL, 45 g) on the limestone substrate of Mangrove Cay. The head of this hatchling was severely compressed with blood seeping from the mouth and tympanum, while the head and thorax were coated with shiny clear and brown residue. The residue extended down half the body and stopped ca. 10 mm anterior to the transmitter, which was attached on the dorsal side of the pelvic girdle. On 4 and 11 September 2003 (3 days after release for each hatchling), we found dead hatchling iguanas (98 mm SVL, 43 g; 93 mm SVL, 38 g) on the limestone substrate of Sandy Cay. The skull of each hatchling was similarly compressed with blood seeping from the mouth and tympanum. These hatchlings differed from the first observation in that only the head was coated with shiny clear and brown residue and stopped at the pectoral girdle. These observations are similar to a failed predation attempt on *Sceloporus occidentalis* (Sabo and Ku, *op. cit.*) and led us to conclude that the hatchlings had been captured, partially swallowed but regurgitated by a predator. Only two snakes (*Alsophis vudii* and *Epicrates striatus*) occurring at our study sites have been confirmed to be capable of ingesting hatchling *C. c. cychlura* iguanas. Indeed, we recorded 18 *A. vudii* individuals consuming 19 *C. c. cychlura* hatchlings and six *E. striatus* individuals consuming nine hatchlings. We infer that the failed predation attempts were attributable to *A. vudii* based on the fresh, wet residue on the carcasses, which were discovered during the day. Additionally, based on observations of predator-prey interactions for both species of snakes using radio telemetry, the open locations of the carcass discoveries are indicative of typical kill sites for the diurnal *Alsophis* rather than the nocturnal *Epicrates*. Snakes are known to feed selectively, and hence need to discriminate between objects that are or are not acceptable as food (Shine and Sun 2003, *op. cit.*). Our observations are significant because they indicate that potentially gape–limited snakes may be successful in capturing and subjugating prey but can fail in their ingestion attempts. Sabo and Ku (*op. cit.*) concluded that a failed predation attempt of a gravid *S. occidentalis* was the direct result of the girth of the body cavity caused by the internal egg mass. In our case, the first failed predation event where the clear and brown residue extended to within 10 mm of the pelvic transmitter could be attributable to the increased girth caused by the transmitter. However, it appeared as if the ingestion process was aborted anterior to the pectoral girdle in the latter two observations indicating that the snakes were able to dispatch but not ingest their prey items. We suspect that failed predation events may be more common than expected and that these events can provide interesting hypotheses for testing evolutionary predator-prey relationships.

Submitted by **CHARLES R. KNAPP,** Conservation and Research for Endangered Species, Zoological Society of San Diego, 15600 San Pasqual Valley Road, Escondido, California 92027 USA, and Conservation Department, John G. Shedd Aquarium, Chicago, Illinois 60605, USA (e-mail: cknapp@ufl.edu); and **AUDREY K. OWENS,** Arizona Game and Fish Department, 2221 W. Greenway Rd., Phoenix, Arizona 85023, USA (e-mail: audreykowens@yahoo.com).

ECPLEOPUS GAUDICHAUDII (NCN). **REPRODUCTION.** *Ecpleopus gaudichaudii*, a poorly known gymnophtalmid lizard, is thought to be endemic to the Atlantic Rainforest of southeastern Brazil (Peters et al. 1986. U.S. Nat. Mus. Bull. 297:1–293). Data on clutch size and reproductive behavior is limited to one observation of two individuals (Uzzell 1969. Postilla 135:1–23). Herein, we report data on seven gravid females collected in Minas Gerais, southeastern Brazil.

All specimens are deposited in the herpetological collection of the Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Brazil. All seven females, collected in arthropod and/or herpetofauna pitfall traps, contained one developed egg averaging 7.0 ± 0.3 mm SD (range: 7.5–6.7 mm). UFMG 987 (36.6 mm SVL) was collected in an area of secondary forest of a small urban park, the Estação Ecológica da UFMG (19.92°S, 43.93°W; elev. 850 m) in the interval 24–30 October 2000. UFMG 1659, 1663, 1661, and 1660 (respectively 34.9, 34.7, 35.2, and 35.3 mm SVL) were collected in primary forest of a large Atlantic Rainforest reserve, the Parque Estadual do Rio Doce (19.80°S, 42.63°W; elev. 230–515 m) in the interval 1–10 September 2001. UFMG 1094 (38.4 mm SVL) was collected in primary forest of another Atlantic Rainforest reserve, the Reserva do Patrimônio Natural Feliciano Miguel Abdala (19.83°S, 41.83°W; elev. 340–680 m) in the interval 22 December 2000–16 January 2001, whereas UFMG 1095 (37.1 mm SVL) was collected in the same locality, but lacks a collection date. These observations agree with the previous observation (Uzzell 1969, *op. cit.*) that *E. gaudichaudii* clutch size is typically one egg.

Submitted by **FERNANDO A. PERINI**, Laboratório de Biodiversidade Molecular, Departamento de Genética, Instituto de Biologia, Universidade Federal do Rio de Janeiro, CP 68011, Rio de Janeiro, RJ, CEP 21941–590, Brazil (e-mail: faperini@yahoo.com.br); and **MARIELLA BUTTI**, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, CP 486, Belo Horizonte, MG, CEP 31270–901, Brazil (e-mail: maributti@uol.com.br).

ELGARIA COERULEA (Northern Alligator Lizard). **JUVENILE GROWTH**. Rutherford (2004. Can. J. Zool. 82:817-822) provided the only juvenile growth data for *Elgaria coerulea*, but those data were based on individuals from the Creston Valley, British Columbia, located toward the northern end of the species range

(Stebbins 2003. A Field Guide to Western Reptiles and Amphibians, 3rd ed. Houghton Mifflin Co., Boston, Massachusetts. 560 pp.). Hence, we provide an observation of juvenile growth in *E. coerulea* from west-central Washington State.

We recorded these observations along the south edge of a second-growth Douglas-fir (*Pseudotsuga menziesii*) stand in a rural neighborhood < 0.15 km from Puget Sound near Olympia, Washington (47°06'59"N, 122°56'08"W, WGS 84; elev. 37 m). All measurements were made with a 15-cm ruler to the nearest 0.5 mm; and masses were obtained with a top-loading Ohaus 1320 field scale with 0.01 g accuracy.

While cleaning yard debris at 2010 h on 29 May 2007, CBH captured a juvenile female *E. coerulea* (49.0 mm SVL, 65.0 mm tail [unbroken], 1.70 g) beneath a discarded painting tarp exposed daily to midday and afternoon sun. Based on having recaptured *E. coerulea* under similar objects, we opted not to remove the tarp, marked the animal with a single toe clip, and released it at the capture point. MPH subsequently recaptured this animal at the same location three times over the next 65 days. On 15 June, it was 52.5 mm SVL (75 mm tail, 2.26 g); on 2 July, it measured 55 mm SVL (82.5 mm tail, 2.50 g); and on 8 August, it was 60 mm (92 mm tail [still unbroken], 3.55 g). These data reveal mean growth rates of 0.21 mm/dy and 0.59 mm/day for the body and tail in the 1st interval; 0.15 mm/dy and 0.44 mm/day in the 2nd interval; and 0.16 mm/dy and 0.24 mm/dy in the 3rd interval. Mass increased 0.04 g/dy in the 1st interval, declined to 0.01 g/dy in the 2nd interval, but increased again to 0.03 g/dy in the 3rd interval.

Based on the data of Rutherford (*op. cit.*) and the fact that the smallest *E. coerulea* observed locally (28–32 mm SVL) have always been found in later summer and fall (MPH, unpubl. data), the animal we captured belongs to the 2006 cohort. Based on the growth curve of Rutherford (*op. cit.*), the growth of this juvenile seems slightly faster than that of juveniles from the Canadian Okanogan; no animal that Rutherford captured had attained 60 mm by their second winter (see her Figure 2), and after our last recapture, we expect to have at least 40 days of higher-growth-rate temperature conditions in our summer season. One further point merits comment. Growth rate of the tail declining nearly three-fold relative to the roughly constant body growth rate as mass increased indicates that substantial allocation to tail growth occurs early, asymmetry that deserves exploration.

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Submitted by **CHARLEEN BRIGETTE HAYES**, 2636 59th Avenue NW, Olympia, Washington 98502 (e-mail: charleenhayes@msn.com); and **MARC PHILIP HAYES**, Washington Dept. Fish and Wildlife, Habitat Program, 600 Capitol Way North, Olympia, Washington 98501, USA (e-mail: hayesmph@dfw.wa.gov).

EUMECES ELEGANS (Elegant Skink). **PREDATION**. *Eumeces elegans* occurs in eastern China, Taiwan, and the Diaoyutai (=Senkaku) Archipelago (Hikida 1993. Japan. J. Herpetol. 15:1–21). In Taiwan, it inhabits primarily open mountainous areas and
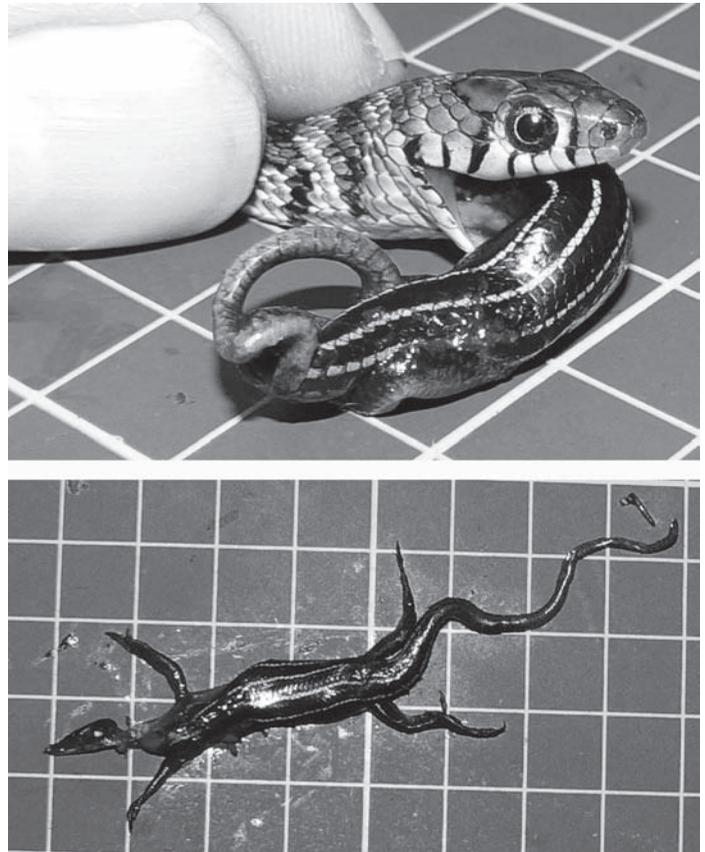

Fig. 1. The *Amphiesma stolatum* in the process of regurgitating the *Eumeces elegans* (top), and the prey item after it has been regurgitated (bottom). Note the partly digested head of the prey in the bottom image.

areas disturbed by human activities below 2500 m (Lue et al. 2002. The Transition World—Guidebook of Amphibians and Reptiles of Taiwan. SWAN, Taipei. 350 pp. [in Chinese]; Pope 1929. Bull. Amer. Mus. Nat. Hist. 58:335–487; Shang and Lin. 2001. Natural Portraits of Lizards of Taiwan. Big Trees Publishers, Taipei. 174 pp. [in Chinese]).

On 14 September 2007, a juvenile male Striped Keelback (*Amphiesma stolatum*) (293 mm SVL, 100 mm tail, 9.3 g post–regurgitation mass) was collected from a drift fence funnel trap set in a Betelnut Palm (*Areca catechu*) plantation in Santzepu, Sheishan District, Chiayi County (23.4267°N, 120.4856°E; datum: WGS84; elev. 85 m). Habitat consisted of *A. catechu*, *Alocasia odora*, *Bidens pilosa* var. *radiata*, *Ipomoea cairica*, *Mikania micrantha*, and *Panicum maximum*; canopy cover, created by the crowns of *A. catechu*, was 25%. The *A. stolatum* had an enlarged mid-body, and after gentle palpation, the snake regurgitated a juvenile *E. elegans* (Fig. 1) with a partly digested head (45 mm SVL, 59 mm tail, 1.4 g). After being scale-clipped for future identification, the snake was released in the area where it was collected.

Little is known about the feeding habits of *A. stolatum*, but the following prey types have been recorded: insects (Acrididae), tadpoles, toads, frogs, fish (Lee and Lue 1996. Biol. Bull. Nat. Taiwan Normal Univ. 31:119–121 [in Chinese]), earthworms, geckoes, lizards, and scorpions (Das 2002. A Photographic Guide to Snakes and Other Reptiles of India. New Holland Publishers [UK] Ltd., London. 144 pp.). Prey size of the skink reported here, at

15% of predator mass, is typical for a colubrid (Greene 1997. Snakes: The Evolution of Mystery in Nature. University of California Press, Berkeley. 351 pp.). This is the first description of *E. elegans* as prey of *A. stolatum*.

Submitted by **GERRUT NORVAL**, Applied Behavioural Ecology & Ecosystem Research Unit, Department of Nature Conservation, UNISA, Private Bag X6, Florida, 1710, Republic of South Africa (e-mail: gerrutnorval507@yahoo.com); **JEAN-JAY MAO,** Department of Natural Resources, National Ilan University. No. 1, Sec. 1, Shen-Lung Rd., Ilan, Taiwan 260, R.O.C.; and **HSIEN-PIN CHU,** Taitung Animal Propagation Station. No. 30, Community 27, Binlang Village, Beinan, Taitung County 954, Taiwan, R.O.C.

FURCIFER LABORDI (Labord's Chameleon). **REPRODUCTION.** Though nesting behavior in *Chamaeleo chamaeleon* is relatively well-studied in Spain (Blázquez et al. 2000. Herpetol. J. 10:91–94), nest excavation behavior in chameleons of Madagascar remains undescribed. Additionally, such behavior in nature may differ from that described for captives or under semi-natural environments (e.g., Bourgat 1968. Bull. Soc. Zool. France 93:355–356.; Ferguson et al. 2004. The Panther Chameleon: Color Variation, Natural History, Conservation, and Captive Management. Krieger Publishing Co., Malabar, Florida. 118 pp.). Here, we describe clutch size and nest excavation behavior in a chameleon from Madagascar, *Furcifer labordi*. To our knowledge, no other published field observations of nesting in this species exist.

On 03 February 2004, we observed nest excavation and egg deposition by an adult female *F. labordi* (77.2 mm SVL) at Ranobe forest (23.0250°S, 43.6100°E, datum: WGS84; elev. 17 m), ca. 30 km N of the provincial capital of Toliara (Tuléar), southwestern Madagascar. We located this female ca. 2 h before dusk at 1654 h, after she had already excavated a burrow deep enough to have submerged ca. 10 cm of her total body length below the substrate. The female dug the entrance burrow in the sand substrate at a roughly 45° angle. For the next 4 h and 18 min, she remained underground. In *Chamaeleo chamaeleon*, and in captive chameleons from Madagascar, females use only one burrow during nest excavation (Blázquez et al., *op. cit.*; KBK, pers. obs.). However, the female of this species deposited eggs without exiting the same burrow, and instead, excavated upwards at an angle almost perpendicular to the entry burrow. She emerged from the opposite end at 2112 h, filling in the burrow as she exited. By 2137 h, she had completely exited and remained motionless for the next 18 min. By 2155 h, she began to crawl toward the burrow entrance, and began covering the partially collapsed entrance. She completed filling the entrance by 2230 h, after which she climbed nearby vegetation to roost. We estimate that nesting behavior in this individual lasted at least 6 h given that she had begun excavation before we arrived, much shorter than that described in *C. chamaeleon* (Blázquez et al., *op. cit.*).

The next day, we recorded egg and nest dimensions. The entrance burrow measured 175 mm in length and the exit angle was acute, resulting in the exit burrow being only about 150 mm. Nest depth, measured from the substrate to the top of the egg mass, was 138 mm. On 30 January 2004, the female weighed 12 g, but only 6.4 g after egg deposition on 04 February. The 11-egg clutch had a total mass of 4.4 g. Egg length averaged 11.7 ± 0.37 mm SD (N = 11). After data collection, we replaced all eggs to their original orientation and re-covered the nest. We recorded nest temperature at the same level as egg depth over the next several days between 0800–2200 h. Mean nest temperature was 27.2 ± 0.92°C (N = 9) during this early period of incubation. We were unable to record nest temperatures beyond 11 February. Hatching occurs in early November in this species (KBK, unpubl. data).

Submitted by **KRISTOPHER B. KARSTEN**, Department of Zoology, Oklahoma State University, Stillwater, Oklahoma 74078, USA (e-mail: kris.karsten@okstate.edu); and **LAZA N. ANDRIAMANDIMBIARISOA**, Département du Biologie Animale, Université d'Antananarivo, BP 906, Antananarivo 101, Madagascar.

HELODERMA SUSPECTUM (Gila Monster). **PREY**. Gila Monsters are specialized nest predators; their diet includes eggs of ground-nesting birds and reptiles, and juvenile mammals (e.g., *Ammospermophilus leucurus*, *Neotoma albigula*, and *Sylvilagus audubonii*; Beck 2005. Biology of Gila Monsters and Beaded Lizards. University of California Press, Berkeley. 247 pp.). Here, we report prey not previously known for *H. suspectum*, Desert Kangaroo Rats (*Dipodomys deserti*). We describe predation episodes on juvenile kangaroo rats in the field, and we document adult kangaroo rat rescue of nestlings from *H. suspectum* predation.

We radio-tracked *H. suspectum* from March 2000 to August 2004 at a Mojave Desert site near Lake Mead, Nevada (36.5°N, 114.5°W; elev. 600 m; Gienger 2003. Natural History of the Gila Monster in Nevada. Unpubl. MSc Thesis. Univ. of Nevada, Reno. 55 pp.). We located each lizard 2–4 times per day during the active season (March–October). When we found *H. suspectum* surface active, we followed each lizard from a distance of 5–10 m to record successful foraging bouts and specific prey.

At 0710 h on 30 May 2003, we observed an adult female *H. suspectum* excavating an entrance to a rodent burrow complex at the base of a sandy mound (Fig. 1a). After 2 min of excavation, the *H. suspectum* disappeared into the burrow and an adult kangaroo rat ran out of a hole on the other side of the sand mound. Immediately, two altricial (eyes still closed) kangaroo rat pups were observed trying to crawl out of the burrow. The *H. suspectum* then emerged from the burrow behind the pups (Fig. 1b) and seized one pup by the mid-body. After consuming the first pup, along with considerable sand, the Gila Monster then exited the burrow, seized the second pup by the head (Fig. 1c), and consumed it as well.

At 0758 h on 19 June 2003, we observed the same female *H. suspectum* excavating a rodent burrow. After digging for ca. 1 min, the burrow collapsed on itself and the lizard disappeared inside. An adult Desert Kangaroo Rat then sprinted out of a second burrow entrance 70 cm from the collapsed entrance. Three juvenile Desert Kangaroo Rats (pre-weening age; eyes still closed) became visible at the second entrance of the collapsed burrow, with one pup attempting to crawl out of the burrow. The adult Desert Kangaroo Rat (presumably the mother) returned to the opening of the second burrow (Fig. 2a), grabbed the pup that was outside of the burrow (Fig. 2b) and carried it to a third burrow opening located 3.5 m away from the second (Fig. 2c). The mother then stood out-

FIG. 1. Excavation and consumption of a nest of kangaroo rats (*Dipodomys* sp.) by a foraging Gila Monster.

FIG. 2 (opposite). Sequence showing adult female Desert Kangaroo Rat (*Dipodomys deserti*) attempting to rescue her pups from predation by a Gila Monster. The Gila Monster is inside the burrow and the mother removes one of the pups before it can be eaten.

side the third burrow and began a foot-drumming display (Kenagy 1976. J. Mammal. 57:781–785; Randall and Matocq 1997. Behav. Ecol. 8:404–413.) in which she rapidly and repeatedly beat her feet against the sand.

The remaining pups inside the second burrow were squeaking, and the mother returned and moved quickly into the burrow with both the remaining two visible pups and the *H. suspectum*. At 0807 h, the mother emerged from the second burrow (without any pups) and moved over to the third burrow where she had left the rescued pup. At 0820 h, the mother left the third burrow without her pup and moved out of sight. For 20 min, the *H. suspectum* remained inside the second burrow. At 0840 h, squeaking noises emanated from the third burrow where the Desert Kangaroo Rat mother had placed the rescued pup. The Gila Monster remained underground in the second burrow until 0923 h, and then emerged from the burrow (Fig. 2d) and walked to, and into, the third burrow, where it presumably consumed the rescued pup. The *H. suspectum* remained inside the third burrow for ca. 30 min and then emerged above ground. After walking a few steps, the *H. suspectum* licked its face and arched its back with snout pointed upward, a posture Gila Monsters often assume after eating large meals (pers. obs.; Beck 2005, *op. cit.*). This arching posture may help force food items down into the stomach, especially when the stomach is already full.

We were also able to verify nest predation by three other Gila Monsters on kangaroo rats at this Nevada site on four additional occasions. Each time, we were able to verify the genus of the prey (*Dipodomys*) by observing adults leaving the nest or pups attempting to crawl out of the burrow. Most of the time we were not able to identify *Dipodomys* to species, as the adults fled the nest once it was discovered, and Gila Monsters immediately consumed the pups. The possible kangaroo rat species in this area include *D. deserti and D. merriami* (Hall 1946. Mammals of Nevada. University of California Press, Berkeley. 710 pp.), but because these observations were made as part of a larger natural history study of Nevada *H. suspectum*, we did not interfere with lizard foraging activities to determine which of the two *Dipodomys* species were involved. However, the observation of 19 June 2003 is undoubtedly a nest of *D. deserti*, as the kangaroo rat we observed was large and had white hairs on the terminal end of its tail (*D. merriami* are smaller and have black terminal tail hairs).

These six observations suggest that kangaroo rats can constitute an important part of the diet for certain populations of Gila Monsters. Our study site had a considerable amount of sand dunes and Creosote Bush (*Larrea tridentata*), both of which are appropriate habitat elements for *Dipodomys* (Longland and Price 1991. Ecology 72:2261–2273; Schroder 1987. Ecology 68:1071–1083). Most previous ecological studies of Gila Monsters have been conducted at sites lacking sand dunes (Beck 2005, *op. cit.*), hence *Dipodomys* might not be available prey to those populations. Additionally, our Nevada study site lacks conspicuous populations of Desert Cottontail Rabbits (*S. audubonii)*, which constitute the most common food item at other study populations of Gila Monsters (populations in Arizona and Utah; Beck 2005, *op. cit.*).

Submitted by **C. M. GIENGER** and **C. RICHARD TRACY**, Program in Ecology, Evolution, and Conservation Biology, Department of Biology, University of Nevada, Reno, Reno, Nevada 89557, USA (e-mail [CMG]: gienger@biodiversity.unr.edu).

HEMIDACTYLUS MABOUIA (Tropical House Gecko). **HUMAN-INDUCED INTRODUCTION.** *Hemidactylus mabouia* occurs in urban and other anthropogenic environments as well as varied less disturbed habitats such as tropical rainforest, sand dunes and rock outcrops (Teixeira 2001. Atlântica 23:77–84). A small lizard native to sub-Saharan Africa, it was accidentally introduced to and has colonized most of the South and Central America and Florida (Butterfield et al. 1993. Herpetol. Rev. 24:111–112), Caribbean islands (Townsend and Krysko 2003. Florida Scient. 66:204–208), and Atlantic islands such as Cape Verde (Jesus et al. 2001. J. Herpetol. 35:672–675), Madeira (Jesus et al. 2002. Herpetozoa 15:179–180), São Thomé and Príncipe (Jesus et al. 2005. Mol. Phylogenet. Evol. 34:480–485), and the Abrolhos Archipelago, 70 km off the Brazilian coast (Rocha et al. 2002. Braz. J. Biol. 62:285–291). Populations in the Gulf of Guinea and Macronesian islands are genetically homogenous likely as a result of recent introductions (Jesus et al. 2005, *op. cit.*). Introduction to the Brazilian mainland likely occurred through slave ships from Africa (Vanzolini 1968. Arq. Zool. São Paulo 17:1–84). Here, we describe the recent colonization of the oceanic Trindade Island in the mid-Atlantic Ocean and discuss the likely introduction event. Trindade Island, located 1140 km off the Brazilian coast, is a small volcanic island (5 km × 2.5 km) with an area of 13.5 km^2 and elevations over 600 m (Almeida et al. 2001. *In* Schobbenhaus et al. [eds.], Sítios Geológicos e Paleontológicos do Brasil, pp. 369–377. DNPM, Brasília, Brazil). Originally covered by forests of *Colubrina glandulosa*, fire and domestic grazing (sheep and goats) drove this tree to extinction (Alves 1998. Ilha da Trindade & Arquipélago de Martin Vaz, um Ensaio Geobotânico. Serviço de Documentação da Marinha, Rio de Janeiro, Brazil). Reforestation was begun in 1994, and eradication of goats occurred over the interval 1999–2005 (Alves 2006. *In* Alves and Castro [eds.], Ilhas Oceânicas Brasileiras, da Pesquisa ao Manejo, pp. 83–104. MMA, Brasília, Brazil). Both these domestic grazers are now eradicated, but despite its success, reforestation has ceased. Apart from humans, the only terrestrial vertebrate on Trindade Island is the exotic House Mouse, *Mus musculus*, which is now abundant throughout the island. Since 1957, a small number of Navy personnel (currently ~25 people) who maintain a weather station live on Trindade Island. A boat transports food, equipment, and personnel to the island every two months.

We first observed *H. mabouia* at dusk on 31 December 2006 on a plateau above Príncipe Beach (20.5165°S, 29.3096°W; datum: Córrego Alegre; elev. 140 m) in rock outcrops bordered by the dense, tall (ca. 50 cm high) sedge, *Cyperus atlanticus*. The next day, we captured one *H. mabouia* and found one semi-buried clutch of two eggs and a second clutch of three eggs, both under rocks. Because this species typically deposits two eggs, this may have been a communal nest (Rocha et al., *op. cit.*). After this initial discovery, we made several subsequent observations of adults and juveniles. From January to April 2007, we found up to 10 individuals during search sessions lasting about 1 h, with higher num-

bers recorded near the reforestation area where we first recorded the species.

H. mabouia or their eggs were probably introduced with saplings during the reforestation interval in the late 1990s or early 2000s (Alves 2006, *op. cit*.). As no harbor exists on Trindade and because of its steep topography, saplings were usually transported from boats to the drop areas by helicopters, which would explain the absence of *H. mabouia* near human settlement. Despite the abundance of the terrestrial crab, *Gecarcinus lagostoma,* on the island that could prey on this lizard, a well-established population now exists that is apparently spreading to other areas. We also found 3 *H. mabouia* at sea level on Andradas Beach on different occasions at dusk and at night, roughly 400 m SE from the place where it was presumably first introduced. The nocturnal and crepuscular habit of *H. mabouia* is well known (Rocha et al. 2002, *op. cit*.).

Four specimens were collected and deposited in Setor de Herpetologia, Museu Nacional do Rio de Janeiro (MNRJ 17117, one juvenile collected 1 January 2007; MNRJ 17118 one adult collected 28 February 2007), and in the Museu de Biologia Prof. Mello Leitão, Santa Teresa, Espírito Santo (MBML 2107 and 2108, one juvenile recently hatched and one adult, both collected 19 January 2007). We also found exoskeleton fragments of insects and spiders underneath rocks inhabited by *H. mabouia*. Arthropods are the main prey of *H. mabouia* in Brazil in both urban (Bonfiglio et al. 2006. Biociências, Porto Alegre 14:107–111) and less disturbed coastal environment (Teixeira 2001, *op. cit*.). To our knowledge, no detailed study of the arthropods on Trindade has been undertaken, but the island is home to varied arthropod species including dragonflies, beetles, spiders, flies, moths, grasshoppers, and exotic cockroaches, and may include several introduced species as on Gough Island in the South Atlantic (Jones et al. 2003. Biol. Cons. 113:75–87). *H. mabouia* is expected to expand its distribution throughout the island and arrive at the human settlement soon. As it is the only terrestrial reptile on the island, no conservation concern for related species as a function of *H. mabouia* presence currently exists, as has occurred on other islands (Arnold 2000. Bonn. Zool. Monogr. 46:309–323), but it may represent a threat to endemic invertebrates.

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Submitted by **LEANDRO BUGONI**, University of Glasgow, Department of Environmental and Evolutionary Biology, G8 12QQ, Glasgow, United Kingdom (e-mail: L.bugoni.1@research.gla.ac.uk); **PEDRO WELFF-NETO**, Rua Diógenes Nascimento das Neves, 165/ 704, CEP 29057–670, Vitória, Espírito Santo, Brazil.

IGUANA DELICATISSIMA (Lesser Antillean Iguana). **MORTALITY.** Major natural disturbances such as hurricanes have been reported responsible for the extirpation of island biotas (Schoener et al. 2004. Proc. Natl. Acad. Sci. USA 101:177–181) and as a mechanism for overwater dispersal (Censky et al. 1998. Nature 395:556). Indeed, these catastrophic disturbances can have profound effects on insular ecosystems and influence current biogeographical patterns (Spiller et al. 1998. Science 281:695–697).

Though extirpations and population reductions have been inferred to be caused by catastrophic hurricanes, to our knowledge, direct evidence of hurricane-induced mortality on larger squamates is lacking. Here, we report direct evidence of mortality on *Iguana delicatissima* caused by Hurricane Dean. The eye of Hurricane Dean passed south of Dominica between St. Lucia and Martinique during the morning of 17 August 2007. Hurricane Dean was a Category 2 storm with sustained winds of ca. 160 kph.

On 17 August 2007, hours after Hurricane Dean struck the Commonwealth of Dominica, SV was inspecting damage along the main western coastal road east of Layou Village. Approximately 100 m N of the Layou Quarry is a 10-m wide ravine (15.3989°N, 61.4236°W, datum: WGS84; elev. 20 m), which runs down the slope of the western coastal ridge to the main coastal road. The ravine is typically dry but a 1-m diameter culvert under the road accommodates runoff. On this day, the culvert was blocked with debris, causing runoff to overflow the main coastal road as it made its way toward the sea. Rapidly moving water, ca. 35 cm deep, was choked with debris including branches, leaves, and stones. Within this debris-choked flow, SV observed the head of an adult iguana (ca. 28 cm SVL) on the surface of the road being battered by the onrushing water. The force of the water appeared to have wedged the iguana between rocks. As the iguana lacked signs of rigor mortis or decomposition, we presumed it had recently died. However, whether the iguana was dead prior to becoming wedged in the rocks or it drowned as a result of being trapped in the rushing water was unclear.

On 19 August 2007, CRK was inspecting hurricane damage on a communal iguana nesting area (ca. 72 m^2) located on the coastal slope between the main western coastal road and Batali Beach (15.4497°N, 61.4478°W; elev. 16 m). The storm caused the upper portion of the ridge to fail, resulting in a landslide of large boulders (up to 2 m long; 1 m high) and trees. The heavy rains also caused severe erosional rutting up to 1.5 m deep. Twenty-five torn and crushed iguana eggs with near-term neonates were counted scattered about the lower and middle portions of the slope. One dead hatchling iguana was discovered partially unearthed while trapped in a 2-cm wide collapsed exit burrow located toward the lower portion of the slope. A group of dead hatchlings was found 5 m above the first hatchling. Three iguanas in the group were visible, protruding partially from the surface of the slope while 14 others were entombed just under the surface. All hatchlings were facing the same outward direction and appeared to be in the process of exiting the same ca. 10 cm wide collapsed tunnel of compressed soil. Three hatchlings had crushed skulls. These animals are presumed to have died in their exit burrow as a result of the landslide.

Hurricane season in the Caribbean is typically from 1 June to 30 November, which encompasses the incubation and emergent period for *I. delicatissima* hatchlings, and therefore can impact not only existing iguana populations but also the annual recruitment of hatchlings into these populations. In fact, hurricanes have been implicated in population declines of *I. delicatissima* on the Petite Terre Islands in the French West Indies (Lorvelec et al. 2004. Rev. Ecol. Terre Vie 59:331–344). By reporting mortality in multiple life stages (egg, hatchling, adult), our observations provide evidence for the ecological mechanisms of such population declines caused by catastrophic disturbance.

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Submitted by **CHARLES R. KNAPP,** Conservation and Research for Endangered Species, Zoological Society of San Diego, 15600 San Pasqual Valley Road, Escondido, California 92027, USA (e-mail: cknapp@ufl.edu); and **SHERMAIN VALERI**, Layou Village, Commonwealth of Dominica, West Indies.

LEIOCEPHALUS CARINATUS (Northern Curly-tail Lizard). **SAP FEEDING**. Despite their widespread distribution and locally high densities throughout the Caribbean, the natural history of lizards in the genus *Leiocephalus* is relatively poorly known. The few studies of *Leiocephalus* diet suggest that these lizards are omnivorous, eating vegetation, insects, and vertebrates, including lizards (Fong G. and Del Castillo 2002. Herpetol. Rev. 33:205–206; Jenssen et al. 1989. Anim. Behav. 38:1054–1061; Micco et al. 1997. Herpetol. Nat. Hist. 5:147–156; Schoener et al. 1982. Oecologia 53:160–169; Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. University of Florida Press, Gainesville. 720 pp.). They can also be scavengers (Iverson and Smith 2006. Herpetol. Rev. 37:345–346). Here, we describe a previously unreported potential food source for *Leiocephalus carinatus*.

On 25 June 2007, we observed an adult *L. carinatus* (sex unknown) feeding on the sap of a Bay Cedar (*Suriana maritima*) on Alligator Cay, Exumas, Bahamas (24.3931°N, 76.6428°W, datum: WGS84; elev. 2 m; see Knapp 2001. J. Herpetol. 35:239–248 for description of the island). The sap originated from a crack in a branch of the Bay Cedar. The lizard was observed to lick the surface of the Bay Cedar branch repeatedly at the location of sap "bubbles," which disappeared when the lizard licked them, suggesting that the tongue was used to consume the sap, rather than being used in exploratory tongue-flicking behaviors (digital video available from authors). To date, sap feeding has been documented in only one other lizard, the gecko *Gehyra australis* (Letnic and Madden 1997. West. Austr. Nat. 21:207–208; see review by Cooper and Vitt 2002. J. Zool. 257:487–517). Combined with the previous observations on the diets of *Leiocephalus*, our results suggest that these lizards are more broadly omnivorous than previously recognized.

Submitted by **GEOFFREY R. SMITH**, Department of Biology, Denison University, Granville, Ohio 43023, USA (e-mail: smithg@denison.edu); **LYNNE PIEPER**, College of Education, University of Illinois at Chicago, Chicago, Illinois 60607, USA (e-mail: lypieper@juno.com); and **JOHN B. IVERSON**, Department of Biology, Earlham College, Richmond, Indiana 47374, USA (e-mail: johni@earlham.edu).

PLESTIODON REYNOLDSI (Florida Sand Skink). **ALBINISM**. *Plestiodon reynoldsi*, a federally threatened species, is restricted

Fig. 1. Albinistic and typical juvenile of *Plestiodon reynoldsi*.

to upland scrub and sandhill habitats in central Florida (McCoy et al. 1999. Conserv. Biol. 13:190–194). On 1 September 2007, we collected an albino juvenile (30.5 mm SVL, 27.0 mm tail; 0.18 g) in an Inopina Oak (*Quercus inopina*) scrubby flatwood at Archbold Biological Station, Lake Placid, Highlands Co., Florida, USA (27.1346°N, 81.3597°W, datum: WGS84; elev. 40 m). This individual was recaptured at the same location on 16 and 19 September 2007. Albinism has never before been reported in *P. reynoldsi*. The background color was pink with a paler dorsal area and little contrast between dorsal and either the lateral or ventral coloration (Fig. 1). Juveniles are typically gray-brown with a distinctly dark brown lateral band from the snout to the tip of the tail on each side of the body. The heart, major circulatory system vessels, and parts of the digestive system were visible through its ventral side. Non-albino juveniles have a pattern of small, dark brown spots on a gray-brown light background on top of the head, whereas this albinistic juvenile had but one slightly darker spot on one of the parietal scales against a pale pink bakground. The irises of the albino juvenile were red (black in typical juveniles). We deposited digital color images of the specimen in the Calphotos database (http://calphotos.berkeley.edu/).

Submitted by **ALESSANDRO CATENAZZI**, **HENRY R. MUSHINSKY**, and **EARL D. McCOY**, Division of Integrative Biology, University of South Florida, Tampa, Florida 33142, USA (e-mail: acatenazzi@gmail.com).

SCELOPORUS POINSETTII (Crevice Spiny Lizard)**. DIET.** Lizards of the genus *Sceloporus* are mainly insectivorous (e.g., Ballinger 1978. Southwest. Nat. 23:641–649; Goldberg and Bursey 1990. J. Herpetol. 24:446–448; Pough 1973. Ecology 54:837–844), with notable herbivorous exceptions (*Sceloporus torquatus torquatus;* Búrquez et al. 1986. J. Herpetol. 20:262–264; *S. poinsettii*; Ballinger et al. 1977. Amer. Midl. Nat. 97:482–484). Ballinger et al. (*op. cit.*) described a shift in diet preference from insects to plants during ontogeny in *S. poinsettii*. We examined the diets of 21 *S. poinsettii* from northwestern Mexico, including 11 juveniles (44–93 mm SVL), 5 young adults (83–93 mm SVL), and 5 older adults (93–100.2 mm SVL), allowing examination of any potential ontogenetic dietary shift. As part of a taxonomic and

TABLE 1. Prey taken from 21 *Sceloporus poinsettii* stomachs from northwestern Chihuahua, México.

Prey Taxon	Individuals		Items		Volume	
	N	%	N	%	cm³	%
Invertebrates						
Annelida	1	4.8	1	0.3	0.20	1.1
Insecta						
Coleoptera						
Adults	12	57.1	37	12.4	6.96	37.8
Larvae	1	4.8	1	0.3	0.02	0.1
Hemiptera	1	4.8	1	0.3	0.32	1.7
Homoptera	2	9.5	4	1.3	0.41	2.2
Hymenoptera						
Ants	4	19.1	156	52.2	5.06	27.5
Other	1	4.8	1	0.3	0.03	0.2
Isoptera	4	19.1	83	27.8	0.16	0.9
Orthoptera	4	19.1	83	27.8	0.16	0.9
Grasshoppers	1	4.8	1	0.3	0.09	0.5
Other	9	42.9	13	4.4	4.77	25.9
Unknown	4	19.1	83	27.8	0.16	0.9

distributional survey of the Chihuahuan Desert and surrounding areas (Lemos-Espinal et al. 2004. Introducción a los Anfibios y Reptiles del Estado de Chihuahua. UNAM/CONABIO, Ciudad de México. 128 pp.), specimens were captured in spring and summer 2001 and 2002 from various localities in northwestern Chihuahua, México. We removed their stomachs by dissection for dietary analysis. SVL, head-length (HL), and head-width (HW) were measured with digital calipers to the nearest 0.1 mm. We identified prey items to the lowest possible taxonomic category, usually order. We measured prey length and width with digital calipers to the nearest 0.1 mm and calculated prey volumes using the formula for a prolate spheroid (Vitt et al. 2005. Herpetol. Monogr. 19:137–152).

The *S. poinsettii* that we examined consumed nearly 100% insect material, with ants being most important numerically (156) and beetles being the most important volumetrically (37.83%) (see Table 1). We found no significant relationships among SVL, HL, or HW; and prey length, width, or volume (all $P > 0.30$).

Our findings are contrary to those of Ballinger (*op. cit.*) and Ballinger et al. (*op. cit.*) who report ontological diet shifts from insects to plants. Our samples showed no such shift. Thus, ontogenetic dietary shifts in *S. poinsettii* seem to vary among populations.

Submitted by **CHRISTOPHER J. DIBBLE, GEOFFREY R. SMITH,** Department of Biology, Denison University, Granville, Ohio 43023, USA (e–mail: smithg@denison.edu); and **JULIO A. LEMOS–ESPINAL**, Laboratorio de Ecología, Tecnología y Prototipos, Facultad de Estudios Superiores Iztacala, UNAM, Apartado Postal 314, Avenida de Los Barrios No. 1, Los Reyes Iztacala, Tlalnepantla, Estado de México, 54090 México (e-mail: lemos@servidor.unam.mx).

TRACHYDOSAURUS RUGOSUS ASPER (Shingle Back, Boggi, or Pine-cone Lizard) **PREDATION**. *Trachydosaurus rugosus*, including four subspecies, is a lizard widespread across much of the southern half of continental Australia and selected western off-shore islands (Shea 1992. Unpubl. Ph.D. thesis, University of Sydney; Shea 2000. *In* Hauschild et al. [eds.], Blauzungenskinke. Beitrage zu *Tiliqua* und *Cyclodomorphus*, pp. 108–112. Natur und Tier Verlag, Munster), but few records of its predators exist. This note documents an observation of predation on *T. r. asper* by Wedge-tailed Eagles, *Aquila audax*.

At ~0900 h on 8 December 2007, MD observed 3 *A. audax* ca. 40 km N of Conargo, New South Wales, on Conargo-Carrathool Road ca. 400 m S of its intersection with Steam Plains Road (35.0708°S, 145.3779°E, datum: WGS84; elev. 110 m). Two were sitting on a stock watering-trough drinking, and the third was circling in the air ~100 m distant from the other two. The latter was observed to swoop to the ground, where it stood erect with its head above the grass; when approached by the observer to within 25 m, it flew into the air ~4 m above the ground with an adult *T. r. asper* (ca. 25 cm SVL) in its talons, and briefly hovered for 2–3 seconds until the observer veered off. The *A. audax* then settled back on the ground, where it was joined by one of the other two eagles; both then commenced feeding on the lizard. Habitat was very open *Acacia pendula* woodland with sparse graminoid herbaceous layer; air temperature was ~22°C, with no cloud cover and no wind. *A. audax* is a well-known scavenger of road-kills and farm animal mortalities, and as a predator of small wallabies and introduced rabbits, however predation on reptiles is somewhat unusual. Interestingly, an *A. audax* was observed to seize a live adult Eastern Brown Snake, *Pseudonaja textilis*, in March 2007, ca. 16 km S of Riverina Highway on Aratula Road (Katrina Molesworth, pers. comm.), which is ca. 50 km SW of the above locality. There has been an extended drought in the region over the previous four years, which might partly explain the willingness of *A. audax* to take reptilian prey in this region, as rabbits and road-kills are currently few.

We thank M. Hayes for editorial suggestions.

Submitted by **DEAN C. METCALFE**, PO Box 4056, Werrington, New South Wales, Australia 2747 (e-mail: dean_metcalfe@yahoo.com.au); and **MARTIN DRIVER**, Murray Catchment Management Authority, PO Box 835, Deniliquin, New South Wales, Australia 2710 (e-mail: Martin.Driver@cma.nsw.gov.au).

TROPIDURUS OREADICUS (Neotropical Ground Lizard). **DIET**. *Tropidurus oreadicus* occurs in savanna-like habitats. In Belém, it is usually seen on the trunks of isolated trees, and in some places, on walls and fences; in Amazonia, the species is also frequently terrestrial (Ávila-Pires 1995. Lizards of Brazilian Amazonian [Reptilia:Squamata]. Zool. Verhandelinger 299:1–706). Food consists of diverse insect arthropods, but can sometimes include centipedes, millipedes, and plant matter (Ávila-Pires, *op. cit.*). However, arthropod prey are typically not identified to species. Here I describe an observation of an adult *T. oreadicus* preying on an adult centipede, *Scolopendra viridicornis*.

At 1120 h on 13 July 2006, I found an adult male *T. oreadicus* (ca. 110 mm SVL) running in the leaf litter with an adult (ca. 85

mm) *S. viridicornis* in its mouth in a urban park of Museu Paraense Emílio Goledi (MPEG) (1.4523°S, 48.4762°W, datum: WGS84, elev. 25 m), where the trees are closely spaced but significant open areas still exist. The *T. oreadicus* exhibited some difficulty ingesting the centipede because its caudal appendices and the last two pair of legs were protruding from the lizard's mouth for 9 min before the lizard was able to completely swallow it.

My observation reveals that medium-sized (> 90 mm) centipedes can be vulnerable to medium-sized lizards, like *Tropidurus* species. In 71 *T. oreadicus* stomachs, centipedes were present in six (Ávila-Pires, *op. cit.*). Scolopendromorph centipedes can deliver a painful bite that has potential medical implications for humans and have been reported to sometimes prey upon small lizards (Lewis 1981. The Biology of Centipedes. Cambridge University Press, Cambridge, United Kingdom. 476 pp.), so they may present some risk that is in part related to size. *Scolopendra viridicornis* is a common large or medium-sized species in Brazil that can also be found in Guyana, Venezuela, Bolivia, Paraguay, and Argentina (Adis 2002. *In* Adis [org.], Amazonian Arachnida and Myriapoda—Identification Keys to All Classes, Orders, Families, Some Genera, and Lists of Known Terrestrial Species. Pensoft Publishers, Sofia, Bulgaria. 590 pp.).

Submitted by **FERNANDO DA SILVA CARVALHO-FILHO,** Departamento de Biologia, Universidade Federal do Pará, Rua Augusto Corrêa, 01, CEP 66040-170, Guamá, Belém-PA, Brazil; e-mail: fernanbio@yahoo.com.br.

TROPIDURUS OREADICUS (Neotropical Ground Lizard). **CNEMIDOPHORUS LEMNISCATUS** (Rainbow Whiptail). **PREDATION.** *Tropidurus oreadicus* and *Cnemidophorus lemniscatus* are common lizards in open and sunny areas in eastern Amazonia (Ávila-Pires 1995. Lizards of Brazilian Amazonian (Reptilia: Squamata). Zool. Verhandelinger 299:1–706). Hawks of the genera *Leucopternis* and *Gampsonyx* and the Common Egret, *Egretta alba,* are documented avian predators of *C. lemniscatus* (Hoogmoed 1973. Biogeographica 4:1–419; Ávila-Pires, *op. cit.*), but few avian predators of *T. oreadicus* have been reported (Ávila-Pires, *op. cit.*). Here, I describe an observation of Guira Cuckoo (*Guira guira*) predation on *T. oreadicus* and *C. lemniscatus* from northern Brazil.

At 1520 h on May 2006, a clear sunny day, I observed a flock of 11 adult *G. guira* foraging on mowed grass on the campus of Universidade Federal do Pará, Belém, Pará State, Brazil (1.47°S, 48.45°E). During my observation, I noted a disturbance in bird group as one member of flock arose with a dead juvenile of *T. oreadicus* (ca. 5 cm SVL) in its bill. The *G. guira* began to run to avoid another member of its flock that tried to steal the lizard. When the *G. guira* with the lizard had distanced itself from its congener, it swallowed the lizard by head first. The entire predation episode took 9 min.

Forty minutes later, I noted another *G. guira* with a *C. lemniscatus* (ca. 10 cm SVL) in its beak. The lizard, held sideways by its neck, was entirely limp (including tail and limbs) and seemed dead. The lizard remained limp during the entire 2 min observation period, after which the *G. guira* flew out of view with its prey to a nearby tree, because three members of its flock simultaneously tried to steal the lizard.

Our observations suggest that *G. guira* may be important lizard predators in open habitats. The Guira Cuckoo, one of the best-known abundant birds in eastern Brazil, is common in parks, cities, pastures, and plantations, but is absent from most of Amazonia because it avoids continuous forests; it is also frequent in grasslands along the Amazonian estuary (Sigrist 2006. Aves do Brasil, uma Visão Artística. Brazil, São Paulo. 672 pp.). This bird is an active forager, preying on insects and small vertebrates such as frogs, mice, and small birds (Martins and Donatelli 2001. Ararajuba 9:89–94; Sigrist 2006, *op. cit.*), but few records exist of its preying on lizards.

Submitted by **FERNANDO DA SILVA CARVALHO-FILHO,** Departamento de Biologia, Universidade Federal do Pará, Rua Augusto Corrêa, 01, CEP 66040-170, Guamá, Belém-PA, Brazil; e–mail: fernanbio@yahoo.com.br.

SQUAMATA — SNAKES

BOTHROPS ASPER (Terciopelo). **PREDATION.** Few predators of neotropical lanceheaded pitvipers (*Bothrops*) have been identified (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Cornell University Press, Ithaca, New York. xviii+870+[28] pp.). I herein report predation on *B. asper* by a land crab (*Gecarcinus quadratus*, Gecarcinidae). On 26 August 2003 at 2000 h I found a juvenile *B. asper* (SVL ca. 60 cm) coiled up next to a trail in the coastal rain forest near La Leona station, Corcovado National Park, Peninsular de Osa, Costa Rica. When I passed the spot again at 2230 h, the snake was dead, with the anterior half of its body laying inside a hole in the ground. The hole turned out to be the burrow of a large land crab, which was found at the end of the burrow. It had already eaten the snake's head and anterior parts of the body. The short period between the two observations makes it unlikely that the snake was killed otherwise and only subsequently eaten by the crab. *Gecarcinus quadratus*, which is considered a seed and seedling predator, is abundant in the coastal forest of the Corcovado National Park, with up to six crabs / m^2 (Sherman 2002. J. Trop. Ecol. 18:67–89), and can be found several hundred meters from the coast inside the forest (pers. obs.). It is therefore possible that this crab is a regular, though opportunistic, predator of *B. asper* and other snakes in this area.

Submitted by **JONAS MAXIMILIAN DEHLING**, Department of Animal Ecology and Tropical Biology, Biozentrum, University of Würzburg, Am Hubland, D-97074 Würzburg, Germany; e-mail: Jonas.M.Dehling@stud-mail.uni-wuerzburg.de.

GEOGRAPHIC DISTRIBUTION

Instructions for contributors to Geographic Distribution appear in Volume 39, Number 1 (March 2008, p. 102). Please note that the responsibility for checking literature for previously documented range extensions lies with authors. Do not submit range extension reports unless a thorough literature review has been completed.

CAUDATA – SALAMANDERS

AMBYSTOMA JEFFERSONIANUM (Jefferson Salamander). USA: OHIO: Shelby Co.: Washington Township: Lockington Dam Road. 1.5 km NW of Lockington. (40.21633°N, 84.25759°W). 13 April 2007. Jeffrey G. Davis. Verified by John W. Ferner. Voucher specimens deposited at Cincinnati Museum Center, Frederick and Amye Geier Research and Collections Center. (CMC 10672 and 10673). New county record (Pfingsten and Matson. 2003. Ohio Salamander Atlas. Ohio Biol. Surv. Misc. Contr. No. 9).

Submitted by **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA; e-mail: anura@fuse.net.

AMBYSTOMA OPACUM (Marbled Salamander). USA: ILLINOIS: Hamilton Co.: Hamilton County State Fish and Wildlife Area, vernal pond ca. 1.2 km SE of the Dolan Lake spillway parking lot (38.0508333°N, 88.3913889°W). 20 Jan 2008. Cy L. Mott. Verified by Ronald A. Brandon. SIUC H-8684. Larval specimens. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.).

Submitted by **CY L. MOTT**, Cooperative Wildlife Research Laboratory, Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901, USA; e-mail: cm8755@siu.edu.

AMBYSTOMA TIGRINUM (Tiger Salamander). USA: ILLINOIS: Clark Co.: Sparkling Waters Tree Farm; 500 m W of Cooper Chapel Road on Fishback Road (39.3795°N, 87.5898°W; NAD83). 20 March 2008. Andrew R. Kuhns and John A. Crawford. Verified by Christopher A. Phillips. INHS 20813. One of five males captured in minnow traps from the westernmost pond on the property. County record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois xii + 282 pp.), further verified by checking recent issues of *Herpetological Review* and databases located at the Illinois Natural History Survey containing records of amphibians and reptiles from Illinois in 30 museum and private collections and unvouchered records from herpetologists and other state biologists. We thank the Pickering Family for granting us access to their ponds, and the Illinois Wildlife Preservation Fund for financial support.

Submitted by **ANDREW R. KUHNS**, Illinois Natural History Survey, Division of Biodiversity and Ecological Entomology, Section of Biotic Surveys and Monitoring, 1816 South Oak Street, Champaign, Illinois, USA (e-mail: arkuhns@uiuc.edu); and **JOHN A. CRAWFORD**, Indiana University, School of Medicine – TH and Lakehead University, Faculty of Forestry and Forest Environment, 135 Holmstedt Hall, Terre Haute, Indiana 47809, USA (e-mail: jcrawford10@isugw.indstate.edu).

AMPHIUMA PHOLETER (One-toed Amphiuma). USA: ALABAMA: Covington Co.: Found under log in saturated muck of seepage in Conecuh National Forest, 50 m SW of Covington CR 24 bridge over Pond Creek (31.1015°N, 86.5390556°W). 28 March 2007. S. Graham. Verified by C. Guyer. AU 37412. New county record. This is only the third time this species has been reported in Alabama, and this specimen is the first voucher for this species collected in Alabama since 1985 (Carey 1985. Herpetol. Rev. 16:31). This record extends this species' range ca. 50 km N from the closest populations to the south (Eglin AFB). *Amphiuma pholeter* exists syntopically at this locality with *Pseudotriton ruber*, *Desmognathus cf. conanti*, *Eurycea cirrigera*, and *Amphiuma means*.

Submitted by **SEAN GRAHAM** , Auburn University Department of Biological Sciences, 331 Funchess Hall, Auburn University, Auburn, Alabama 36849, USA.

BOLITOGLOSSA PLATYDACTYLA (Broad-footed Mushroom-tongued Salamander). MÉXICO: HIDALGO: Municipality of Huejutla de Reyes (21.04543°N, 98.24259°W; WGS849), 148 m elev. 31 March 2006. A. Ramírez-Bautista and U. Hernández-Salinas. Verified by G. Parra. Herpetology collection, Laboratorio Ecología de Poblaciones, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo, México (UHS-UAEH-00057). First record for Municipality and second for state, and a range extension of 20 km W from the closest record at Chapulhuacán, Hidalgo (Smith and Taylor 1966. Herpetology of Mexico. Annotated Checklist and Keys to the Amphibians and Reptiles. A reprint of Bulletins 187, 194, and 199 of the USNM. Eric Lundeberg, Ashton, Maryland. 610 pp.). The salamander was found under a log in rainforest. Field work was funded by SEP-PROMEP-1103.5/03/1130, Projects PIFI-PROMEP 3.3. 2007, CONACYT-S 52552-Q, and CONACYT-43761.

Submitted by **URIEL HERNÁNDEZ SALINAS** (e-mail: hu128613@uaeh.reduaeh.mx), **AURELIO RAMÍREZ BAUTISTA** (e-mail: aurelior@edu.uaeh.mx), and **ADRIAN LEYTE-MANRIQUE,** Centro de Investigaciones Biológicas (CIB), Universidad Autónoma del Estado de Hidalgo, A. P. 1-69 Plaza Juárez, C.P. 42001, Pachuca, Hidalgo, México (e-mail: leytebi2@yahoo.com.mx).

NECTURUS MACULOSUS (Mudpuppy) CANADA: MANITOBA: Berens River. Single larva collected while electro-fishing over shallow bedrock outcrop along the south shore of the Berens River (ca. 52.3291417°N, 96.918713°W). 15 August 1991. University of Manitoba, Department of Zoology (MZH17; field sample KWS 91-22). Verified by K.W. Stewart, University of Manitoba. Previously known only to about 51°N around southern end of the Narrows of Lake Winnipeg, Manitoba (Preston 1982. The Amphibians and Reptiles of Manitoba. Manitoba Museum of Man and Nature, Winnipeg, Manitoba. 128 pp.); new record is ca. 110 km N of previously known range.

Submitted by **GAVIN F. HANKE**, Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia, V8W 9W2 Canada; e-mail: ghanke@royalbcmuseum.bc.ca.

NECTURUS MACULOSUS (Common Mudpuppy). USA: NORTH CAROLINA: Alleghany Co.: Adult caught in minnow trap in New River at New River State Park, 18.8 km airline NW Sparta. 09 March 2007. Lori Williams, Ed Corey, and New River State Park staff, Jeff Matheson, and Paul Bailey. First documented record in the New River for Alleghany County (Williams 2007. NC NHP Special Animal Survey Form). Specimen verified by Jeffrey C. Beane. North Carolina State Museum of Natural Sciences photo voucher (accession number 12194). Closest previous historical record is one occurrence from the New River at New River State Park in Ashe Co., North Carolina, 16 km airline SSW (Williams and Corey. 2007. Herpetol. Rev. 38:472.)

Submitted by **LORI A. WILLIAMS**, North Carolina Wildlife Resources Commission, 177 Mountain Laurel Lane, Fletcher, North Carolina 28732, USA; and **J. EDWARD COREY III**, North Carolina Division of Parks and Recreation, 12700 Bay Leaf Church Road, Raleigh, North Carolina, 27614-9633, USA.

NOTOPHTHALMUS VIRIDESCENS (Red-spotted Newt). CANADA: ONTARIO: Lake of the Woods. Single eft found under barrel when outhouse was renovated 02 September 1991, (49.4352111°N, 94.0198333°W). University of Manitoba, Department of Zoology (MZH27). Verified by K. W. Stewart, University of Manitoba. Collected by W. G. Franzin (Department of Fisheries and Oceans, Winnipeg) along with a *Plethodon cinereus*. This specimen is from the western-most limit of the species' range, with the nearest record in the Ontario Ministry of Natural Resources database at 49.4236111°N, 94.0877778°W (Oldham and Weller 2000. Ontario Herpetofaunal Atlas. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. http://www.mnr.gov.on.ca/MNR/nhic/herps/ohs.html (updated 15-01-2001). http://nhic.mnr.gov.on.ca/herps/salamanders.html http://nhic.mnr.gov.on.ca/herps/Northern_Ont/Salamanders/cene.jpg). See also the generalized range map by MacCulloch (2002. Amphibians and Reptiles of Ontario. Royal Ontario Museum, Toronto, Ontario. 168 pp.).

Submitted by **GAVIN F. HANKE**, Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia, V8W 9W2 Canada; e-mail: ghanke@royalbcmuseum.bc.ca.

NOTOPHTHALMUS VIRIDESCENS LOUISIANENSIS (Central Newt). USA: ARKANSAS: Dallas Co.: 5.6 km S Sparkman off St. Hwy 7 at Brushy Creek (Sec. 15, T10S, R17W). 07 May 1986. Henry W. Robison. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ 30829). New county record filling a distributional gap between Clark and Cleveland counties (Trauth et al. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.), and leaving only Lafayette County without documentation of *N. v. louisianensis* for all of south Arkansas.

Submitted by **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@saumag.edu); and **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: drctmcallister@aol.com).

NOTOPHTHALMUS VIRIDESCENS LOUISIANENSIS (Central Newt). USA: MISSOURI: Perry Co.: larva found in farm pond near PCR 606, Biehle (37.644444°N, 89.8575°W; WGS84). 02 September 2006. Collected by Richard L. Essner, Jr., Paul E. Brunkow, Roma Patel, Daniel L. Huff, and James H. Robins. Verified by Ralph W. Axtell, Southern Illinois University Edwardsville (SIUE 2949). New county record. This is the first report from Perry County (Daniel and Edmond 2008. Atlas of Missouri Reptiles and Amphibians for 2007).

Submitted by **RICHARD L. ESSNER, JR.** (e-mail: ressner@siue.edu)**, PAUL E. BRUNKOW** (e-mail: pbrunko@siue.edu), **ROMA PATEL, DANIEL L. HUFF,** Department of Biological Sciences, Southern Illinois University Edwardsville, Illinois, 62026, USA; and **JAMES H. ROBINS** Department of Biology, Southeast Missouri State University, Cape Girardeau, Missouri, 63701, USA (e-mail: jhrobins@semo.edu).

PLETHODON GLUTINOSUS (Slimy Salamander). USA: ILLINOIS: Hamilton Co.: Hamilton County State Fish and Wildlife Area, forested hillside ca. 10 m S of Kiwanis Point Picnic Area (38.060277°N, 88.4°W). 06 Oct 2007. Cy L. Mott. Verified by Ronald A. Brandon. SIUC H-8683. Adult specimen. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.).

Submitted by **CY L. MOTT**, Cooperative Wildlife Research Laboratory, Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901, USA; e-mail: cm8755@siu.edu.

PLETHODON MISSISSIPPI (Mississippi Slimy Salamander). USA: TENNESSEE: Gibson Co.: Bradford (36.03358°N, 88.47916°W; datum WGS 84). 04 February 2008. Joshua M. Hall. Verified by A. Floyd Scott. Austin Peay State University's David H. Snyder Museum of Zoology (APSU 18883 [color photo]). Two adult specimens found underneath damp log in heavily wooded area; one photographed and released. New county record (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Austin Peay State Univ. Misc. Publ. 12:1–94; Redmond and Scott 1996. Atlas of Amphibians in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. http//www.apsu.edu/amatlas/).

Submitted by **JOSHUA M. HALL**, 4105 Caldwell Drive, Milan, Tennessee 38358, USA.

ANURA – FROGS

ATELOGNATHUS JEINIMENENSIS. ARGENTINA: SANTA CRUZ: Departamento Lago Buenos Aires: 71 km by road (50 km air line) S of Los Antiguos (46.977444°S, 71.828222°W; datum: WGS84; 1256 m elev.). 23 March 2007. A. Scolaro. Herpetological collection, Museo de La Plata, Buenos Aires (MLP A 4994–4999, three adults and three juveniles, collected at a small stream in the arid Patagonian steppe). Verified by J. D. Williams. The species was only known from the type locality, a small pond in the Reserva Nacional Lago Jeinimeni, southern Chile, 46.8332222°S, 71.99925°W (Meriggio et al. 2004, Bol. Mus. Nac. Hist. Nat. Chile 53:99–123), and is listed as Near Threatened by the IUCN, Conservation International, and NatureServe (2006, Global Amphib-

ian Assessment. <www.globalamphibians.org>). The habitat differs from the type locality in lacking a *Nothofagus pumilio* forest. First country record, extends the known range of the species to the E of the Andes, 20.7 km air line SE from the type locality.

Submitted by **ALEJANDRO SCOLARO, LIZA B. MARTINAZZO,** and **NESTOR G. BASSO,** Centro Nacional Patagónico, Blvd. Brown 2825, 9120 Puerto Madryn, Chubut, Argentina.

BATRACHYLA ANTARTANDICA (Marbled Wood Frog). CHILE: DE LOS RIOS REGION (XIV): Valdivia Province, San Pablo de Tregua Farm (39.6127778°S, 72.0911111°W) 30 km by road from Panguipulli City. 09 December 2007. C. Cuevas and Y. Ugarte. Colección de Anfibios del Instituto de Zoología, Universidad Austral de Chile, Valdivia (IZUA 0001, female). The locality is in Pre-Andean Mountain (692 m elev.) with native forest dominated by *Nothofagus dombeyi*, *Laurelia philippiana*, and *Saxogotea conspicua*.Verified by R. Formas. *Batrachyla antartandica* has a wide distribution along the Andes (54.9333333°S to 40.5833333°S), and Coastal Range (42.6333333°S to 39.3833333°S) (Atalah and Sielfeld 1976. Anales del Instituto de la Patagonia [Chile] 7:169–170; Díaz and Ortiz 2003. Revista Chilena de Historia Natural 76:509–525). Northernmost record for the species along the Andes Range, extends distribution 102 km N from Puyehue (40.7497222°S, 72.2008333°W) the closest record previously known (Formas 1979. *In* W. E. Duellman [ed.], The South American Herpetofauna, pp. 341–379. Monograph 7, Museum of Natural History, University of Kansas).

Submitted by **CÉSAR C. CUEVAS**, Instituto de Zoología, Universidad Austral de Chile, Casilla 567, Valdivia-Chile (e-mail: ccuevas@uach.cl); and **YURI E. UGARTE**, Instituto de Botánica, Universidad Austral de Chile, Casilla 567, Valdivia-Chile (e-mail: yuriugarte@uach.cl).

BUFO OLIVACEOUS (Olivaceous Toad): INDIA: HARYANA: Gurgaon District: Sultanpur Bird Sanctuary (28.6166667°N, 77.0666667°E, 230 m elev.). 16 August 2006. Sukumar Ray and Sukesh Ray. ZSIC A 10667. Verified by Saibal Sengupta and compared with syntypes, ZSIC 3523–3525 from Balochistan, Pakistan. Adult male, SVL 54.6 mm. Found on moist ground, ca. 20 m from wetland. Previously known from Baluchistan Province, Pakistan (Blanford 1874. Ann & Mag. nat. Hist. Ser 414:35). Eastward range extension by ca. 750 km and a new record for India. We are grateful to the Director, ZSI, for support.

Submitted by **SUKUMAR RAY** and **KAUSHIK DEUTI**, Zoological Survey of India, 27 Jawaharlal Nehru Road, Kolkata 700 016, West Bengal, India; e-mail: kaushikdeuti@rediffmail.com.

CACOSTERNUM PLIMPTONI (Plimpton's Dainty Frog). ETHIOPIA: OROMIA REGION: Awash River, 40 km SW of Addis Ababa (08.84635°N, 38.4570333°E), 2048 m elev. 24 July 2006. B. M. Zimkus, R. Kerney, and D. Pawlos. AAU A2008–324–346 (23 specimens). Muti Deyo, 53 km S of Addis Ababa (08.6536333°N, 38.58155°E), 2108 m elev. 24 July 2006. B. M. Zimkus, R. Kerney, and D. Pawlos. AAU A2008-356–360 (5 specimens). Verified by D. C. Blackburn. Originally documented from northern Tanzania and highlands of Kenya (Channing et al. 2005. African J. Herpetol. 54[2]:139–148). New country records for Ethiopia, substantially extending range ca. 1300 km NNE from type locality at Musabi Plain in Serengeti National Park, Tanzania. Original species description postulated that populations isolated in Ethiopia as *C. boettgeri,* were in fact, *C. plimptoni*; additional study required to confirm this.

Submitted by **BREDA M. ZIMKUS,** Department of Organismic and Evolutionary Biology, Harvard University, 26 Oxford Street, Museum of Comparative Zoology, Cambridge, Massachusetts 02138, USA; e-mail: bzimkus@oeb.harvard.edu.

HEMIPHRACTUS SCUTATUS (Spix's Horned Treefrog). BOLIVIA: PANDO: Nueva Esperanza, Province Federico Román (10.0635278°S, 65.4026111°W; 114 m elev.). 02 November 2006. A. Muñoz. Museo de Historia Natural Alcide d'Orbigny Cochabamba, Bolivia (MHNC AF 1227, Digital photo, an adult specimen found dead in forest litter). Verified by I. De la Riva. Previously known from Brazil (Porto Walter and Juruá); Colombia; Ecuador (Parque Nacional Yasuní), and Perú, (Ucayali, Iquitos and Ampiyacu), (Lehr 2001. Herpetol. Rev. 32:130–132; InfoNatura: Birds, mammals, and amphibians of Latin America. 2004: NatureServe. Available: http://www.natureserve.org/infonatura; Vitt and Caldwell 1996. Inventário e Ecologia da Herpetofauna da Amazônia: Rio Juruá, Porto Walter, Acre, Brazil. Report Proj. NSF Project DEB-9505518, unpublished report). First country record extends known distribution 164 km E from range cited by Coloma et al. 2004. (IUCN Red List of Threatened Species. <www.iucnredlist.org>).

Submitted by **ARTURO MUÑOZ-SARAVIA**, Museo de Historia Natural Alcide d'Orbigny, Casilla Postal 843, Cochabamba, Bolivia; e-mail: hyla_art@yahoo.com.

HYLA CINEREA (Green Treefrog). USA: ARKANSAS: Lincoln Co.: 1.6 km S Glendale off St. Hwy 54 at Sanders Creek (Sec. 8, T19S, R8W). 14 June 2003. Henry W. Robison. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ 30830). New county record filling a distributional gap between Cleveland (Robison and McAllister 2007. Herpetol. Rev. 38:245–246) and Desha counties (Trauth et al. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.).

Submitted by **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@saumag.edu); and **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: drctmcallister@aol.com).

HYLA VERSICOLOR (Gray Treefrog). USA: ARKANSAS: Searcy Co.: Off AR 14, ca. 2 km down Ramblewood Trail by private residence. 12 June 2007. J. S. Hicks, M. B. Connior. Verified by S. E. Trauth. Arkansas State University Museum of Zoology Herpetology Collection (ASUMZ 30743). First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univeristy of Arkansas Press, Fayetteville. 421 pp.).

Submitted by **MATTHEW B. CONNIOR** and **IDUN GUENTHER**, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA; e-mail: matthew.connior@smail.astate.edu.

LITHOBATES CATESBEIANUS (American Bullfrog). USA: ARKANSAS: Searcy Co.: Off AR 14, ca. 2.2 km down Ramblewood Trail in small drainage creek (36.0566°N, 92.6002°W; NAD 83). 07 October 2007. M. B. Connior. Verified by S. E. Trauth. Arkansas State University Museum of Zoology Herpetology Collection (ASUMZ 30805). First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville. 421 pp.).

Submitted by **MATTHEW B. CONNIOR,** Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA; e-mail: matthew.connior@smail.astate.edu.

LITHOBATES CLAMITANS (Green Frog). USA: ARKANSAS: Searcy Co.: Off AR 14, ca. 2.2 km down Ramblewood Trail in small drainage creek (36.0566°N, 92.6002°W; NAD 83). 06 October 2007. M. B. Connior. Verified by S. E. Trauth. Arkansas State University Museum of Zoology Herpetology Collection (ASUMZ 30806). First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univeristy of Arkansas Press, Fayetteville. 421 pp.).

Submitted by **MATTHEW B. CONNIOR,** Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA; e-mail: matthew.connior@smail.astate.edu.

LITHOBATES CLAMITANS (Green Frog). USA: TENNESSEE: Gibson Co.: Bradford (36.03175°N, 88.47956°W: datum WGS 84). 08 February 2008. Joshua M. Hall. Verified by A. Floyd Scott. Austin Peay State University's David H. Snyder Museum of Zoology (APSU 18882 [color photo]). One adult specimen found underneath damp log in drainage ditch. New county record (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Austin Peay State Univ. Misc. Publ. 12:1–94; Redmond and Scott 1996. Atlas of Amphibians in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. http://www.apsu.edu/amatlas/).

Submitted by **JOSHUA M. HALL**, 4105 Caldwell Drive, Milan, Tennessee 38358, USA.

LITHOBATES PALUSTRIS (Pickerel Frog). USA: ARKANSAS: Van Buren Co.: Choctaw at Choctaw Creek off St. Hwy 65 (Sec. 12, T10N, R14W). 10 July 1990. M. Evans. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ 30828). New county record partially filling a distributional hiatus in north-central Arkansas among Cleburne and Pope counties (Trauth et al. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.).

Submitted by **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@saumag.edu); and **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: drctmcallister@aol.com).

LITHOBATES SYLVATICUS (Wood Frog). USA: ILLINOIS: Gallatin Co.: Shawnee National Forest, vernal pond ca. 1 km from Pounds Hollow Rd. on York Lane Rd. (37.6038889°N, 88.2627778°W). 26 March 2007. Cy L. Mott. Verified by Ronald A. Brandon. SIUC H-8685. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.).

Submitted by **CY L. MOTT**, Cooperative Wildlife Research Laboratory, Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901, USA; e-mail: cm8755@siu.edu.

LITHOBATES SYLVATICUS (Wood Frog). USA: OHIO: Greene Co.: Spring Valley Township: Caesar Creek Wildlife Area. 3.5 km SE of Roxanna from floodplain of Caesar Creek. (39.57876°N, 83.93340°W). 03 June 2007. Jeffrey G. Davis. Verified by John W. Ferner. Cincinnati Museum Center, Frederick and Amye Geier Research and Collections Center (CMC 10799). New county record (Davis and Menze 2000. Ohio Frog and Toad Atlas. Ohio Biol. Surv. Misc. Contr. No. 6).

Submitted by **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA; e-mail: anura@fuse.net.

NANORANA CHAYUENSIS (Chayun Bull Frog). INDIA: WEST BENGAL: Darjeeling District: Neora Valley National Park: hill stream, 3 km from Kolakham village (27.1138889°N, 88.8905556°E, 1860 m elev.). 07 August 2007. A. K. Ayyaswamy and K. Deuti. ZSIC A10683. Verified by A. Ohler. Adult female (SVL 76.12 mm) on boulders under dense bushes, ca. 2 m from hill stream. Previously known from holotype (CIB 7319524), collected from Chayu (28°25'N, 97°06'E, 1540 m elev.), Xizang Zizhiqu Dixing, China (Ye 1977. Acta Zool. Sinica 23:58, 62). Westward range extension by ca. 920 km (map distance), and new record for India. We thank the Director, Zoological Survey of India, for support, West Bengal Forest Department for permission, and Raj Bose, Help Tourism, for logistic facilities.

Submitted by **KAUSHIK DEUTI** and **ANAND KUMAR AYYASWAMY**, Zoological Survey of India, Nizam Palace Office, 234/4 A. J. C. Bose Road, Kolkata 700 020, India; e-mail: kaushikdeuti@rediffmail.com.

NASIRANA ALTICOLA (Annandale's Frog). BANGLADESH: Rangamati District: Kaptai National Park (22.5°N, 92.2°E; 201–210 m elev). 13 July 2007. A. H. M. Ali Reza. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0082). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG] 1.24). Verified by Guin Wogan. First verified locality for Rangamati District. Reported from Dhaka (ca. 200 km NE) with no voucher specimens or photograph (Dutta 1997. Amphibians of India and Sri Lanka. Odyssey Publishing House, Bhubaneswar, India. xiii + 342 + xxii pp.). Mentioned in herpetofaunal list of Bangladesh, without voucher specimens, photographs, or locality information (Khan 2004. Cobra 57:1–31). Fieldwork supported by Cleveland Metroparks Zoo and Rufford Small Grants Foundation and conducted with permission of Bangladesh Forest Department (CCF [Wildlife]/2M–47/2006). I thank Md. Kamal Hossain from JU for assistance in the field.

Submitted by **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas

79409, USA, and Department of Zoology, Jahangirnagar University, Dhaka 1342, Bangladesh; e-mail: wild_reza@yahoo.com.

OCCIDOZYGA BOREALIS (Northern Trickle Frog). BANGLADESH: Bandarban District: Bandarban Hill District (22.1666667°N, 92.2166667°E; 195–210 m elev.). 16 July 2007. A. H. M. Ali Reza. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0088). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG] 1.23). Verified by Guin Wogan. First country record for species. Nearest population reported from Nameri National Park, Assam, > 500 km N (Pawar and Birand 2001. A Survey of Amphibians, Reptiles, and Birds in Northeast India. CERC Tech. Rep. No. 6, Centre for Ecological Research and Conservation, Mysore, India. 118 pp.). Fieldwork financed by Cleveland Metroparks Zoo and Rufford Small Grants Foundation, and was conducted with permission of Bangladesh Forest Department (CCF [Wildlife]/2M–47/2006). Thanks are due to Md. Kamal Hossain for assistance in the field.

Submitted by **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA, and Department of Zoology, Jahangirnagar University, Dhaka 1342, Bangladesh; e-mail: wild_reza@yahoo.com.

PHRYNOBATRACHUS BULLANS (Bubbling Puddle Frog). ETHIOPIA: SOUTHERN NATIONS, NATIONALITIES, AND PEOPLE'S REGION: East shore of Lake Awassa (07.04845°N, 38.4609833°E), 1692 m elev. 25 June 2006. B. M. Zimkus, R. Kerney, and D. Pawlos. AAU A2008–032. KENYA: NYANZA PROVINCE: Homa Bay (0.5166667°N, 34.45°E). 14 May 2003. D. R. Buchholz, T. B. Hayes, A. Espira, K. M. Haston, and M. Kahindi. MVZ 238716. TANZANIA: MWANZA REGION: Lamadi, near Lake Victoria (02.2434167°N, 33.8522167°E), 1145 m elev. 23 May 2000. D. R. Buchholz, T. B. Hayes, A. Vonk, E. Marquez, and A. Espira. MVZ 234151. All specimens verified by D. C. Blackburn. Originally documented from central Tanzania in the Arusha, Tabora, and Singida regions (Crutsinger et al. 2004. Afr. Zool. 39[1]:19–23). These specimens represent new country records for Ethiopia and Kenya and a new province record for Tanzania, and substantially extend range by over 1600 km N from holotype locality along Great Ruaha River, Tanzania, and suggests occurrence in additional areas in Kenya and Ethiopia. Presence in northwest Tanzania, as well as southwestern Kenya, suggests its distribution may be continuous along the shores of Lake Victoria.

Submitted by **BREDA M. ZIMKUS**, Department of Organismic and Evolutionary Biology, Harvard University, 26 Oxford Street, Museum of Comparative Zoology, Cambridge, Massachusetts 02138, USA; e-mail: bzimkus@oeb.harvard.edu.

PSEUDACRIS TRISERIATA (Upland Chorus Frog). USA: TENNESSEE: Madison Co.: Field adjacent to a creek and woodland area along Old Pinson Road (35.513291°N, 88.760154°W;WGS 84). 23 February 2006. Mandy Messer. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 18281, audio recording). New county record (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Misc. Publ. No. 12. The Center for Field Biology, Austin Peay State University, Clarksville,

Tennessee. 25 pp.). Gibson Co.: Woodland area adjacent to Rutherford Fork of the Obion River along Cades-Atwood Road (35.978074°N, 88.772482°W; WGS 84). 08 March 2006. Mandy Messer. (APSU 18257, audio recording). New county record (Redmond and Scott 1996, *op. cit.*). Carroll Co.: Grassland area with temporary pools along Cutlip Road (35.931891°N, 92.146490°W; WGS 84). 08 March 2006. Mandy Messer (APSU 18248, audio recording). New county record (Redmond and Scott 1996, *op. cit.*).

Submitted by **MANDY MESSER, LAURIE BENNIE,** and **BRIAN P. BUTTERFIELD,** Department of Biology, Freed-Hardeman University, Henderson, Tennessee 38340, USA (e-mail: bbutterfield@fhu.edu).

TESTUDINES – TURTLES

CHELYDRA S. SERPENTINA (Eastern Snapping Turtle). USA: OHIO: Champaign Co.: Urbana Township: Gravel quarry ponds in the Mad River Valley 1.5 km SW of Urbana (40.09651°N, 83.78784°W). 01 June 2007. Jeffrey G. Davis. Cincinnati Museum Center, Frederick and Amye Geier Research and Collections Center (CMC HP 469–471, photo vouchers). Clark Co.: Moorefield Township, Prairie Road Fen (39.9971833°N, 83.7092667°W). 11 April 2006. Jeffrey G. Davis. (CMC HP 252, photo voucher). Both specimens verified by John W. Ferner. New county records (Wynn and Moody 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10).

Submitted by **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA; e-mail: anura@fuse.net.

CLEMMYS GUTTATA (Spotted Turtle). USA: GEORGIA: Jeff Davis Co.: Found crossing Hwy. 107 between Snipesville and Coffee County line (31.76214°N, 82.82097°W). 26 February 2008. John B. Jensen and Dirk J. Stevenson. Verified by Elizabeth McGhee. Georgia Museum of Natural History (GMNH 50086, photographic voucher). First record for county (Jensen et al. [eds.] 2008. Amphibians and Reptiles of Georgia, Univ. Georgia Press, 575 pp.).

Submitted by **JOHN B. JENSEN**, Georgia Department of Natural Resources, Nongame Conservation Section, 116 Rum Creek Drive, Forsyth, Georgia 31029, USA (e-mail: john_jensen@dnr.state.ga.us); and **DIRK J. STEVENSON**, 414 Club Drive, Hinesville, Georgia 31313, USA.

GRAPTEMYS GEOGRAPHICA (Northern Map Turtle). USA: OHIO: Clark Co.: Springfield Township. Buck Creek below the CJ Brown Reservoir spillway (39.9502817°N, 83.7515883°W). 30 May 2006. Brian Menker. Verified by John W. Ferner. Cincinnati Museum Center (CMC Herp Photodocumentation Collection HP 254). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10, Columbus).

Submitted by **BRIAN T. MENKER**, C.J. Brown Dam and Reservoir, 2630 Croft Road, Springfield, Ohio 45503, USA (e-mail: Brian.T.Menker@lrl02.usace.army.mil); and **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier

Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA (e-mail: anura@fuse.net).

GRAPTEMYS GEOGRAPHICA (Northern Map Turtle). USA: ILLINOIS: Hancock Co.: Turtle was captured in a Mississippi River side channel between Eagle Island and the Illinois bank. Aproximate Mississippi River Mile 362 (40.37840°N, 091.39471°W). 03 June 2007. James T. Lamer, Sean E. Jenkins, Brian P. Jenkins, and Samuel W. Jenkins. INHS 20749. Verified by Chris Phillips. Specimen is a first county record and located at the Illinois Natural History Survey in Champaign/Urbana, Illinois (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.). Male turtle was captured in a Legler-style hoop net baited with Common Carp (*Cyprinus carpio*) carcasses. Turtle drowned during 24 h set. The following measurements were recorded: carapace length = 131 mm, carapace width = 95 mm, carapace height = 44 mm, plastron length = 107 mm, and mass = 236 g.

Submitted by **JAMES T. LAMER, SEAN E. JENKINS, BRIAN P. JENKINS, SAMUEL W. JENKINS,** Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA; **CHAD R. DOLAN** and **JOHN K. TUCKER,** Illinois Natural History Survey, 8450 Montclair Ave, Brighton, Illinois 62012, USA.

GRAPTEMYS PSEUDOGEOGRAPHICA (False Map Turtle). USA: ILLINOIS: Pike Co.: Turtle was dip-netted during a 300 m stretch of shoreline electro-fishing off of Denmark Island in the Mississippi River at River Mile 292 (39.54534°N, 91.13331457°W. 25 September 2006. Eric Ratcliff, Eric J. Gittinger, and Adam Carey. INHS 20222. Verified by Chris Phillips. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.). Male turtle was not immobilized during electro-fishing, but was disoriented to allow capture.

Submitted by **JAMES T. LAMER,** Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA; **JOHN K. TUCKER, CHAD R. DOLAN, ERIC RATCLIFF, ERIC J. GITTINGER,** and **ADAM CAREY**, Illinois Natural History Survey, 8450 Montclair Ave, Brighton, Illinois 62012, USA.

GRAPTEMYS PSEUDOGEOGRAPHICA (False Map Turtle). USA: ILLINOIS: Tazewell Co.: Turtle was captured in a fyke net at Lower Powerton on Illinois River; mile 151 (40.55012°N, 89.68115°W). 03 October 2006. Kevin Irons, Melissa Smith, and Nerissa Michaels. INHS 20221. Verified by Chris Phillips, Illinois Natural History Survey. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.). Male turtle was captured in a standard fyke net set perpendicular to the shoreline, set for a duration of 24 h. This individual had a *kohni* morph head pattern. Carapace length = 90 mm.

Submitted by **JAMES T. LAMER,** Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA; **JOHN K. TUCKER, CHAD R. DOLAN,** Illinois Natural History Survey, 8450 Montclair Ave, Brighton, Illinois 62012, USA; **KEVIN IRONS, MELISSA SMITH,** and **NERISSA MICHAELS,** Illinois Natural History Survey, 704 North Shrader, Havana, Illinois 62644, USA.

GRAPTEMYS PSEUDOGEOGRAPHICA PSEUDOGEOGRAPHICA (False Map Turtle). USA: FLORIDA: Columbia Co.: O'Leno State Park, Santa Fe River, 1.2 km upstream from River Sink (29.917°N, 82.574875°W; datum WGS84). 1 October 2007. Anthony Lau and Gerald R. Johnston. UF 150678. Verified by Kenneth L. Krysko. New county record. Adult male (carapace length 131 mm, plastron length 122 mm, mass 320 g) captured in turtle hoop trap baited with canned sardines and frozen fish chum. This is the only *Graptemys* that we observed in over 400 trap nights conducted during freshwater turtle surveys in O'Leno State Park from May 2006 to November 2007. This non-native species is commonly sold in the pet trade, and given its role as an omnivore in the Mississippi River drainage (Ernst et al. 1994. Turtles of the US and Canada. Smithsonian Inst. Press, Washington. 578 pp.), the potential exists for establishment if additional releases of unwanted pets occur. This is the second record of a *G. p. pseudogeographica* in Florida (K. Krysko, pers. comm, UF 121459, Miami-Dade Co.).

Submitted by **ANTHONY LAU,** Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida 32611, USA (e-mail: alau0924@ufl.edu); and **GERALD R. JOHNSTON**, Department of Natural Sciences, Santa Fe Community College, Gainesville, Florida 32606, USA (e-mail: jerry.johnston@sfcc.edu).

MESOCLEMMYS PERPLEXA. BRAZIL: CEARÁ: Viçosa do Ceará (03.3655278°S; 41.1555833°W; 707 m elev.). 29 May 2007. D. Loebmann. Verified by M. Trefaut Rodrigues. Coleção de referência do Instituto Butantan, São Paulo, Brazil (CRIB 289). Previously reported only from type locality, Serra das Confusões National Park, Piauí state (09°16'S, 43°51'W) in Bour and Zaher (2005. Papeis Avulsos Zool. 45[24]:295–311). First state record extends the species distribution nearly 780 km N from the type locality.

Submitted by **DANIEL LOEBMANN**, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Caixa Postal 199, CEP 13506-970, Rio Claro, São Paulo, Brazil; e-mail: contato@danielloebmann.com.

TERRAPENE C. CAROLINA (Eastern Box Turtle). USA: OHIO: Clark Co.: Moorefield Township. Crabill Homestead (39.9602612°N, 83.7338066°W). 21 May 2006. Brian Menker. Verified by John W. Ferner. Cincinnati Museum Center (CMC Herp Photodocumentation Collection HP 253). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10, Columbus).

Submitted by **BRIAN T. MENKER**, C. J. Brown Dam and Reservoir, 2630 Croft Road, Springfield, Ohio 45503, USA (e-mail: Brian.T.Menker@lrl02.usace.army.mil); and **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA (e-mail: anura@fuse.net).

TRACHEMYS SCRIPTA ELEGANS (Red-eared Slider). USA: FLORIDA: Columbia Co.: River Rise Preserve State Park, Santa

Fe River, 0.3 km downstream from River Rise (29.8716389°N, 82.5897917°W; datum WGS84). 13 June 2007. Gerald R. Johnston. UF 152605. Verified by Kenneth L. Krysko. New county record. Adult male (carapace length 160 mm, plastron length 148 mm, mass 680 g) captured by hand while snorkeling. A second specimen, UF 152604, was collected in Santa Fe River on 12 October 2007. This non-native turtle was previously observed in the Santa Fe River in 1987 (K. Enge, pers. comm.), 1991 (R. Ashton, pers. comm.), and 2006 (GRJ), but no voucher specimen was collected. Alachua County is the southernmost distribution where *T. s. scripta* naturally occurs (Thomas 2006. *In* P. A. Meylan [ed.]. Biology and Conservation of Florida Turtles. Chelonian Research Monog. 3:296–312). Morphological intermediates between native *T. s. scripta* and non-native *T. s. elegans* have been recorded from the Florida panhandle in Leon County (Aresco and Jackson 2006. Herpetol. Rev. 37:239–240), as well as the Santa Fe River (AL, YVK, and GRJ, pers. obs.), suggesting that *T. s. elegans* might be negatively affecting the existence of the native population.

Submitted by **ANTHONY LAU** (e-mail: alau0924@ufl.edu) and **YURII V. KORNILEV** (e-mail: yukornilev@gmail.com), Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida 32611, USA; and **GERALD R. JOHNSTON**, Department of Natural Sciences, Santa Fe Community College, Gainesville, Florida 32606, USA (e-mail: jerry.johnston@sfcc.edu).

TRACHEMYS SCRIPTA ELEGANS (Red-eared Slider). USA: ILLINOIS: Hancock Co.: 600 North County Rd. (40.17833°N, 091.46452°W) 14 May 2007. Specimen collected by James T. Lamer. INHS 20750. Verified by Chris Phillips, Illinois Natural History Survey. Specimen is a first county record and located at the Illinois Natural History Survey in Champaign/Urbana, Illinois (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.). Turtle was found dead on road between two small drainage ditches.

Submitted by **JAMES T. LAMER,** Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA; **CHAD R. DOLAN,** and **JOHN K. TUCKER,** Illinois Natural History Survey, 8450 Montclair Ave, Brighton, Illinois 62012, USA.

TRACHEMYS SCRIPTA ELEGANS (Red-eared Slider). USA: OHIO: Clark Co.: Springfield Township. Pond at Old Reid Park (39.949005°N, 83.7551133°W). 30 May 2006. Brian Menker. Verified by John W. Ferner. Cincinnati Museum Center (CMC Herp Photodocumentation Collection HP 256). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10, Columbus).

Submitted by **BRIAN T. MENKER**, C. J. Brown Dam and Reservoir, 2630 Croft Road, Springfield, Ohio 45503, USA (e-mail: Brian.T.Menker@lrl02.usace.army.mil); and **JEFFREY G. DAVIS**, Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA (e-mail: anura@fuse.net).

TRACHEMYS SCRIPTA SCRIPTA (Yellow-bellied Slider). CANADA: BRITISH COLUMBIA: Vancouver Island. Victoria, Beacon Hill Park, Fountain Pond (48.4130556°N, 23.3655556°W),

(RBCM Herpetology 1955). 02 July 2005. Verified by C. Copley, Royal BC Museum. A second female with dark facial markings identified in Beacon Hill Park, Goodacre Lake (48.415°N, 123.3641667°W), 13August 2005. A smaller third specimen with bright facial markings found in Goodacre Lake (48.415°N, 123.3641667°W), 22 April 2006. This is a first record of *T. scripta scripta* in British Columbia (Matsuda et al. 2006. Amphibians and Reptiles of British Columbia. Royal BC Museum Handbook. Victoria, British Columbia. 266 pp.). Range extension of over 3245 km northwest of Alabama (western-most state with native *T. s. scripta*), and 2220 km northwest of the western-most native range of *T. s. elegans* (range extension estimated Ernst 1990. *In* Gibbons [ed.], Life History and Ecology of the Slider Turtle, pp. 57–67. Smithsonian Institution Press, Washington, DC).

Submitted by **GAVIN F. HANKE**, Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia, V8W 9W2 Canada; e-mail: ghanke@royalbcmuseum.bc.ca.

SQUAMATA – LIZARDS

AMPHISBAENA MENSAE (Cobra-de-duas-cabeças; Worm Lizard). BRAZIL: MATO GROSSO: Municipality of Rondonópolis (16.4713056°S, 54.6371111°W, elev. ca. 304 m). 02 July 2007. E. Silva de Brito and R. A. Kawashita-Ribeiro. Verified by M. A. de Carvalho. Coleção Zoológica de Vertebrados da Universidade Federal do Mato Grosso, Cuiabá, Brazil (UFMT 6303–6309). Previously known from Brazil in Goiás State, municipality of Minaçú, Serra da Mesa, 14.0333333°S, 48.3166667°W (Castro-Mello 2000. Pap. Avul. Zool. 41[16]:243–246, type locality) and Distrito Federal, Brasilia (16.0°S, 47.9333333°W), nearly 250 km S of type locality (Campos-Nogueira 2001. Herpetol. Rev. 32:285–287). First state record, extends the known distribution about 730 km W from the type locality.

Submitted by **TAMI MOTT,** Departamento de Zoologia, Instituto de Biociências, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, s/n, Bairro Coxipó, 78060-900, Cuiabá, MT, Brazil (e-mail: tamimott@yahoo.com); **ELIZANGELA SILVA DE BRITO,** Programa de Pós-Graduação em Ecologia e Conservação da Biodiversidade, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, s/n, Bairro Coxipó, 78060-900, Cuiabá, MT, Brazil (e-mail: elizlinz@hotmail.com); and **RICARDO ALEXANDRE KAWASHITA-RIBEIRO,** Coleção Zoológica de Vertebrados, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, s/n, Bairro Coxipó, 78060-900, Cuiabá, MT, Brazil (e-mail: serpentesbr@gmail.com).

ANOLIS (= NOROPS) SAGREI (Brown Anole). USA: GEORGIA: Charlton Co.: St Mary's River boat ramp along Georgia Highway 94. 09 March 2008. Giff Beaton. Georgia Museum of Natural History (GMNH 50087). Verified by John B. Jensen. First county record for this exotic anole (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press. 575 pp.). The individual was observed and photographed as it foraged along a rocky rip-rap.

Submitted by **GIFF BEATON**, 320 Willow Glen Drive, Marietta, Georgia 30068, USA; e-mail: giffbeaton@mindspring.com.

BRONCHOCELA VIETNAMENSIS (Vietnam Long-tailed Agama). VIETNAM: Dong Nai: Cat Tien (11.35°–11.8°N, 107.1666667°–107.5666667°E). 19 May 2001. Paul Moler. IEBR 657. Verified by Jakob Hallermann. Adult male, SVL 86.0 mm, TL 316 mm, Previously known from Gia Lai and Phu Yen provinces (Hallermann 2005. Russian J. Herpetol. 12[3]:176; Ananjeva et al. 2007. Mitt. Mus. Naturk. Berl., Zool. Reihe 83, Suppl.:17). Third and most southward record from Vietnam , and ca. 250 km from type locality in Gia Lai Province .

Submitted by **NGUYEN QUANG TRUONG**, Institute of Ecology and Biological Resources, 18 Hoang Quoc Viet, Hanoi, Vietnam; current address: Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany (e-mail: nqt2@yahoo.com); and **WOLFGANG BÖHME**, Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany (e-mail: w.boehme.zfmk@uni-bonn.de).

GEHYRA LACERATA (Kanchanaburi Four-clawed Gecko). THAILAND: KHON KHAEN PROVINCE: Ban Fang District, Hin Chang See. June 2004. K. Kunya. Institut Royal des Sciences Naturelles de Belgique, Brussels (IRSNB 17032). Verified by G. L. Lenglet (IRSNB). This adult male specimen (58.6 mm SVL, single series of 17 precloacal pores) and others found active at ca. 2200 h on rocks and on ground on limestone hill. Locally abundant and was found in syntopy with *Gehyra mutilata* (IRSNB 17031). First provincial record, and known from Chonburi, Kanchanaburi, Khon Kaen, Nakhon Ratchasima, Phetchaburi, and Sakaeo provinces, Thailand (Brown 1999. Copeia 1999[4]:990–1001; Chuaynkern 2004. Advanced Thailand Geographic 9[3]:42 [in Thai]; Nabhitabhata and Chan-ard 2005. Thailand Red Data: Mammals, Reptiles and Amphibians. Office of Natural Resources and Environmental Policy and Planning, Bangkok. 234 pp.; Nabhitabhata et al. "2000" 2004. Checklist of Amphibians and Reptiles in Thailand. Office of Environmental Policy and Planning, Bangkok. 152 pp.). *Gehyra lacerata* has previously been recorded from Thành Phô Hô Chí Minh, Vietnam (Szczerbak and Nekrasova 1994. Vestn. Zool. 1994:48–52; Bobrov 1995. Smithson. Herpetol. Inform. Serv. 105:1–28), but has not been included in the most recent checklist (Nguyen et al. 2005. Danh luc êch nhái và bò sát Viêt Nam. A Checklist of Amphibians and Reptiles of Vietnam. Nhà Xuât ban Nông Nghiêp, Hà Nôi. 180 pp. [in Vietnamese]) and its occurrence outside Thailand needs confirmation. We thank Yodchaiy Chuaynkern (National Science Museum, Pathumthani) for providing literature.

Submitted by **OLIVIER S. G. PAUWELS**, Département des Vertébrés Récents, Institut Royal des Sciences naturelles de Belgique, Rue Vautier 29, 1000 Brussels, Belgium (e-mail: osgpauwels@yahoo.fr); **KIRATI KUNYA**, Korat Zoo, Muang District, Nakhon Ratchasima, Thailand (e-mail: kkunya2006@yahoo.com); and **AARON M. BAUER**, Department of Biology, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085, USA (e-mail: aaron.bauer@villanova.edu).

HEMIDACTYLUS TURCICUS (Mediterranean House Gecko). USA: SOUTH DAKOTA: Fall River Co.: Turkey Track Rd., 4.8 km W Hot Springs (43.426°N; 103.5370333°W). 01 September 2005. Steven G. Platt. Verified by Lars Bryan Williams. Campbell Museum, Clemson University (CUSC 2326). Found among debris in heated outbuilding. First record for South Dakota (Ballinger et al. 2000. Trans. Nebraska Acad. Sci. 26:29–46). Nearest documented populations in Utah and Nevada (Reed et al. 2006. Herpetol. Rev. 37:106).

Submitted by **STEVEN G. PLATT,** Department of Biology, P.O. Box C-64, Sul Ross State University, Alpine, Texas 79832, USA; **THOMAS R. RAINWATER**, The Institute of Environmental and Human Health, Department of Environmental Toxicology, P.O. Box 764, Jefferson, Texas 75657, USA; and **STANLEE MILLER**, Department of Biological Sciences, 132 Long Hall, Clemson University, Clemson, South Carolina, 29634-1903, USA (e-mail: amblyommavt@gmail.com).

KENTROPYX CALCARATA. BRAZIL, RIO GRANDE DO NORTE, Municipality of Parnamirim, Mata do Jiqui (05.9166667°S, 35.1833333°W). 03 February 2006. Pablo A. G. Sousa. Verified by Miguel T. U. Rodrigues. Coleção Herpetológica do Departamento de Botânica, Ecologia e Zoologia, Universidade Federal do Rio Grande do Norte, Natal. Rio Grande do Norte (CHBEZ 1316, 1487, 1488, 1566). The species was known from Venezuela to Maranhão State in Brazil. In the coastal areas of Brazil, it occurs from 19°S in Espírito Santo State to the Ambiental Preservation Area of Mamanguape in the Paraíba State and the Serra de Baturité, an isolated forested mountain range in the semi-arid Caatingas in Ceará State. The Rio Grande do Norte State constitutes a gap between those two localities (Ávila-Pires 1995. Zool. Verh. Leid. 299:1–706; Gallagher and Dixon 1992. Boll. Mus. reg. Sci. nat. Hist. 10[1]:125–171; Vanzolini 1988. Proc. Work. Neotropical Distribution Patterns, pp. 317–342; Borges-Nojosa and Caramaschi 2003. Ecol. Cons. Caat. v. 01, pp. 489–540). First state record, extends the range 450 km E and 225 km N from the areas of Ceará and Paraíba states, respectively, and fills the gap in the distribution of the species.

Submitted by **PABLO A. G. SOUSA** and **ELIZA M. X. FREIRE**, Laboratório de Herpetologia. Departamento de Botânica, Ecologia e Zoologia, Centro de Biociências, Universidade Federal do Rio grande do Norte, Campus Universitário, Lagoa Nova, CEP 59072-970, Natal, Rio Grande do Norte, Brazil.

LEIOLEPIS TRIPLOIDA (Malaysian Butterfly Lizard). MALAYSIA: KEDAH: Kampung Wang Perah (6.3645333°N, 100.46005°E). 26 October 2008. M. S. Shahrul Anuar. La Sierra University Herpetological Collection (LSUHC 8734). Kuala Nerang (18.9 km SW of Kampung Wang Perah). 10 March 1930 and 15 March 1930. G. Hope Sworder. Raffles Museum of Biodiversity Research, National University of Singapore, Zoological Reference Collection (ZRC 2.961 and ZRC 2.962–63, respectively). Pokok Sena (22.2 km S of Kampung Wang Perah). 16 February 1930. G. Hope Sworder. ZRC 2.964. PENANG: Mengkuang Dam (5.3897833°N, 100.5025833°E). 25 October 2008. M. A. Muin. LSUHC 8715. All specimens verified by J. L. Grismer. Type locality given as "Malayisch-thailändisches Grenzgebiet auf der Malayischen Halbinsel" (= Malaysia-Thailand border of the Malay Peninsula; Peters 1970. Zool. Jb. Syst. Bd. 98:11–130), which could conceivably mean any place along the ca. 400 km border. A locality was subsequently illustrated on distribution maps (Darevsky and Kupriyanova 1993. Herpetozoa

6:3–20; Aranyavalai et al. 2004. Nat. Hist. J. Chulalongkorn Univ. 4:15–19), showing it to be near the Thai border in northern Kedah, Malaysia at the town of Baling (5.6752333°N, 100.9170167°N). We visited Baling on 26 October 2008 but residents indicated this species was not present and directed us to Kampung Bandar (5.7500333°N, 100.8808333°E), 9.2 km to the NW, where we found five specimens (LSUHC 8710–14). In reference to Kampung Bandar, the presence of this species at Kuala Nerang, 68 km to the NNW; at Kampung Wang Perah, 84 km to the NW; and at Pokok Sena, 68 km to the WNW, extends the distribution of this species along the Malaysia-Thailand border to the northwest. Its presence at the Mengkuak Dam in Seberang Perai, 57.8 km to the SW extends its distribution towards the west coast. These widely distributed localities suggest *L. triploida* ranges throughout most of Kedah, rather than being restricted to the border of Malaysia and Thailand.

Submitted by **L. LEE GRISMER,** Department of Biology, La Sierra University, 4700 Riverwalk Parkway, Riverside, California 92515, USA (e-mail: lgrismer@lasierra.edu); **M. S. SHAHRUL ANUAR,** School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia; **PERRY L. WOOD, JR.,** Department of Biology, Villanova University, 800 Lancaster Ave, Villanova, Pennsylvania 19085, USA; **M. A. MUIN,** School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia; and **N. NUROLHUDA**, World Wildlife Fund for Nature Malaysia, No. 49, Jalan SS23/15, Taman SEA, 47301, Petaling Jaya, Selangor, Malaysia.

LIOLAEMUS JOSEI (NCN). ARGENTINA: LA PAMPA PROVINCE: Chical Co Departament: Provincial road 14, 54 km W junction Nacional Road 151 (36.708833°S, 67.950111°W; datum: WGS84, elev. 802 m). 30 November 2001. N. Frutos, C. H. F.Perez and L. J. Avila (LJAMM 4229). Verified by N. Basso. Previously known from Agua del Toro, Salinillas, Puente El Zampal and 15 km N Matancilla; all localities from Malargüe departament, Mendoza province (Abdala 2005. Cuad. Herpetol. 19[1]:3–33). First province record and easternmost distributional record for the species extending 70 km E from the nearest vouchered locality in eastern Mendoza Province.

Submitted by **NICOLAS FRUTOS,** CENPAT-CONICET, Boulevard Almirante Brown 2825, U9120ACV, Puerto Madryn, Chubut, Argentina (e-mail: frutos@cenpat.edu.ar); **CRISTIAN HERNÁN FULVIO PEREZ** (e-mail: liolaemu@criba.edu.ar); and **LUCIANO JAVIER AVILA,** CENPAT-CONICET, Boulevard Almirante Brown 2825, U9120ACV, Puerto Madryn, Chubut, Argentina (e-mail: avila@cenpat.edu.ar).

LIPINIA VITTIGERA (Striped Tree Skink). CAMBODIA: SIEM REAP PROVINCE: Preah Khan Temple (13.4619444°N, 103.8722222°E), Angkor. 30 August 2004. S. Mahony. Actively foraging when found at 1300 h, ca. 1.5 m up on tree trunk within a moderately disturbed forest patch at rear of temple. Specimen not collected; digital voucher deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG].2.71). Verified by Bryan L. Stuart. First record for northwestern Cambodia. Nearest recorded locality in Cambodia is >100 km S, from Phnom Aural (12°01'N, 104°08'E), Phnom Aural Wildlife Sanctuary in the eastern Cardamom Mountains

(Grismer et al. 2007. Hamadryad 31:216–241).

Submitted by **STEPHEN MAHONY**, Madras Crocodile Bank Trust, Post Bag 4, Mamallapuram, Tamil Nadu 603 104, India; e-mail: stephenmahony2@gmail.com.

PLESTIODON FASCIATUS (Common Five-lined Skink). USA: ILLINOIS: Wayne Co.: Fairfield Reservoir (38.3738889°N, 8.2369444°W). 31 July 2007. Michael A. Steffen. Verified by Ronald A. Brandon. Color photo voucher SIUC R-03449. New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.).

Submitted by **MICHAEL A. STEFFEN**, Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901, USA; e-mail: bass2187@siu.edu.

PLESTIODON LATICEPS (Broad-headed Skink). USA: OHIO: Ross Co.: Scioto Township. Earl G. Barnhart Nature Preserve (39.34805°N, 83.0571667°W). 15 Sept. 2007. Greg Gentry and William J. Letsche. Verified by Jeffrey G. Davis. Cincinnati Museum Center (CMC 11,000). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10, Columbus).

Submitted by **WILLIAM J. LETSCHE**, 168 Crouse-Chapel Rd., Chillicothe, Ohio 45601, USA; e-mail: salamanderhunter71@yahoo.com.

PTYCTOLAEMUS GULARIS (Green Fan-throated Lizard). BANGLADESH: Moulvibazar District: Lawachara National Park (24.3166667°N, 91.7833333°E; 144–150 m elev.). 27 June 2007. A. H. M. Ali Reza. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0056). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG].2.69). Verifed by Aaron M. Bauer. First country record for genus and species. Nearest population reported from Barail Reserved Forest of Assam, northeast India, > 100 km E (Pawar and Birand 2001. A Survey of Amphibians, Reptiles, and Birds in Northeast India. CERC Tech. Rep. No. 6, Centre for Ecological Research and Conservation, Mysore, India. 118 pp.). Fieldwork financed by Cleveland Metroparks Zoo and Rufford Small Grants Foundation, with permission from Bangladesh Forest Department (CCF [Wildlife]/2M–47/2006). Thanks are due to Md. Kamal Hossain and DM Kamruzzaman for assistance in the field.

Submitted by **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA, and Department of Zoology, Jahangirnagar University, Dhaka 1342, Bangladesh; e-mail: wild_reza@yahoo.com.

SAUROMALUS ATER (Common Chuckwalla). MÉXICO: SONORA: Isla Pájaros (27.88798°N, 110.84722°W; NAD 27), 10 m elev. 10 July 2007. J. Ventura-Trejo. Verified by J. Angel Soto-Centeno. SDNHM-HerpPC 5204. First record for Isla Pájaros, which lies 6 km SW of Guaymas, Sonora, where the southernmost mainland populations of the species occur (Hollingsworth 1998. Herpetol. Monog. 12:38–191).

Submitted by **JESUS VENTURA-TREJO**, Protección de Flora y Fauna de las Islas el Golfo de California SEMARNAT-CONANP

Oficina Regional Guaymas, Guaymas, Sonora, México (e-mail: jventurat@yahoo.com.mx); **JORGE H. VALDEZ-VILLAVICENCIO**, Grupo de Ecología y Conservación de Islas, A.C. Ave. López Mateos 1590-3 Fracc. Playa Ensenada, Ensenada, Baja California, México, C.P. 22880 (e-mail: jorge.valdez@conservaciondeislas.org); and **BRADFORD D. HOLLINGSWORTH**, Department of Herpetology, San Diego Natural History Museum, P.O. Box 121390, San Diego, California 92112-1390, USA (e-mail: bhollingsworth@sdnhm.org).

STENOCERCUS ROSEIVENTRIS (NCN). BRAZIL: RONDONIA: Municipality of Vilhena (12.7°S, 60.25°W). 24 October 2007. A. Pansonato and E. Silva de Brito. Verified by C. Strüssmann. Coleção Zoológica de Vertebrados of the Universidade Federal de Mato Grosso, Mato Grosso, Brazil (UFMT 6269). The species was known from western Amazon basin and eastern slopes of the central and southern Andes, in Peru, Brazil, Bolivia, and Argentina (Torres-Carvajal 2007. Herpetol. Monog. 21:76–178). Reported from Brazil from the state of Acre, by Etheridge (1970. *In* Peters and Orejas Miranda [eds.], Catalogue of the Neotropical Squamata. Bull. U.S. Nat. Mus. 297:254–258) (unvouchered), and Torres-Carvajal (2005. Phyllomedusa 4[2]:123–132). First state record and easternmost locality for the species, extends known distribution 1027 km southeast of Purus River (Torres-Carvajal, *op. cit*.).

Submitted by **ANDRÉ PANSONATO** (e-mail: andrepan@hotmail.com), **ELIZÂNGELA SILVA BRITO** (e-mail: esbbr@yahoo.com.br), and **DRÁUSIO HONÓRIO MORAIS**, Instituto de Biociências, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa, 780760-900 Cuiabá, Mato Grosso, Brazil (e-mail: amblyommavt@gmail.com).

SQUAMATA – SNAKES

COLUBER (=MASTICOPHIS) TAENIATUS (Striped Whipsnake). MÉXICO: AGUASCALIENTES: Municipality of Tepezalá: Western side of Cerro Altamira, 2 km airline E from the town Tepezalá (22.234032°N, 102.139619°W; NAD 27), 2299 m elev. 31 July 2004. Jorge Ivan Sigala-Rodríguez. Museo de Zoología, Departamento de Biología, Universidad Autónoma de Aguascalientes (UAA-VR-00317). Municipality of El Llano: 5 km airline E from El Llano (21.92441667°N, 101.93025°W; NAD 27), 2120 m. elev. 22 September 2005. Rarámuri Reyes Ardit. UAA-VR-00318. Municipality of Asientos: 2 km N vicinity of Las Adjuntas, Asientos (22.055990°N, 101.922762°W; NAD 27), 2044 m elev. 06 June 2006. Gustavo E. Quintero-Díaz and Joel Vázquez-Díaz. UAA-VR-00319. All verified by Jeffrey D. Camper. First records for Aguascalientes, and fills the approximate 300 km distributional gap between the closest previous records at 13.1 km ESE of Tepetatillo, Jalisco (CAS 165260) and two specimens (FMNH 106181; CAS 165223) from north of Ciudad Zacatecas, Zacatecas (Camper and Dixon 1994. Ann. Carnegie Mus. 63:1–48). All snakes were found on rocky hillsides covered with lower montane dry forest vegetation, as classified by Campbell (1999. *In* W. E. Duellman [ed.], Patterns of Distribution of Amphibians: A Global Perspective, pp. 111–210. John Hopkins Univ. Press, Baltimore, Maryland).

Submitted by **J. JESÚS SIGALA-RODRÍGUEZ**, Department

of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, New York 14853-2701, USA (e-mail: js324@cornell.edu); **JOEL VÁZQUEZ-DÍAZ,** Departamento de Investigación y Desarrollo Tecnológico, Internacional de Relojes, Arte y Diseño S. A. de C. V., Ave. Aguascalientes Sur 203, Fracc. Prados del Sur, Aguascalientes 20280, México; and **GUSTAVO E. QUINTERO-DÍAZ, JORGE IVAN SIGALA-RODRÍGUEZ,** and **RARAMURI REYES ARDIT,** Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Ave. Universidad 940, Aguascalientes, 20100, México.

CROTALUS ATROX (Western Diamondback Rattlesnake). USA: TEXAS: Caldwell Co.: Plumb Creek Farm off Farm Road 672, 3 miles NE of Lockhart (29.8983833°N, 97.6494667°W). 01 February 2006. Verified by J. R. Dixon, Texas A&M University, Texas Cooperative Wildlife Collection. TCWC 90669. New county record (Dixon 2000. Amphibians and Reptiles of Texas. Texas A&M University Press, College Station, Texas. 148 pp.). A total of 3 adult females, 1 adult male, and 1 juvenile female *Crotalus atrox* were collected from an old farm shed under a wood pile. These are the first reported specimens from within Caldwell County. Each individual was measured, weighed, and had a blood sample (MF-19885,19914–19917) and digital photo taken. The specimens ranged in size from SVL length of 38–96 cm and tail length of 22–71 mm. One individual was retained as a specimen voucher and preserved and accessioned into the Texas Cooperative Wildlife Collection (TCWC 90669).

Submitted by **MELISSA JONES, JEFF TROY,** and **M.R.J. FORSTNER**, Department of Biology, Texas State University at San Marcos, San Marcos, Texas 78666, USA; e-mail: mj46953@txstate.edu.

CROTALUS PUSILLUS (Tancitaran Dusky Rattlesnake). MÉXICO: JALISCO: Municipality Quitupan: 24.5 km (by road) S of Valle de Juarez (19.42630°N, 102.57527°W, WGS 84), 2288 m elev. 06 August 2007. Chris I. Grünwald and Jason M. Jones. Verified by Robert W. Bryson, Jr. UTA Digital Collection 1087. Fills a distributional gap of ca. 160 km between Nevado de Colima (14.4 km W of Atenquique, Jalisco) and Carapan, Michoacán (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere, Vol. II. Comstock Pub. Assoc., Ithaca, New York, xiv + 477–870 pp.). The snake was found AOR at night in an area of humid pine-oak forest.

Submitted by **JACOBO REYES-VELASCO**, Centro Universitario de Ciencias Biológicas y Agropecuarias, Carretera a Nogales Km. 15.5. Las Agujas, Nextipac, Zapopan, Jalisco, México (e-mail: jackobz@gmail.com); **CHRISTOPH I. GRÜNWALD**, 450 Jolina Way, Encinitas, California 92024, USA (e-mail: cgruenwald@switaki.com); and **JASON M. JONES**, 16310 Avenida Florencia, Poway, California 92064, USA (e-mail: jjones@switaki.com).

DIADOPHIS PUNCTATUS (Ring-necked Snake). USA: MISSOURI: Perry Co.: limestone bluffs along Apple Creek near PCR 614, Biehle (37.631861°N, 89.866167°W; WGS84). 01 October 2006. Richard L. Essner, Jr. Verified by Paul E. Brunkow, Southern Illinois University Edwardsville (SIUE 2948). New county

record. First report from Perry County (Daniel and Edmond 2008. Atlas of Missouri Reptiles and Amphibians for 2007).

Submitted by **RICHARD L. ESSNER, JR.** (e-mail: ressner@siue.edu) and **RALPH W. AXTELL,** Department of Biological Sciences, Southern Illinois University Edwardsville, Illinois, 62026, USA (e-mail: raxtell@siue.edu)**.**

DIPSAS GAIGEAE (Gaige's Thirst Snake). MÉXICO: MICHOACÁN: Municipality of Aquila: 2.5 km N Maruata, on road to Pomaro (18.174679°N, 103.204734°W; WGS 84), 32 m elev. UTA Digital Collection 1084. 0.8 km E Maruata, on Hwy 200 (18.162361°N, 103.202725°W; WGS 84), 17 m. elev. UTA Digital Collection 1083. 15 August 2005. Daniel Grubb and Jason M. Jones. Verified by Jonathan A. Campbell. First records for the state and a range extension of ca. 60 km S from previously known records in southern Colima (Kofron 1982. J. Herpetol. 16:270–286). The snakes were AOR at night in tropical deciduous forest.

Submitted by **JACOBO REYES-VELASCO**, Centro Universitario de Ciencias Biológicas y Agropecuarias, Carretera a Nogales Km. 15.5. Las Agujas, Nextipac, Zapopan, Jalisco, México (e-mail: jackobz@gmail.com); **CHRISTOPH I. GRÜNWALD,** 450 Jolina Way, Encinitas, California 92024, USA (e-mail: cgruenwald@switaki.com); and **JASON M. JONES,** 16310 Avenida Florencia, Poway, California 92064, USA (e-mail: jjones@switaki.com).

ECHINANTHERA AFFINIS (Günther's Forest Snake). BRAZIL: CEARÁ: Ubajara (03.8404722°S, 40.9076389°W; 896 m elev.). 02 Jul 2007. D. Loebmann. Ubajara (03.8475278°S, 40.8890833°W; 884 m elev.). 05 Sep 2007. H. Klein. Coleção Instituto Butantan, São Paulo, Brazil (IBSP 76363–76364). Verified by M. Trefaut Rodrigues. The species was known from the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Minas Gerais, Espírito Santo, and Bahia (Di-Bernardo and De Lema 1988. Acta Biol. Leopol. 10[2]:223–252; Argôlo 1998. Herpetol. Rev. 29:176). These new records represent an isolated population in the rain forests of Ibiapaba's plateau and also are the first records for Ceará state. Extends distribution ca. 1230 km N from Vitória da Conquista, Bahia state, Brazil (Argôlo, *op. cit.*).

Submitted by **DANIEL LOEBMANN**, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Caixa Postal 199, CEP 13506-970, Rio Claro, São Paulo, Brazil; e-mail: contato@danielloebmann.com.

LAMPROPELTIS CALLIGASTER OCCIPITOLINEATA (South Florida Mole Kingsnake). USA: FLORIDA: Charlotte Co.: 4.4 km NE of intersection of Graham Road and County Road 74 (26.9711389°N, 81.6781667°W). 07 March 2008. Robert A. O'Horo. Adult male (825 mm SVL) collected alive on an unpaved road at 1215 h in an area of dry prairie habitat surrounded by agricultural fields. Verified by Kenneth L. Krysko. Florida Museum of Natural History photo voucher (UF 152523). New county record. Extends range ca. 22 km SE of the nearest record from DeSoto Co. (UF 152370). Vouchers of this subspecies also exist from Brevard and Okeechobee counties (Layne et al. 1986. Florida Sci. 49:171–175), and we have reports unsupported by vouchers from nearby Glades, Indian River, and Osceola counties. A purported

specimen (UMMZ 77481) collected from Leesburg, Lake Co. (Layne et al., *op. cit.*), was a misidentified *Pantherophis guttatus* (G. Schneider, pers. comm.).

Submitted by **ROBERT A. O'HORO**, Florida Fish and Wildlife Conservation Commission, 2423 Edwards Drive, Ft. Myers, Florida 33901, USA (e-mail: robert.ohoro@myfwc.com); and **KEVIN M. ENGE**, Florida Fish and Wildlife Conservation Commission, 1105 S.W. Williston Road, Gainesville, Florida 32601, USA (e-mail: kevin.enge@myfwc.com).

LAMPROPELTIS TRIANGULUM ARCIFERA (Jalisco Milksnake). MÉXICO: MÉXICO: Municipality of Tejupilco, (18.51314°N, 100.25347°W; NAD27 México), 1800 m elev. 14 April 2001. Octavio Vilchis. Verified by Óscar Sánchez. IBH 15741. First record for Tejupilco and a 49.5 km range extension W from the closest known locality at Sultepequito, México (Casas and Aguilar 1998. Biol. Soc. Herpetol. Mex. 8:22–24). The record also fills the distributional gap on the southcentral portion of the Mexican Plateau that was depicted by Williams (1988. Systematics and Natural History of the American Milk Snake, *Lampropeltis triangulum*. 2nd revised ed. Milwaukee Pub. Mus., Milwaukee, 176 pp.). The snake was found in pine-oak forest (*Quercus elliptica* and *Pinus oocarpa*).

Submitted by **FELIPE RODRÍGUEZ-ROMERO, OCTAVIO MONROY-VILCHIS,** and **OSWALDO HERNÁNDEZ-GALLEGOS,** Facultad de Ciencias, Centro de Investigación en Recursos Bióticos–CIRB, Universidad Autónoma del Estado de México, Instituto Literario # 100, 50000, Toluca, Estado de México, México (e-mail: fjrr@uaemex.mx).

LAMPROPELTIS TRIANGULUM SYSPILA (Red Milksnake). USA: ARKANSAS: Pulaski Co.: 34.791535°N, 92.487877°W; WGS84, 195 m elev. 29 March 2007. UALR HPC 0001. 34.475527°N, 92.342141°W, WGS84, 165 m elev. 03 April 2007. UALR HPC 0002. Verified by M. V. Plummer. New county records (Trauth et al. 2004. Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.).

Allocation to *L. t. syspila* based upon features of distinctive coloration and markings (Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. 3rd ed. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.). UALR HPC 0001 was captured under a piece of discarded carpet within a utility right-of-way adjacent to a mixed hardwood woodlot. It is currently housed as a live specimen within the University of Arkansas at Little Rock Biology Department and will be preserved as an alcohol specimen upon its death. The adjacent area from which UALR HPC 0001 was captured is currently undergoing development as a gated housing community. Urban sprawl in Little Rock might pose a threat to the habitat for *L.t. syspila* at this particular locality.

UALR HPC 0002 was captured at a private residence within a mixed hardwood forest and was photographed and released at the capture site. An additional individual was sighted 15 August 2007 at the same location as UALR HPC 0002.

Submitted by **DARRELL R. HEATH**, **DAVID W. CLARK,** and **KRYSTIAN A. SAMEK**, Department of Biology, University of Arkansas at Little Rock, Little Rock, Arkansas 72204, USA (e-mail: drheath@ualr.edu).

MICRURUS TENER (Texas Coralsnake). MÉXICO: HIDALGO: Municipality of Metztitlán, San Pablo Tetlapayac, Reserva de la Biosfera Barranca de Metztitlán (20.38311°N, 98.55400°W; WGS849), 993 m elev. 23 March 2007. V. D. Vite-Silva and U. Hernández-Salina. Verified by Adrian Leyte-Manrique. Herpetology collection, Laboratorio Ecología de Poblaciones, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo (VDVS-UAEH-0042). First record for the municipality and a range extension of 51 km S of record in the Municipality of Tlanchinol (Mendoza-Quijano et al. 2006. Publicación Especial de la Sociedad Herpetológica Mexicana [3]:99–109). The snake was found in tropical dry forest. Fieldwork was funded by SEP-PROMEP-1103.5/03/1130, Projects PIFI-PROMEP 3.3. 2007, CONACYT-S 52552-Q, and CONACYT-43761.

Submitted by **URIEL HERNÁNDEZ SALINAS** (e-mail: hu128613@uaeh.reduaeh.mx), **VICTOR D. VITE-SILVA** (e-mail: dark_land121@hotmail.com), and **AURELIO RAMÍREZ BAUTISTA**, Centro de Investigaciones Biológicas (CIB), Universidad Autónoma del Estado de Hidalgo, A.P. 1-69 Plaza Juárez, C.P. 42001, Pachuca, Hidalgo, México (e-mail: aurelior@edu.uaeh.mx).

NERODIA ERYTHROGASTER (Plain-bellied Watersnake). USA: ILLINOIS: Henderson Co.: Snake was captured as it basked on riprap stone embankment alongside lake at Crystal Lake Gun Club, Gulfport, Illinois (40.83540°N, 091.06121°W). 08 June 2007. James T. Lamer and Sean E. Jenkins. Illinois Natural History Survey in Champaign/Urbana, Illinois (INHS 20745). Verified by Chris Phillips. First county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. xii + 282 pp.)

Submitted by **JAMES T. LAMER, SEAN E. JENKINS,** Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA; **JOHN K. TUCKER** and **CHAD R. DOLAN,** Illinois Natural History Survey, 8450 Montclair Ave, Brighton, Illinois 62012, USA.

NERODIA ERYTHROGASTER ERYTHROGASTER (Red-bellied Watersnake). USA: VIRGINIA: Henrico Co.: 11.4 km ESE Sandston, Whiteoak Swamp Creek (37.4683333°N, 77.2086111°W). 10 August 2004. H. Lacy. Verified by William M. Palmer. North Carolina State Museum of Natural Sciences (NCSM 73872). New county record. Extends range ca. 59 km NNE and ca. 68 km WNW of nearest records in Sussex and York counties, respectively (Mitchell 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, DC. xv + 352 pp.).

Submitted by **JEFFREY C. BEANE**, North Carolina State Museum of Natural Sciences, Research Laboratory, 4301 Reedy Creek Road, Raleigh, North Carolina 27607, USA (e-mail: jeff.beane@ncmail.net); and **THOMAS J. THORP**, Three Lakes Nature Center and Aquarium, 400 Sausiluta Drive, Richmond, Virginia 23227, USA (e-mail: tho56@co.henrico.va.us).

OPHEODRYS VERNALIS (Smooth Greensnake). USA: ILLINOIS: DeKalb Co.: Kishwaukee River State Fish and Wildlife Area in Kirkland (42.09431°N, 88.86872°W). A live female individual (SVL 217 mm) was captured under cover boards on 20 April 2007. The individual was photographed and released as part of an ongoing herpetological survey within the park (verified and vouchered via photograph by Chris Phillips at the Illinois Natural History Survey, voucher number: INHS 2008-3). This is the second verified sighting of this species within this county, the first sighting was published as a county record (Walley 1977. Herpetol. Rev. 8:125). Walley's sighting occurred in the southern portion of the county, and this latest record documents that this species persists in the far northern portion of the county and potentially countywide. This capture extends the known range of this species 53.7 km NW, and is 123 km NW from the only viable population of this species in northern Illinois known to us.

Submitted by **JACE W. ROBINSON** and **JESSE W. RAY**, Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois 60115, USA; e-mail: z052078@wpo.cso.niu.edu.

OXYRHOPUS GUIBEI. BRAZIL: RIO DE JANEIRO: Municipality of Resende: Serrinha do Alambari (22.3833333°S, 44.5333333°W, ca. 700 m elev.). 02 September 2005. U. Caramaschi and H. Niemeyer. Museu Nacional, Rio de Janeiro, RJ, Brazil (MNRJ 13737, 13738). Resende: District of Visconde de Mauá (22.3333333°S, 44.5333333°W, ca. 1000 m elev.). 02 January 2006. M. A. S. Alves. Museu Nacional (MNRJ 14627). Municipality of Barra Mansa (22.55°S, 44.1666667°W, ca. 450 elev.). 14 March 2006. A. Chiessi. Museu Nacional (MNRJ 15603). All localities in the Atlantic Forest biome. Verified by R. Fernandes. Species was previously known from Brazilian states of Minas Gerais, São Paulo, Goiás, Mato Grosso, Mato Grosso do Sul, Paraná, Bahia, and Alagoas, and the Distrito Federal; Bolivia, Paraguay, and northeastern Argentina (Argôlo 2004. As Serpentes dos Cacauais do Sudeste da Bahia. Editora da UESC, Ilhéus, 259 pp.; França and Araújo 2006. S. Amer. J. Herpetol. 1[1]:25–36; Freire 1999. Herpetol. Rev. 30:55; Zaher and Caramaschi 1992. Bull. Mus. Natl. Hist. Nat. 14[3–4]:805–827). First state records, the record from Barra Mansa extends known distribution ca. 230 km NE from the closest previous record (Municpality of Guarulhos, São Paulo; Zaher and Caramaschi, *op. cit.*) and ca. 320 km S from the closest record in Minas Gerais (Municipality of Lagoa Santa; Zaher and Caramaschi, *op. cit.*).

Submitted by **ADRIANO LIMA SILVEIRA**, Setor de Herpetologia, Departamento de Vertebrados, Museu Nacional / Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, São Cristóvão, CEP 20940-040, Rio de Janeiro, RJ, Brazil; e-mail: biosilveira@yahoo.com.br.

OXYRHOPUS RHOMBIFER BACHMANNI (False Coralsnake). ARGENTINA: CHUBUT: Telsen Department: Estancia Maria de las Nieves, 15–20 km NW Sierra Chata (42.53124°S, 65.6369°W; WGS84) by Ruta Provincial 4. September 2007. V. Marquez and H. Vallejos. Verified by C. H. F. Perez. Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires, Argentina (MACN 39042). First province record, southermost record for the species in Argentina, extends the known distribution 600 km (airline) S from previous and southernmost vouchered citation (Avila and Morando 1999. Herpetol. Rev. 30:114). Previous records in Argentina are for Catamarca, Córdoba, La Pampa, La Rioja, Mendoza, Río Negro, San Juan, San Luis, Santiago del Estero, and Tucumán (Giraudo and Scrocchi 2002. Smithson. Herpetol. Infor. Serv. 132:1–53).

Herpetological Review 39(2), 2008

Submitted by **MARCELO CARRERA** and **LUCIANO JAVIER AVILA**, CENPAT-CONICET, Boulevard Almirante Brown 2825, U9120ACF, Puerto Madryn (Chubut) Argentina; e-mail: avila@cenpat.edu.ar.

PHILODRYAS PATAGONIENSIS. BRAZIL: RIO GRANDE DO NORTE: Municipality of Parnamirim, Mata do Jiqui (05.9166667°S, 35.1833333°W). 31 January 2007. P. A. G. Sousa. Verified by M. T. U. Rodrigues. Coleção Herpetológica do Departamento de Botânica, Ecologia e Zoologia, Universidade Federal do Rio Grande do Norte, Natal. Rio Grande do Norte (CHBEZ 1609); Municipality of Natal, unknown collector (05.8°S, 35.15°W; CHBEZ 1400). This species presents a wide distribution from southern Argentina through Uruguay, Paraguay, and Bolivia to central Brazil in Brasília, Amazonian savannahs in the Pará State and all coastal regions of the state of Bahia (Laurent 1973. Acta Zool. Lilloana 26[20]:291–298; Thomas 1976. Ph.D. Thesis. Texas A&M University; Di-Bernardo et al. 2007. *In* Nascimento and Oliveira [organizers], Herpetologia no Brasil II, pp. 222–263. Sociedade Brasileira de Herpetologia; Marques and Sazima 2004. *In* Marques and Duleba [organizers], Estação Ecológica Juréia-Itatins: Ambiente Físico, Flora e Fauna, pp. 257–277. Ribeirão Preto: Holos Editora-FAPESP; Nogueira 2001. Herpetol. Rev. 32:285–287; Giraudo and Scrocchi 2002. Smithson. Herpetol. Infor. Serv. 132, 53 pp.; França et al. 2006. Occas. Pap. Oklahoma Mus. Nat. Hist.17:1–13; Freitas 1999. Serpentes da Bahia e do Brasil – Suas Características e Hábitos. Ed. Dall. 77 pp.). First state record extends range ca. 700 km N from the limit of coastal region of Bahia.

Submitted by **PABLO A. G. SOUSA** and **ELIZA M. X. FREIRE**, Laboratório de Herpetologia, Departamento de Botânica, Ecologia e Zoologia, Centro de Biociências, Universidade Federal do Rio Grande do Norte, Campus Universitário, Lagoa Nova, CEP 59072-970, Natal, Rio Grande do Norte, Brazil.

PHYLLORHYNCHUS BROWNI (Saddled Leaf-nosed Snake). USA: ARIZONA: PINAL CO.: East side of Goldmine Mountains (33.191596°N, 111.616985°W) 461 m elev. 17 May 2004. Justin P. Pullins and Tanzy D. Pullins. University of Arizona Museum (photo voucher; UAZ 56666-PSV). Verified by George Bradley. This record fills a gap in the known distribution of this species. Specimen found ca. 28 km NW of a series of specimens collected near Florence, Arizona and ca. 90 km ENE of the nearest specimen (ASU 33136) to the west (A. T. Holycross, pers. comm; Brennan and Holycross 2006. A Field Guide to Amphibians and Reptiles in Arizona. Arizona Game and Fish Department, Phoenix, Arizona. 150 pp.).

Submitted by **JUSTIN P. PULLINS**, Arizona State University Polytechnic Campus, 7001 E. Williams Field Road, Mesa, Arizona 85212, USA.

SISTRURUS MILIARIUS STRECKERI (Western Pigmy Rattlesnake). USA: ARKANSAS: SEARCY CO.: Off AR 14, ca. 2 km down Ramblewood Trail by private residence. 21 June 2007. J. S. Hicks, M. B. Connior. Verified by S. E. Trauth. Arkansas State University Museum of Zoology Herpetology Collection (ASUMZ 30742). First county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville. 421 pp.).

Submitted by **MATTHEW B. CONNIOR** and **IDUN GUENTHER**, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: matthew.connior@smail.astate.edu).

STORERIA DEKAYI (DeKay's Brown Snake). USA: OHIO: BROWN CO.: Pleasant Township: White Oak Creek at Old State Route 125 bridge, 1.0 km W of Georgetown (38.86546°N, 83.86546°W). 14 June 2007. Jeffrey G. Davis, John W. Ferner, and Paul J. Krusling. Verified by Jason Folt. Voucher specimen deposited at Cincinnati Museum Center, Ferderick and Amye Geier Research and Collections Center (CMC 10919). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10).

Submitted by **JEFFREY G. DAVIS** (e-mail: anura@fuse.net), and **PAUL J. KRUSLING** (e-mail: pkrusling@fuse.net), Cincinnati Museum Center – Fredrick and Amye Geier Research and Collections Center, 1301 Western Avenue, Cincinnati, Ohio 45203-1130, USA; and **JOHN W. FERNER**, Department of Biology, Thomas More College, Crestview Hills, Kentucky 41017, USA (e-mail: JohnFerner@Thomasmore.edu).

THAMNOPHIS EQUES (Mexican Gartersnake). USA: ARIZONA: GILA CO.: Tonto Creek, between Gisela and Punkin Center. On 23 August 1995 at 2200 h, we found a *Thamnophis eques* (UAZ 50327) dead on State Route 188, ca. 3 km N of Punkin Center at 720 m elev. The specimen measured 310 mm SVL and 91 mm tail. This specimen is the first record of *T. eques* from the Tonto Creek watershed, and fills a substantial gap in the distribution of the species in the Gila River watershed between voucher specimens from Maricopa and Yavapai counties ca. 80 airline km to the west and records from the Black River and its tributaries ca. 110 airline km to the east.

On 14 July 2004, 18–19 August 2004, and 20–24 June 2005 we spent 165 person-hours searching along the banks of Tonto Creek between Gisela and "The Box" (ca. 3 km of stream at 870 m elev.); a location approximately 26 river km upstream of the collection locality of UAZ 50327 (Holycross et al. 2006. Surveys for *Thamnophis eques* and *Thamnophis rufipunctatus* in the Gila Watershed of Arizona and New Mexico. Report to Arizona Game and Fish Department. 105 pp.). We also deployed 32 Gee's "minnow traps" along the banks on 18–19 August 2004 (704 trap-hours) and 210 traps from 20–24 June 2005 (19,740 trap-hours). One adult female *T. eques* (ASU 34844) was trapped. From 20–23 June 2005 we captured 14 neonates (163–216 mm SVL, mean = 184; 2.5–6.0 g, mean = 3.8) and one adult female (820 mm SVL, 170 g) by hand. A second adult female (650 mm SVL, 135 g) was trapped twice.

Non-native predators (Bullfrogs, *Lithobates catesbeianus;* crayfish, *Orconectes virilis;* catfish, *Ameirus* spp.; bass, *Micropterus* spp.) were abundant, whereas a native prey species (Lowland Leopard Frog, *Lithobates yavapaiensis*) was not found. Only relatively large adult females and neonates were captured in 2004 and 2005. Low catch per unit effort (adults), absence of intermediate age classes, and presence of non-native predators suggest a low density population and raise the possibility that recruitment may be

declining in this recently discovered population.

Submitted by **J. ERIC WALLACE**, School of Natural Resources, University of Arizona, Tucson, Arizona 85721, USA (e-mail: batrachia@yahoo.com); **ROBERT J. BRAUMAN**, New York City Department of Environmental Protection, 182 Joline Avenue, Staten Island, New York 10307, USA; **JOHN WINDES**, 1128 West Emerine Drive, Tucson, Arizona 85704, USA; **WILLIAM P. BURGER**, Arizona Game and Fish Department, 7200 East University, Mesa, Arizona 85207, USA; **ERNEST J. NIGRO, THOMAS C. BRENNAN,** and **ANDREW T. HOLYCROSS**, School of Life Sciences, Arizona State University, Tempe, Arizona 85287-4501, USA.

TROPIDODIPSAS REPLETA (Black Snail-eating Snake). MEXICO: SONORA: Municipio de Yecora: West slope of the Sierra Madre Occidental, west of Yecora Junction on Mex Hwy 16 (28.22336°N, 109.03293°W; WGS 84),1581 m elev. 17 August 2007. Young Cage and Kenneth Sharrocks. Verified by Jim Rorabaugh. LACM PC 1446. Second record for Sonora (Smith et al. 2005. Bull. Maryland Herpetol. Soc. 41:39–41), and only the third documented specimen of *T. repleta* (Lemos Espinal and Smith 2007. Amphibians and Reptiles of the State of Chihuahua México, Universidad Nacional Autónoma de México and CONABIO). The snake was found DOR in pine-oak forest.

Submitted by **ERIC A. DUGAN**, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, California 92350, USA (e-mail: edugan04g@llu.edu); **YOUNG CAGE**, 5839 West Sonoran Links Lane, Marana, Arizona 85653, USA (e-mail: ydcage@aol.com); and **KENNETH SHARROCKS**, 20437 North 17th Way, Phoenix, Arizona 85024, USA (e-mail: freeformdesigns@cox.net)

TYPHLOPS BRONGERSMIANUS (Brongersma's Worm Snake). BRAZIL: CEARÁ: Ubajara (03.8619444°S; 40.9172222°W; 834 m elev.). 06 April 2007. D. Loebmann. Coleção Instituto Butantan, São Paulo, Brazil (IBSP 76365). Verified by M. T. Rodrigues. Species widely distributed with recognized records from Trinidad, Peru, Ecuador, Colombia, Venezuela, Guiana, French Guiana, Suriname, Brazil, Bolivia, Paraguay, and Argentina (Dixon and Hendricks 1979. Zool. Verh. Leiden. 173:1–39; McDiarmid et al. 1999. Snake Species of the World: A Taxonomic and Geographic Reference, Vol. 1. Herpetologists' League, Washington, DC, xii + 511 pp.). First state record, extends the distribution previously known as follows: ca. 760 km NW from the João Pessoa city, Paraíba state, Brazil (Santana et al. 2008. Biotemas. 21[1]:75–84); ca. 700 km N from the ecological station of Uruçui-Una, Piauí state, Brazil and ca. 700 km NE from the Balsas city, Maranhão state, Brazil (Barreto 2007. Cerrado Norte do Brasil = North Cerrado of Brazil. União Sul Americana de Estudos da Biodiversidade, Pelotas, Brazil, 378 pp.); also ca. 620 km E from the Junco do Maranhão city, state of Maranhão, Brazil (Cunha and Nascimento 1993. Bol. Mus. Para. Emílio Goeldi, sér. Zool. 9[1]:1–191).

Submitted by **DANIEL LOEBMANN**, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Caixa Postal 199, CEP 13506-970, Rio Claro, São Paulo, Brazil; e-mail: contato@danielloebmann.com.

Noteworthy Geographic Distribution Records for Colubrid Snakes from the Arkansas Valley Ecoregion of Westcentral Arkansas, USA

HENRY W. ROBISON
Department of Biology, Southern Arkansas University
Magnolia, Arkansas 71754, USA
e-mail: hwrobison@saumag.edu

and

CHRIS T. McALLISTER
Department of Physical and Life Sciences, Chadron State College
Chadron, Nebraska 69337, USA
e-mail: drctmcallister@aol.com

Thirty-eight species and subspecies of colubrid snakes occur in Arkansas (Trauth et al. 2004). Since the compilation of Trauth et al. (*op. cit.*), numerous investigators have recently reported new county records for colubrids in various parts of the state (Engelbert and Patrick 2007; Engelbert et al. 2007; Howey and Dinkelacker 2007; Plummer and McKenzie 2007; Robison and McAllister 2007). Between December 2005 and September 2006, additional geographic (new county) records for eight species of colubrids were collected from Johnson, Pope, and Yell counties of the Arkansas Valley of west-central Arkansas. Township, section, and range are provided for each locality. Specimens were verified by S. E. Trauth and vouchers are deposited in the Arkansas State University Herpetological Museum (ASUMZ), State University, Arkansas. Current common and scientific names follow Crother et al. (2000) except where noted.

Colubrinae

Lampropeltis calligaster calligaster (Prairie Kingsnake). Johnson Co.: Clarksville, Clark Road (Sec. 1, T9N, R23W). 05 July 2005. Joe Kremers. ASUMZ 30796. New county record that partially fills a distributional gap among Franklin and Newton counties and near a previous record from Madison County (Roberts et al. 2005). Juvenile specimen.

Lampropeltis getula holbrooki (Speckled Kingsnake). Johnson Co.: Clarksville, Clark Road (Sec. 1, T9N, R23W). 05 July 2005. Joe Kremers. ASUMZ 30794. New county record that fills a hiatus in the northwestern Arkansas River Valley among Franklin, Logan, and Pope counties. Juvenile Specimen. This snake is one of the most common colubrids of the state, now being reported from 73 of 75 (97%) counties.

Opheodrys aestivus (Rough Greensnake). Yell Co.: Mt. George (Sec. 4, T5N, R21W). 08 June 2006. Joe Kremers. ASUMZ 30800. New county record partially filling a hiatus in the southern Arkansas River Valley among Perry and Scott counties.

Natricinae

Nerodia rhombifer rhombifer (Northern Diamond-backed Watersnake). Johnson Co.: Clarksville, Clark Road (Sec. 1, T9N, R23W). 27 December 2005. Joe Kremers. ASUMZ 30793. New county record and juvenile specimen.

Storeria dekayi wrightorum (Midland Brownsnake). Johnson Co.: Clarksville, Clark Road (Sec. 1, T9N, R23W). 11 September 2006. Joe Kremers. ASUMZ 30797. New county record.

Storeria occipitomaculata occipitomacula (Northern Red-bellied Snake). Pope Co.: 1.6 km N London (Sec. 17, T8N, R21W). 15 September 2006. Joe Kremers. ASUMZ 30799. New county record among Johnson, Logan, and Pope counties. This snake is uncommon in the state although it is widely distributed among all ecoregions (Trauth et al., *op. cit*.).

Thamnophis proximus proximus (Orange-striped Ribbonsnake). Johnson Co.: Clarksville, Clark Road (Sec. 1, T9N, R23W). 27 December 2005. Joe Kremers. ASUMZ 30795. New county record.

Thamnophis sirtalis sirtalis (Eastern Gartersnake). Pope Co.: 3.2 km S Dover (Sec. 3, T8N, R20W). 15 September 2006. Joe Kremers. ASUMZ 30798. New county record partially filling a hiatus among Conway and Johnson counties.

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Engelbert, J., and M. Patrick. 2007. Geographic distribution: *Thamnophis proximus proximus*. Herpetol. Rev. 38:106.

———, ———, and M. Solis. 2007. Geographic distribution: *Opheodrys aestivus*. Herpetol. Rev. 38:105.

Howey, C. A., and S. A. Dinkelacker. 2007. New distributional records for reptiles in central Arkansas. Herpetol. Rev. 38:237–238.

Roberts, K., C. E. Montgomery, and S. J. Beaupre. 2005. Geographic distribution: *Lampropeltis calligaster calligaster*. Herpetol. Rev. 36:82.

Robison, H. W., and C. T. McAllister. 2007. New geographic distribution records of amphibians and reptiles in south Arkansas. Herpetol. Rev. 38:245–246.

Plummer, M. V., and D. F. McKenzie. 2007. Geographic distribution: *Storeria dekayi*. Herpetol. Rev. 38:106.

Trauth, S. E., H. W. Robison, and M. V. Plummer. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.

New Distribution Records for Reptiles and Amphibians from the Charlotte-Metropolitan Area of the Western Piedmont of North Carolina

EVAN A. ESKEW
Department of Biology, Davidson College
Davidson, North Carolina 28035-7118, USA
e-mail: eveskew@davidson.edu

STEVEN J. PRICE
Department of Biology, Wake Forest University
Winston-Salem, North Carolina 27109, USA
and
Department of Biology, Davidson College
Davidson, North Carolina 28035-7118, USA
e-mail: sjprice@davidson.edu

MICHAEL E. DORCAS
Department of Biology, Davidson College
Davidson, North Carolina 28035-7118, USA
e-mail: midorcas@davidson.edu

Knowledge of reptile and amphibian distribution patterns is essential for the development of effective conservation strategies (Tuberville et al. 2005), especially in regions that are becoming increasingly urbanized. Here we report new county records of reptiles and amphibians from the rapidly growing Charlotte-metropolitan area in the western Piedmont of North Carolina. The following records were collected from 2003 to 2007 by members of the Davidson College Herpetology Laboratory. All coordinates listed use NAD83/WGS84 datum and were recorded using a Garmin® hand-held geographic positioning system or online mapping software (www.carolinaherpatlas.org/utmfinder/). New distribution records were verified by Jeffrey C. Beane and/or Alvin L. Braswell at the North Carolina State Museum of Natural Sciences (NCSM) and were based on Palmer and Braswell (1995) or Braswell (1996). All specimens or photo vouchers are housed at NCSM.

Caudata– Salamanders

Eurycea guttolineata (Three-lined Salamander). Lincoln Co.: 0.8 km ENE of intersection of Woodcock trail and Killian Farm Rd (35.4143°N, 80.9676°W). 03 May 2007. Steven J. Price and Kristen K. Cecala. NCSM 73513. New county record.

Gyrinophilus porphyriticus (Spring Salamander). Mecklenburg Co.: Stephen's Road Nature Preserve, ca. 1.5 km SW of intersection of Stephen's Rd and Beaties Ford Rd (35.4013°N, 80.9448°W). 18 April 2007. Steven J. Price. NCSM 73512. New county record.

Pseudotriton ruber (Red Salamander). Iredell Co.: Davidson College Ecological Preserve, ca. 1.0 km E of intersection of Dunmurry Rd and State Hwy 115 (35.5104°N, 80.8278°W). 1 May 2004. Yurii V. Kornilev and William J. Johnson. NCSM photo DC-308. New county record.

Anura – Frogs

Hyla cinerea (Green Treefrog). Cabarrus Co.: 0.9 km NW of intersection of Cox Mill Rd and Christenbury Rd (35.3853°N,

80.7372°W). 02 November 2005. Steven J. Price and Yurii V. Kornilev. NCSM 72672. New county record.

Testudines – Turtles

Chelydra serpentina (Snapping Turtle). IREDELL CO.: Five Mile Branch Stream Restoration Site, 0.3 km SSE of intersection of River Hill Rd and Swann Rd (35.4143°N, 80.9676°W). 23 February 2007. Leigh Anne Harden and Wesley M. Anderson. NCSM photo DC-305. Observation reported by Palmer and Braswell (1995). First photo voucher from county.

Chrysemys picta (Painted Turtle). IREDELL CO.: Five Mile Branch Stream Restoration Site, ca. 1.0 km ESE of intersection of River Hill Rd and Swann Rd (35.8462°N, 80.7680°W). 2 July 2007. Leigh Anne Harden and Steven J. Price. NCSM photo DC-306. New county record.

Kinosternon subrubrum (Eastern Mud Turtle). IREDELL CO.: ca. 0.7 km NE of intersection of Midway Lake Rd and Beracah Place (35.5294°N, 80.8210°W). 24 April 2006. Shannon E. Pittman. NCSM 72703. Observation reported by Palmer and Braswell (1995). First specimen from county.

Sternotherus odoratus (Eastern Musk Turtle). CABARRUS CO.: 0.3 km NE of intersection of Blackwelder Rd and Roberta Rd (35.3506°N, 80.6324°W). 8 July 2005. Elisabeth L. Failey. NCSM 72705. New county record.

Squamata – Snakes

Lampropeltis getula (Common Kingsnake). CABARRUS CO.: Morrison Rd, 0.3 km E of intersection with Pioneer Mill Rd (35.2612°N, 80.5870°W). 24 April 2006. Steven J. Price and Kristen K. Cecala. NCSM 72677. Observation reported by Palmer and Braswell (1995). First specimen from county.

Storeria dekayi (Dekay's Brownsnake). IREDELL CO.: Five Mile Branch Stream Restoration Site, ca. 2.0 km ESE of intersection of River Hill Rd and Swann Rd (35.8510°N, 80.7535°W). 29 October 2006. Leigh Anne Harden and Wesley M. Anderson. NCSM photo DC-307. Observation reported by Palmer and Braswell (1995). First photo voucher from county.

Storeria occipitomaculata (Red-bellied Snake). IREDELL CO.: Davidson College Ecological Preserve, ca. 1.0 km ENE of intersection of Dunmurry Rd and State Hwy 115 (35.5097°N, 80.8305°W). 30 April 2003. Kristine L. Grayson. NCSM 73525. Observation reported by Palmer and Braswell (1995). First specimen from county.

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New County Records of Reptiles and Amphibians from East Texas

JESSICA L. COLEMAN
and
JAKE A. PRUETT
Department of Biology, University of Texas at Tyler
Tyler, Texas 75799, USA
e-mail (JLC): jessicoleman@gmail.com

Here we report several new reptile and amphibian county records for the state of Texas. Despite the number of researchers working throughout the state, many common species have not been documented (Dixon 2000). During the summer and fall of 2007, we surveyed various east Texas counties to document unrecorded reptile and amphibian species. The nomenclature used is in accordance with Crother et al. (2000) and identifications were verified by C. J. Franklin. Voucher specimens are deposited at the Amphibian and Reptile Diversity Research Center (UTA), University of Texas at Arlington, Arlington, Texas and the University of Texas at Tyler, Tyler, Texas. All specimens were collected under the authorization of the Texas Parks and Wildlife Department (permit no. SPF-0806-713).

Anura – Frogs

Anaxyrus americanus charlesmithi (=Bufo americanus charlesmithi) (Dwarf American Toad). CAMP CO.: Approximately 0.48 km N from the intersection of County Rd 2319 and Farm Rd 1520 (33.06639°N, 095.02459°W; NAD27), 105 m elev. 14 September 2007. Jake A. Pruett and Jessica L. Coleman. UTA A-58017. Found in an oak-hickory woodland near Bob Sandlin Lake with at least 3 other *A. a. charlesmithi*, as well as several *Acris crepitans* and *Rana sphenocephala*.

Testudines – Turtles

Chelydra serpentina (Common Snapping Turtle). LAMAR CO.: Camp Maxey, Texas Army National Guard training site. Approximately 16.1 km N of Paris, Texas on Hwy 271 (33.79811°N, 095.567703°W; NAD27), 167 m elev. 24 July 2007. Jessica L. Coleman. UTA R-55473. Shell was found on shore of a small pond among sedges and grass species. Holes were present in the carapace resembling punctures of small mammal incisors; however, predation could not be determined.

Graptemys pseudogeographica kohnii (Mississippi Map Turtle). WOOD CO.: Texas Parks and Wildlife Department Old Sabine Bottom Wildlife Management Area. Approximately 12.8 km N of Lindale, Texas on County Rd. 4106 (32.60190°N, 095.32918°W; NAD27), 85 m elev. 15 May 2007. Jessica L. Coleman. UTADC 1094–95. Adult male photographed basking (1125 h) in a 1.5 km section of the Sabine River with approximately nine *G. p. kohnii* and five other species of turtles (Emydidae). In this section of river a total of 116 individual turtles of various species were observed basking that day.

Sternotherus carinatus (Razorback Musk Turtle). Tɪᴛᴜs Co.: Bob Sandlin State Park. Approximately 19.3 km SW of Mt. Pleasant, Texas (33.06188°N, 095.06506°W; NAD27), 127 m elev. 14 September 2007. Jake A. Pruett and Jessica L. Coleman. UTA R-55474. Shell was found within 2 m of the north shoreline of Bob Sandlin Lake in oak woodland habitat.

Trachemys scripta elegans (Red-eared Slider). Uᴘsʜᴜʀ Co.: Approximately 0.2 km W from the intersection of West Lake Drive and Woodbine Drive (32.54222°N, 94.94694°W; NAD27). 15 September 2005. Jessica L. Coleman. University of Texas at Arlington (UTADC 1099). A female was found crossing West Lake Drive, ca. 50 m S of Gladewater Lake in a residential area.

Squamata – Snakes

Regina grahamii (Grahams Crayfish Snake). Sᴍɪᴛʜ Co.: Texas Parks and Wildlife Department Old Sabine Bottom Wildlife Management Area. Approximately 12.8 km N of Lindale, Texas on County Rd. 4106 (32.58589°N, 095.35719°W; NAD27), 129 m elev. 20 May 2007. Jake A. Pruett. University of Texas at Tyler (UT Tyler 516). Snake captured in minnow trap placed at the land/water interface of an oxbow lake. An unidentified species of crayfish (determined by palpation) had been consumed by the snake, but it could not be determined if predation occurred after entering the trap.

Lɪᴛᴇʀᴀᴛᴜʀᴇ Cɪᴛᴇᴅ

Cʀᴏᴛʜᴇʀ, B. I. (ed.) 2000. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding. SSAR Herpetol. Circ. 29:1–82.

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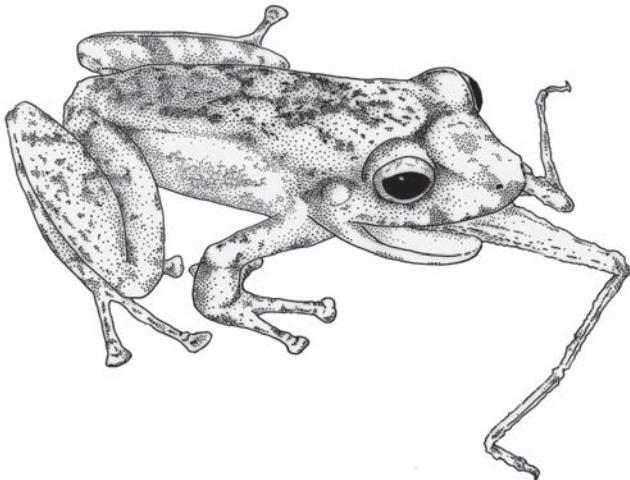
Pristimantis palmeri (Brachycephalidae) eating a small cricket. Illustration by Fernando Vargas-Salinas based on a photograph taken in western Andes, Department of Valle del Cauca, Colombia.

BOOK REVIEWS

Atlante degli Anfibi e dei Rettili d'Italia/Atlas of Italian Amphibians and Reptiles, edited by Roberto Sindaco, Giuliano Doria, Edoardo Razzetti and Franco Bernini. 2006. Edizioni Polistampa, Firenze, Italy (www.polistampa.com). 789 pp. Hardcover. € 70.00 (approx. $US 109.00). ISBN 88-8304-941-1.

AARON M. BAUER
Department of Biology, Villanova University
800 Lancaster Avenue, Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu

Most Western and Central European countries have recently compiled national atlases of their herpetofaunas. The Italian effort to map the national herpetofauna has been noteworthy for its generation of many regional and provincial atlases, as well as a preliminary atlas (Societas Herpetologica Italica, 1996), prior to the publication of the definitive work. The result is a spectacular, highly readable and highly useful volume. The book provides a dual Italian/English text, making it accessible to a broad range of readers.
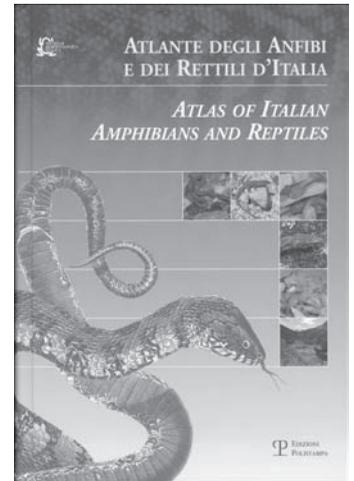
The book begins with an engaging history of Italian herpetology by Violani and Barbagli. This well illustrated chapter, with portraits of Italian herpetologists and illustrations and title pages from their works covers the gamut from the earliest forays into herpetology to the great collectors of the 19th and 20th centuries. Among the more illustrious names included are Aldrovandi, Redi, Malpighi, Vallisneri, Spallanzani, Rafinesque, Rusconi, Panizza, Gené, Peracca, Camerano, Lessona, Bonaparte, Jan, Scortecci, and Doria.

Chapter two, by Massimo Delphino, summarizes the fossil record of the living species. The Miocene to Holocene record is surprisingly representative of the living diversity, with 38 taxa represented plus another 11 genera that are extant, but no longer occur in Italy (e.g., *Tomistoma*, *Agama*, *Varanus*, *Eryx*). This chapter is illustrated by drawings of selected fossils and small photographs of the corresponding living taxa.

Chapter three overviews the genesis of the atlas project and relevant data gathering. The project was begun in 1994 and resulted, only two years later, in the publication of the provisional atlas (Societas Herpetologica Italica, 1996). Over the intervening years many regional and provincial atlases were published. In all over 70,000 data points were plotted on 3382 10 × 10 km UTM coordinates. These were gathered by more than 900 collaborators. Although most of Italy has been at least moderately well covered by

this effort, 7% of the 10 × 10 km units (chiefly in Basilicata and Sardegna [Sardinia]) have no records for any species.

A short chapter on altitudinal distribution presents data in the form of bar graphs by province and shows the results of a simple cluster analysis. Figure 4.1 (p. 142) would have been easier to use had the areas mentioned been clearly indicated on the map.

The final prelude to the accounts themselves is a checklist with taxonomic remarks. Ninety-one species (40 amphibians and 51 reptiles) inhabit Italian territory. The list is accompanied by extensive endnotes that provide useful information on dates of publication of names, ICZN rulings, recent generic allocations, and instances of taxonomic confusion, conflict, or uncertainty in the Italian herpetofauna.

The species accounts themselves begin with a convenient "how to read distributional maps" section. Each account except two of the sea turtles, *Chelonia mydas* and *Dermochelys coriacea*, and the naturalized Red-Eared slider, *Trachymys scripta*, is accompanied by full page, color, topographic map, marked with a half degree grid. Plotted points are divided into 1984 and earlier records, 1985 and later records from the SHI database, other records without specific locality (some provinces provided only imprecise localities to protect the animals), and doubtful records. Account sections are: taxonomy (including phylogenetics), general distribution, comments on the distribution map (often very detailed), habitat, altitudinal distribution, annual activity cycle, reproduction, and status of populations in Italy. All accounts are illustrated by multiple color photos. For some species these include eggs, larvae or juveniles, and views of courtship. In general the quality of the photos is good—only a photo of the venter of *Bombina pachypus* (p. 274) appears out of focus. The provenance of most photos is noted and the majority of photos actually depict Italian specimens.

Chapter 7 by Corti, Lo Cascio, and Razzetti is an overview of the Italian island herpetofaunas. The island groups include the relatively extensive island groups surrounding Sardinia and Sicily and off the coast of Tuscany, as well as the smaller archipelagoes and islands of Liguria, Latium (the Pontine Islands), Venetia, and southern Italy (Campania, Basilicata, Calabria, and Apulia). An extensive table provides species lists by island and a short text section outlines relevant literature and taxonomic issues. The islands have a disproportionately high number of outstanding taxonomic problems and conservation issues as many subspecies and even species have been described from them.

Razzetti and Sindaco briefly discuss 15 additional unconfirmed taxa that may or may not occur in Italy. Some are introductions (e.g., *Xenopus laevis* and *Agama agama*), whereas others approach the borders of Italy and might eventually be added to the fauna (e.g., *Rana arvalis* and *Pseudopus apodus*). Most interesting is the bizarre case of *Rana osca*, which the authors conclude is a synonym of *R. italica*—it was described multiple times, once in an unlocatable reference of uncertain date, and its type material appears to have disappeared within a decade of its description.

A biogeographic chapter by Bologna and Mazzotti reviews the geological history of Italy from the mid-Tertiary onwards and emphasizes the diversity of spatial patterns reflected by the herpetofauna and the resulting biogeographic mosaic. Among the faunal components recognized are widespread Euro-Asiatic elements, Western and Eastern Mediterranean forms, North African species, and peninsular, Sardinian, and Sicilian endemics. Of particular note are taxa with affinities outside of Europe, e.g., *Speleomantes* and *Proteus*, each with North American sister taxa. A variety of historical factors, including the Messinian salinity crisis and glacial advance and retreat, are proposed to explain some of the observed affinities of the fauna. Italian endemism at the species level is especially high for amphibians (50%), whereas reptile endemism is lower (17%) and largely restricted to Sardinia and Sicily, which are the most distinctive herpetofaunal regions of the country based on cluster analysis.

The last two chapters deal with herpetofaunal conservation and legislation. In Chapter 10, Roberto Sindaco evaluates the status of the Italian herpetofauna. Like most amphibians and reptiles worldwide, a lack of data regarding threats and population sizes necessitates categorization based chiefly on areas of occupancy and habitat fragmentation. All taxa are assigned to categories based on this information as well as the proportion of the global range in Italy and, for endemics, the specific nature of their distribution (e.g., insular or mainland). In the following chapter Vincenzo Ferri outlines the complex set of regulations than govern the protection of the herpetofauna. This includes European, Italian, and provincial statutes, some of which protect certain species and others of which focus on habitat protection. Tables summarize the categorization of each species under the Bern Convention, the European Union Habitats Directive, and CITES. All species are covered under the Bern Convention, and most by the Habitats Directive, but only sea turtles, tortoises, and *Vipera ursinii* are CITES listed. Twentone regional and provincial laws affecting amphibians and reptiles are also summarized.

As is fitting for such a comprehensive volume, the bibliography includes more than 1500 references, a resource in itself, as noted by Benedetto Lanza in his preface to the book. In a welcome change from many recent books, a good deal of care seems to have been paid to bibliographic accuracy. Finally the book concludes with short biographical sketches of the 54 authors who contributed to the volume, photo credits, and a taxonomic index listing entries by genus, species, and both English and Italian common name. Unfortunately, the references only relate to the species accounts proper; mentions in other chapters are not cited.

Aside from the inadequacy of the index, I find little to criticize in this aesthetically attractive volume. Although my knowledge of Italian is rudimentary, it appears that the English translation is faithful. The information provided is up-to-date and I especially appreciate the fact that potentially confusing taxonomic and distributional issues are explained and that the reader is lead to the original literature throughout the book. This volume is a testament to the vibrant herpetological community in Italy today. In addition to producing this atlas, the highly active Societas Herpetologica Italica has also recently launched the predominantly English language journal, *Acta Herpetologica*. I highly recommend the *Atlas of Italian Amphibians and Reptiles* to anyone with an interest in any aspect of the European herpetofauna.

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OLIVIER S. G. PAUWELS
Département des Vertébrés Récents
Institut Royal des Sciences Naturelles de Belgique
Rue Vautier 29, 1000 Brussels, Belgium
e-mail: osgpauwels@yahoo.fr

No synthetic work on Homalopsidae has been published since the group's revision by the late Myanmar herpetologist Ko Ko Gyi, which dates back to 1970. Much research has been done since then, including many ecological and taxonomic studies by Daryl Karns, John C. Murphy, Harold K. Voris and their collaborators. Several species have been described or re-validated, others synonymized, and after nearly four decades the time is right for a new major work on these snakes. Taxonomically, the main recent contributor to the knowledge of this group is John C. Murphy, who (co-)described *Enhydris chanardi*, *E. gyii*, and *E. vorisi*. He is, thus, the best placed herpetologist to provide us with an overview of the group, and his new opus is a very welcome contribution.

The book includes two main parts, i.e., the introduction and keys (pp. 1–48) preceded by the preface and acknowledgments, and the generic and specific accounts (pp. 49–212) followed by the literature cited, appendices and the index to scientific names. The author recognizes 10 genera and 37 species in the Homalopsidae, and adds a section on three homalopsid-like *incertae sedis* snakes (*Anoplohydrus aemulans*, *Brachyorrhos albus,* and *B. jobiensis*), which might eventually turn out to be homalopsids once detailed taxonomic studies have been conducted.

The introduction provides a well-written presentation of the group, its general ecology and classification. Figure 1 shows a snake phylogeny to help understand the homalopsids' position among other snakes; its caption mentions that groups containing at least one aquatic representative are marked with an "A." However, no A was associated to *Grayia ornata*, a strictly aquatic snake, nor to the Boidae, which however contain freshwater snakes such as *Eunectes murinus* (see Pauwels et al., 2008 for a review of freshwater snake diversity). The introduction also includes a chapter co-authored by Brooks et al. on the water snake harvest at Tonlé Sap Lake, giving really impressive figures on the homalopsid meat and skin business in Cambodia.

The identification keys include all homalopsid snakes, but unfortunately not the three *incertae sedis* ones. These keys are not fully reliable, since many ranges of characters provided are in con-tradiction with those given in the species accounts. As an example, couplet 9a mentions that female *Enhydris jagorii* have more than 50 subcaudals, while the species account (p. 134) says they have 48–54 subcaudals, and that males have about 68, while the species account gives a variation of 53–68. Another example is that couplet 2a, "Nasal scales in contact" leads a.o. to *Myron richardsonii* (couplet 4c), which actually has separated nasal scales, as rightly mentioned in its species account. I noted in total 34 such discrepancies between the keys and the main text, with more-or-less significant consequences on species identification. It is also to be noted that there is no entry to couplet 9 of the key, excluding identification of snake specimens identifiable as *Enhydris jagorii* and *E. longicauda*. Consequently, an identification using these keys must be carefully double-checked with a comparison of the specimen to the presumably associated species account.

The generic and species accounts are well constructed, with clear sections on etymology, species content, distribution, and diagnosis, and a partial chreso-synonymy. Each species account includes a partial chreso-synonymy and sections on etymology, common names, distribution, diagnosis (except *Enhydris punctata*), size, external morphology, habitat, diet and feeding behavior, reproduction, relationships, and on the museum material examined by the author. In cases in which certain aspects of natural history are particularly well known, additonal sections have been added (predators, etc.). The chreso-synonymies are most often incomplete; their literature references are mentioned using the authors, dates, and abbreviated titles. Since there is a literature section at the end of the book, citing the authors and dates only in the chreso-synonymy would have been sufficient and would have saved a lot of space. The external morphology section follows the same organization for all species and this is helpful for interspecific comparisons. A point locality map is provided for each species. Unfortunately, although there was an effort to track literature references even in local journals, as stressed by Luiselli (2008) in his review of this book, many such references were not listed by the author and numerous localities are thus missing from the maps of many species, sometimes giving a misleading impression of rarity or disparate populations.

Most species are illustrated in life and in color—the book includes 76 color photos. One species only, *Brachyorrhos jobiensis*, is not illustrated at all. There are also 38 black-and-white plates, each composed of six pictures, showing details of head or body. Additional illustrations, mainly drawings, are provided in 47 figures throughout the book, and there are often several drawings per figure. The book is thus lavishly illustrated, most illustrations being of very good quality. A number of specimen photographs present important information, such as the only known picture of a live *Enhydris dussumieri*, or a very unusually patterned *Homalopsis buccata* from Songkhla Lake, southern Thailand. Many photographs are accompanied by precise locality data, which increases their informational value. The natural history of Homalopsidae is extremely interesting, and is well detailed for each species: specialized diets and habitats, hunting strategies, etc. Typical biotope photographs are provided for a number of species.

The main text often refers to the work of Gyi (1970), re-evaluating the accuracy of his observations and updating the data and diagnostic characters for each species, indicating real progress in
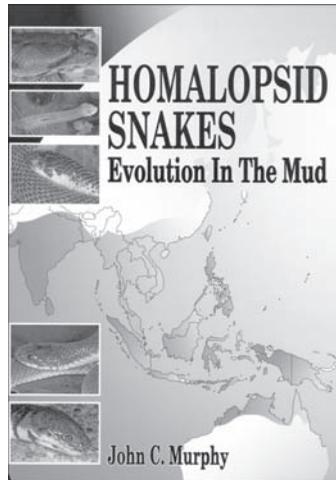
the knowledge of the group. The author moreover stresses a number of gaps in the current knowledge of homalopsids and highlights interesting variation among populations (see for example p. 75 for *Cerberus rynchops*), and thus provides useful directions for future research. The inclusion of species accounts for the *incertae sedis* species is also an excellent feature and underscores the need of additional taxonomic studies on these taxa.

The literature cited section (pp. 213–229) is not exhaustive, but provides all of the most important references. The most recent reference dates from 2007 (only one for that year). A number of references cited in the main text are not in the literature section, some perhaps due to a *lapsus calami* with respect to publication date. Among those referred to in the text and which were certainly omitted from the literature section (since the authors do not even appear in the literature section) are the following: Biswas and Acharyo (1977) (p. 121), Duvernoy (1832) (p. 24), Frith and Boswell (1978) (p. 63), Hundley (1964) (p. 95), Iskandar and Nio (1996) (p. 116, etc.), Kaup (1858) (p. 56), Mattison (1995) (p. 63), Mocquard (1907) (p. 139, 166, etc.), Obst (1977) (p. 155), Phisalix (1922) (p. 139), Reitinger (1978) (p. 148, etc.), Seba (1735, etc.) (p. 233), Shaw (1802) (p. 72, etc.), Sing et al. (1970) (p. 76, etc.) and Thu (2001) (p. 94, etc.). I will not list here the presumed associated references, since this would be too speculative given the possibility of erroneous dates.

Appendix 1 gives a list of species names and their current status, information on the type material and type locality. Appendix 2 is a summary of species distribution by country. This latter information must be used with caution, since I detected not less than 19 discrepancies between this table and the maps and/or text provided in the species accounts. Appendix 3 gives the maximal known sizes for each species. One regrets that the errata on p. 244 could not have been included within the main text.

The most disturbing weakness of the book is the huge number of misspellings. Indeed, I counted more than 450 misspelled words, and this figure is certainly not exhaustive. Most such mistakes are found in the scientific names, authors' names, and in the French and English citations (chreso-synonymy and literature cited). As an example, the binomen *Homalopsis buccata* was spelled five different ways. So many easy-to-detect mistakes and the existence of an errata section seems to indicate that the book was published in a hurry. It would have greatly benefitted from a careful reading, particularly by French- and German-speaking herpetologists, since so many important literature references were written in these languages.

Discrepancies between character variations are not limited to the above mentioned contradictions between the keys and the species accounts. These discrepancies are also found within the text and between the text and tables. A striking example is found in the *Enhydris jagorii* species account (p. 133), where the type specimen is described twice, once in the left column, once in the right one. For the same specimen and on the same page, two different total lengths are given (463 vs. 471 mm), as well as two dorsal scale row numbers before vent (21 vs. 20) and two numbers of subcaudal scales (86 vs. 68). Another example is found in the *Enhydris punctata* species account, where one reads "The subcaudal scales are divided and number 27–46 (32–44 in females, 46–48 in males)." The diagnosis for *Myron richardsonii* (p. 205) mentions that the species has a white belly, while a picture on the

same page shows a yellowish-pinkish belly with transverse lines on each ventral and a black mid-line; and so on. Often these discrepancies have an influence on the diagnosis and species identification. For instance, on p. 168 *Enhydris subtaeniata* is compared with *E. enhydris*. Their respective ventral scale numbers are given as 136–153 vs. 153–174, thus with nearly no overlap. However, on p. 170, the minimum ventral scale number for *E. subtaeniata* is given as 134, and on p. 118 (Table 9) the minimum number for *E. enhydris* is given as 148; their ventral numbers are thus to be corrected to 134–153 and 148–174, respectively, this time with a wide overlap. In addition to the discrepancies in morphological variation between the keys and the main text, I noted 106 problems within and between the main text and the tables, or sometimes between the text and the figures; this number does not include the discrepancies between the main text and Appendix 2. Tables 5, 6, and 11 exhibit an especially large number of discrepancies with the associated species accounts and information available on figures.

The preface explains that the main goal of the book is threefold: to "provide a means of identification for the species of homalopsid snakes, clear up some taxonomic confusion, and provide the reader with a summary of what is known about their natural history." With the caveat indicated above, i.e., always carefully compare a key-based identification with the associated species account, the book indeed does provide a means for identification. The second and third goals are achieved more successfully, and this makes of the present book an important reference to have not only for all herpetologists, but also for readers interested in general natural history and Southeast Asia. The price indicated on Krieger Publishing's website for the book is US $68.50. Given the very good binding and glossy paper quality, the well-illustrated hard cover, the high number of color pictures and the important content of the book, this is a very reasonable price. I thank Patrick David (Muséum National d'Histoire Naturelle, Paris) for useful comments on this review.

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WILLIAM H. ESPENSHADE III
Department of Biology, Villanova University
PO Box 26018, Philadelphia, Pennsylvania 19128, USA
e-mail: william.espenshadeiii@gmail.com

This book is the English translation of the third edition of the original French language work. It is difficult to know what the three authors set out to accomplish with this book, as there is neither a foreword nor a preface. Peter Pritchard, however, in his "translator's notes," suggests that their intent is to distinguish the book from other works with a chelonian world view by being taxonomically up-to-date and by including discussions of survival status.

This book is divided into two major sections, General Biology (9 pp.), and Identification (401 pp.), followed by a short list of references and index of scientific names. The volume is illustrated by 403 photos, two diagrams, and numerous maps. The binding and paper are of high quality, and there are handy colored page margins organized by family or section description throughout.

General Biology begins with a description of the placement of chelonians among living things. *Proganochelys*, considered by the authors the ancestor [sic] of all turtles, is the basis for further taxonomic discussion. The unique chelonian skeleton and other organ systems are treated in about one page, as are senses, sexual dimorphism, metabolism, ethology, and threats and protection. Caveats about taxonomy being a dynamic science always find their way into turtle books; there is a single highlighted paragraph at the end of the General Biology section which states that the nomenclatural concepts in the book incorporate many recent changes by Roger Bour, and that only minor disagreements are to be expected from turtle systematists around the world.

The Identification section is organized alphabetically by family, genus and species, first within Pleurodira, then within Cryptodira. There are 311 species accounts, 280 of which have at least one accompanying photo (of those lacking photos, over half have been described since 1950). Each species account begins with the scientific name, author, and year of description. Common names are also provided, but appear in the page margin adjacent to the reference maps (see below). Most accounts are divided into the subsections Distribution, Description, Natural History, and Protection, each of which may be followed by just one sentence or several detailed paragraphs for the chelonian of interest. A few accounts also include extra sections, such as 'Ethnozoology' for *Carettochelys insculpta* and *Centrochelys* (*Geochelone*) *sulcata*. Some short sections of text were inadvertently left untranslated and appear in the original French, as in the introduction to the Platysternidae (p. 116).
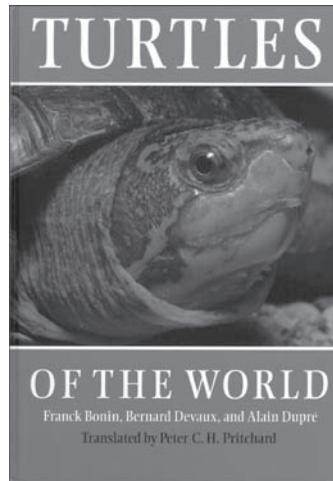
All accounts have a shaded range map indicating the approximate distribution of each species. In the page margin of each account is a continental scale reference map with a square box indicating the location of the more detailed distribution map featured in the main part of the account. Several of the range descriptions from the text are not in agreement with the distribution maps. Associated specimen photos are placed at various places within their respective accounts, but most figure legends do not mention the species name. As a consequence, the identity of photos immediately following the text for one species and preceding that for the next may be unclear to readers. Most of the photos are acceptable, but several have severe shadows, show animals posed in people's hands, or have poor depth-of-field. Interestingly, there is a short biographical appreciation of John Cann on page 30, lauding his skills as a photographer. Indeed, Cann's photos are as near perfect as they can be—no shadows, excellent focus, and alert subjects looking at the camera, always in a natural setting and pose. It is unfortunate that only six of his photos were included in the book!

The Distribution subsection uses both geographic features (rivers or mountains) and political boundaries for a general idea of the range. While usually straight forward, there are some confusing mix ups in this section, e.g., in the range description for *Manouria impressa,* it seems there was an intended comparison with *M. emys*, but the text reads as if to compare *M. impressa* with itself. 'Description' includes a general color and size scheme for the species as well as any other noteworthy shell, skin, or coloration feature. The Natural History subsection lists habitat type within the occupied range; some diet and reproductive information may be included too. The Protection text includes an incomplete listing of national and international laws or treaties that offer some level of legal protection. Appendix III listings under CITES are not included, and some species covered under Appendices I or II are not listed as such. Status, as listed by the IUCN and/ot the Turtle Conservation Fund, is sporadically noted and localized threats or conservation practices known to the authors are also mentioned. Protective status is always in flux, but the simple consistent reference to CITES, IUCN, and Turtle Conservation Fund status for each species would have increased the utility of the book.

Most references included in species accounts cannot be found in the book's reference section. For example, the account for the Pantanal swamp turtle, *Acanthochelys macrocephala*, cites "Buskirk (1988)" for documentation of Paraguay within the range of the species. Neither this paper, published in *Herpetological Review*, or any other senior authored works by Buskirk appear in the reference list. This systematic oversight severely hampers the use of the book by anyone wishing to obtain further information. Additionally there are errors for the works that are listed. *Turtle and Tortoise Newsletter* (TTN) is listed under "Kalb, J.H. 1992." Heather Kalb was one of two editors for the premier issue of this newsletter that was first published in January 2000, with a publication city and state of Lunenburg, Massachusetts, not Evansville, Indiana as the citation reads. The parent publication for TTN, is the peer reviewed journal *Chelonian Conservation and Biology*

which is listed under "Rhodin, A.," who is a founding editor, and sometime author in this journal, which was first published in November 1993, not 1997 as the citation reads.

The index of scientific names only lists taxa by genus, then species, following the authors' taxonomic interpretation. This does not provide user-friendly access, particularly in light of the taxonomic and nomenclatural changes that have occurred in recent years. For instance, the Western Pond turtle of North America cannot be found under the still widely used name *Clemmys marmorata*, but only under *Actinemys marmorata*. At a minimum, cross-listing by specific epithet followed by genus would have greatly facilitated reader use of the index.

After only two years, the English edition of *Turtles of the World* is already in its second printing. The online library catalogue WorldCat (www.worldcat.org) shows that at least 448 institutional libraries worldwide have a copy. It would be prudent for the thrifty turtle book enthusiast to seek one of these library holdings to inspect a copy before making a purchase.

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Buskirk, J. R. 1988. New locality records in Argentina and Paraguay for chelid turtles *Platemys pallidectoris* (Freiberg) and *Platemys macrocephala* (Rhodin et al.). Herpetol. Rev. 19:74–75.

Les Urodèles du Monde, by Jean Raffaëlli. 2007. Penclen Édition, Plumelec, France (contact: jean.raffaelli@laposte.net). 377 pp. Softcover. ISBN 978-2-9528246-0-6. € 65.00 (approx. US $97.00).

AARON M. BAUER
Department of Biology, Villanova University
800 Lancaster Avenue, Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu

Jean Raffaëlli has produced a strange, but useful and inspiring book on salamanders. *Les Urodèles du Monde* can best be understood in light of author's own background, interests, and motivations, which are summarized in the 26 pages of "L'aventure personnelle autour des salamanders." Raffaëlli began his personal odyssey with salamanders in his native France, studying them both in the field and in the terrarium. His love of all things urodelan led him to expand, not only his captive studies, but his field work to encompass much of the world, but particularly the Americas, where salamander diversity is greatest. Raffaëlli's narrative incorporates comments on and by a diversity of salamander experts from both Europe (e.g., Marc Alcher, Robert Thorn) and America (e.g., David Wake, James Hanken, Richard Highton, C. Kenneth Dodd, Jr.), all of whom have influenced his passion for salamanders or contributed to his own knowledge of and appreciation for these amphibians. This personal background, which also touches on chytrid fungus, habitat destruction in Mexico, and the secrets of maintaining salamanders in captivity, is illustrated by small photos of the people, places and salamanders that have made the deepest impressions on him.
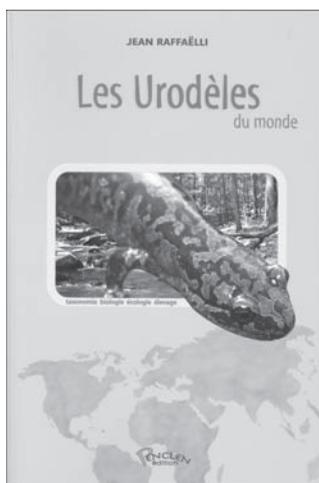
The main body of the book consists of concise species accounts of all salamander taxa recognized as of June 2006. These have drawn heavily from the Global Amphibian Assessment (GAA; www.globalamphibians.org), using GAA threat categories, maps, and estimates of extent of occurrence. For each taxon (subspecies through all higher order ranks within Amphibia) the author and date of description are provided and for all groupings less inclusive than Urodela there is accompanying text. For supraspecific categories, diagnostic features, fossils, phylogeny and taxonomy are discussed. The currency of the taxonomy is impressive. I suspect that many of the genera, subgenera, and species detailed will be unfamiliar, even to most amphibian specialists, unless their own knowledge of the literature is both global and comprehensive.

Each species/subspecies account (all recognized forms, as well as several undescribed forms of *Chiropterotriton* and *Pachytriton*, are illustrated and discussed) occupies between a quarter of a half-page column and a full page. Although not divided into discrete subsections, each account provides information about taxonomy (particularly recent changes), characteristic features, color (including ontogenetic and sexual variation), habitat, reproduction (number of eggs, phenology), diet, threats, distribution (including extent of occurrence), and GAA threat/status category. For some accounts a separate "note d'élevage," in bold, provides husbandry observations. More extensive husbandry information is provided in boxed features scattered throughout the text and tailored for groups with similar housing and rearing requirements (e.g., ambystomatids, *Triturus* and related genera plus *Cynops*, *Plethodon*, small-bodied bolitoglossines).

The main complaint that I had and, I suspect, most readers will have is with the maps and illustrations. Each species account has a small (and I mean small!, mostly ~35 × 33 mm) map associated with it (subspecies are typically shown together on a single map, which for *Salamandra salamandra*, with 15 subspecies, is a problem). These are sometimes sufficient to allow the reader to get his/her bearings, but in other cases all but the most geographically savvy will be lost. In many instances the range markings on the maps are so small and inconspicuous that only careful inspection reveals them (a surprisingly large number of species have areas of occurrence of <20 km^2). This is particularly problematic for high elevation forms, as the red distribution shading is hard to distinguish from the reddish-orange used to denote areas of high elevation on the maps (see for example *Tylototriton verrucosus*, p. 145, as well as many of the bolitoglossine maps). In some cases the maps extend to the absolute inner margins of the page, nearly disappearing in the binding.

The illustrations are also almost uniformly too small. The vertebrate phylogeny on p. 35, for example, is nearly unreadable. Even the larger photos are only 60 × 40 mm, whereas some of the smallest are 30 × 20 mm. In part, this is the result of using (with permission) downloaded low resolution images from AmphibiaWeb. Adults of most taxa are illustrated by color photo-

graphs (although there are none for any of the five species of the subgenus *Oaxakia* within *Bolitoglossa* and few of *Oedipina*), and in some instances larvae and/or eggs are also depicted. For some Chinese taxa colored drawings are provided instead and in some cases, chiefly within the *Ambystoma tigrinum* group, museum specimens have been photographed. The photos come from many sources and, as such, are highly variable in quality. Some are adequate to illustrate diagnostic features, but many, especially given their small size, leave much to be desired. In one case the same photo, showing *Ambystoma macrodactylum* eggs, has been used twice (pp. 76 and 97). Some photos are on neutral backgrounds, others are clearly taken in aquaria or terraria, and still others on naturalistic backgrounds. On page 113 a photo of *Ommatotriton vittatus cilicensis* floating in a water column has an out of focus street scene behind it!

The text concludes with a table comparing the suprageneric taxonomy of Dubois (2005) with that of Frost et al. (2006) and a large table summarizing the familial and less inclusive taxonomy employed in the book, with allocation to subgenera, species groups and complexes as well as genera noted. There is a glossary of 58 terms and a bibliography of >450 references. The index entries are by genus only, except (rather confusingly) for species group names, such as "*dunni*" and "*elongatus*," which appear without reference to the genera to which they belong. At least one taxon, *Pseudoeurycea cephalica rubrimembris*, is not indexed, despite having a full text account.

What makes this book so unique is the juxtaposition of information of various types. On the one hand, the book should appeal to herpetoculturalists who specialize in urodeles. In comparison to other groups of amphibians and reptiles, the literature on salamander husbandry is limited, and Rafaëlli has provided concise, taxon-specific information about the care and breeding of most groups. On the other hand, the book's species accounts provide the only complete summarization of all living salamanders using current taxonomy in book form, and should be attractive to systematists and conservationists. Although much of the information is available from the Global Amphibian Assessment, Raffaëlli has added material and, of course, made everything available in book form. These two seemingly disparate elements of the book, however, make perfect sense in light of the third component — the author's autobiographical introduction. I especially enjoyed reading this "personal adventure" and suspect that it might inspire some readers with rather focused interests to expand their horizons and appreciate the "holistic salamander" as it is clear the author does. Jean Raffaëlli has written a book not for herpetoculturalists or for systematists, but for those, like himself, with an abiding fondness for urodeles in all contexts. On a more practical note, despite the too small images, *Les Urodèles du Monde* has become my "go to" source for basic information about salamanders on a global scale. For anyone with a serious interest in salamanders, amateur or professional, this book will serve as a global urodelan who's who.

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Reptiles of the Solomon Islands, by Michael McCoy. 2006. Pensoft Publishers, Sofia, Bulgaria (www.pensoft.net). 147 pp. Hardcover. ISBN 978-954-642-275-0. € 45.00 (approx. US $67.00).

AARON M. BAUER
Department of Biology, Villanova University
800 Lancaster Avenue, Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu

This book is a new edition of a work initially published in 1980 and subsequently revised and released as a CD-ROM (McCoy 2000). The geographic scope of the volume includes the entirety of the nation of Solomon Islands, including the Santa Cruz Group to the southeast of the main Solomon chain, and Bougainville and nearby islands, which constitute a part of the North Solomons and are politically part of Papua New Guinea. The reptile fauna of the Solomons is both species-rich (86 species), and phylogenetically diverse. Lying close to New Guinea, these islands support reptiles, such as crocodiles, varanids, agamids, acrochordids, and terrestrial elapids, that are lacking from most of the more distant island groups of Oceania. Among the more widely-distributed scincid lizards, the Solomons boasts 11 genera, including the monotypic endemics *Corucia zebrata*, which was CITES listed in 2002, and *Geomyersia glabra*, and 16 species of *Emoia*. The need for a new edition of this work is clear given both the taxonomic advances and environmental losses (particularly the degradation of lowland forests and impact of the pet trade) of the last quarter century.

The introduction includes a brief overview of the topography, geological history, and climate of the region, and an explanation of the species accounts, each of which includes information on English and Latin names, author and date of description, distribution (extralimital and within the Solomons) and type locality, description (based on specimens and published data), color and pattern (based chiefly on observations of live specimens), and natural history. In general, the most recent taxonomic revisions have been followed, for example Zug (2004) for *Carlia*, and Manthey and Denzer (2006) for *Hypsilurus*. McCoy also provides insight (usually based on consultation with experts on particular groups) into remaining taxonomic problems, indicating that *Lepidodactylus guppyi*, *Emoia pseudocyanura,* and *Sphenomorphuis solomonis* are probably composite, signaling the presence of an undescribed species of *Sphenomorphus* (listed as *S. undulatus* by McCoy 1980),
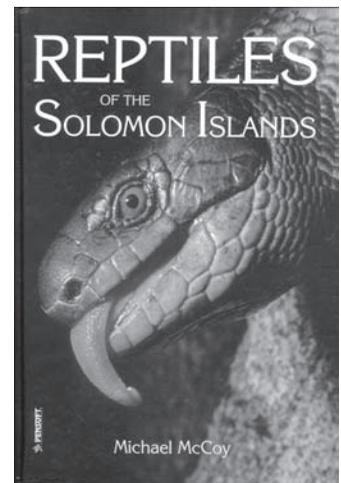
noting that *Sphenomorphus bignelli* is currently incorrectly assigned to genus, and rejecting the validity of *Varanus juxtindicus* (Böhme et al. 2002) from Rennell Island. His observation that Solomons populations of *Cyrtodactylus louisiadensis* are probably not conspecific with those from the Louisiade Archipelago has subsequently been confirmed and *C. solomonensis* has been erected to accommodate these geckos (Rösler et al. 2007).

Keys are provided for marine turtles and for families and genera of lizards and snakes. Keys to species are also presented for all genera with two or more species. One significant problem is that the keys for geckos, as well as the corresponding text in species accounts, confuse digit I and digit V (e.g., on pp. 28 and 36 *Hemiphyllodactylus* is said to have a reduced and clawless digit V, whereas these features characterize digit I only). This error has some potential ramifications; most importantly, are the reported lamellar counts for digit IV (a standard character reported for geckos with scansors) actually referring to digit II because of the incorrect polarity? This aside, I noted only two substantive errors in the text: 1) Sprackland is credited as author of *Varanus spinulosus*, but the taxon was actually described by Mertens (1941) and subsequently elevated to full species by Sprackland (1994); and 2) *Ramphotyphlops angusticeps* is listed as occurring in New Caledonia as well as the Solomons; the New Caledonian type locality, and sole record, is considered incorrect (Bauer and Sadlier 2000).

Some of the most useful and interesting aspects of the text relate to the natural history notes, many of which are drawn from McCoy's own observations. While a few accounts, most notably that of *Corucia zebrata*, cite other sources, the majority of natural history data are unreferenced. At least for serious users of the book, it would have been beneficial to have citations in the relevant primary literature (e.g., pseudocopulation in *Lepidodactylus lugubris*, p. 41).

This new edition is far better illustrated than McCoy's first edition. Most taxa are illustrated by color photos (exceptions include *Caretta caretta*, *Dermochelys coriacea*, *Hypsilurus longii*, *Lepidodactylus mutahi*, *L. shebae*, *Acutotyphlops kunuaensis*, *A. solomonis*, *Ramphotyphlops mansuetus*, and the three regional *Hydrophis*) that appear two per page—large enough to be useful. Not only are the photos generally sharp and illustrative of important features, they are also accompanied by localities, with all but four species represented by animals from the Solomons. A few rare species are represented by photos of preserved specimens (*Sphenomorphus fragosus*, *S. tanneri*, *S. taylori*, *S. transversus*, *Parapistocalamus hedigeri*), but these are also of high quality. In comparison with the first edition (McCoy 1980), which had 20 plates (8, with 64 separate photos, in color), the current version has 128 color photos. The current volume is also nearly twice the length of the older book and offers a new set of checklists giving the occurrence of reptiles for each of 17 islands or island groups within the Solomons. The 82-entry glossary is essentially unchanged from the 1980 edition and the literature cited includes 71 references, only 15 more than the older book, but with many older

entries replaced by more recent ones. A few seemingly relevant citations are missing but given that the corresponding text is not intended to be a technical monographic this is understandable. Only the index is a disappointment by comparison with the earlier book; the 1980 index conveniently included index entries by specific epithet as well as genus, whereas the 2006 index lists entries only by genus.

Although not every herpetologist needs a guide to the reptiles of the Solomon Islands, those who do will find this book to be concise, authoritative, and well illustrated. Although Euro prices make the book relatively expensive by American standards, it is the only up-to-date source for the region and should certainly find a place on the shelves of anyone working on insular herpetofaunas or interested in Pacific biodiversity.

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Erratum

In the article "Detection of Crotamine and Crotoxin Gene Sequences in Genomic DNA from Formaldehyde-fixed Rattlesnakes" by Corrêa et al., published in Volume 38, Number 2 (2007) of *Herpetological Review*, PCR conditions indicated on p. 159 should have read: 0.2 mM of dNTP, 2 mM of MgCl2 and 0.6 U of Taq polymerase.

A New Batrachological Reprint

Jean-Louis AMIET

Publications sur les Batraciens du Cameroun
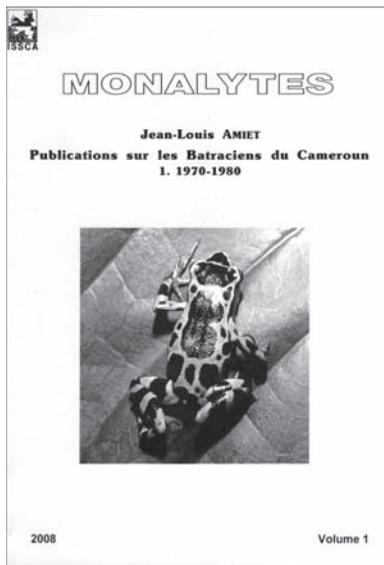
From 1970 to 2007, Jean-Louis AMIET published 53 papers dealing with the amphibians of Cameroun. These papers covered many fields of the study of these animals: systematics (description of 42 new taxa), ethology, ecology, faunistics. Most of these papers were published in periodicals which no longer exist and may be difficult to find, especially for young biologists who do not have direct access to major libraries. The author decided to prepare a complete facsimile reprint of these works, including in many cases post-scriptum notes providing additional unpublished information on the topic of the paper.

The whole reprint covers 1587 pages, published by ISSCA as two separate volumes that will constitute the first two issues of *Monalytes*, a new series of batrachological monographs issued by ISSCA. Both volumes will be published in 2008. Volume 1 (748 pages) covers the period 1970–1980.

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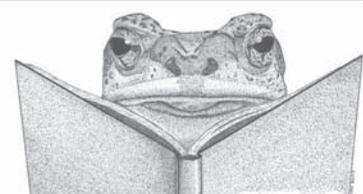
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