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SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES

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The Society for the Study of Amphibians and Reptiles, the largest international herpetological society, is a not-for-profit organization established to advance research, conservation, and education concerning amphibians and reptiles. Founded in 1958, SSAR is widely recognized today as having the most diverse society-sponsored program of services and publications for herpetologists. Membership is open to anyone with an interest in herpetology—professionals and serious amateurs alike—who wish to join with us to advance the goals of the Society.

All members of the SSAR are entitled to vote by mail ballot for Society officers, which allows overseas members to participate in determining the Society's activities; also, many international members attend the annual meetings and serve on editorial boards and committees.

All members and institutions receive the Society's primary technical publication, the *Journal of Herpetology,* and its news-journal, *Herpetological Review*; both are published four times per year. Members also receive pre-publication discounts on other Society publications, which are advertised in *Herpetological Review*.

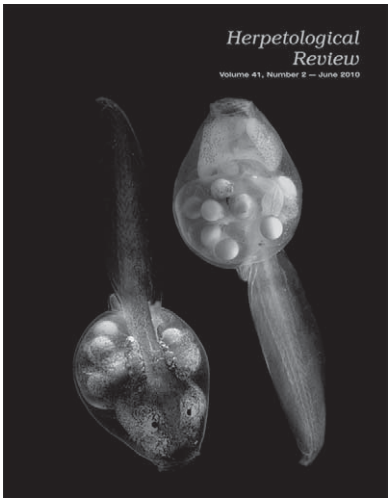
To join SSAR or to renew your membership, please visit the secure online ZenScientist website via this link:

http://www.ssarherps.org/pages/membership.php

Future Annual Meetings

2010 — Providence, Rhode Island, 7–12 July (with ASIH, HL)
2011 — Minneapolis, Minnesota, dates TBA (with ASIH, HL)
2012 — Vancouver, British Columbia, dates TBA (with ASIH, HL, WCH)

About Our Cover: *Anotheca spinosa*



Middle America, the waistband of the Western Hemisphere, seems to contain all of its features. Land forms, climate, soils, vegetation and fauna are more varied in Mexico and Central America than most anywhere else on earth. Owing to its contemporary mountain-building, the region boasts no fewer than four tectonic patterns that leave it rich in rugged plateaus sundered by steep escarpments and dotted with massive volcanic cones. Pristine montane rainforests at low to moderate elevations from Veracruz, Mexico, south into western Panama contain a rarely seen and engrossingly distinctive gargoyle of a frog called *Anotheca spinosa*.

It dwells in trees, usually at heights, so the monotypic *Anotheca* remains poorly known. Our knowledge of its life history derives mostly from captive observations performed 132 years after Steindachner described *Anotheca* (Jungfer 1996. Herpetologica 52:25–32; Steindachner 1864. Verh. Zool. Bot. Ges. Wien. 14:539–552). Fertilized eggs are deposited just above the water line in flooded tree holes, bamboo internodes, and other phytotelmata so the larvae must rely on the female for nutrition. She provides them with infertile eggs which often are ingested whole by the tadpoles. Depending upon need and opportunity, minute arthropods and fellow tadpoles may also be included in the diet.

William E. Duellman (pers. comm.) relates an amusing encounter between two accomplished, but feuding, herpetologists—Edward H. Taylor and Emmett Reid Dunn. Having just acquired strange anuran larvae with egg-filled body cavities, Taylor rushed back from fieldwork in Central America and made a preliminary presentation at the 1953 herpetological meetings. He believed he had stumbled upon a gravid neotenic tadpole about to lay eggs. Dunn, taking a wild guess, openly suggested that Taylor was unable to distinguish between the reproductive and digestive tracts. Turns out Dunn was correct and the larvae were subsequently found to be *Anotheca* (Taylor 1954. Univ. Kansas Sci. Bull. 36[8]:589–595). Considering how little was known about oophagous macrophage anuran larvae at the time, Taylor's error is understandable.

Likely uncommon in nature, *Anotheca* is being bred in captivity at the Atlanta Botanical Garden as part of their work with imperiled anurans from Panama. This live collection of amphibians was initially developed as a collaboration between Zoo Atlanta and the Atlanta Botanical Garden and has subsequently evolved into a resource with multiple purposes: 1) to provide an emergency genetic repository for imperiled species, 2) to provide specimens for research and education at other institutions, 3) to develop and refine captive breeding and husbandry techniques for these species, and 4) to transfer the resultant methodology to collaborators working with the same imperiled amphibian species in Panama. Success with this ambitious effort may help assure that future herpetologists might hear that rarest of nocturnal songs: the mysterious "boop-boop" of a calling *Anotheca* in the mist-shrouded treetops of Middle America.

PHOTO BY W. W. LAMAR

A female *Anotheca* kept in the Garden's "Frog Pod" was observed producing food eggs for a clutch of tadpoles from which the cover image was produced. **Danté Fenolio** used a digital Sony Alpha 100 at a shutter speed of 1/125th of a second with a 100mm macro lens set at f/25 and a Sony Macro Flash Unit to record the cover image.

Fenolio is the resident Amphibian Conservation Scientist for the Atlanta Botanical Garden's amphibian conservation program. His work with the Garden currently focuses on Darwin's Frog (*Rhinoderma*) conservation in Chile and ecological and population studies of the Georgia Blind Salamander (*Eurycea wallacei*). An avid wildlife photographer for most of his life, Fenolio is wrapping up a photographic book that focuses on wildlife that spends all or much of their lives in the dark.

SSAR BUSINESS

Thomas Beauvais Fund to Support Color Photographs in SSAR Publications

SSAR is pleased to announce the establishment of the Thomas F. Beauvais Fund to support the increased use of color in both the *Journal of Herpetology* and *Herpetological Review*. The goal of this fund is to encourage the use of high quality color images of amphibians and reptiles for both scientific and aesthetic purposes. This especially applies to new or never-before-illustrated species. Where authors have appropriate images to accompany their articles, they should contact the editor for particulars.

Thomas Beauvais is an amateur herpetologist who lives in Ann Arbor, Michigan. For several years he has been engaged in an extensive bibliographic, biogeographic, and distributional monograph on the Eastern Massasauga (*Sistrurus c. catenatus*). The accompanying photo shows Tom with an exceptionally large specimen from Indiana at the Field Museum in Chicago. Tom is a graduate of Eastern Michigan University and recently retired from a research position at NSF International, a public health and safety company in Ann Arbor. In 2001, he won a Conservation Achievement Award from the Niagara Peninsula Conservation Authority in Ontario for his cartographic and historical research on the massasauga. SSAR salutes his vision and generosity in establishing this fund, which will more fully record the natural appearance of these beautiful animals that we are privileged to study and enjoy. Those persons who wish to contribute to the Beauvais Fund may contact the SSAR Treasurer, Kirsten Nicholson (address on inside front cover).

NEWSNOTES

New Herpetology Collections Manager at LACM

The sections of Ichthyology and Herpetology at the Natural History Museum of Los Angeles County (LACM) are pleased to announce the appointment of Neftali Camacho as Collections Manager of Herpetology. Neftali has worked in Ichthyology and Herpetology for the past six years, assisting with our skeleton fungus decontamination project, curating our frozen tissue collections, and performing a variety of curatorial duties in both sections. Prior to that he was employed at the museum's Marine Biodiversity Processing Center. Neftali brings extensive natural history collections experience to his new position, as well as ex-

pertise on the herpetofauna of California. Many of you are already familiar with Neftali from specimen loan and data requests; he will continue to provide these services in Herpetology as well as overseeing the Herpetology collection and providing access and assistance to collection visitors. Neftali's appointment fills a position left vacant for the past seven years, during which time the Herpetology collection has been overseen by Ichthyology staff. Herpetology holds an estimated 178,000 catalogued specimens from around the world, with special emphasis on collections from the southwestern United States, Mexico, Central America, the Galapagos Islands, and Australia. All inquiries regarding loans, data requests, or collection visits may be directed to Neftali at 213-763-3371 or at <ncamacho@nhm.org>.

Integration of USGS Herpetology Collection Completed at UNM Museum of Southwestern Biology

The collection of amphibians and reptiles curated by the U.S. Geological Survey (USGS) Arid Lands Field Station in Albuquerque has been integrated into the University of New Mexico's Museum of Southwestern Biology (MSB). Specimen data have been merged and the combined database is now available online through several portals, including HerpNET <www.herpnet.org>.

With more than 12,300 fluid-preserved specimens and 200 skeletons, the USGS collection contains large holdings from Colorado (40%), Nevada (32%), and Nebraska, Arizona, Utah, and California (18% combined). The collection includes early (1920s-1940s) reference specimens for studies of food habits (skeletons) collected by Charles C. Sperry, as well as the Colorado State University herpetological teaching collection, with specimens collected by D. Pettus, A. W. Spencer, D. D. Post, and T. P. Maslin. A large series (3500) of reptiles collected from the Nevada Test Site in the 1960s was catalogued in 2008 and includes many Side-blotched Lizards (*Uta stansburiana*) and Western Whiptails (*Aspidoscelis tigris*), as well as other lizards and snakes. These specimens were donated by USGS scientist Phil Medica. Drs. Bruce Bury and Steve Corn of USGS have provided vital support to the collection in many ways during their studies in the western United States. Voucher specimens from surveys of national parks on the Colorado Plateau are the most recent acquisitions.

The USGS collection was relocated from Fort Collins, Colorado to Albuquerque, New Mexico when MSB collections moved to a renovated facility. Specimens previously cited in the published literature with the acronym BS/FC (Biological Surveys Collection/Fort Collins) have been assigned MSB catalog numbers and are cross-referenced with the original BS/FC catalog number. Although the specimens are property of the U.S. Department of the Interior, and primary responsibility for their care and management rests with USGS, integration of the specimens and their associated data with MSB facilitates their use by the greater scientific community.

Information and loan requests can be directed to collection managers Tom Giermakowski (MSB) at <tomas@unm.edu>; 505-277-5130, and Cindy Ramotnik (USGS) at <ramotnik@usgs.gov>; 505-277-5369.

Seeking Herpetologists with Military Experience

Joseph Mitchell and Rob Lovich are gathering information for an article on herpetologists with military experience. The article is to be published in *Natural Selections*, a newsletter produced by the U.S. Department of Defense Legacy Resource Management Program. If you have military service with your country, please consider providing information for their article. The following elements are needed:

1) A brief paragraph on your military experience—branch, where stationed, combat experience if any, other service of note, awards, rank, dates of service, and anything else you can add.

2) A copy of your CV.

3) A photograph of you holding a herp.

The authors will create a paragraph for each herpetologist and will highlight accomplishments subsequent to military service especially if in the area of management where appropriate.

Information and questions should be directed to Joseph C. Mitchell at <dr.joe.mitchell@gmail.com>.

Instituto Butantan Collection Destroyed in Fire

One of South America's largest herpetological collections, focused on snakes and numbering approximately 80,000 preserved specimens, was destroyed in a fire on 15 May 2010. The curatorial offices were not affected. Founded in 1901 by the Brazilian physician Vital Brazil as the Instituto Serumtherapico Butantan, it was renamed as Instituto Butantan in 1915. Aside from its size, the IB collection has been the focus of ongoing active research and had historical importance in that many specimens were endemic to Brazil, and represented large series, often from habitats that no longer exist. Discussions are underway regarding how the international community can come to the aid of our colleagues at Instituto Butantan.

MEETINGS

Meetings Calendar

Meeting announcement information should be sent directly to the Editor (HerpReview@gmail.com) well in advance of the event.

7–12 July 2010—Joint Meeting of Ichthyologists and Herpetologists (ASIH / HL / SSAR), Providence, Rhode Island, USA. Information: http://www.dce.k-state.edu/conf/jointmeeting/

21–24 July 2010—33rd Annual International Herpetological Symposium, Tucson, Arizona, USA. Information: http://www.kingsnake.com/ihs/

5–8 August 2010—Southwest Partners in Amphibian and Reptile Conservation, Colorado State University, Fort Collins, Colorado, USA. Information: www.swparc.org.

10–11 August 2010—Northeast Partners in Amphibian and Reptile Conservation Annual Meeting, Acadia National Park, Maine, USA. Information: http://www.pwrc.usgs.gov/neparc/

13–15 August 2010—Midwest Partners in Amphibian and Reptile

Conservation Annual Meeting. Theme: "Blanding's Turtle Biology, Conservation, and Management." Lorado Taft Field Campus of Northern Illinois University, Oregon, Illinois, USA. Information: http://www.mwparc.org/meetings/2010/

16–19 August 2010—Turtle Survival Alliance & IUCN/SSC Tortoise and Freshwater Turtle Specialist Group Joint Symposium, Orlando, Florida, USA. Information: http://www.turtlesurvival.org/get-involved/2010-conference.

22–26 September 2010—VIII National Congress of Societas Herpetologica Italica, Abruzzo, Italy. Information: shiabruzzo2010.iscrizioni@gmail.com

12–14 November 2010—5th National Symposium on the Ecology, Status, and Conservation of the Diamondback Terrapin, at Louisiana University's Marine Consortium (LUMCON) in Chauvin, Louisiana, USA. Hosted by the Diamondback Terrapin Working Group. Information: www.dtwg.org.

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.

A listing of current contents of various herpetological journals and other publications is available online. Go to: http://www.herplit.com and click on "Current Herpetological Contents."

Partitioning of Temporal Activity in Desert Lizards

Competition between similar species coexisting in an ecological community is ameliorated if the species segregate along the lines of food, habitat, or activity time. Of these three factors, foraging ecology and habitat use have received considerable attention; however, research on temporal partitioning is much more limited. In this study, the authors investigated temporal activity in a diverse lizard assemblage in the Simpson Desert in central Australia. Three time periods were defined; sunset to sunrise (daytime), sunset to midnight (early night), and midnight to sunrise (late night), and were examined in both September and November. Ambient temperature and invertebrate prey activity were measured at these times as well. Thirteen lizard species were observed in the assemblage (*Ctenotus ariadne, Ctenotus dux, Ctenotus pantherinus, Egernia inornata, Morethia ruficauda, Menetia greyii, Ctenophorus isolepis, Ctenophorus nuchalis, Pogona vitticeps, Nephurus levis, Varanus brevicauda, V. eremius, V. gouldii*) with 77% of all captures occurring in the day. Only three species (*Ctenotus pantherinus, Egernia inornata, Nephurus levis*) were observed to demonstrate significant nocturnal activity. Abundance of invertebrates was variable, depending on time of day and month, and some lizards, in particular the skink species, had a wider degree of temperature tolerances than the agamids and varanids. The authors conclude that partitioning within the lizards in this assemblage is not evenly distributed temporally.

Gordon, C. E., C. R. Dickman and M. B. Thompson. 2010. Partitioning of temporal activity among desert lizards in relation to prey availability and temperature. Austral Ecology 35:41–52.

Correspondence to: Chris Dickman, Institute of Wildlife Research, School of Biological Sciences, Heydon-Laurence Building (A08), University of Sydney, New South Wales 2006, Australia; e-mail: cdickman@bio.usyd.edu.au.

Impact of Low Population Densities on Fertility in Marine Turtles

Depensation, or the Allee Effect, the reduced per capita growth rate in low density populations, can have severe consequences for already dangerously small populations. Many marine turtles worldwide have suffered serious declines, primarily due to historic overexploitation. In this study, the authors conducted a meta-analysis to examine the potential for depensation on Green Turtles (*Chelonia mydas*) and Loggerhead Turtles (*Caretta caretta*). Using hatching success as an indicator of fertilization success, the authors found no evidence for depensation for either of these species in small nesting aggregations throughout the world. The authors propose a number of mechanisms which may mitigate depensation, including a polyandrous mating system, opportunistic matings between breeding aggregations, and interchange between rookeries. The authors emphasize the importance of monitoring small nesting aggregations, in part to understand the mechanisms that mitigate depensation in these species.

Bell, C. D., J. M. Blumenthal, A. C. Broderick, and B. J. Godley. 2010. Investigating potential for depensation in marine turtles: How low can you go? Conservation Biology 24:226–235.

Correspondence to: B. J. Godley, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter, Cornwall Campus, Penryn TR10 9E2, United Kingdom; e-mail: b.j.godley@exeter.ac.uk.

Senescence in Garter Snakes

Within a life-history context, evolutionary theories of senescence (aging) focus on a trade-off between investing in survival versus investing in growth and reproduction. In high mortality environments, organisms are predicted to develop rapidly and invest in high early reproduction, instead of survival and longevity. In contrast, longevity and delayed reproduction is predicted to be favored in less hazardous environments. Despite these theoretical predictions, investigating these hypotheses empirically is difficult. In this study, the authors investigated six northern Californian populations of Western Terrestrial Garter Snakes (*Thamnophis elegans*), which can be divided into high and low mortality habitats. These populations have been extensively studied and have been demonstrated to have evolved different life spans in keeping with theoretical predictions. In this study, the authors examined a number of physiological traits in neonates after stressed or control gestations to examine different responses of the two populations. Results indicated that neonates from the long-lived

populations were smaller, had more efficient DNA repair mechanisms (but also suffered higher levels of DNA damage), and had more efficient cellular antioxidant defenses and mitochondria. The authors conclude that their study highlights the interrelatedness of stress and life history evolution in reptiles.

Robert, K. A., and A. M. Bronikowski. 2010. Evolution of senescence in nature: Physiological evolution in populations of garter snake with divergent life histories. The American Naturalist 175:147–159.

Correspondence to: Anne M. Bronikowski, Department of Ecology, Evolution and Organismal Biology, Iowa State University, Ames, Iowa 50011; e-mail: abroniko@iastate.edu.

Costs of Mate Guarding Behavior in Male Whiptail Lizards

Males of many species guard their mates following mating, which may have a number of benefits including reducing extra-pair copulations by females. Despite the potential benefits to the male in terms of fertilization success, mate guarding is also energetically costly. In this study, the authors have examined mate guarding in the Western Mexican Whiptail Lizard (*Aspidoscelis costata*), paying particular attention to the reduction in energy intake when guarding and the increase in male-male competition. The authors also tested whether males adjust their guarding behavior in relation to the perceived fecundity (as assessed by body size) of the female. Observations of a number of matings and subsequent mate guarding behaviors were made. The authors observed that males engaged in mate guarding consumed substantially smaller and less prey than non-guarding males. Further, guarding males were subject to 120% more male-male competitive behaviors than when not guarding. Finally, males were more aggressive when females were large. The authors suggest that these demonstrated costs of mate guarding, and possible survival consequences, must be less than the benefits accrued through mate guarding for this behavior to persist.

Ancona, S., H. Drummond, and J. Zaldívar-Rae. 2010. Male whiptail lizards adjust energetically costly mate guarding to male-male competition and female reproductive value. Animal Behaviour 79:75–82.

Correspondence to: Sergio Ancona, Laboratorio de Conducta Animal, Departmento de Ecología Evolutiva, Instituto de Ecología, Universidad Nacional Autónoma de México, A.P. 70-275, C.P. 04510, México; e-mail: ancona.s@gmail.com.

Patterns of Malagasy Chameleon Diversity Revealed

With its impressive diversity and incredibly high level of endemism, the island of Madagascar has long been an area of elevated interest for researchers studying the factors responsible for speciation and endemicity. Chameleons of the genus *Brookesia* are particularly diverse in the region (26 described species) and display a pattern of elevated microendemism, with as many as half only known from a single locality. In this paper, the authors explored three hypotheses potentially driving speciation, geographic distribution, and community assembly. First, mountains may serve as refugia during dry periods; if this is the case, endemic species would be restricted to these high-elevation regions and sister species would tend to occur on adjacent mountains. Second, watersheds may also serve as refugia during dry periods; in this scenario, watersheds with high-elevation headwaters would contain mostly wide-ranging species, endemic species would occur in headwaters with low-elevation headwaters, and sister species pairs would tend to occupy adjacent watersheds (especially low-elevation watersheds and therefore low elevation regions would exhibit greater diversity). Originally postulated by previous researchers, these first two hypotheses were suggested to be caused by Pliocene and Pleistocene climatic fluxuations. A third hypothesis, major rivers functioning as important barriers to dispersal, was also evaluated; this hypothesis predicts that the distributions of species pairs meet at major rivers and that low elevations are the most species-rich. To determine species pairs and examine the timing of speciation, using both mitochondrial and nuclear DNA data from most of the described members of the genus as well as several undescribed taxa (and including samples from multiple localities if possible), the authors simultaneously reconstructed the *Brookesia* phylogeny and inferred the divergence dates within the group. Second, distributional information was accumulated for all taxa (for the nine species known from seven or more localities, correlative niche modeling methods were employed to construct predicted distributions; otherwise point localities were used). These distributional data were used to infer regional species richness and endemism values across the island. The phylogenetic analyses revealed most of the species level diversification far predates the Pliocene. Furthermore, the patterns of species richness and sister species distribution reject rivers or watersheds as important drivers of speciation but support the mountain refugia hypothesis. This study exemplifies the importance of explicit hypothesis testing in evaluating hypotheses of evolutionary history.

Townsend, T. M., D. R. Vieites, F. Glaw, and M. Vences. 2009. Testing species-level diversification hypotheses in Madagascar: the case of microendemic *Brookesia* leaf chameleons. Systematic Biology 58:641–656.

Correspondence to: Ted Townsend, Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, California 92182-4164, USA; e-mail: townsend@sciences.sdsu.edu.

Resource Use Over Different Spatial Scales in a Snake

Resource selection within a species can be broadly thought of occurring on three different spatial scales: 1) the entire geographical range of a species, 2) the home range of an individual within the landscape, and 3) specific locations within the home range. Most studies of resource selection occur on the second and third of these levels, but as resources in a landscape may be scale dependent, in order to fully understand a species habitat and resource use, wider scales must be considered. In this study, the authors have examined landscape level resource use in the Eastern Hognose Snake (*Heterodon platirhinos*), in southern New Hampshire, USA. Eight snakes were radiotracked for two years, and once landscape availability was controlled for, at the landscape level, snakes were found to choose forest-edge and old field habitats preferentially, and neglect forested habitats and

wetlands. Investigating resource allocation at the landscape level also indicated that snakes preferred low slope and sandy loam soils. These patterns were not detected when only the home range of an individual was considered. The authors therefore emphasize the importance of taking a landscape approach when investigating resource use.

LaGory, K. E., L. Walston, C. Goulet, R. A. Van Lonkhuyzen, S. Najjar, and C. Andrews. 2009. An examination of scale-dependent resource use by eastern hognose snakes in southcentral New Hampshire. The Journal of Wildlife Management 73:1387–1393.

Correspondence to: Kirk LaGory, Environmental Science Division, Argonne National Laboratory, 9700 S Cass Avenue, Argonne, Illinois 60439, USA; e-mail: lagory@anl.gov.

Predator Avoidance Outweighs Thermal Benefits in a Gecko

Many species are faced with multiple predators, which may pose different levels of risk. According to the threat-sensitive predator avoidance hypothesis, prey should match their behavior to the level of risk posed by each predator. In this study, the authors have examined this in the nocturnal Velvet Gecko (*Oedura leseurii*), from eastern Australia, which is preyed upon by two snakes, the relatively dangerous Broad-headed Snake (*Hoplocephalus bungaroides*), which preys on geckos, and the less dangerous Small-eyed Snake (*Cryptophis nigrescens*), which preys on skinks. In the laboratory, geckos show generalized antipredator behaviors to chemical cues from both snakes, however, in nature, these behaviors may have costs, in particular thermal costs. In this study, a number of laboratory trials were used to investigate this question. In the first trial, geckos were presented with two identical shelters, one unscented and the other containing chemical cues from either the Broad-headed or Small-eyed Snake. Next, geckos were presented a cold unscented shelter and a warm shelter, again scented with either Broad-headed or Small-eyed snake chemicals. Finally, two warm shelters were presented, this time one was scented like the Broad-headed Snake, and the other like the less dangerous Small-eyed Snake. In each trial, regardless of the thermal suitability of the shelter, geckos avoided equally shelters scented with either snake, preferring to remain outside a shelter when both were scented, suggesting that Velvet Geckos treat these snakes as equally dangerous. These results were then confirmed in a natural setting, with geckos avoiding sites previously used by both snake species.

Webb, J. K., D. A. Pike and R. Shine. 2009. Olfactory recognition of predators by nocturnal lizards: Safety outweighs thermal benefits. Behavioural Ecology 21:72–77.

Correspondence to: Jonathan Webb, School of Biological Sciences, A08, University of Sydney, NSW 2006, Australia; e-mail: jwebb@bio.usyd.edu.au.

Function of Tentacles in the Aquatic Snake, *Erpeton tentaculatus*

The Tentacled Aquatic Snake (*Erpeton tentaculatus*), has a unique pair of scaled tentacles projecting from the rostral margins of the head. For over a century their function has remained a source of contention, with suggestions that they aid in camouflage, act as lures or ornaments, or aid in the detection of prey by sensing water movement. In this study, in an attempt to shed light on the function of these tentacles, the authors investigated snake behavior and tentacle morphology, induced the optic and trigeminal nerves, and mapped the resulting visual and somatosensory responses in the optic tectum and trigeminal ganglion, respectively. Dissection and microscopy failed to reveal minute sensory structures (which could bestow electromagnetic reception) associated with the tentacle scales; however tentacles were found to be heavily innervated via the trigeminal nerve (as is the pit organ of crotaline viperids). Furthermore, recordings of nervous impulses returning from the tentacles revealed that the tentacles were able to sense very minute water movements (equivalent to the force exerted by 8mg). Finally, snakes were found to strike accurately at digital fish under both normal and infrared conditions, suggesting that detection of water movement alone was sufficient to locate prey. The authors suggest that these tentacles operate alongside the visual system to aid in prey detection, especially in low-light environments.

Catania, K. C., D. B. Leitch, and D. Gauthier. 2009. Function of the appendages in tentacled snakes (*Erpeton tentaculatus*). The Journal of Experimental Biology 213:359–367.

Correspondence to: Ken Catania, Vanderbilt University, Department of Biological Sciences, Nashville, Tennessee, USA; e-mail: ken.catania@vanderbilt.edu.

Are Amphibians Good Indicators of Ecosystem Health?

Amphibians are often considered important indicators of ecosystem health. This is primarily because they are expected to be sensitive to a range of contaminants as they possess permeable skin, a complex terrestrial and aquatic life cycle, and a relatively simple immune system. In this study, the authors have examined the veracity of this reputation, completing a meta-analysis comparing the sensitivity to environmental challenges of amphibians relative to other taxa. Almost twenty-four thousand studies involving 1075 species and 73 chemical agents were examined. Overall, the results suggested that amphibians demonstrate only moderate responses to waterborne toxins. Amphibians are relatively insensitive to heavy metals and pesticides, but demonstrate high sensitivity to phenols, a class of toxins that has been largely overlooked in amphibian studies. The authors suggest that amphibians may not serve as very good barometers of ecosystem health and are prone to persisting in areas that have already been severely impacted. While chemical contaminants may play a role in amphibian declines, this may be indirect, reflecting the population loss or extinction of more sensitive taxa, in particular invertebrates.

Kerby, J. L., K. L. Richards-Hrdlicka, A. Storfer, and D. K. Skelly. 2010. An examination of amphibian sensitivity to environmental contaminants: are amphibians poor canaries? Ecology Letters 13:60–67.

Correspondence to: Jacob Kerby, Department of Biology, University of South Dakota, Vermillion, South Dakota 57069, USA; e-mail: Jacob.kerby@usd.edu.

ZOO VIEW

Herpetological Review, 2010, 41(2), 134–142.

The Evolution of Keeping Captive Amphibians and Reptiles

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SEVERAL OF THE LADIES IN SOUTHPORT HAVE PURCHASED PETS AMONG THEM, AND IT MAY BE THAT NO SOUTHPORT LADY WILL CONSIDER HER ESTABLISHMENT PERFECT WITHOUT A BABY ALLIGATOR TO BASK ON THE HEARTH RUG, AND GO OUT ON A WALK ON THE PROMENADE WITH HER. WHEN THE PET DEFUNCTS, HE CAN BE STUFFED, GILT, AND PUT IN THE HAT FOR AN ORNAMENT, DON'T YOU KNOW?

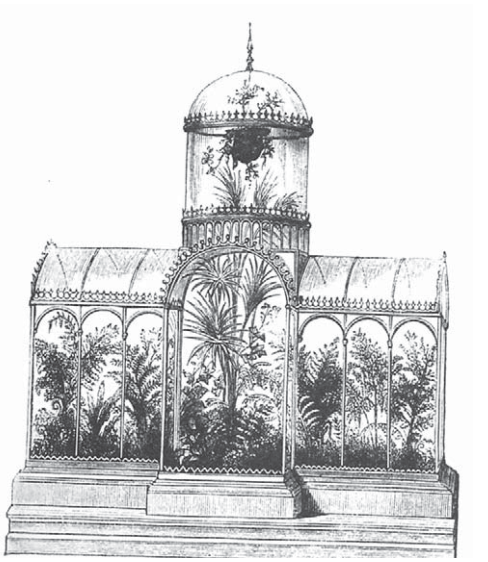
—Frank Buckland in *Notes and Jottings from Animal Life* in 1882

Nature Encased in Glass

In 1688, the French produced polished plate glass in large sizes by casting and hand polishing. Over 45 years later in the United Kingdom, Robert Lucas Chance introduced improved cylinder sheet glass using a German process to produce finer quality and larger panes. "A better system of making sheet glass, from blown cylinders, was introduced into England in 1832 by Chance Brothers and Bontemps. Although the new method, already established in Germany and France, required five types of skilled workers, it was cheaper, produced bigger sheets, and was free from the blemish in the centre… But after only seven years Chance Brothers devised a process by which the sheets could be ground and polished like plate glass… The manufacture of plate glass was introduced into England from Northern France in 1773…" (Derry and Williams 1961:594–595). This glass was used to create the first Crystal Palace in London in 1851. The process was used extensively until early in the 20th Century to make window glass. From this period onwards machines were developed to automate the production of window glass.

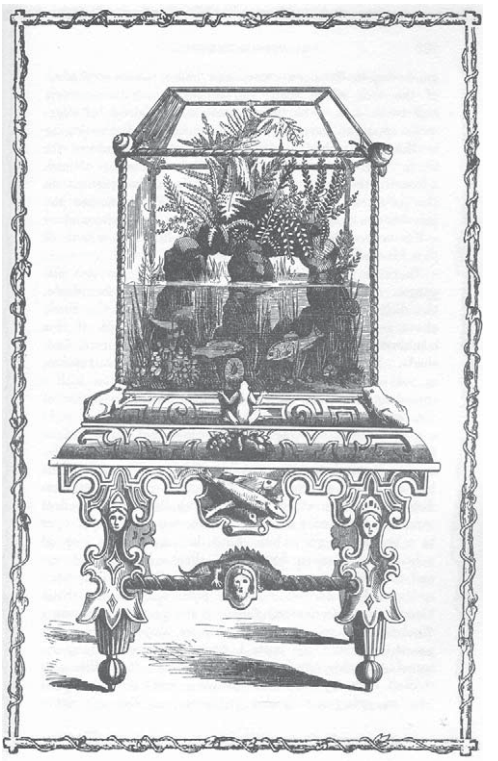
There is no question but that the availability of inexpensive window glass was one of the main factors for the rise of fern cases, aquaria, terraria, and vivaria in Europe. Fanciers interested in the behavior and biology of fishes, tadpoles, and newts were now able to look closely at them in an aquarium rather than peering into a pond or small bottle to catch a fleeting glimpse.

In 1829, Nathaniel Bagshaw Ward discovered that two seedlings, a grass and a fern, had *accidentally* sprouted in a closed glass bottle, containing a layer of damp soil he was using to pupate a sphinx moth chrysalis. He experimented with other closed glass containers and found that he could keep a number of ferns successfully. Glass was expensive as it was subject to a heavy excise tax (to pay for the Napoleonic wars) until 1845. After the tax was repealed, glass was affordable so Ward's "Closely Glazed Cases" were available widely and his invention reached its full potential. Wardian Fern Cases became the rage and virtually every wealthy Victorian lady's drawing room had fern-growing cases. Shirley Hibberd (1856) loved ferns: "Plumy emerald green pets glistening with health and beadings of warm dew." Pteridomania, the craze for ferns, was fueled by books such as *The Ferns of Great Britain* by Anne Pratt in 1855, *Hardy Ferns: How I Collected and Cultivated Them* by Nona Bellairs in 1865, and even as late as 1905 with George Schneider's work called *Choice Ferns for Amateurs: Their Culture and Management in the Open and Under Glass*. Well-dressed Victorian women often collected wild plants and animals for their enclosures, as seen in the picture "Gathering Ferns" from *London Illustrated News* in 1871. The picture is by William Kay Blacklock and is available on the web at http://goldenagepaintings.blogspot.com/2009/02/william-kay-blacklock-gathering-ferns.html. Orchids and other tropical plants were kept in fern-cases as well.



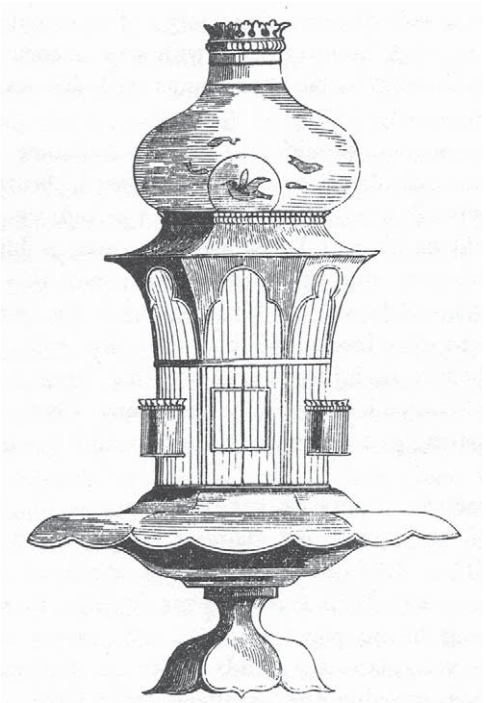
Wardian Fern Cases could be very elaborate. This terrarium was modeled after the Crystal Palace of London's Great Exhibition in 1851.

By the mid-1800s, the drawing rooms of the wealthy were often filled with a myriad of glass containers, large and small, housing plants and animals. All of these items were sometimes advertised in natural history books available during this time. One of the curious facts is that fern and aquarium crazes were almost always feminine interests during the Victorian era. "But the role of women as encouragers of natural history must not be underrated. It is unlikely that so many natural history societies, museums, zoological and botanical gardens and public aquaria would have been founded if they could not have relied on regular female support." (Barber 1980). Charles Kingsley described the Victorian lady naturalist at home in *Glaucus* in 1855: "I have seen the young London beauty, amid all the excitement and temptation of luxury and flattery, with her heart pure and her mind occupied in a boudoir full of shells and fossils, flowers and sea-weeds, and keeping herself unspotted from the world, by considering the lilies of the field, how they grow." Why were



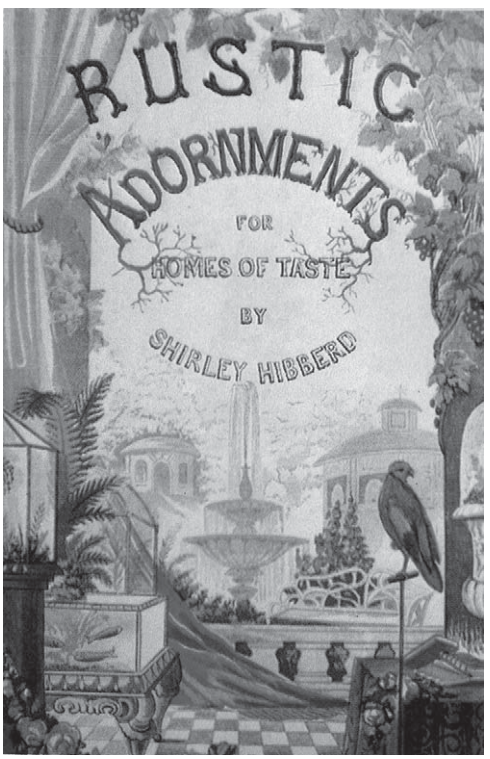
In 1856, Shirley Hibberd published *Rustic Adornments for Homes of Taste*. Pictured here is Aquarium combined with Fernery. Note frogs at base.

so many natural history books and periodicals published during this period? Victorians believed that it was slightly common to obtain animals and plants for parlors and drawing rooms simply for amusement; if flora and fauna were to be shown, there had to be an educational component attached to their passion for collecting. George Brettingham Sowerby the Second in *Popular History of the Aquarium* put it this way in 1857: "Nor is it only for amusement that such parlour oceans and lakes are prepared and stocked; they are invaluable as a means of instruction."



Combination aquarium and bird cage from *Rustic Adornments for Homes of Taste*. At top of enclosure are two bowls. Birds had access (from lower wire cage) to smaller bowl within the larger one where they were juxtaposed to fishes swimming around them. This was a popular Victorian design feature.

In 1856, the pioneer naturalist Shirley Hibberd published *Rustic Adornments for Homes of Taste and Recreations for Town Folk in the Study and Imitation of Nature* . This is the most complete book published during the Victorian era covering fern cases, marine and freshwater aquaria, aviaries, apiaries, and outdoor gardens and it is one of the most beautiful with elaborate drawings and colored floral borders on each page. Hibberd wrote in the Preface, "Whatever serves to heighten the enjoyments of home, and add fresh graces to the domestic hearth, must be worthy of encouragement and culture."



Cover from *Rustic Adornments for Homes of Taste*.

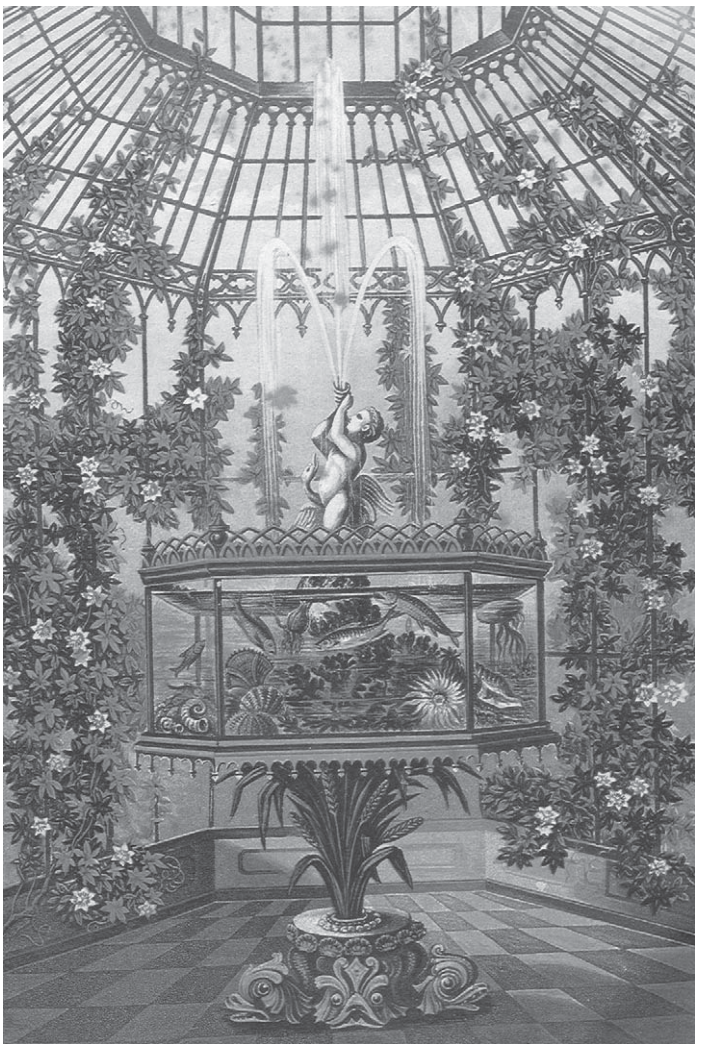
But there was a downside to the fern craze: "The poor Ferns, like the wolves in olden times, have a price set upon their heads, and they in like manner will soon disappear. We must have 'Fern laws,' and preserve them like game" (Bellairs 1865). Another problem which surfaced was that ferns quickly died in the polluted London air. As interest in ferns began to wane in England, the development of aquaria filled the void. "When every drawing-room contained a fern case, they began to seem a little dull, or even—horrid thought!—a little vulgar." (Barber 1980.).

From Land to Water

The keeping of goldfish substantially predates the aquarium craze, dating back to at least 1000 AD in China. The Chinese exported goldfish breeding to Japan and Korea around 1500 AD. Goldfish reached Europe around the beginning of the 17th Century and the US in 1876. These fishes were bred to be seen from above in shallow porcelain bowls.

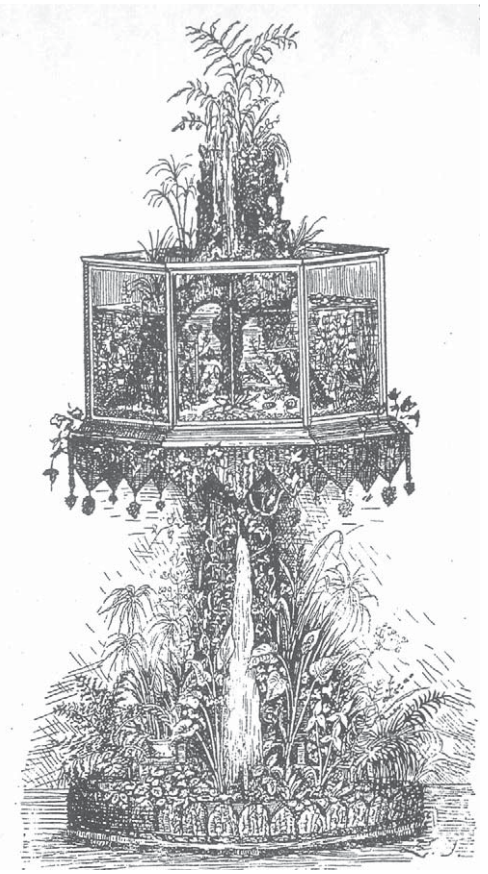
In 1850, Robert Warington kept two small goldfish and a *Valisneria spiralis* plant in a twelve-gallon tank for almost a year without changing the water. He is credited with discovering the "Balanced Aquarium." During the same period, Philip Henry Gosse was independently pursuing the same experiments. Gosse published *A Naturalist's Rambles on the Devonshire Coast* which described his somewhat unsuccessful adventures at aquarium-keeping. In 1853, he said "Let the word AQUARIUM then be the one selected to indicate these interesting collections of aquatic animals and plants."

Warington and Gosse were important figures in contributing to the new aquarium craze in Victorian England. In 1856, Gosse wrote the first book on the marine aquarium entitled *A Handbook to the Marine Aquarium* . . . and it contained an advertisement by W. Alford Lloyd: For Sale—15,000



Some aquarium presentations were stunning. Illustration from *Cassell's Household Guide* in 1869?–1871?.

specimens comprising over 200 genera in 50 large glass aquaria. Other authors published books on aquarium keeping: *Ocean Gardens: The History of the Marine Aquarium, and the Best Methods Now Adopted for its Establishment and Preservation* by H. Noel Humphreys in 1857; *The Marine Aquarium: Directions for its Preparation and Management* by R. M. Stark in 1857; *Common Objects of the Sea-Shore* by Reverend John G. Wood in 1857; *The Family Aquarium; or, Aqua Vivarium ... Being a Familiar and Complete Instructor upon the Subject of the Construction, Fitting-up, Stocking, and Maintenance of the Fluvial and Marine Aquaria* by Henry D. Butler in 1858; *Cassell's Household Guide* in 1869?–1871?; *The Student's Aquarium (Marine and Fresh Water): How to Make and Manage* by S. Jacob in 1886; *The Amateur Aquarist* by Mark Samuel in 1894; and *Das süsswasser-aquarium. Geschichte, flora und fauna des süsswasser-aquariums, seine anlage und pflege* by Ernst Bade in 1898. Some of these books offered instructions for collecting animals and plants at the seashore and early pictures again show Victorian women with billowing dresses, buckets, and long-handled dip nets searching the tide-pools (see Bedell 2009).



Beautiful aquarium from *Das süsswasser-aquarium. Geschichte, flora und fauna des süsswasser-aquariums, seine anlage und pflege* by Ernst Bade in 1898.

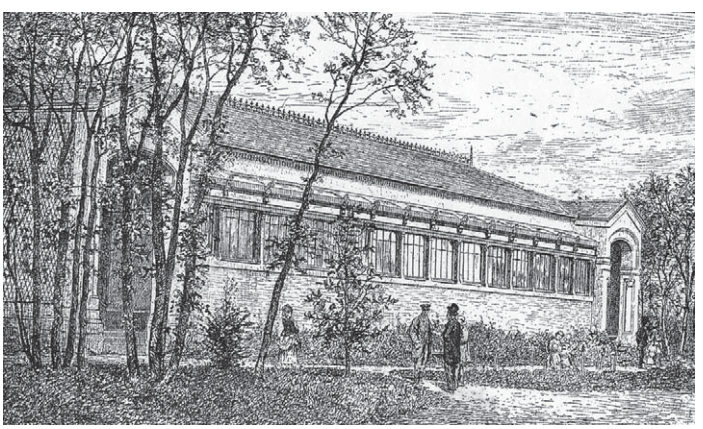


Illustration of public aquarium in Jardin Zoologique d'Acclimatation in Paris from *Le Jardin d'acclimatation illustré: Animaux et plantes / par Pierre-Amédée Pichot ... Avec une préface par M. Albert Geoffroy-Saint-Hilaire . . .*

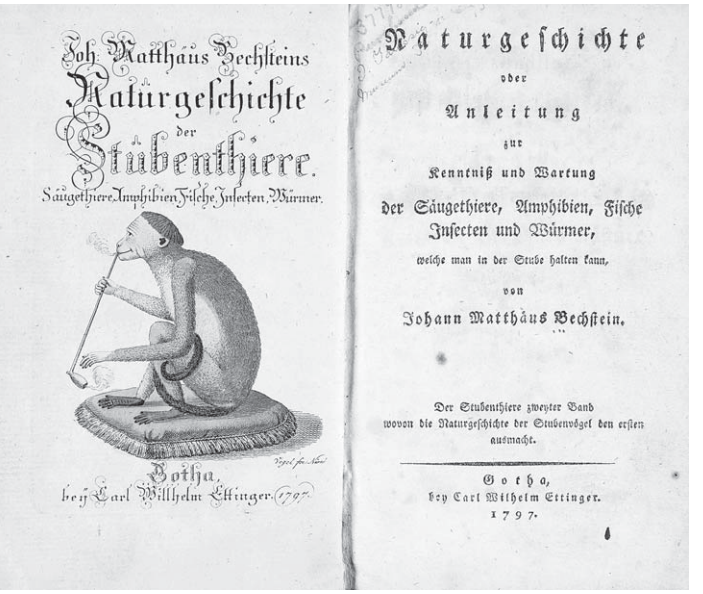
Imprint: Paris, Hachette et cie [etc.] 1873. Credit: Courtesy of Polly Lasker, Smithsonian National Zoological Park.

Public interest in aquatic organisms gave rise to three public aquariums in Europe: Natura Artis Magistra in Amsterdam in 1838, London Zoo in 1858, and Jardin d'Acclimatation in France in 1873.

But then interest in aquaria began to slow down as well. "Some years ago, a complete aquarium mania ran through the country. . . The fashionable lady had magnificent glass-plated aquaria in her drawing room, and the schoolboy managed to keep an aquarium of lesser pretensions in his study. . . So, in due course of time, nine out of every ten aquaria were abandoned; many of the shops were given up, because there was no longer any custom; and to all appearance the aquarium fever had run its course, never again to appear, like hundreds of similar epidemics." (Wood 1859).

Reptiles and Amphibians Are Added to the Mix

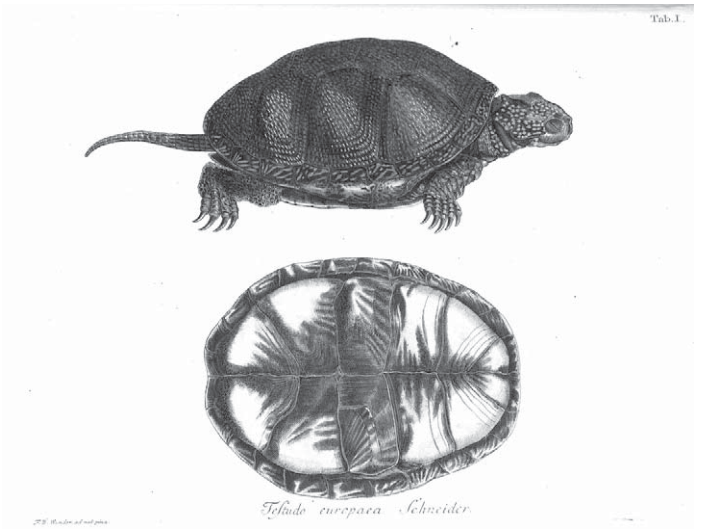
Johann Matthaeus Bechstein wrote the first book on captive care of domestic animals and pets in 1797. This intriguing volume was called *Naturgeschichte; oder, Anleitung zur Kenntniss und Wartung der Säugethiere, Amphibien, Fische, Insecten und Würmer, welche man in der Stube halten kann* (Natural History; or, Guide to the Knowledge and Care of Mammals, Amphibians, Fish, Insects and Worms Which Can Be Kept in the Home). His book dealt with five herp species: European Pond Turtle (*Testudo orbicularis*, now *Emys orbicularis*), Common Treefrog (*Rana arborea*, now *Hyla arborea*), sand lizard (*Lacerta agilis*), Great Crested Newt (*Lacerta palustris* and *lacustris*, now *Triturus cristatus*) and European Grass Snake (*Coluber Natrix*, now *Natrix natrix*). The terms aquarium, terrarium, or vivarium had not yet arrived and plate glass was not widely available, so Bechstein used descriptors like little boxes, buckets, sugar glasses, containers made of porcelain, stoneware and so on (Heichler and Murphy 2004).



Engraved title page and printed title page of *Naturgeschichte; oder, Anleitung zur Kenntniss und Wartung der Säugethiere, Amphibien, Fische, Insecten und Würmer, welche man in der Stube halten kann* by Johann Matthaeus Bechstein in 1797. Published in color in *Herpetological Review* 2004, 35(1):8–13.

Nathaniel Ward discovered a robin trapped in his fern-house—it lived and thrived for six months until escaping. This episode gave him the idea of developing the vivarium. He described this idea in an article called "On vivaria" in the *Garden Chronicle* in 1855.

When the reptile building opened at the London Zoo in 1849 and the collection needed to be expanded, zoo employees exchanged herps with private fanciers to fill in the gaps (Keeling 1992). One such example was C. R. Walker at the establishment called "The Vivarium" who sent twenty-five assorted skinks, geckos (possibly *Naultinus*?) from New



Johann Matthäus Bechstein on the Commendable Characteristics of the European Pond Turtle (translated from German): "It cannot be said that their movements are varied or beautiful, or that these animals may be counted among those which are entertaining; however, their very rarity, and the desire to have something alive also from this class of animals under one's care and supervision makes them attractive to the amateur. They can also be fattened up so as to make use of their tasty (even though hard to digest) meat, once the eyes have been satisfied by their sight. Already clever experiments have been made with these animals: Mr. Merz in Paris shut the mouth of one with wire and closed up the nostrils with sealing wax; nevertheless the animal lived another 30 days without food or breathing. This reveals the tenacious vitality which these animals possess."

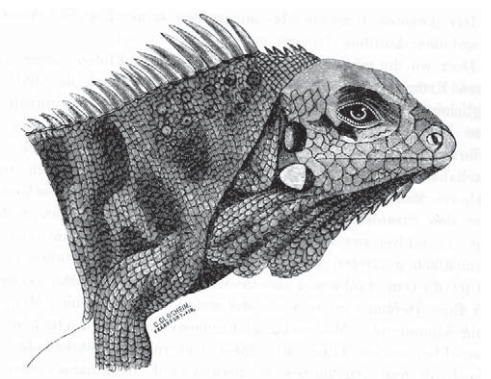
Illustration from *Ioannis Davidis Schoepff Historia testudinum iconibus illustrata* by Johann David Schöpf, 1792 [–1801].

Credit: Collections of Ernst Mayr Library, Museum of Comparative Zoology, Harvard University.

Zealand, and treefrogs. In addition to the exchanges, many private parties generously donated rare and unusual amphibians and reptiles to the Zoo, such as Long-Nosed Crocodiles, Radiated Tortoises, and a variety of cobras, African Rock Pythons, Emerald Tree Boas, and a multitude of European taxa.

The Exeter Exchange in London was a famous menagerie, beginning in the 1770s and lasting until 1829, which specialized in the sale of exotic reptiles. In 1810, the menagerie was acquired by Edward Cross, who renamed the operation the "Royal Grand National Menagerie" and developed a thriving commercial supply company with customers in Europe and the US. Another well-known dealer in London was a Mr. Kendrick who assured his clients that every reptile for sale came from "Brazil," including Red-eared Sliders, Painted Turtles, and Chameleons (Coote 2001).

In 1884, Johann von Fischer from Vienna, known by many as the founder of modern herpetoculure, published *Das Terrarium, seine Bepflanzung und Bevölkerung,* with recommendations for aquaria and terraria design, plants suitable for the terrarium, food and feeding, and detailed descriptions of the husbandry requirements for a wide array of amphibians and reptiles; his book is accompanied by many drawings. In addition to his book, Johann von Fischer published detailed descriptions on the maintenance and behavior of other captive herpetofauna, many of which were published in the journal *Der zoologische Garten* (see Murphy, 2005 for list). In his book (1884), Johann von Fischer listed his recommendations for amphibian and reptile combinations in various mixed-species terrariums. His lists were long and varied, and filled with rare taxa. What seems true is that there were many sources throughout the world for obtaining herps to be sold in Europe. One example should suffice: taxa which can be kept in the "Chamaeleonshaus" with the Common Chameleon (*Chamaeleo chamaeleon*): *Platydactylus*, *Hemidactylus*, *Ptyodactylus*, *Phyllodactylus*, *Spaeriodactylus*, *Gymnodactylus*, *Stenodactylus*, various *Phrynosoma*, *Ecphymotes torquatas*, *Stellio vulgaris*, *S. cyanogaster*, *Tropidosaura algira*, *Psammosaurus Edwardsii*, young *Scuicus officinalis* and *Gongylus ocellatus*, *Seps chalcides*, *Heteromeles mauritanicus*, *Ophiomorus miliaris*, and *Typlops vermicularis* (nomenclature follows J. v. Fischer).



In 1884 Johann von Fischer published *Das Terrarium, seine Bepflanzung und Bevölkerung*. Shown here is Tuberculated Iguana (*Iguana tuberculata,* now *Iguana iguana*).

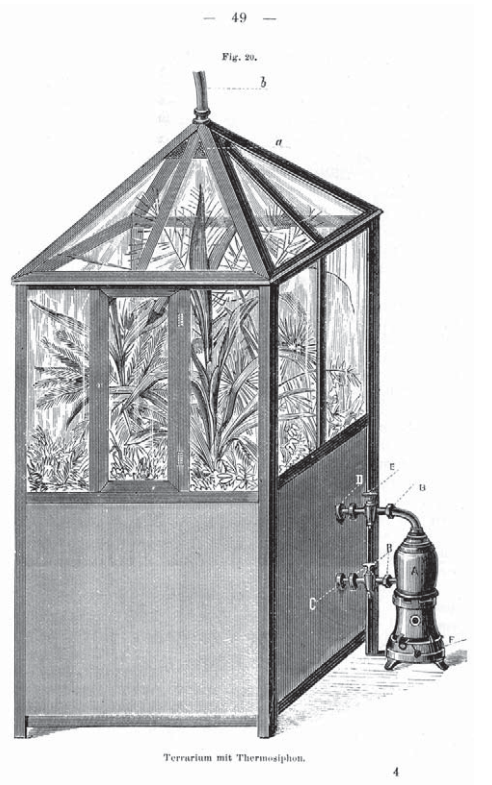


Illustration of Terrarium with "Thermosiphon" for temperature control from *Das Terrarium, seine Bepflanzung und Bevölkerung*.

The first book on herpetoculture in English was the Reverend Gregory Climenson Bateman's *The Vivarium,* published in 1897. There were many advertisements for animals, plants, and supplies in his book. According to Bateman, a broad range of live reptiles and amphibians were obtainable in London in 1897. In addition to the common European species, a number of rarer exotic types were offered for sale: Small Monitor Lizards, Common and Red Tegus, Bearded Dragons, young American Alligators and Crocodiles, Diamond Pythons, African Rock Pythons approximately 4 feet long, Ball Pythons, Anacondas, Horned Frogs, Giant Salamanders, and Olms. Remarkably, Tuataras were accessible, described by Bateman: "Some time ago, I was looking at the various animals in a very large dealer's establishment, when I made a remark about a fine pair of Tuateras which I saw in a big cage. The assistant who was with me immediately opened the door of the den and seized one of the reptiles by the tail, and I shall not readily forget the ominous sound made by the animal's closing jaws as he just missed the man's fingers, at which he had just snapped. I at once mentally resolved never to catch a Tuatera by the tail. As I congratulated the man upon his escape, he said, 'I am a bit lucky this time, for I have just come out of the 'orspital, where I have been laid up with blood-poisoning through the bite of one of them pythons.'"

Bateman also published on aquarium construction, captive husbandry of plants, weeds, fishes, mollusks, insects, etc, and management of freshwater and marine aquaria. Murphy (2007) provided a list of amphibians and reptiles with prices which were available in London during the time.

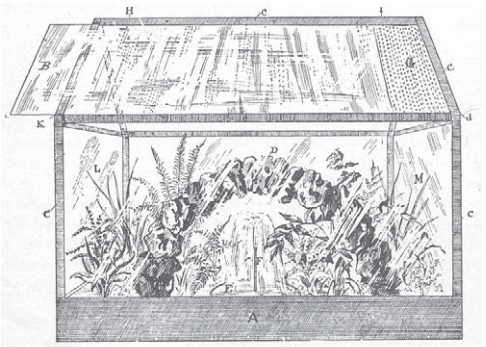


FIG. 9.—FERNERY, WITH FOUNTAIN AND ARCH, VERY SUITABLE FOR SOME REPTILES AND BATRACHIANS.

James L. Willson,

Live Stock Provider,

6 & 8, Goodge St., London, W.

(Two doors from Tottenham Court Road).

IMPORTER AND EXPORTER OF

Every Description of Wild or Domestic Animal,

ALSO

REPTILES, Cold Water GOLDFISH, and BIRDS.

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SUPPLIED AND STOCKED.

Every Appliance and Requisite. Ants' Eggs, Mealworms, and Fish Food to value remitted, sent by return.

Choice Singing Canaries.

AVIARIES, CAGES, AND SPECIAL SEEDS.

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ERNEST CLIFTON & CO.,

43, Oxford Street, & 1, Saville Street,

MANCHESTER.

Aquarium, Vivarium, & Fern Case Manufacturers, Rockworkers, &c.

THE rapid and general appreciation of the Vivarium in the last few years has caused us to largely import and cater for the stocking of same. We have now collectors in Algiers, Cairo, Alexandra (Africa), Bologna, Rome (Italy), Berlin, Vienna, Buda Pesth, Sydney, Paris, &c., and nearer home, so we have no hesitation in asking new and old patrons to write to us for our list from time to time.

When we say that the Professors of Owen's College (Manchester), University College (Liverpool), University (Edinburgh), Royal College of Science (Dublin), Queen's College (Cork), &c., patronise us largely, and solely rely on us for special reptiles, &c., it speaks for itself.

In the Manufacturing Department we are able to compare most favourably with others, and in addition to our sixteen-page Illustrated Catalogue we will send a sketch and price of any new idea that our patrons wish carried out. As a proof of the soundness of our work, Mr. Walmsley, Manager, Blackpool Aquarium, has engaged our Mr. Clifton to make sixty Vivaria (various sizes) for the next season.

[COPY.]

Brighouse, July 10th, '97.

Dear Sir,—Permit me to give you a perfectly unsolicited testimonial, not only as to the value of your wares, but also as to the *base fides* of yourself. I have done business with you for years, and *every* transaction I have had with you has been executed with a completeness and promptitude beyond compare. The specimens dealt in by yourself and the prices charged for them compare most favourably with those charged by the best London, Parisian, and Continental wholesale dealers, with whom I am frequently in contact.

Faithfully yours,

MR. ERNEST CLIFTON. HENRY J. BARBER.

AQUARIUM & FERN CASES

Of Every Description for Exhibitions, Dining Rooms, Halls, Restaurants, Hospital Wards, &c.

REPTILE CASES, WINDOW CONSERVATORIES, BOXES, &c., MANUFACTURED BY

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Estimates Free.

A. GREEN,

Taxidermist and Dealer in British Reptiles, and British and Foreign Birds,

4, CUMNOR TERRACE, BOURNEMOUTH.

GENUINE SPECIMENS of the CORONELLA often ON HAND. ESTABLISHED 1871.

EDWARD GERRARD & SONS,

Naturalists, Taxidermists, & Osteologists,

61, College Place, Camden Town, LONDON,

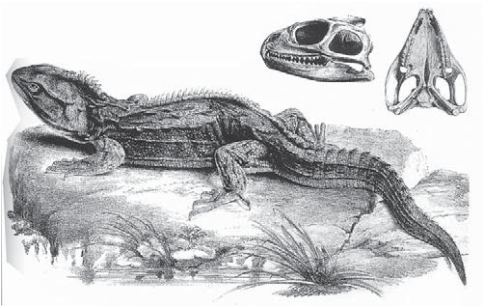
HAVE A

Large Collection of Reptiles in Spirit,

For sale. Lists sent on application.

Skins Dressed and Mounted for Museums or Decoration.

Advertisements for animals and equipment from Reverend Gregory Climenson Bateman's *The Vivarium*, published in 1897. Bateman offered sage advice for the herpetoculturist in 1897. "In the construction of Vivaria, all chance of the captive's escape should be avoided as far as possible. For it is rather mortifying to realise the loss of a valuable Snake, or a favourite lizard; nor does one get much encouragement in a hobby of this kind should he be often obliged to ask the ladies or servants of his home if they may happen to have seen anything of the missing Reptiles."



At the end of the 19th Century, Tuataras were offered for sale by London animal dealers. Reverend Bateman purchased a pair from the London Zoo for £2.00 ($3.00 US). John Edward Gray had described the "Tuatera" from New Zealand in his *The Zoological Miscellany* in 1842, naming it *Hatteria punctata* and placing the taxon in the lizard family Agamidae. Today it is called Tuatara (*Sphenodon punctatus*) and placed in the Suborder Rhynchocephalia. This lovely plate (#20) is from *The Lizards of Australia and New Zealand in the Collection of the British Museum* by Gray, 1867.

Carl Hagenbeck Senior is a name known by virtually every zoo and aquarium professional for in 1907 he developed one of the finest zoos in the world in Hamburg, Germany: Carl Hagenbeck's Tierpark at Stellingen. He built the first exhibits without bars for zoos and served as a design consultant for zoos throughout the world. From 1841 until 1863, he ran a small pet shop featuring exotic animals, including reptiles such as boas and pythons. Later in 1866, his son Carl Junior took over the reins and built the operation into a major animal supplier, sending reptiles to dealers and zoos throughout the world (Coote 2001).

Oskar Boettger described a unique herpetological cooperative arrangement in his paper *Bericht über die Leistungen* in 1890: "Regarding the purpose and setup of the Laboratoire d'Erpetologie in Montpellier [France], a trading and buying organization, one finds information in Humboldt (Dammer), Volume 8, pages 34–35." [translated from German in *Archiv für Naturgeschichte* on p. 160.]. This paper in Humboldt is here loosely translated with some comments in parentheses to clarify how the text was interpreted: "The Laboratoire d'Erpetologie in Montpellier is an organization that exchanges and sells under the direction of our worthy colleague, the well-known herpetologist Dr. J. v. Fischer. The Laboratoire, in which salesmen (researchers would be a better word) can offer living wares, encompasses 147 members throughout Europe and 203 in other parts of the world. The purpose of the organization is to offer reptiles and amphibians of all sorts to members at cost and to make the study of these animals easier. The excess (surplus animals) are released and the profits are divided among members. Donated animals are not sold. Each member is obligated annually to publish two articles in a domestic or foreign publication. The honorarium for

Direkter Import

von

Aquarien- und Terrarien-Tieren.

Seltenheiten stets auf Lager.

Alleiniger Vertreter der Firma Otto Eggeling-New-York.

Es kommen nur gesunde gut fressende Tiere zum Versand.

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Eimsbüttler Chaussee 55.

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Aquarien und Terrarien

in einfacher und besserer Ausführung.

Aquarien- und Terrarientiere und -Pflanzen in grösster Auswahl, sowie sämtliche Hilfsapparate. — Preisliste frei.

Heinrich Henkel

Neuwiese Glasberg,

Darmstadt.

Gross. Hess. Hofbouquetlieferant, Kaiserlich Russischer Hoflieferant. Hoflieferant weiland Ihrer Majestät der Königin Victoria von England.

Permanente Aquarium-Ausstellung.

Nymphaea, Flor März bis Oktober; **Nelumbium,** Flor Juni, Juli, August. **Vorzüglichste Neuheiten in Pflanzen und Fischen durch eigene Sammler.** — Cataloge auf Anfrage frei. — Besuch jederzeit gestattet.

Advertisement from Hugo Kukhoff's *Das Terrarium und seine Bewohner: ein kurzer illustrierter Ratgeber für Terrarienfreunde* around 1903.

each publication is given to the organization and at the end of the fiscal year is allotted equally. In addition, these colleagues take charge of distributing the excess animals and disposing of dead animals and retain 50% of the profit. The Laboratoire has a fund donated by members to encourage young people to go to unexplored provinces or regions of the world to collect and learn. In addition, for the best collectors there are prizes, which include a microscope from Zeiss in Jena, books, or further travel. Anyone can become a member as long as he demonstrates that he works in this field. Members must prove that they give any uncommon animals to appropriate institutions at no cost if they (the institution) promise to publish accounts of the animals. They keep the honorarium. Eventually a society journal will appear. Each violation—so far there have been none—will result in ejection from the society. The personal word of honor is the only guarantee other than the signature of the member. No hearing will be held, but his name will be circulated as 'manquant a sa parole' (a breaker of his word). The institute up to this point makes a profit of about 1000–1200 francs. The director holds sole responsibility for leadership and is only assisted by a book keeper."

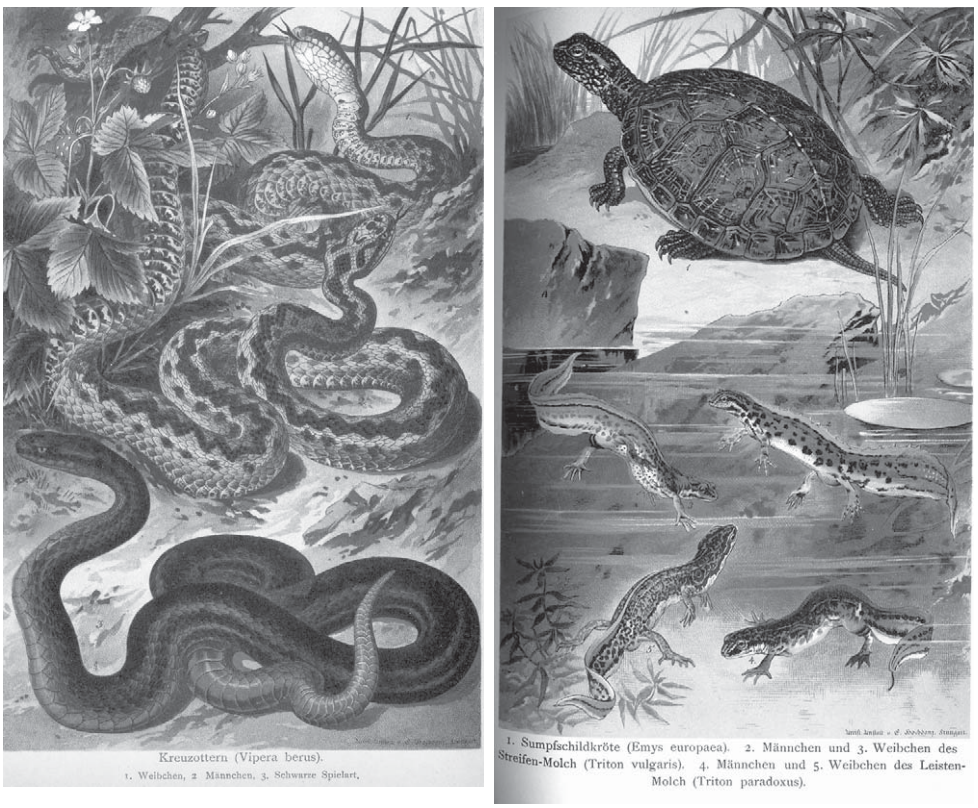
Paul Krefft wrote a major guide to terrarium science in 1908 called *Das Terrarium* with many illustrations of aquaria and terraria. Pictured here are living plants suitable for the terrarium.

Strolling on the promenade in 19th Century Paris with a live turtle was all the rage, as described by Walter Benjamin in his essay: "Around 1840, it was briefly fashionable to take turtles for a walk in the arcades. The *flâneurs* [idlers] like to have the turtles set the pace for them. If they had had their way, progress would have been obliged to accommodate itself to this pace . . . this attitude did not prevail."

A number of books and articles on herpetoculture began to appear after the Bateman volume. Hugo Kukhoff's *Das Terrarium und seine Bewohner: ein kurzer illustrierter Ratgeber für Terrarienfreunde* was written around 1903. Five years later, Paul Krefft wrote a seminal guide to terrarium science called *Das Terrarium*. Dr. Ernst Bade published *Praxis der Terrarienkunde*, a slim volume filled with pictures of terraria and suitable inhabitants for the enclosures. *The Freshwater Aquarium and its Inhabitants; A Guide for the Amateur Aquarist with Many Illustrations from Nature* by Otto Eggeling and Frederick Ehrenberg, written in 1908, had many references to captive herps.

There were books that combined the amateur literature on herp keeping with professional literature, such as Robert Snedigar's *Our Small Native Animals: Their Habits and Care* (1939) and Vinson Brown's *How to Make a Miniature Zoo* (1956). Raymond L. Ditmars of the Bronx Zoo popularized captive herps in his many books during the early part of the 20th Century although he did not write a specific guide to herp keeping.

During the second half of the 20th Century, books and papers on captive amphibians and reptiles exploded on to the scene. In 1955, Wilhelm Klingelhöffer, a German medical doctor, compiled an extraordinary treatment of reptiles and amphibians in captivity called *Terrarienkunde*. This four volume work was the "bible" for European zoo workers and herpetoculturists. Six years later, Alfred Leutscher, founder and secretary of the British Herpetological Society wrote *Vivarium Life*.



Some books on keeping amphibians and reptiles in captivity had beautiful artwork. These original colored drawings are from Ernst Bade's *Praxis der Terrarienkunde* in 1907. Also shown is a terrarium from the period.

A Manual on Amphibians, Reptiles and Cold-Water Fish.

Around 1952 in Great Britain, there were three main suppliers: Palmers of Camden Town; South-Western Aquarists of Glenburnie Road, Balham, owned by George Boyce; and Robert Jackson from Altrincham, Cheshire. Most of the stock was from Europe: Grass Snake, Tessellated Water Snake, Aesculapian Snake, Four-lined Ratsnake, Wall Lizard, Jewelled or Eyed Lizard, Berber Skink, European Pond Turtle, Spur-Thighed and Hermann's Tortoises, and Spanish Terrapin (Keeling, 1992).

Germany was and continues to be one of the strongest centers for herpetoculture. For example, a recent catalogue by the antiquarian book dealer Chimaira in Frankfurt/Main, lists hundreds of titles in German and English dealing with captive amphibians and reptiles. In the book *Die Geschichte der Herpetologie und Terrarienkunde im deutschsprachigen Raum* (edited by Rieck, W., et al., 2001; p. 263), a contribution by Gerhard Hallman is titled as "A selection of traders that offer animals for terrariums, or terrarium technology to the society and its members through ads or price lists." Hallman wrote, "The number of specialty traders that handle reptiles is large. . .The following list, with no aspiration to being complete, attempts to demonstrate this." Then, the chapter shows names of dozens of dealers between 1950 and 2001 in a variety of countries and includes some lists of the herps available as well as their prices. People today might believe that reptile shows or expos are a recent phenomenon but in chapters written by Werner Rieck, there are three fascinating photographs of enormous shows held in Germany in the years 1896 [p. 47], 1908 [p. 50], and 1924 [p. 71].

In the UK from the mid-1960s onwards, the most important resource for the herpetoculturist was the book by Zdeněk Vogel entitled *Reptiles and Amphibians. Their Care and Behaviour* (J. Coote, pers. comm.). In 1969 and 1972, Günther Nietzke summarized much of what was known about terrarium animals in two volumes: (1) Construction, Technical Equipment, and Planning of Terraria; (2) Care and Feeding of Terrarium Animals. The set was called *Die terrarientiere: Bau, technische Einrichtung und Bepflanzung der Terrarien: Haltung, Fütterung und Pflege der Terrientiere in zwei Bänden*.

As ideas, protocols and technologies improved for keeping herps in zoos, two of the most important persons disseminating this vital information were Carl F. Kauffeld at the Staten Island Zoo, and Hans-Günter Petzold at Tierpark Berlin-Friedrichsfelde. Kauffeld deserves special mention, for in addition to his classic *Snakes: The Keeper and the Kept*, he wrote many papers on captive management. Petzold's book (1982), translated from German and published by SSAR in 2008, is the most thorough overview of captive management currently available: *Petzold's The Lives of Captive Reptiles* (see HR 2009, 40:471–472 for review). Later, other zoo workers published books on terrarium keeping: Eugène Bruins (1999) from Natura Artis Magistra in Amsterdam, and Sergei Kudryavtsev and associates (1991) from the Moscow Zoo.

With numbers of captive herps increasing, there was a need to address medical management. H.-H. Reichenbach-Klinke published the first book on the topic called *Krankheiten der Amphibien* in 1961 and *Krankheiten der Reptilien* two years later. An English version was available in 1965 by Reichenbach-Klinke and E. Elkan: *The Principal Diseases of Lower Vertebrates*. For a complete list of titles, consult Murphy (2007; Table 2.1).

The SSAR published two other books on captive and medical management: *Reproductive Biology and Diseases of Captive Reptiles* (Murphy and Collins, 1980) and *Captive Management and Conservation of Amphibians and Reptiles* in 1994 (Murphy et al.). It is beyond the scope of this contribution to list all of the books, serials and papers that have been valuable to our understanding of captive animals but many references have been published in the four-part series called "Updating the Bookshelves" in *Herpetological Review* during 2008–9.

The herpetoculturist of today owes much to his or her predecessors who developed the beautiful and ornate planted terrariums filled with exotic foliage, the heavily planted aquaria, the spectacular semi-aquatic vivaria placed on pedestals in the drawing room with fishes and herps, and the arresting terrestrial terraria filled with mesic or xeric plants, truly a showcase in the home. It is not surprising that there are dealers specializing in antique aquaria and terraria to this day for these are often lovely works of art. Animal collectors and dealers filled a void: they provided specimens from exotic locales that were out of reach to the average fancier.

Acknowledgments.—This paper is dedicated to the late Carl Kauffeld and Harry W. Greene. When one of us (KM) wrote letters full of questions about herpetology, each took his valuable time and responded in writing to the inquiries of a fourteen-year old boy. We thank David Barker, Judith Block, David Chiszar, Jon Coote, Gary Ferguson, Rick Hudson, John Moriarty, Louis Porras, John Simmons, and Trooper Walsh for reviewing early drafts and suggesting improvements. Smithsonian Librarians Polly Lasker, Leslie Overstreet, and Daria Wingreen allowed us to examine publications under their care and arranged loans of obscure books and papers. Margie Gibson and Lucian Heichler assisted with translations. We are grateful to Emily Becker, Dana Fisher, and James Hanken from the Museum of Comparative Zoology, Harvard University for providing illustrations.

The opinions expressed in this article are those of the authors and do not necessarily represent the opinions of any organization.

References

Publications embedded in text plus suggestions for additional readings are listed below:

Allen, D. E. 1976. The Naturalist in Britain: A Social History. A. Lane, London.

Bade, E. 1898. Das süsswasser-aquarium. Geschichte, flora und fauna des süsswasser-aquariums, seine anlage und pflege, / von dr. E. Bade ... Pfenningstorff, Berlin.

———. 1907. Praxis der Terrarienkunde. Creutz'sche Verlagsbuchhandlung, Magdeburg,

Barber, L. 1980. The Heyday of Natural History 1820–1870. Doubleday, Garden City New York.

Bateman, G. C. 1897. The Vivarium, Being a Practical Guide to the Construction, Arrangement, and Management of Vivaria, Containing Full Information as to all Reptiles Suitable as Pets, How and Where to Obtain Them, and How to Keep Them in Health. L. Upcott Gill, London.

———. 1904. Fresh-Water Aquaria: Their Construction, Arrangement, and Management, with Full Information as to the Best Water-Plants and Live Stock to be Kept, How and Where to Obtain Them, and How to Keep Them in Health. L. Upcott Gill, London; Scribner, New York.

———, and R. A. R. Bennett. 1902. The Book of Aquaria: Being a Practical Guide to the Construction, Arrangement, and Management of Fresh-Water and Marine Aquaria, Containing Full Information as to the Plants, Weeds, Fishes, Molluscs, Insects, etc. Part I.--Fresh-Water Aquaria. Part II.—Marine Aquaria. L.Upcott Gill, London; C. Scribner's Sons, New York.

Bechstein, J. M. 1797. Naturgeschichte; oder, Anleitung zur Kenntniss und Wartung der Säugethiere, Amphibien, Fische, Insecten und Würmer, welche in der Stube halten kann, / von Johann Matthäus Bechstein (Natural History, or, Guide to the Knowledge and Care of Mammals, Amphibians, Fish, Insects and Worms Which Can Be Kept in the Home) . . . C.W. Ettinger, Gotha.

Bedell, R. 2009. The History of the Earth: Darwin, Geology and Landscape Art. Pp. 49–79 *In* Donald, D., and J. Munro (editors). Endless Forms. Charles Darwin, Natural Science and the Visual Arts. Yale University Press. [A painting of a family's interest in natural history was included in a book about Darwin. The painting is "Pegwell Bay, Kent—A Recollection of October 5th, 1858" by William Dyce. It is Figure 66. The author's description of the painting in part says "Pegwell Bay recalls the artist's autumn holiday at this beach resort on the east coast of Kent. Members of Dyce's family are arranged in a frieze across the foreground…They and the rocks, shells, seaweed, and skate egg cases at their feet are rendered with a hyperclarity of detail that seems to contradict the recollective nature of the painting. The boy's shovel and the women's filled baskets suggest that they are passing their vacation in the study of seaside natural history…" p. 63].

Bellairs, N. 1865. Hardy Ferns: How I Collected and Cultivated Them. Smith, Elder, London.

Benjamin, W. 1969. On some motifs in Baudelaire, p. 197. *In* H. Arendt (ed.), Illuminations, trans. Harry Zorn. Schocken, New York.

Brown, V. 1956. How to Make a Miniature Zoo. Little, Brown, Boston, Massachusetts.

Bruins, E. 1999. Encyclopedia of Terrarium. Rebo International b. v., The Netherlands. [extensive coverage of insects, arachnids, amphibians and reptiles. This is one of the most valuable and comprehensive treatments available on invertebrate

care. Topics include legislative issues, captive management, and feeding. There are many color photographs.].

Buckland, F. T. 1882. Notes and Jottings from Animal Life. Smith, Elder, London.

Butler, H. D. 1858. The Family Aquarium; or, Aqua Vivarium . . . Being a Familiar and Complete Instructor upon the Subject of the Construction, Fitting-up, Stocking, and Maintenance of the Fluvial and Marine Aquaria ... Dick & Fitzgerald, New York.

Cassell's Household Guide: Being a Complete Encyclopædia of Domestic and Social Economy, and Forming a Guide to Every Department of Practical Life. Cassell, Petter, and Galpin, London; New York : [1869?–1871?]

Coote, J. G. 2001. A history of western herpetoculture before the 20th century. *In* W. E. Becker (ed.), 25th International Herpetological Symposium on Captive Propagation and Husbandry, pp. 19–47. International Herpetological Symposium, Detroit, Michigan.

Darwin, C. 1868. The Variation of Animals and Plants under Domestication. / By Charles Darwin ... Orange Judd & Company, New York.

Daszkiewicz, P. 2001. "Moult of the Serpens [*sic*], Their Laying, Their Dissection". An interesting document for the history of European herpetology by Georg Segerus, physician to the Polish kings. Herpetol. Bull. 78:3–6. [The first published observations on captive snakes were recorded by Georg Seger (= Segerus in Latin) in Germany in 1663. Seger kept snakes for scientific purposes and recorded shedding and egg-laying in "Aesculapian snakes." He removed their tongues initially as this organ was thought to inflict mortal wounds but snakes were less vigorous after this primitive surgery. Seger assisted one of his snakes during oviposition and shed another by hand.].

Derry, T. K., and T. I. Williams. 1961. A Short History of Technology from the Earliest Times to A.D. 1900. [Reprinted by Dover Books in 1993].

Eggeling, O., and F. Ehrenberg. 1908. The Freshwater Aquarium and its Inhabitants; A Guide for the Amateur Aquarist, // by Otto Eggeling and Frederick Ehrenberg, with many Illustrations from Nature. H. Holt and Company, New York.

Fischer, J. v. 1884. Das Terrarium, seine Bepflanzung und Bevölkerung (The Terrarium, Its Plantings and Population). Frankfurt am Main, Mahlau & Waldschmidt. [reprint of this work published in 1989 by BINA Verlag für Biologie und Natur, Berlin (BINA Publisher for Biology and Nature, Berlin.)].

Gosse, P. H. 1853. A Naturalist's Rambles on the Devonshire Coast. J. Van Voorst, London.

———. 1856. A Handbook to the Marine Aquarium: Containing Practical Instructions for Constructing, Stocking, and Maintaining a Tank, and for Collecting Plants and Animals. J. Van Voorst, London.

Heichler, L., and J. B. Murphy. 2004. Johann Matthäus Bechstein: The father of herpetoculture. Herpetol. Rev. 35:8–13.

Hibberd, S. 1856. Rustic Adornments for Homes of Taste, and Recreations for Town Folk, in the Study and Imitation of Nature. Groombridge and Sons . . . , London. [2nd edition, 1857].

Hinterwaldner, J. M. 1889. Wegweiser für Naturaliensammler. Vienna.

Humphreys, H. N. 1857. Ocean Gardens: The History of the Marine Aquarium, and the Best Methods Now Adopted for its Establishment and Preservation. Sampson Low ..., London.

Jacob, S. 1886. The Student's Aquarium (Marine and Fresh Water): How to Make and Manage / / by S. Jacob, naturalist, late of Great New York Aquarium, &c., &c. . . F.W. Marshall, printer, Newport, Rhode Island.

Kauffeld, C. 1969. Snakes: The Keeper and the Kept. Doubleday, Garden City, New York.

Kawata, K. 2003. New York's Biggest Little Zoo. A History of the Staten Island Zoo. Kendall/Hunt Publishing Co., Dubuque, Iowa [biography of Carl Kauffeld].

Keeling, C. H. 1992. A Short History of British Reptile Keeping. Clam Publications, Guilford UK.

Kete, K. 1994. The Beast in the Boudoir: Petkeeping in Nineteenth-Century Paris. Univ. California Press, Berkeley, California.

Klee, A. 2003. The Toy Fish: A History of the Aquarium Hobby in America: The First One-Hundred Years. Finley Aquatic Books, Pascoag, Rhode Island.

Klingelhöffer, W. 1955–1959. Terrarienkunde (Terrarium Science). Alfred Kernen Verlag, Stuttgart.

Krefft, P. 1908. Das Terrarium (The Terrarium). Fritz Pfenningstorff, Berlin.

Kudryavtsev, S. V., V. E. Frolov, and A. V. Korolev. 1991. The Terrarium and Its Inhabitants (A List of Species and Their Maintenance in Captivity, A Handbook.). Lesnaya promyschlennost, Moscow.

Kukhoff, H. 1903? Terrarium und seine Bewohner: ein kurzer illustrierter Ratgeber für Terrarienfreunde. F. Pfenningstorff, Berlin.

Leutscher, A. 1961. Vivarium Life. A Manual on Amphibians, Reptiles and Cold-Water Fish. Cleaver-Hume Press Ltd, London.

Leutscher, A. 1976. Keeping Reptiles and Amphibians. Scribner, New York.

Murphy, J. B. 2005. Chameleons: Johann von Fischer and other perspectives. SSAR Herpetol. Circ. 33.

———. 2007. Herpetological History of the Zoo and Aquarium World. Krieger Publishing Co., Malabar, Florida.

———, K. Adler, and J. T. Collins (eds.). 1994. Captive Management and Conservation of Amphibians and Reptiles. SSAR Contrib. Herpetol. 11.

———, and J. T. Collins (eds.). 1980. Reproductive Biology and Diseases of Captive Reptiles. SSAR Contrib. Herpetol. 1.

Nietzke, G. 1969, 1972. Die terrarientiere: Bau, technische Einrichtung und Bepflanzung der Terrarien: Haltung, Fütterung und Pflege der Terrientiere in zwei Bänden (Terrarium Animals: Construction, Technical Equipment, and Planning of Terraria: Care and Feeding of Terrarium Animals in Two Volumes). Eugen Ulmer, Stuttgart.

Petzold, H.-G. 1984. Aufgaben und Probleme bei der Erforschung der Lebensäusserungen der Niederen Amnioten (Reptilien) (Tasks and Problems Connected with Research into the Life Expressions of the Lower Amniotic Animals (Reptiles)). This book (Nr. 38) is in the series "Berliner Tierpark-Buch," published by Bina in Berlin [Note: Nachdruck aus Milu, Bd. 5, Heft 4/5:485–786 (1982). Translated English version: Petzold, H.-G. 2008. Petzold's The Lives of Captive Reptiles / / Hans-Günter Petzold; translated by Lucian Heichler and edited by James B. Murphy. Society for the Study of Amphibians and Reptiles, in association with National Zoological Park, Smithsonian Institution. Salt Lake City UT.].

Pratt, A. 1855. The Ferns of Great Britain and their Allies the Club-Mosses, Pepperworts, and Horsetails. Frederick Warne and Co., London.

Reichenbach-Klinke, H.-H. 1961. Krankheiten der Amphibien (Diseases of Amphibians). Gustav Fischer Verlag, Stuttgart.

———. 1963. Krankheiten der Reptilien (Diseases of Reptiles). Gustav Fischer Verlag, Stuttgart/Jena.

———. 1965. The Principal Diseases of Lower Vertebrates // H. Reichenbach-Klinke and E. Elkan. Academic Press, London, New York.

Rieck, W., G. T. Hallmann, and W. Bischoff (editors). 2001. Die Geschichte der Herpetologie und Terrarienkunde im deutschsprachigen Raum (History of Herpetology and Terrarium Science in German-Speaking Areas) - Mertensiella 12. Deutschen Gesellschaft für Herpetologie und Terrarienkunde e.V. (DGHT). [This book deserves a place on the fancier's library shelf. There are chapters on pioneers in herpetology and herpetoculture, and lists of significant literature, including serials on terrarium science, in Europe. Some of the most spectacular vintage aquaria and terraria are pictured.].

Samuel, M. 1894. The Amateur Aquarist. How to Equip and Maintain a Self-Sustaining Aquarium. Baker & Taylor Co., New York.

Schneider, G. 1905. Choice Ferns for Amateurs: Their Culture and Management in the Open and under Glass. Abridged from the "Book of Choice Ferns" / by George Schneider. L. Upcott Gill, London; Charles Scribners Sons, New York.

Schöpf, J. D. 1792 [–1801]. Ioannis Davidis Schoepff Historia testudinum iconibus illustrata. Sumtibus Ioannis Iacobi Palm, Erlangae [Erlangen]. German edition *Naturgeschichte der Schildkröten* (Erlangen, J. J. Palm, 1792 [–1801]).

Snedigar, R. 1939. Our Small Native Animals; Their Habits and Care. Random House, New York.

Sowerby, G. B. 1857. Popular History of the Aquarium of Marine and Fresh-Water Animals and Plants. Lovell Reeve, London.

Stark, R. M. 1857. The Marine Aquarium: Directions for its Preparation and Management. Edmonston and Douglas, Edinburgh.

Thwaite, A. 2002. Glimpses of the Wonderful: The Life of Philip Henry Gosse, 1810–1888. Faber, London.

Vassiliev, D. B. 1999. Turtles: Husbandry, Diseases and Treatment in Captivity. Akvarium, Moscow.

———, and A. Sokolov. 1999. Turtles, Lizards, Snakes: Husbandry, Care and Treatment in Captivity. Akvarium, Moscow.

Vogel, Z. 1964. Reptiles and Amphibians, Their Care and Behaviour. // Translated and revised by Gwynne Vevers. Studio Vista, London. [1964, The Viking Press, New York.].

Voss, J. 2009. Monkeys, apes and evolutionary theory: from human descent to King Kong. *In* D. Donald and J. Munro (eds.), Endless Forms: Charles Darwin, Natural Science and the Visual Arts, pp. 215–234. Yale University Press, New Haven, Connecticut ["In the background of Darwin's studies was a development that gripped all of England in the nineteenth century. Never before could so many animals have been found in bourgeois living rooms, ensconced on their sofas, easy chairs, side-tables and carpets. Within a few decades, the middle class had populated their homes with parakeets in cages, and dogs and cats in baskets. In response to the displacement, industrialisation, and urbanisation that had banished them to life in separate worlds, some groups of humans and animals drew closer together than they ever had been before: the bourgeois and their pets

and zoo animals. In a historical sense, these animals thus came to be seen in a new light: they served not just as a kind of ersatz nature or exotic showpieces for the Victorian bourgeoisie, but also as a means to understand the proximity of humans and animals to one another." (p. 217). The statement on the flyleaf states that "This publication accompanies the exhibition "Endless Forms: Charles Darwin, Natural Science and the Visual Arts," which is currently at the Yale Center for British Art.].

WARD, N. B. 1852. On the Growth of Plants in Closely Glazed Cases. John Van Voorst, London.

WARWICK, C., F. L. FRYE, AND J. B. MURPHY (eds.). 1995. Health and Welfare of Captive Reptiles. Chapman-Hall Publ., New York.

WOOD, J. G. 1859. Common Objects of the Sea Shore: Including Hints for an Aquarium / / by the Rev. J.G. Wood . . . ; With Coloured Illustrations. Routledge, Warnes & Routledge . . . London.

OBITUARIES

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Carl Gans (1923–2009) and the Integrative Biology of Reptiles

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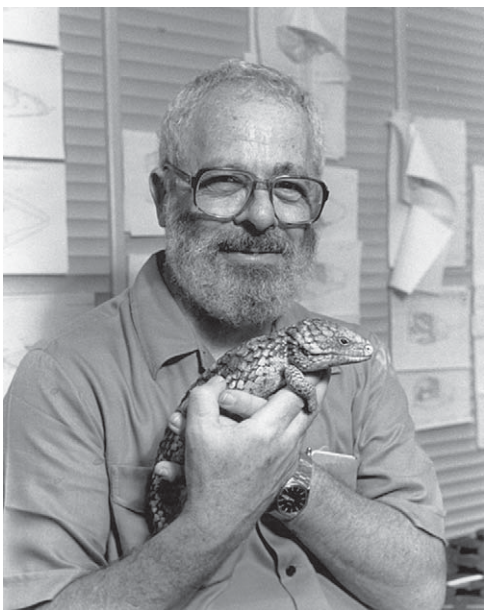
Carl Gans, the preeminent specialist on reptilian biology of his generation, died on 30 November 2009 at the age of 86. This occurred after nearly a decade of poor health that followed a stroke in January 2001. Originally trained as a mechanical engineer, Gans made contributions to the systematics, comparative and functional morphology, physiology, biomechanics, and behavior of reptiles and, to a lesser extent, amphibians, all within an evolutionary context. His ability to integrate diverse approaches to life science—a field today called "integrative biology" that he helped to pioneer—was unrivaled, both conceptually and technically, and has laid the foundation for numerous studies across a broad spectrum by other biologists around the world.



In his laboratory at the University of Michigan with an Australian skink, *Tiliqua rugosa* (ca. 1997). Photo courtesy Robert Dudley.

Carl Gans was born in Hamburg, Germany, on 7 September 1923 where he attended the Talmud Thora Realschule. In his early teens while still in Germany, he loved to read books by the German storyteller, Karl May, first-person narratives about overseas explorations, especially in Asia, and collecting exotic animals. May's books were fiction because he never left Germany until very late in his life. Nevertheless, these volumes made a real impression on Carl who later enjoyed extensive international travel in search of unusual reptiles and amphibians. These books were important enough for him to purchase English translations of them that were still in his home library at his death.

The Gans family immigrated to the United States as Jewish refugees in 1939 and settled in New York City where Carl finished his schooling at George Washington High School. They lived in Upper Manhattan near the George Washington Bridge and on Sundays Carl would walk across this mile-long span to the wet undeveloped lands and high cliffs of the New Jersey Palisades along the Hudson River to capture frogs and snakes for his collection. His first herpetological paper, in *Copeia* in 1945, reported on salamanders and snakes he caught near the Harlem River on Manhattan. He discovered a natural population of the Dusky Salamander (*Desmognathus fuscus*) there, the first report on the island since C. S. Rafinesque's in 1820, and he appealed for it to be conserved. (A breeding population was reported from the site as recently as 2005.) Despite this early interest in animals (and conservation), his father insisted that he would financially support him in college only on the condition that he choose a practical career, so he studied mechanical engineering at New York University (B.Mech.Eng. 1944) and then joined the U.S. Army Corps of Engineers. After basic training, he served in the Pacific Theater during World War II, first in the Philippines and then in Japan. It was then the practice of the U.S. Government not to send soldiers overseas unless they were U.S. citizens; accordingly, Gans was naturalized in January 1945, just before departing for the Pacific. He was slated to be part of the invasion of Japan, clearing beaches with the engineering unit to which he was assigned in the Philippines.

After discharge from the army in September 1946, Gans was hired as a mechanical engineer by Babcock and Wilcox Co. of New York City (1947–1955) to install power boilers in electric generating stations in Pennsylvania and Ohio. Through home study courses he completed a graduate degree in mechanical engineering at Columbia University (M.S. 1950), the year his father died. He had begun to publish on herpetological topics in the mid-1940s including notes on the breeding dates of rhacophorid frogs based on observations he had made in Japan, a bibliography of the herpetology of Japan, and an article on adaptations for egg-eating in a Japanese ratsnake, but Gans continued his career as an engineer. He held several patents for devices he had invented. One of his early engineering ideas, never realized, was the development of automobile headlights that would follow the road.

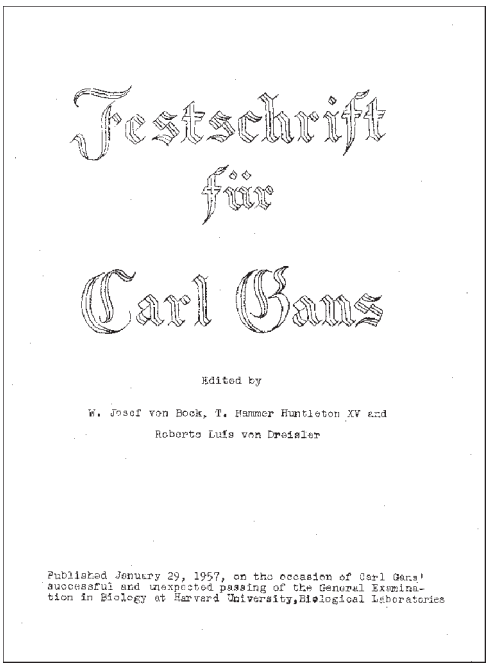
During 1953–1954, Gans took leave from his job to do fieldwork in Brazil and Bolivia supported by a Guggenheim Memorial Foundation fellowship, during which time he was introduced to amphisbaenians, fossorial squamates that were to become one of his favorite subjects for studies in systematics and functional morphology. He duly returned to his engineering position in 1954, but by then his career goals had radically changed. In 1955, he was accepted as a doctoral student in biology at Harvard University by the vertebrate morphologist, paleontologist, and doyen of American zoologists, Alfred Sherwood Romer. At the age of 32, Gans embarked on an entirely new career in biology and on a fast track. Ernest E. Williams, curator of herpetology in the Museum of Comparative Zoology at Harvard, eventually became his doctoral advisor and by 1957 Gans had completed his dissertation.

Because of his relative seniority to the other graduate students and his esteemed position among them, his professors and fellow graduate students played a good-humored prank on him by issuing a booklet of articles—entitled "Festschrift für Carl Gans"—on the occasion of his "successful and unexpected passing" of his general examination. Inside the booklet there was a table showing major events in Carl's life in the first column and corresponding world events in the other. A sampling: "Born 1923 in Germany" vs. "Panic, inflation and great distress in Germany"; "Left Germany in 1939" vs. "World War II starts"; and "Enters Harvard

in 1955" vs. "President Eisenhower has a heart attack." Even Carl's professors had some fun: "He has done so little in his life so far and yet that little has disturbed the world so much (E. E. W[illiams].)."

As a senior graduate student at Harvard University (about 1957). Photo courtesy Kraig Adler.

Gans's dissertation combined his interests in engineering and evolution, as well as his keen observational skills, in a study of the African egg-eating snakes (*Dasypeltis*) from which he drew major insights. (He had begun to publish on the egg-eating adaptations of *Dasypeltis* in 1952, based on his private research.) He described the morphological and biomechanical adaptations that allow these nearly toothless snakes to eat large eggs, crack the shells within the esophagus, empty out the liquid contents, and regurgitate the shell as a cigar-shaped mass. Later, he used vector analysis to describe in trigonometric terms the initial swallowing process, among other actions. He also discovered that the color patterns of these snakes varied geographically and in parallel to those of several small vipers (*Bitis*, *Causus*, and especially *Echis*). These, in addition, display C-shaped coiling behaviors and, in *Dasypeltis* and *Echis*, stridulating warning reactions when disturbed. He recognized that the color pattern and behavioral convergence of these snakes represented an example of Batesian mimicry and then extended this idea to develop a new concept of "empathic learning" that explains how mimicry can evolve even when the model is lethal. This project, integrating Gans's interests in systematics, morphology, biomechanics, and evolution, provided the pattern for his highly versatile research career.



Cover of the spoof booklet, "Festschrift für Carl Gans," prepared by fellow students and professors at Harvard University on completion of his doctoral studies (1957). Photo courtesy Kraig Adler.

On completing his doctoral work, Gans became a postdoctoral fellow at the University of Florida before joining the faculty of the University of Buffalo in western New York State in 1958. His most extensive publication from this period was his book-length monograph, "A Taxonomic Revision of the African Snake Genus *Dasypeltis*" (1959). He quickly rose from assistant professor to full professor and by 1970 was chairman of the biology department. The next year he moved to the University of Michigan, which had long been a prominent center for herpetological research and graduate education, as chairman of the zoology department (1971–1975). He was a hard-driving leader of the department who set very high standards for his faculty and became the nemesis of the botany department, which shared a building with zoology and competed for the same space. After retiring as professor in 1997, Gans moved to Austin, Texas, where he was an adjunct professor at The University of Texas.

Gans's research program covered a very broad scope including functional morphology (mainly of vertebrates), systematics of reptiles, the evolution of early vertebrates, and adaptations of limbless and burrowing tetrapods (mainly caecilians, amphisbaenians, and uropeltid snakes). His pioneering studies on the origin of vertebrates focused on the invention of the head (and thus the neck), which was made possible by the evolution of a new kind of embryonic cell (called neural crest) that he believed led to bone. This project was conducted together with his former zoology colleague at Michigan, R. Glenn Northcutt, and arose from their teaching a course on the comparative anatomy of vertebrates.

Carl took an engineer's approach to studying and experimenting with functional problems such as locomotion, burrowing, feeding (especially chewing), respiration, sound production, and hearing, all studied from an evolutionary perspective. His classic studies on breathing in frogs were conducted primarily in collaboration with a Dutch functional morphologist, H. J. de Jongh. They used sophisticated technologies in their work (electromyography, cinematography, and cinefluorography; monitoring buccal and pulmonary pressures; and recording gas flow in frogs placed in atmospheres with variable concentrations of argon and nitrogen) and demonstrated that relatively pure air was pumped into the lungs. Carl's favorites, the amphisbaenians, provided yet other models for application of biomechanical analysis. These burrowing wormlizards propel themselves underground using concertina and rectilinear mechanisms and he discovered that significantly different digging methods were employed among the families of wormlizards. Gans's textbook, "Biomechanics: An Approach to Vertebrate Morphology" (1974) summarized much of his early work in functional morphology and has become the standard sourcebook for the field.

First and foremost, however, Gans was a naturalist who loved reptiles and was fascinated with the ways in which they lived their lives. He was equally at ease studying them in the lab as he was in the field and regularly made numerous trips overseas to study them in South America, Africa, Australia, and especially in India and Sri Lanka. He collaborated and published regularly with numerous biologists at universities and museums throughout the world. He was also a major proponent of the value of collaborations with herpetologists at zoos. Although relatively few graduate students took their degrees with Carl, many colleagues and their students flocked to work with him on joint projects. His wife, Kyoko A. (Mabel) Gans, who had been the executive secretary of the biology department at Harvard and who he married in 1961, actively supported his research, writing, and editing and she graciously hosted legions of visitors who came to work with Carl. They were a real team until she died of cancer in 1999.

Besides his personal research contributions, Gans served the biological community in numerous ways. He was president of several major societies (American Society of Ichthyologists and Herpetologists, American Society of Zoologists [now called Society for Integrative and Comparative Biology], and Society for the Study of Amphibians and Reptiles) and served as editor of the *Journal of Morphology* for 25 years. While still a postdoc at Florida, he joined SSAR during its first year (1958) and under its former name, The Ohio Herpetological Society. When he discovered that it was run by a bunch of teenagers, he promptly resigned. He rejoined OHS a few years later, however, and in 1967 showed up for the 10th Anniversary Meeting in Columbus, Ohio, and thereafter became a regular participant in society meetings. He became involved in many other society activities and helped to draft the new SSAR Constitution

As president of SSAR, together with the presidents of the American Society of Ichthyologists and Herpetologists (Marvalee Wake) and The Herpetologists' League (Ronald Brandon), at the Joint Meeting of Ichthyologists and Herpetologists at the University of Oklahoma (August 1984). Photo by Kraig Adler.

in 1970. As SSAR president for 1984, he was an activist leader who enjoyed his freedom to innovate without the encumbrance of an overly circumscriptive society constitution.

Carl's supreme achievement in his service to our discipline, however, was the 22-volume series, "Biology of the Reptilia" (1969–2010), which he conceived, edited, and partly wrote. This compendium, covering the behavior, development, ecology, neurology, physiology, and especially the morphology of reptiles, is one of the monuments of modern herpetological and biological science. Some 169 persons from 21 countries contributed 142 chapters to it. After 42 years, the final volume, a comprehensive list and cross-index to the literature on reptilian biology, appeared in March 2010. It was a great honor when Carl entrusted publication of this classic series to SSAR, which had the privilege to issue the final four volumes.

Carl was also one of the most prolific authors in our field and published more than 700 titles including five books, in addition to the 22 volumes of "Biology of the Reptilia." Among them were a photographic atlas of shark anatomy (1964), his highly popular "Reptiles of the World" (1975, later translated into several other languages including Chinese), and a practical manual on electromyography (1986). Most of his taxonomic papers dealt with the systematics of amphisbaenians (on this topic, from 1957 to 2008, 94 titles including 10 major works), but he also authored numerous titles on the evolutionary basis of adaptation, physiology of snake venom, evolutionary origin of vertebrates, mechanics of hearing and sound production, functional significance of muscle architecture, mechanics of limbless locomotion, and feeding mechanisms in tetrapods.

Despite his long list of titles, his distinguished reputation, and his sometimes gruff demeanor, Carl also had a soft heart and a tendency for pranks. At scientific meetings, he could be very tough (and also usually very helpful) during the Q&A period following a graduate student's presentation when he sometimes displayed a trace of his German accent. He would often then invite the student to go swimming with him (he routinely brought his bathing suit if there was to be a pool or ocean nearby). At SSAR's 25th Anniversary Meeting in Raleigh, North Carolina, Carl was scheduled to present a plenary lecture on amphisbaenians, but wanted instead to talk about functional morphology. He hatched a plot in which Steve Arnold, Paul Hertz, Ray Huey, Ken Miyata, and I were conscripted as co-conspirators. After Carl talked about amphisbaenians for a few minutes, Paul stood up to declare, "With due respect, sir, you've been talking about amphisbaenians for years. Do you really have anything new to say about them?" There was an audible gasp from the audience. One of them leaned over to tell Paul that he had just committed academic suicide! Carl, glaring down at Paul over the top rim of his glasses and seeming quite annoyed, continued on with amphisbaenians. One at a time, the rest of us stood up to voice other comments or complaints. More gasps. Finally, one of us asked him to talk about functional morphology instead, which Carl proceeded to do with feigned resignation. (This event was accurately, but cryptically, reported in *Herpetological Review*, 13:107, 1982: "After repeated interruptions by the audience, the author switched his topic to functional morphology.") After the talk, one senior herpetologist and close friend of Carl's, who was completely taken in and who had wanted to hear about amphisbaenians, dressed me down in no uncertain terms for interrupting the talk. Carl's master plan thus worked perfectly and he was absolutely thrilled to have completely fooled the audience!

Carl Gans was, of course, one of our most distinguished herpetologists. Other biologists, however, tend to think of him as a physiologist, behaviorist, bioengineer, comparative morphologist, or an evolutionary biologist. He also became an active conservationist. Above all, he was a naturalist in the most integrative sense of that old-fashioned, yet refreshingly modern label. And he knew every facet of the lives and evolutionary history of his animals. As he once replied to a newspaper reporter's question, "I can look at a reptile and know if it is happy or not." And Carl Gans could probably do it, too.

Acknowledgments.—Leo Gans kindly filled in the early years of his older brother's life. Several academic colleagues have read over and commented on my manuscript, for which I am most grateful. For help in locating some photos, I thank Robert Dudley, Andrew Gans, and Gregory Schneider.

Carl Gans: The Buffalo Years of 1961–1967

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I met Carl in 1961 when he was 38, clean shaven, unmarried, and had completed just three years at the University of Buffalo (UB) as a faculty member in the Biology Department. He was at UB from 1958–1971 and I worked under him for about half his stay there. I was a "floating" grad student at first and enrolled in Carl's course in evolutionary biology. Two things stand out from that course: 1) an evening field trip in the pouring rain searching for spring peepers in roadside ditches while Carl, replete in suit, tie, and raincoat directed the soaked students in their quest; and 2) enlightening discussions about Lee Dice's work on black and white mice in areas of black lava flows and white sand.

During his days as an assistant professor at the University of Buffalo (1962). Photo by M. Graham Netting; courtesy Kraig Adler.

Somehow I scraped through the course and one night Carl wandered into my grad cubicle, handed me a jar of preserved Emerald Tree Boa heads and two papers by Albright and Nel-

son. He challenged me to see what I could make of the snake's head morphology. Thus started a relationship that lasted some 48 years. Carl was my teacher, PhD advisor, mentor, den mother, role model, friend, and anything else he needed to be for this aspiring but clueless kid from Brooklyn whose knowledge of natural history extended from stickball to the Brooklyn Dodgers. Carl's first grad students were A. A. Alexander, Jim Bonin, Aaron Taub, then there was me, followed by Ed Saiff and H. M. Pandit.

Animals kept in Carl's lab: amphisbaenids, cobras and kraits, and *Bitis gabonica*

Carl's grad students were expected to become familiar with all aspects of herp care hence we served as his animal care technicians in those early, lean years. Carl had a great affinity for amphisbaenids and he focused on biomechanical analyses of their burrowing behavior. Many of these limbless squamates tunnel in sand so it was our job to autoclave vast quantities of sand, set up aquaria filled with sand, keep the sand at the proper humidity, feed the amphisbaenids a variety of food, and observe their feeding behavior. In most cases ingestion takes place after the reptiles draw their food back into the tunnel. We spent many hours staring at mealworms and pinks wriggling on a sandy plane but were rarely rewarded by observations of feeding behavior.

Carl had discovered that he had to attack the taxonomy and relationships of the amphisbanids in order to place his biomechanical observations into a meaningful framework. Part of the lab became a museum-like shipping department as parcels containing preserved specimens arrived from all over the world. We learned how to become curatorial assistants unpacking specimens, checking them off the shipping documents, and setting up jars for future study. We went through enough ethanol to pickle the entire campus but filtered out debris and reused alcohol whenever possible.

What does one do with a preserved amphisbaenid? Measure length of body regions, count annuli, record patterns of head and pre-anal shields, plot characters on geographic grids, take photographs (so we learned every aspect of macrophotography and darkroom technique), and then help Charlene (Carl's technician) prepare the manuscript for publication. Much of this work was later summarized (Gans 2005. Checklist and bibliography of the Amphisbaenia of the world. Bulletin of the American Museum of Natural History 289:1–130).

One of my earliest grad projects with Carl was a histological study in 1967 of serial cross sections that I prepared of everted amphisbaenian hemipenes (to be followed up by an SEM study in 1991). I obtained specimens to be sectioned by rummaging through the jars of preserved specimens in Carl's collection. One day Carl called me into his office and began to tear a strip off my hide….I had snipped off the everted hemipenis of a type specimen from the MCZ! Carl phoned Dr. Williams and the tempest was calmed when Ernest suggested that when the type is returned we include the slide box of serial sections as well. This is one of the very few times I saw Carl lose his temper. So somewhere on a shelf of the herp collection at the MCZ, hidden by jars of preserved whole specimens, sits a little box of slides made by yours truly.

At least amphisbaenids are not venomous! Carl focused on ophidian envenomation as an offshoot of his interest in reptilian feeding mechanisms. Aaron Taub worked on the structure and function of Duvernoy's gland, Elazar Kochva from Tel Aviv University spent a long sabbatical with Carl furthering his investigations of viperid venom glands, the late Bill Elliott fractionated and analyzed fresh venom, and I chipped in with a thesis on venom glands of elapids and sea snakes.

Thus Carl began to house all sorts of kraits, cobras, and vipers in his "animal room." Why is it that shipments of live kraits from Thailand always arrive in the middle of the night? Carl and grad students would drive to the airport with snake sticks, Pilstrom tongs, cages, bags, etc. We always offered to open the boxes for customs but somehow they always declined our offer. That's when my true colors began to show. It's one thing to stare at the mealworms in an amphisbaenid's sandy world but it's something else to clean the cage of a cobra or the fattest Gaboon Viper I ever saw. Carl never hesitated to keep these dangerous reptiles but I must say he was very cautious. Thus, he would never order live specimens unless he had a supply of the proper antivenin in his fridge. Carl developed an elaborate protocol with campus security so that each time we had to take dangerous specimens out of their cages, the campus police had to sit in his lab (while the red light was on) prepared to do a hospital run with the "victim" and a stock of antivenin. As far as I know, there never was a mad dash to the Buffalo General but there were several entertaining practice runs.

Formal portrait with Kyoko A. (Mabel) Gans, three years after their marriage and during his period at the University of Buffalo (December 1964). Photo courtesy Andrew Gans.

Caged animals somehow manage to escape. Venomous snakes were not a problem as they were all secured in padlocked cages designed by Carl. I will never forget one Saturday night when some arboreal lizard managed to gain its freedom and Carl was immediately notified as per his instructions. Carl and Mabel arrived dressed to the nines for a night at the theatre. Carl slipped out of his jacket and suspenders, then stepped out of his trousers and took off after the lizard in his boxer shorts, shirt, and tie. Mabel and I averted our gaze not so much out of modesty but to prevent bursting out in laughter. Carl caught the lizard, dressed, and headed off for a night on the town with Mabel.

Work habits in the Gans lab: time, technology, and writing

There is Eastern Standard Time and there was Gans time. Carl had a very different biological clock. He would usually arrive at the lab in the mid-afternoon and work till early morning of the next day. Of course his grad students were expected to be in the lab while he was there but they often had to teach an undergrad lab at 8 AM the next morning! Several times a week Carl would treat us to pizza at 2 AM; he would return to work and we would stagger home with our sleep impeded by a gastrolith of spicy, rubbery cheese and dense dough. Those were our good old days!

Carl would arrive at his office, spend time with phone messages, incoming mail, signing letters that had been typed by his secretary (Gloria) during the morning, and checking on grad students. Then he would settle down to work and revise manuscripts. Each manuscript was kept in a three-ring binder with the most recent version on top. Carl would read and "mark up" the manuscript in a very distinct, almost illegible scrawl for his secretary to retype the next morning. Thus, a manuscript was gone over again and again and eventually honed into a finished product to be submitted for publication. Grad students read the "final" version and were rewarded for any typos we might spot (they were few and far between). When the proofs were sent to Carl we would team up and

the grad student would read every word, punctuation mark, and number (think of all those columns of scale counts!) while Carl corrected the proof. Talk about hands-on learning. We followed the same process as we wrote our theses and prepared them for publication. Carl always acknowledged our help in print at the beginning of each publication we had been involved with.

One pillar of Carl's reputation rightly rests on the huge number of his publications (those written alone and those co-authored with colleagues). He had to rely on the technology of the day and would have been very much more productive if his entire career had been supported by computer-based word processing. When I arrived in Buffalo, Carl was progressing through a wide variety of voice recorders that he would use to dictate letters, memos, and first drafts of the several manuscripts he was working on. He always had a pocket- sized recorder with him to dictate memos to himself, students, et al. and these were constantly being replaced by newer models. Remember, his handwriting was not easy to decipher so his secretary played back his words through earphones while she typed the transcription. Carl would read through what was typed, edit the text, mark up the pages, and return them to the secretary for re-typing. This process would be repeated again and again with total retyping often being required! When I first arrived there was a manual office typewriter, then there was an IBM Selectric, followed by an IBM Magcard Selectric that stored information on magnetic cards, and eventually word processing (after I had moved on). When Carl finished with one typewriter, he would place it in the lab for his students to use; we were always one step behind in IT.

Carl was very innovative when he turned to biomechanical, physiological, and functional morphological investigations. Even before that he constantly sought to improve his efficiency in the lab. Thus, he invented (along with Bill Tanski) a foot pedal device (manufactured by Gomco in Buffalo) that allowed the operator to focus a dissecting microscope and leave both hands free to hold dissecting instruments (U.S. Patent Office 3,350,977). My role in this was to be the male model, sit at the lab bench, and pretend to be dissecting a snakehead for the sake of the publicity photos. While I was decked out in a tie and starched lab coat, my feet were clad in worn-out basketball sneakers. Imagine my surprise when the ad that appeared in *Bioscience* showed me wearing well-polished brogues that had been airbrushed over the sneakers (and this before the advent of Photoshop)! Later, Carl added a second foot pedal that activated a tape recorder so he could dissect with both hands, continue to keep the field of work in focus, and record his observations on tape all at the same time.

Carl became a great proponent of electromyography (EMG) as an analytical tool for functional studies. He spent a sabbatical in the lab of George Hughes learning the basics of EMG and was sure that if Hughes could record electrical activity from branchial muscles of sharks in tanks of water, he could certainly record from muscles used by tortoises in pulmonary ventilation on dry land. Thus started a prolonged series of EMG studies in a great diversity of vertebrates that focused on feeding, locomotion, ventilation of lungs, and other topics. Carl became involved with electrodes, amplifiers, oscilloscopes, all sorts of recording devices, and high-speed movie cameras (in some cases using strobe lights designed for aircraft!). Most of these technical accomplishments were reported in Loeb and Gans (1986. Electromyography for Experimentalists. The University of Chicago Press, Chicago, Illinois. 373 pp.).

Surrounded by the Central Dogma

The molecular biology bandwagon started to roll in the Biology Department at Buffalo in the early1960s. Suddenly, new faculty members arrived on the scene, vast areas of "open space" were occupied (goodbye to graduate cubicles), and the hum of ultracentrifuges filled the air. The nature of seminar programs was altered and traditional graduate pathways were complemented by those that went from DNA to RNA to protein synthesis. Carl more than held his own during this inundation but tended to spend more time with departmental politics. Friendly competition prevailed on the softball field as well as indoors. When Carl invited Professor Romer to deliver a departmental seminar, he requested his grad students to make the arrangements for coffee and cookies. Here was a chance for us to gain on the molecular types; no Oreo cookies for us. We set up a grand spread of bagels, lox, and cream cheese much to Carl's (and the ever-hungry grad students') delight. What a memorable event that seminar was!

Carl's libraries: in the lab, at home

Carl developed one library in his lab and one at home. The scientific library grew as a result of an extensive network of reprint exchanges with friends and colleagues around the world (*Current Contents* was less than five years old then). He also purchased important volumes from book dealers in North America and Europe. Whole sets of reprints had to be located and ordered whenever a new project took shape. The library was organized in a somewhat confusing but logical (to Carl) fashion so reprints could be retrieved from their boxes. First of all there was a geographical level of organization, set up by continent and then country; then the North American reprints were set up alphabetically by journal title; but there were also a variety of special sections that I was never too sure about. Of course in those lean times grad students would be required to learn about the world's literature by refiling reprints. We tried our best but not to worry, periodically we would "go through the collection" with Carl looking on to set things straight.

The collection at home consisted of cowboy novels, detective stories, science fiction, and whatever Carl happened to enjoy. Steel bookshelves in the attic of his Buffalo (and later Ann Arbor) home were lined with hundreds upon hundreds of paperbacks. Students had access to this collection as well but we never had to reshelve these books.

Barbeques galore

Carl was the consummate host and he loved his beef. Thus for summer, outdoor entertaining he typically fired up the barbecue in his backyard while Mabel produced large bowls of salad (that Carl barely glanced at). Grad students, undergrads, technicians, secretaries, colleagues, and visiting firemen were always invited. The beef was plentiful but almost as important Carl would always introduce the students to visiting zoologists from the famous to the infamous and inform them of our research programs. Just a few who stand out were the Belgian herpetologist G. F. de Witte, the Swiss neuroanatomist Werner Stingelin (who spent a sabbatical with Carl), the morphologist from Brooklyn, Paul Maderson, the morphologist Tom Parsons, the Israeli zoologist Elazar Kochva (who spent a prolonged sabbatical and helped mentor me in venom gland architecture), the Dutch physiologist Hank DeJongh (also spent a sabbatical in Buffalo), Toby and Sandra Gaunt, Carl's mother, and of course, A. S. Romer and E. E. Williams. At times it seemed as if there was a steady stream of visitors to Carl's lab and then backyard.

Conclusion

Thus, Carl's grad students received a very full regime of preparation for the real world. If Carl took you under his wing it meant that he took a deep interest in all facets of your education. Carl required me to complete a course in Botany, a full-year course in Human Anatomy in the UB medical school, a summer field course with OTS in Costa Rica (1965), and a post doc in chemical communication of insects at Cornell University with Carl's friend Tom Eisner (who else would accept me?).

Carl taught me many things beyond zoology. He was generous when it came to supporting various charitable organizations. He went out of his way to invite students, post docs, and faculty members to a stint in his lab from all over the globe knowing that their experience would further their careers once they returned home. He gave back to the profession by serving as the editor of the *Journal of Morphology* for 25 years. Carl also went out of his way to help authors rewrite and polish manuscripts

they submitted to the 21 volumes of "Biology of the Reptilia" that he co-edited and edited. Sure, he was demanding and had high standards but we were the ones who gained and eventually passed on the traditions to our students. Thank you, Carl.

Carl Gans: The Ann Arbor Years

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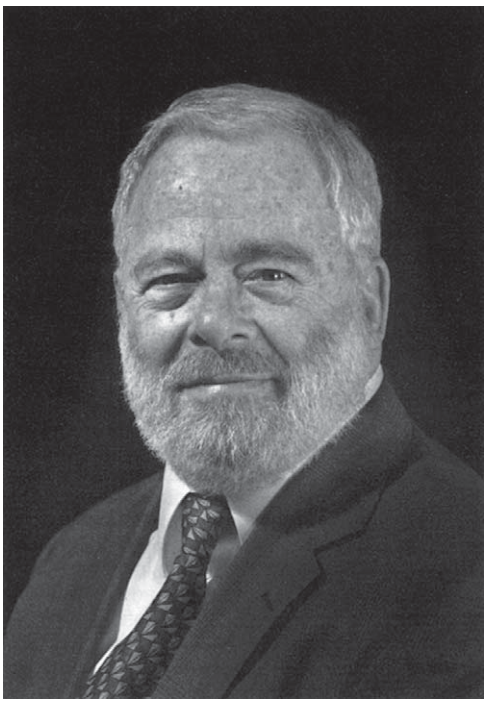

Formal portrait as Professor of Zoology at the University of Michigan (ca. 1994). Photo courtesy of the University of Michigan and Greg Schneider.

In 1971, at age 48, Carl moved to the University of Michigan in Ann Arbor as Chair of the Department of Zoology. He was near the peak of his scientific powers then and for the next 27 years, during which he continued to edit the *Journal of Morphology* and "Biology of the Reptilia" in Ann Arbor. During his first year as Chair, Carl paved the way for my own move to UM, where we taught, collaborated, ate and drank together, often with our wives, for the next 14 years. Our one-semester course in Comparative Vertebrate Anatomy usually involved around 100 students and consisted of four lectures and six hours of laboratory each week. Carl and I usually divided the lectures equally, and after each class we routinely repaired to a local pastry shop to critique the day's efforts, making sure that our discussion ended on a sweet note. Our papers together on the origin of vertebrates literally grew out of our reorganization of the Comparative Vertebrate Anatomy course at Michigan.

During his first four years in Ann Arbor, Carl provided strong leadership for the department at a particularly difficult time. Higher administrative officials were forcing a merger between Botany and Zoology, an action highly unpopular with both departments. The effects of this imposed merger were exacerbated by a downturn in Michigan's economy, which could have resulted in the loss of the university's non-tenured faculty in many departments. To Carl's great credit, he convinced the tenured members of his faculty to forgo raises in order to keep the entire faculty intact. His principles of fairness continued to be in evidence, as he was very active in correcting salary inequalities for women and minorities, at a time when the justice of such parity was anything but assumed.

While in Ann Arbor, Carl maintained an incredibly active laboratory, including graduate students, postdoctoral fellows, and an endless number of international visitors. Carl was a gruff colleague, however, and—although he was basically kind—he could be remarkably caustic, and he was not an ideal mentor for anyone with a hide less thick than a crocodilian's. I first met Carl while I was a graduate student with Hobart Smith at the University of Illinois. Hobart introduced us, then left to attend to other duties. Carl grilled me for at least 30 minutes on my research, albeit offering some good advice in the process. When he finally stopped, I asked, "And what are you working on now, Dr. Gans?", and Carl replied, "Everything," before leaving the room. Despite being somewhat put off by this reply—which I later decided was not totally inaccurate—I thus began my friendship with Carl Gans.

In addition to his scientific passions—namely morphology, biomechanics, and the biology of amphibians and reptiles—Carl had a passion for life in general, including food, wine, the arts, and travel. He did a great deal of the last in the course of his research, and he was an acute observer of political systems in the countries he visited—such as Australia, India, Sri Lanka—reading extensively on their social systems as well as their fauna. It was also rather a badge of honor with him to have endured fairly primitive field conditions in pursuit of his science. He was intensely fond of numerable art forms, everything from grand opera and early Japanese erotica to "The Cremation of Sam McGee," which he could often be persuaded to recite from memory after the wine had been flowing freely. After dinners at Mary Sue's and my home, he also sometimes led other guests in a rousing chorus of Gilbert and Sullivan songs. Carl was an exhaustive reader, virtually inhaling serious literature and hard-boiled detective stories with equal gusto. As a movie fan, his tastes were similarly catholic. He was particularly fond of Clint Eastwood's "Dirty Harry," who became his alter ego, but he appreciated foreign films and "serious" films. He also once persuaded me to accompany him to a showing of "Deep Throat," after which he remarked, "Oh well, there are only so many orifices in the human body." Always the morphologist, Carl was.

His wife Mabel (Kyoko) shared many of his passions, including travel, though not the deprivations of field work. She was confidant, research assistant, social secretary, and hostess. Regardless of whatever professional or personal pressures the two were experiencing, they were unfailingly gracious hosts, and always demonstrated love and support for one another. Scientifically and personally, Carl and Mabel had a profound effect upon Mary Sue and me, as well as on other academic couples who had the good fortune to interact with them for an extended period of time.

During his years in Ann Arbor, Carl was not always easy, as a colleague or as a friend, but what stands out in my mind is the respect and affection I had for him then and now.

Reminiscences of Carl Gans

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Although I never attended a school where Carl Gans taught and cannot claim to have been particularly close to him, he was an important influence on my personal and professional development, as he was for many other herpetologists. Perhaps appropriately, I learned of his death after a week of collecting in the Caprivi Strip of Namibia, which yielded a diversity of organisms that played a role in Carl's career, among them the egg-eating snake *Dasypeltis*—the subject of his doctoral dissertation, and several species of amphisbaenians—the organisms most intensely studied by him.

In the spring of 1980 I was an 18-year-old freshman at Michigan State University and, after taking Comparative Vertebrate Anatomy in the winter quarter, signed up for a graduate seminar in "advanced morphology" taught by Jim Edwards. The course included some lectures and stu-

dent-led discussions of relevant primary literature in vertebrate morphology. Carl's "Biomechanics" was the course text. Each student selected a prominent morphologist and was responsible for selecting and leading the discussion on papers by that author. As a budding herpetologist, I chose Carl Gans, whose work on locomotion in amphisbaenians—a group then practically unknown to me—I found fascinating. The course also featured guest lectures by visiting morphologists, one of whom was Carl. Because of my special interest in reptile morphology and because I was "responsible" for Carl's papers in the course, I was invited to dinner with Carl at the Kellogg Center, just across from my dorm. Although I was clearly out of my depth, I was thrilled to have the opportunity to talk to the great Professor Gans, who engaged me in conversation as if my opinion actually mattered and thus cemented my intention to pursue research in reptile morphology.

I next encountered Carl at my first SSAR meeting (Salt Lake City in 1983). I was in a morphology session, back-to-back with a number of my fellow Berkeley graduate students. Carl was in the audience and all the students in the session were on edge, hoping that he didn't find fault with their presentations and turn the question period into an uncomfortable grilling. For one of the speakers before me it was a worst case scenario. When questions opened, Carl stood up and began by saying "Your premise is fundamentally flawed …." Somehow, seeing that my colleague survived this settled my own nerves and 15 minutes later I gave my first scientific presentation with confidence. Carl's questions were direct and generally on the money and his criticisms were typically valid, revealing either real flaws or inadequacies in presentation that detracted from the arguments presented. Although it could be intimidating to face Carl under such circumstances, his criticisms were typically fair, and his negative opinions, especially in the case of students, were usually aimed at the work and not the individual. However, Carl did make enemies, and close association with those on his bad side could strain relations with him. Carl enjoyed the fact that he was held in awe (or fear) by students (and many more senior colleagues) and that he was taken deadly seriously by nearly everyone. In reality, despite the gruff exterior, he was fond of playing subtle jokes that would be signaled by winks and nods to those in the know.

At the SSAR annual meeting in 1984, Carl, then president of SSAR, had donated several items for the SSAR auction. One was Da Silva's "Snakes of Sri Lanka," which had been published shortly before. The work was not generally available outside Sri Lanka and Carl had picked it up on one of his trips there. For bibliophiles the book was a rare prize and there was spirited bidding. Ultimately I was one of three bidders left when the price exceeded $100 (then more than 10% of my monthly TA salary and more than half my rent). My competitors both had "real" jobs and I eventually dropped out at about $150. Later in the evening Carl came up to me and said "Thanks for driving the bidding up. I'll send you one next week." He did and through the years occasionally remembered my interest and picked up extra copies of obscure titles for me.

After I became gainfully employed, Carl and I began an abortive project on locomotion in limbless skinks of the genus *Acontias*. Having just returned from South Africa with live specimens, I flew to Detroit in the dead of winter and stayed with Carl in Ann Arbor, "running" the lizards on pegboards in his lab and writing in tandem, sitting with Carl at his computer while he typed. Carl's schedule, rising late and working until the wee hours of the morning, was more or less six hours phase-shifted from my own and I could barely stay awake as a new set of animals was introduced to the pegboards at 3 AM. This was exacerbated by an unfortunately timed bout of recurrent malaria. Carl barely noticed that I was sweating and shivering in his single-minded pursuit of the project. However, back at home, he immediately switched modes and became "daddy" to his dog P.C., who brought out his softer side.

Although I would never dare to compare my accomplishments to Carl's, I did end up following in his footsteps in terms of research venues and for many years I have passed in Carl's wake in southern Africa, India, Sri Lanka, Australia, Eastern Europe, and elsewhere. In nearly every place I have visited people know Carl, many personally from his own extensive travels, but certainly at least by reputation. Indeed, Carl was probably the most well-known herpetologist in the world at large for a period of 20 years from about 1970 to 1990. As Carl's health declined and his travels decreased, my foreign colleagues would always ask about him. Many were profoundly affected by him and most considered it a genuine privilege that they were able to interact with him, both personally and professionally. A visit from Carl Gans brought prestige to any researcher or institute.

Carl Gans and field crew in 1978 in the Pilbara region of Western Australia where, on their way back to Perth, the party stopped to see some aboriginal rock carvings at Woodstock Station. Among those present are Gans (crouching) with Harold Cogger on his left (in shorts), Hubert Saint Girons on his right (with cap), and Donald Bradshaw at the wheel of the vehicle Photo courtesy of Donald Bradshaw.

Carl Gans was larger than life. His domination of diverse biological disciplines was unparalleled in the late 20th century. That his was both the first and last word on so many topics is attested to by his bibliography, which lists a score of "prefaces" and "concluding remarks." I only had the opportunity, along with Rainer Günther, to co-author one paper with Carl, in 1997, on the amphisbaenian types in the Berlin Museum. However, my favorite of his 600+ works, or at least my favorite title, is a 1978 paper from *American Zoologist*—"All animals are interesting!" As reflected by his life's work, Carl certainly believed this and helped the rest of us believe it too.

Carl Gans: The Austin Years 1997–2009

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Carl Gans and his wife Mabel retired to Austin, Texas in 1997. Serendipitously, that was the same year I arrived in Austin, but they beat me here by several months. I had maintained a fruitful and entertaining correspondence with Carl for many years, beginning in 1993 with the publication of my first papers on fossil lizards. I sent copies of those papers, as a 'calling card' of sorts, to many people who had published on fossil reptiles, introducing myself and my shared interest in that topic. At the end of the accompanying (and, in retrospect, startlingly naive) cover letter, I included a brief request for copies of all papers the recipient might still have available for distribution. Carl was one of the recipients of that letter. Soon after, I received a reply from him indicating that he was somewhat taken aback by my open-ended request for reprints, but had decided to send me copies of all titles he still had on hand. Even now I cringe a bit when I recall the day I received a large box containing

hundreds of monographs and reprints authored and co-authored by Carl. He apparently was amused by both my initial request and the humble 'thank you' letter that followed, and we continued to exchange letters and publications for several years, but never actually met until I arrived in Austin. A few months after settling here I answered my telephone one afternoon and heard a deep and somewhat gruff voice admonishing me for not having been in contact... "You haven't called me, so I thought I'd better call you." I had no idea to whom I was listening until he identified himself as Carl Gans. He proposed dinner, I accepted, and we met in person for the first time.

Those who knew Carl in his days at the University of Michigan have made clear to me that I knew him in a different way than they did. The descriptions I would provide of my interactions with Carl seemed impossible to some of them, as if I were describing a second person of the same name. A few hints of the sobering interactions that sometimes arose between Carl and graduate students are found in the reflections that accompany my own in this compilation; the rumor mill carries many other stories. Carl even implicated himself one night during dinner with my wife and me, when he joked "I used to eat graduate students for lunch." I knew Carl as a serious scientist, critical thinker, meticulous editor, avid reader, and bibliophile, but also as a genial colleague with a subtle sense of humor who enjoyed a good chuckle, and gave and accepted lighthearted teasing with equal delight. I have no terror stories, no squirming moments of discomfiture as my ideas were dissected and ego bruised in a clash with Carl. Instead, I always received considered advice, support for my endeavors, and a subtle but persistent encouragement toward higher standards in everything. Carl shared his time and expertise freely, along with a seemingly endless supply of reminiscences and anecdotes about his collections, field trips, colleagues from around the world, and parties at the annual herp meetings.

Carl's retirement was not a retreat from science, nor from active engagement with students and his colleagues. He enjoyed acquainting himself with the herpetological fauna of Texas, and took particular delight in announcing his Austin home address on Slow Turtle Cove. He moved here at the invitation of Robert Dudley, a collaborator and colleague who was then on the faculty in the Department of Integrative Biology at The University of Texas at Austin. Carl held the position of Adjunct Professor and maintained a research laboratory in that department, served as a member of PhD student committees, and participated as guest lecturer or discussant in several courses in the departments of Integrative Biology and Geological Sciences. His research activities were truncated shortly after arriving in Austin, when Mabel was diagnosed with cancer. Following her death in 1999, Carl refocused his attention on his scientific and literary pursuits with emphasis on three major projects in herpetology. One was an intensified effort to obtain from authors the final manuscripts for a new volume in the "Biology of the Reptilia" series, and to see those manuscripts through the review and revision process (these were eventually published as volumes 20 and 21 in 2008). The second project was an ongoing collaboration with Ricardo (Ueso) Montero on the cranial osteology and skeletal development of amphisbaenians (published in 1999 and 2008). The third was compiling and editing an updated checklist of the Amphisbaenia of the world, accompanied by an extensive bibliography on the group (2005).

He regularly hired undergraduate and graduate students to help him with research tasks and to work in his libraries. One of those libraries was an extensive collection of paperback novels that were housed in a loft above his master bedroom. His more expansive scientific research library filled a three-car garage and represented an intensely personal collection, incorporating books from his early career as an engineer, and reflecting his broad interests in natural history. He maintained subscriptions to no fewer than 85 serial publications, several of which are rarely seen in personal collections. Carl had a particular fondness for ferreting out what others have called 'obscure' literature, but he was adamant in his denial of the existence of such a category. In his view literature simply exists, and it is our responsibility to seek it out and cite it where relevant. He had an amazing ability to remember exactly what was in his library, as well as how to find it. The latter was no small accomplishment in a library the size of his. Apart from special topics (e.g., mimicry, conference abstract volumes, functional morphology), he generally filed his books, monographs, and reprints geographically. Usually the geographical referent was the topic, but sometimes he filed based on the location of the publisher. For example, Duellman's monograph on the equatorial herpetofauna of Amazonian Ecuador might be filed in South America, or in Kansas, depending on how Carl thought about it at the time he obtained and shelved it. Until you learned to think like he did about the organization, finding particular items could be a challenge.

Carl suffered a debilitating stroke in late January, 2001. After a short period in hospital he returned home, but was confined to a wheelchair. He and his brother arranged for some renovations to his house after the stroke, but among other inconveniences he was no longer able to enter the stacks in his research library. The fixed shelving was spaced to accommodate a maximum of printed material, not the width of a wheelchair. After his return from the hospital, my visits with Carl always included some time in his library, filing newly-received materials and pulling titles that Carl needed or wanted to see as he continued the increasingly frustrating effort to maintain his research activities.

In the years following his stroke a major priority for Carl was making arrangements for the disposition of his remaining collections. Prior to his retirement, most of his skeletal and alcoholic specimens were deposited in the Museum of Comparative Zoology at Harvard University and the Carnegie Museum of Natural History in Pittsburgh. He retained his amphisbaenian and uropeltid snake collections until it became clear that he would no longer be able effectively to work with those specimens. Although a small collection of dry skeletal specimens was donated to the Vertebrate Paleontology Laboratory at UT Austin, the majority of the uropeltid snakes ultimately were deposited at the California Academy of Sciences in San Francisco, and the amphisbaenians went to the Field Museum of Natural History in Chicago.

As far as I know, Carl recognized only two 'subcollections' within his scientific library, constituting materials that were filed and housed independently from the main body of his collection. The first was his lancelet collection, the second his reprints and monographs pertaining to amphisbaenians. His attempt to survey the extensive literature on lancelets included gathering physical copies of the majority of the 2696 titles cited in the published 'bibliography of the lancelets' (1999). That collection was deposited at the Scripps Institute of Oceanography in La Jolla, California. A substantial portion of his literature on the Amphisbaenia was sent to Maureen Kearney at approximately the same time that his specimens went to the Field Museum. The remainder of his library, along with 13 filing cabinets containing his scientific correspondence, was deposited at the Ben Gurion University of the Negev, in Midreshet Ben-Gurion, in the Negev Desert in Israel.

Although he struggled with declining health in his later years in Austin, Carl always enjoyed visits from colleagues and former students, and drew satisfaction from the simple pleasures of a fully retired lifestyle. He especially enjoyed his contact with graduate students, hearing about their projects and offering advice or suggestions for interesting questions or problems. He enjoyed and appreciated letters from other scientists who wrote with data or questions following up on one of Carl's earlier publications. He was especially gratified when he heard the news in 2008 that salamanders had been discovered once again in the parks on Manhattan Island in New York City (see Kraig Adler's account above).

Carl was a connoisseur of fine coffees and chocolates. He pursued these with increasing enjoyment after his stroke, and drew greater satisfaction from the pursuit of favored comestibles as his research activities waned. He maintained an impressive mental list of 'favorite' restaurants in Austin, as well as a slightly more select register of appropriate venues for the consumption of dessert. An evening meal with Carl often was a multi-hour event, and could involve stops at as many as three establishments. Such evenings were always a welcome opportunity for Carl to

enjoy good company, good food, and good conversation. He died on 30 November 2009, and is buried in the Cook-Walden Jewish Cemetery in Pflugerville, Texas.

Citations to Publications Mentioned in Text

Duellman, W. E. 1978. The biology of an equatorial herpetofauna in Amazonian Ecuador. University of Kansas Museum of Natural History Miscellaneous Publication 65:1–352.

Gans, C. 2005. Checklist and bibliography of the Amphisbaenia of the world. Bulletin of the American Museum of Natural History 289:1–130.

———, A. S. Gaunt, and K. Adler, eds. 2008. Biology of the Reptilia, Volume 20, Morphology H. The Skull of Lepidosauria. Society for the Study of Amphibians and Reptiles, Ithaca, New York. 755 pp.

———, ———, and ———, eds. 2008. Biology of the Reptilia, Volume 21, Morphology I. The Skull and Appendicular Locomotor Apparatus of Lepidosauria. Society for the Study of Amphibians and Reptiles, Ithaca, New York. 781 pp.

———, and R. Montero. 2008. An atlas of amphisbaenian skull anatomy. *In* C. Gans, A. S. Gaunt, and K. Adler (eds.), Biology of the Reptilia, Volume 21, Morphology I. The Skull and Appendicular Locomotor Apparatus of Lepidosauria, pp. 621–738. Society for the Study of Amphibians and Reptiles, Ithaca, New York.

———, and E. Saiff. 1996. Bibliography of the lancelets. Bibliography. *In* C. Gans, N. Kemp, and S. Poss (eds.), The Lancelets: A New Look at Some Old Beasts, pp. S-317–S-442. Israel Journal of Zoology 42 (Supplement).

Montero, R., and C. Gans. 1999. The head skeleton of *Amphisbaena alba* Linneaus. Annals of Carnegie Museum 68:15–80.

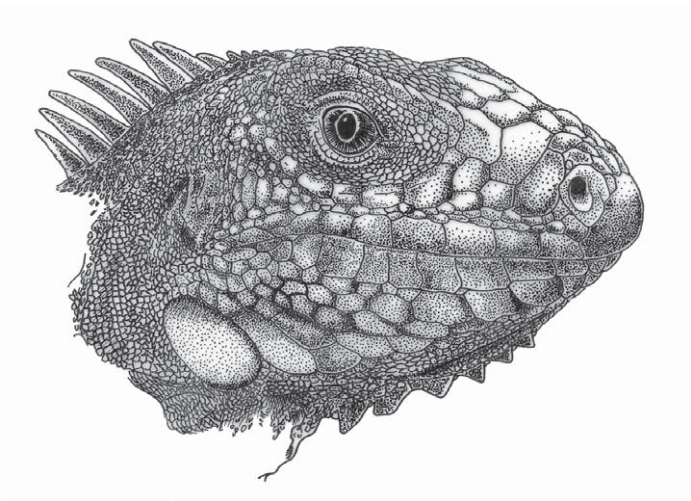
———, ———, and M. L. Lions. 1999. Embryonic development of the skeleton of *Amphisbaena darwini heterozonata* (Squamata: Amphisbaenidae). Journal of Morphology 239:1–25.

Suggested Reading

Bell, C. J. (nd). Bibliography: complete listing of the published works of Carl Gans. Online: http://www.utexas.edu/tmm/vpl/gans_bib_color1.html.

Dudley, R., R. B. Huey, and D. R. Carrier. 2006. Living history of physiology: Carl Gans. Adv. Physiol. Educ. 30: 102–107; online: http://advan.physiology.org/cgi/reprint/30/3/102

New York Times. 2009. Obituary for Carl Gans. Available online:http://www.legacy.com/obituaries/nytimes/obituary.aspx?n=carl-gans&pid=136949124.



Iguana iguana (Green Iguana). Colombia: Department of Casanare: municipality of Orocue. Illustration by Fernando Vargas Salinas, based on a photograph by Luis Alberto Rueda and Fernando Vargas S.

ARTICLES

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Reconsidering Extinction: Rediscovery of *Incilius holdridgei* (Anura: Bufonidae) in Costa Rica After 25 Years

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Amphibian populations are declining around the world (Wake 1991). Of the 6433 amphibians species (Frost 2009), close to 500 species are considered endangered (Stuart et al. 2008). Thirty-eight amphibian species have been declared extinct (IUCN 2008). For Costa Rica, the magnitude of amphibian declines has been so severe that three endemic species were declared extinct: the famous Golden Toad, *Incilius periglenes,* in 2002 (IUCN 2003), and both *I. holdridgei* and *Craugastor escoces* (Craugastoridae) in 2007 (IUCN 2008). The reduced geographic range of these species, their conspicuity, and the substantial search effort invested in areas where they previously were abundant justified categorizing these species as Extinct (IUCN 2008). These disappearances have been attributed to different causes, including climate change (Pounds 1997, 2001) and emergent diseases such as chytridiomycosis (Lips et al. 2006), or the synergistic effect between these two agents (Pounds et al. 2006).

A species is considered extinct when, as defined by IUCN (2001), there is no reasonable doubt that the last specimen has died. Difficulties with this designation may arise for secretive species or when the reproductive behavior of the species changes in relation with the reduction in population density (Mattsson et al. 2008). For example, explosive reproduction is a strategy to reduce the individual predation rate and increase the attraction of females (Duellman and Trueb 1994). When such species decrease in numbers, it is common to assume they are headed to extinction, but it is possible that they use an alternative reproductive behavior. The Costa Rican highland toads represent a classic example of these problems. Most of them are subterranean, emerge during explosive breeding events, and produce little to no audible vocalization. The need to form aggregations during reproduction may

cause difficulties to mate when population densities are reduced (Novak and Robinson 1975).

In 2006, Costa Rican herpetologists created a national strategy for the conservation of amphibians (Bolaños et al. 2007). This strategy included *in situ* and *ex situ* conservation, basic and applied research, and public education. Amphibian species that experienced the most drastic declines were recommended for *ex situ* conservation actions (Bolaños et al. 2008). A fundamental component of the national conservation strategy is increasing fieldwork to locate remaining populations of declining species. Amphibian species with relict populations represent an opportunity to test hypotheses concerning the causes of declines and ecological and evolutionary responses.

Here we report the recent rediscovery of *Incilius holdridgei* in a young secondary forest of Alto El Roble in the Cordillera Volcánica Central of Costa Rica. *Incilius holdridgei* (Taylor 1952) was described based on a single specimen collected at Finca Georgina, on the west slope of Volcán Barva at 2280 m (Savage 1974). Subsequently, other substantial populations were found on the southern and eastern slopes of the same volcano, with known localities including Sacramento (G. Barrantes, pers. comm.), Cerro Chompipe, and Alto El Roble (Novak and Robinson 1975). This species used to be very abundant at the last locality (J. Savage, pers. comm.), and their ecology and reproduction was described by Novak and Robinson (1975). The discovery of *I. holdridgei* represents the first in 25 years and removes the species from the Extinct category (IUCN 2008).

Materials and Methods.—On 1 May 2008, during a field trip by students in the herpetology course from the Universidad Nacional de Costa Rica, eight juvenile bufonids were observed in Alto El Roble (10.0946°N, 84.0624°W, 1900 m elev.) by JA. All juveniles were found during the day in leaf litter, or among rushes and grasses. As only two species of bufonids had been reported in Alto El Roble, the extinct *Incilius holdridgei* and the secretive *Crepidophryne epiotica* (Savage 2002), it should not have been difficult to establish the identity of these specimens. However, the specimens were only photographed by one of the students and the quality of the pictures was not suitable to allow identification.

From April to May, 2009, we visited the same area four additional times to conduct diurnal and nocturnal surveys to collect specimens to resolve the species identification. We searched for eggs and tadpoles in the pond located along the 2 km stretch of road between Alto El Roble and Río Las Vueltas (10.0878°N, 84.0739°W, 2100 m elev.). We collected several tadpoles to determine species; tadpoles were later returned to the same pond. At the small trail in Alto El Roble where the juvenile toads had been observed in 2008, we conducted an exhaustive sampling of the forest floor during the first survey. We inspected the leaf litter, logs and rocks in an area of 2000 m^2. Each amphibian observed was collected, identified in the field, and returned to the forest. Some specimens were collecting as vouchers and were deposited in the Herpetological collections of the Museo de Zoología of the Universidad de Costa Rica. Other survey methods employed by us included 300 m visual encounter transects (Crump and Scott 1994) in the forest. We also surveyed ponds for presence of eggs and tadpoles.

Results.—Contrary to the patterns described in previous decades when pastures and open areas dominated Alto El Roble (Novak and Robinson 1975), today, the area consists of secondary forest

FIG. 1. Adult male *Incilius hodridgei* (UCR 20657), found in Alto El Roble, Costa Rica, 25 years after the last observation in the 1980s. Photograph by José Salazar.

dominated by oak trees (*Quercus* spp.) with dense undergrowth. Water sources near the site include areas of slow drainage and shallow puddles. We also found temporary ponds in the same area in which *Incilius holdridgei* was observed in the 1970s (Novak and Robinson 1975); however, we found only the tree frog *Isthmohyla pseudopuma* in these ponds (egg masses, tadpoles, and adults).

One adult male (UCR 20671), clearly identified as *Incilius holdridgei* (Fig. 1), was found on the night of 24 April 2009 at 2149 h, inactive in the leaf litter, at a location only 5 m away from the site where the juveniles were seen in 2008. During surveys in the forest, both juveniles and adults of *I. holdridgei* were observed in an abandoned trail cover with bushes and grasses. We did not observe eggs, amplexus, or male aggregation in the small ponds surveyed. On the morning of 25 April 2009, one adult male was found 2 cm below the soil surface, possibly indicating that prior to the reproductive season, individuals of this species may remain in underground refugia.

On 3, 9, and 17 May 2009, two juveniles (15 mm SVL) and three adults (34 mm, 31 mm, and 31mm SVL) were observed by JA at the same locality. We have no records of mating thus far, but the fact that we have found juveniles in both years indicates recent reproductive activity. We have yet to see the large aggregations described in the 1970s (Novak and Robinson 1975).

Discussion.—The rediscovery of *Incilius holdridgei* requires reconsideration of this species to the current IUCN category Extinct (IUCN 2008). We suggest reassigning *I. holdridgei* to the Critically Endangered category (IUCN 2001). Also, the rediscovery of *I. holdridgei* indicates the necessity to do more fieldwork to encounter other declined species in Costa Rica. As part of these efforts, we are working on geographic models that combine the potential distributions of the most severely declined species, the localities of the relict populations, and the climatic conditions in these areas. Such analysis should help to define areas with higher probabilities for locating endangered species and facilitate the selection of areas to survey.

This finding also has implications in the discussion of the

emerging diseases hypothesis and the amphibian conservation strategies. Chytridiomycosis has been considered a devastating disease capable of extirpating amphibian populations of sensitive species over large areas (Lips et al. 2006). However, our discovery of a population of *Incilius holdridgei* in a region with well documented chytridiomycosis (Puschendorf et al. 2006), allows a test of its vulnerability to this disease. The survival of some members of this species creates opportunities for amphibian conservation through *ex situ* reproduction and reintroduction programs. However, this discovery forces us to reconsider conservation efforts. Traditionally, conservation has been relegated to *ex situ* efforts or *in situ*-based efforts in protected areas. We believe that the role of recently abandoned agriculture and livestock areas, as in the case of this population of *I. holdridgei*, should be more closely evaluated together with the traditional protected areas, as it appears to have been critical to this species survival. A continuous field monitoring program is needed to quantify the population status of this species, including the identification of potential breeding sites and reproductive aggregations.

In recent years, the Alto El Roble area has become a tourist destination that receives thousands of persons per year, mainly during the weekends. Most of them travel by foot but the use of cars, quadracycles, and mountain bikes is not rare. The breeding sites for treefrogs, ranids, and bufonids in Alto El Roble are the small ponds around the principal road (Novak and Robinson 1975), most of them exposed to tourist traffic. The recovery of the *Incilius holdridgei* population in Alto El Roble could be difficult under an increasing trend in tourist activity with the potential destruction of critical breeding sites.

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Literature Cited

Bolaños, F., R. Arguedas, J. E. Rodríguez, K. Zippel, and Y. Matamoros. 2007. Taller para Establecer una Estrategia de Conservación de los Anfibios de Costa Rica. CBSG Mesoamérica, San José, Costa Rica. 86 pp.

———, K. Johnson, J. E. Rodríguez, and Y. Matamoros. 2008. Taller de Priorización de Especies de Anfibios para Programas de Conservación Ex situ. San José, Costa Rica. 168 pp.

Crump, M. L., and N. J. Scott, Jr. 1994. Visual encounter surveys. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. A. C. Hayek, and M. S. Foster (eds.), Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians, pp. 84–92. Smithsonian Institution Press, Washington, DC.

Duellman, W. E., and L. Trueb. 1994. Biology of Amphibians. Johns Hopkins University Press, Baltimore, Maryland. 670 pp.

Frost, D. R. 2009. Amphibian Species of the World: An Online Reference. Version 5.3. American Museum of Natural History, New York, USA. Available from http://research.amnh.org/herpetology/amphibia/ (accessed 12 February 2009).

IUCN. 2001. Categorías y criterios de la lista roja de la UICN. Versión 3.1 Preparadas por la Comisión de supervivencia de las especies de la UICN. Information Press, UICN, Gland, Suiza y Cambridge, Reino Unido. 33 pp.

———. 2003. 2003 IUCN red list of threatened species. IUCN. Available from www.redlist.org (accessed 6 May 2004).

———. 2008. IUCN red list of threatened species. IUCN. Available from www.iucnredlist.org (accessed 15 October 2008).

Lips, K. R., F. Brem, R. Brenes, J. D. Reeve, R. A. Alford, J. Voyles, C. Carey, L. Livo, A. Pessier and J. Collins. 2006. Emerging infectious disease and the loss of biodiversity in a Neotropical amphibian community. Proc. Natl. Acad. Sci. U.S.A. 102:3165–3170.

Mattsson, B. J., R. S. Mordecai, M. J. Conroy, J. T. Peterson, R. J. Cooper and H. Christensen. 2008. Evaluating the small population paradigm for rare large-bodied woodpeckers, with implications for the ivory-billed woodpecker. Avian Conserv. Ecol. - Écologie et Conservation des Oiseaux 3:online version (1–23).

Novak, R. M., and D. C. Robinson. 1975. Observations on the reproduction and ecology of the tropical montane toad, *Bufo holdridgei* Taylor in Costa Rica. Rev. Biol. Trop. 23:213–237.

Pounds, J. A. 1997. Golden toads, null models, and climate change. Froglog 1997:1–2.

———. 2001. Climate and amphibian declines. Nature 410:639–640.

———, M. R. Bustamante, L. A. Coloma, J. A. Consuegra, M. L. Fogden, P. N. Foster, E. L. Marca, K. L. Masters, A. Merino-Viteri, R. Puschendorf, S. R. Ron, G. A. Sanchez-Azofeifa, C. J. Still, and B. E. Young. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. Nature 439:161–167.

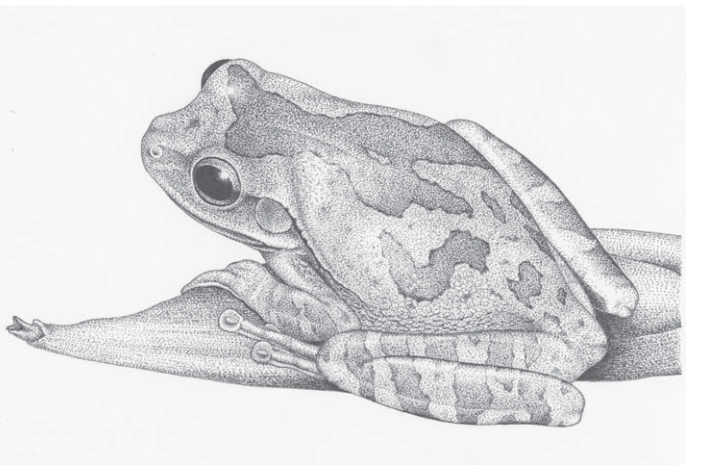
Puschendorf, R., F. Bolaños, and G. Chaves. 2006. The amphibian chytrid fungus along an altitudinal transect before the first reported declines in Costa Rica. Biol. Conserv. 132:136–142.

Savage, J. M. 1974. Type localities for species of amphibians and reptiles described from Costa Rica. Rev. Biol. Trop. 22:71–122.

Stuart, S., M. Hoffman, J. S. Chanson, N. Cox, R. Berridge, P. Ramani, and B. Young. 2008. Threatened Amphibians of the World. Lynx Edicions, Barcelona, Spain. 758 pp.

Taylor, E. H. 1952. The Frogs and Toads of Costa Rica. Univ. Kansas Scie. Bull. 35:577–942.

Wake, D. B. 1991. Declining amphibian populations. Science 253:860.



Smilisca baudinii (Mexican Treefrog). Belize: on bract of *Heliconia* sp. Illustration by Peter Stafford.

Herpetological Review, 2010, 41(2), 153–154.

Toe-Twitching During Feeding in the Australian Myobatrachid Frog, *Pseudophryne corroboree*

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A number of anuran species exhibit behaviors involving pedal movements, which have been suggested to either lure or promote activity in prey animals. A recent review has summarized this behavior from 13 taxa within seven anuran families (Sloggett and Zeilstra 2008). In some larger species that feed primarily on vertebrate prey, the movement of toes as a feeding response appears to be aimed at attracting prey (Bertoluci 2002; Hagman and Shine 2008; Murphy 1976; Radcliffe et al. 1986). This behavior is most elaborate in the South American horned frogs (*Ceratophrys* spp.), where toes from the rear foot are raised and waved in a luring fashion in front of the frog's mouth (Murphy 1976). In smaller species that feed predominantly on small invertebrates, toe-twitching may often occur during feeding (Sloggett and Zeilstra 2008). Sloggett and Zeilstra (2008) proposed that toe-twitching in these instances may provide a vibrational stimulus to ensure that the intended prey continues to move and be detected.

Here we describe toe-twitching behavior as a component of feeding behavior in an Australian myobatrachid frog, the terrestrial Southern Corroboree Frog (*Pseudophryne corroboree*). *Pseudophryne corroboree* is a critically endangered species, restricted to areas above 1300 m elevation in Kosciuszko National Park, New South Wales, Australia. This toxic, yellow and black species reaches a length of only 25–30 mm (Fig. 1). Because of its small size and cryptic nature, direct observations of feeding behavior in the wild are limited. However, studies based on gut contents show that the closely related Northern Corroboree Frog (*P. pengilleyi*) feed predominantly on ants and occasionally other small invertebrates in the wild (Pengilley 1971).

The frogs in this study were housed at Taronga Zoo, Sydney, as a captive component of a collaborative conservation program. All frogs were housed in clear plastic containers (33 cm long x 19 cm wide x 21 cm high) on a substrate of sphagnum moss above a layer of aquarium gravel (Fig. 2). Frogs were fed twice per week, and the substrate was sprayed with water the day after each feeding to help break down and wash away waste.

Observations were made on 88 three-year-old frogs, housed in containers of 2–4 individuals. On 23 September 2008, prior to feeding, all frogs were sighted and no toe-twitching behavior was observed. This is consistent with our observations that toe-twitching has never been observed prior to feeding. At 0800 h, frogs were given 15–20 live hatchling crickets per individual via a central opening in the top of each container. Observations on toe-twitching began five minutes after the addition of crickets and

FIG. 1. Captive example of an adult *Pseudophryne corroboree* at the Taronga Zoo.

continued for almost ten minutes. Each container was observed for 20–30 seconds unless each frog in the container had demonstrated the behavior earlier.

Pedal movements were observed in 84% of frogs (74 of the 88 individuals). The movements could be described as rapid twitches of the outer digit on both rear feet simultaneously. In all cases, the behavior only occurred after the presence of prey was detected by sight. The frogs faced directly toward the moving prey, remaining motionless, with the exception of the twitching digits. Frogs captured crickets with a rapid protrusion of the tongue, and toe-twitching continued immediately after the cricket was eaten, though it was not recorded when the toe-twitching ceased.

Eight frogs were observed continuously for a period of two minutes each within twenty-five minutes of feeding while live crickets were still present. The number of twitches within this time was counted through visual observation with the use of a tally counter and an average was calculated per minute. The outer digit twitched at an average rate of 108 twitches per minute

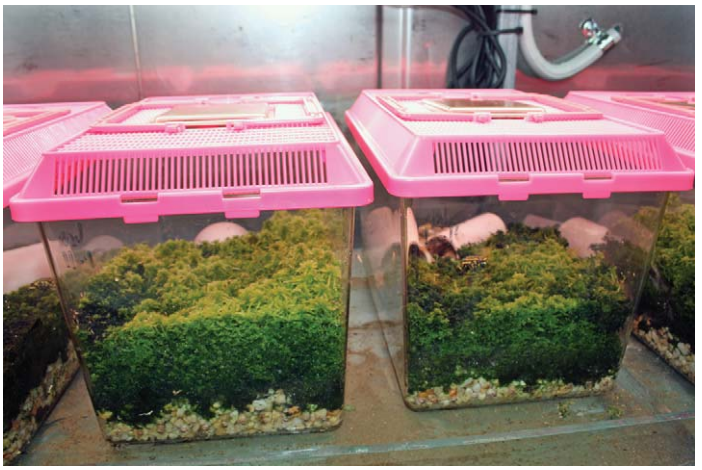

FIG. 2. Housing containing captive *Pseudophryne corroboree* at Taronga Zoo.

(maximum 128, minimum 74). The observations reported here were based on three-year old frogs, but toe-twitching in captive *P. corroboree* has been observed in all ages from metamorphs to adults, beginning as early as six days after the completion of metamorphosis (McFadden, pers. obs.).

Interestingly, for the vast majority of individuals, the twitching digit was raised off the substrate. This would minimize the potential impact of its use as a vibrational stimulus as proposed for a number of anuran species predating on smaller invertebrates (Sloggett and Zeilstra 2008). Rather, the rapid movement of a raised digit would suggest that toe-twitching in this genus might primarily be a visual stimulus, either to attract or displace prey (Radcliffe et al. 1986). Alternately, it is possible that the twitching could be simply an excited response to the presence of prey. In this study, there is no indication that the crickets responded to the twitching digit. However, it is possible that a response could be elicited from their natural prey of ants, though this was not tested in this study.

The genus *Pseudophryne* consists of about 13 endemic Australian species, all of which are small, cryptic ground-dwelling species similar to *P. corroboree*. Toe-twitching has been observed in at least one other species (*P. bibroni*; P. Byrne, pers. comm.) and might prove to be widespread within the genus. The purpose of feeding-induced pedal movements in *P. corroboree* is unknown, but this predominantly ant-feeding genus may use toe-twitching behavior to attract prey or simply to inducing prey movement, which in turn may enhance detection of prey by frogs.

Literature Cited

Bertoluci, J. 2002. Pedal luring in the leaf-frog *Phyllomedusa burmeisteri* (Anura, Hylidae, Phyllomedusinae). Phyllomedusa 1:93–95.

Hagman, M., and R. Shine. 2008. Deceptive digits: the functional significance of toe waving by cannibalistic cane toads, *Chaunus marinus*. Anim. Behav. 75:123–131.

Murphy, J. B. 1976. Pedal luring in the leptodactylid frog, *Ceratophrys calcarata* Boulenger. Herpetologica 32:339–341.

Pengilley, R. K. 1971. The food of some Australian anurans (Amphibia). J. Zool., Lond. 163:93–103.

Radcliffe, C. W., D. Chiszar, K. Estep, J. B. Murphy, and H. M. Smith. 1986. Observations on pedal luring and pedal movements in leptodactylid frogs. J. Herpetol. 20:300–306.

Sloggett, J. J., and I. Zeilstra. 2008. Waving or tapping? Vibrational stimuli and the general function of toe twitching in frogs and toads (Amphibia: Anura). Anim. Behav. 76:E1–E4.

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The Diets of Subadult Fowler's Toads (*Bufo fowleri*) and Eastern Spadefoot Toads (*Scaphiopus h. holbrookii*) at Cape Cod National Seashore, USA

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Fowler's Toad (*Bufo fowleri*) and the Eastern Spadefoot (*Scaphiopus h. holbrookii*) are two ecologically similar, sympatric anuran species that inhabit early successional habitats at Cape Cod National Seashore (CACO), USA. Densities of these two species at CACO rival those from any other known locality in the northeastern U.S., likely in large part due to the abundance of optimal upland and wetland habitats present in combination with limited human development at CACO. Though locally abundant at CACO, these two species are regionally rare (*S. h. holbrookii*; Klemens 1993) and/or are in decline in areas of the northeastern U.S. (*B. fowleri* and *S. h. holbrookii*; Klemens 1993), largely as a result of habitat loss and development occurring in the region. As such, an improved knowledge of specific life-history traits (e.g., dietary composition, upland habitat preferences, movement patterns) of these two species will prove valuable to their long-term conservation in the northeastern U.S.

While several previous studies have reported on the stomach contents of *B. fowleri* (Barbour 1953; Brown 1974; Bush 1959; Bush and Menhinick 1962; Clarke 1974; Klimstra and Myers 1965) and *S. h. holbrookii* (Pearson 1955; Punzo 1992), with the exception of one study reporting stomach contents of *B. fowleri* in Connecticut (Clarke 1974), none of these studies were conducted in the northeastern U.S. Furthermore, none of these studies for either species reported results for subadult age class individuals. Thus the ability to extrapolate results from these studies to subadult *B. fowleri* and *S. h. holbrookii* in the northeastern U.S. is limited.

We report on the stomach contents of subadult *B. fowleri* and *S. h. holbrookii* captured in pitfall traps during terrestrial arthropod sampling in a coastal dune ecosystem (i.e., the "Province Lands") at CACO from early June through late September 2007. We report results only for the subadult age class (~1–2 year-old individuals, determination based on measured snout–vent lengths [SVL] as that was the only age class captured in pitfall traps. To characterize the diet of each anuran species, we calculated the *proportional occurrence* of each invertebrate taxon in the stomach contents (calculated as the proportion of stomachs containing at least one individual of that taxon) and the *proportional abundance* of each invertebrate taxon in the stomach contents (calculated as the proportion, by count, of total stomach contents comprised of each taxon).

To compare dietary overlap of the two anuran species, we calculated Schoener's diet similarity index (*Cxy*; Schoener 1968):

$$Cxy = 1 - 0.5 \Sigma \left| P_{ix} - P_{iy} \right|$$

TABLE 1. Cumulative stomach contents of captured subadult *Bufo fowleri* and *Scaphiopus h. holbrookii*.

Invertebrate Taxon	*B. fowleri*	*S. h. holbrookii*
Araneae	67	16
Opiliones	0	1
Isopoda	10	18
Collembola	19	7
Orthoptera	1	1
Blattodea	14	6
Homoptera	2	0
Coleoptera	43	14
Coleoptera larvae	4	0
Lepidoptera	13	0
Lepidoptera larvae	14	0
Diptera	107	5
Formicidae	2710	60
Hymenoptera (excluding Formicidae)	4	0
Total	3008	128

where P_{ix} and P_{iy} are the proportion of species' *x* and *y* diet comprised of the i^{th} prey taxon. *Cxy* ranges from 0–1 with values approaching 1 indicating greater dietary overlap between species.

To examine dietary niche breadth of the two anuran species, we calculated Hurlbert's niche breadth (*B'*; Hurlbert 1978):

$$B' = 1/\sum (p_j^2/a_j)$$

where, for each species, p_j is the proportion of individuals containing the j^{th} prey taxon in their stomach, and a_j is the proportion of total stomach contents over all individuals comprised of the j^{th} prey taxon. For purposes of comparison we used Hurlbert's standardized niche breadth (B'_A; Hurlbert 1978):

$$B'_A = (B' - a_{min})/(1 - a_{min})$$

where a_{min} is the smallest observed proportion of all the prey taxa for a given species. B'_A ranges from 0-1 and represents the ratio of observed niche breadth to the maximum possible niche breadth.

A total of 76 subadult *B. fowleri* (SVL mean: 36.1mm, range: 25–45 mm) and 18 subadult *S. h. holbrookii* (SVL mean: 36.6 mm, range: 26–45 mm) were captured and had their stomach contents analyzed. Of the total individuals captured, ~6% (5/76) of *B. fowleri* and ~11% (2/18) of *S. h. holbrookii* had empty stomachs. Excluding individuals with empty stomachs, the number of prey items per stomach was greater for *B. fowleri* (mean = 42.37, range = 1–141; total = 3008) than for *S. h. holbrookii* (mean = 8.00, range = 1–25, total = 128).

Fourteen different invertebrate prey taxa and life stages were identified in the anuran stomachs; 13 of these were present at least once in *B. fowleri* stomachs and nine were present at least once in *S. h. holbrookii* stomachs (Table 1). Formicidae was the dominant prey taxon in the stomachs of both anurans, comprising 88% and 90% of the *B. fowleri* diet and 56% and 47% of the *S. h. holbrookii* diet based on proportional occurrence and abundance, respectively (Table 2). The Schoener diet similarity index was 0.556, indicating modest dietary overlap between the two study species. Lastly, the standardized Hurlbert's niche breadth was greater for the stomach contents of *S. h. holbrookii* ($B'_A = 0.152$) compared to *B. fowleri* ($B'_A = 0.028$).

Both species contained a diversity of invertebrate taxa in their stomachs, and although the total number of taxa consumed by *B. fowleri* (13) was greater than by *S. h. holbrookii* (9), the proportion of the diet represented by the various taxa was more highly skewed in *B. fowleri* than in *S. h. holbrookii*, which accounted for the smaller dietary niche breadth of *B. fowleri*. *Bufo fowleri* appeared to be an ant (Formicidae) specialist; ants accounted for 88–90% of the diet (by proportional abundance). *Scaphiopus h. holbrookii* appeared to be more of a dietary generalist; five invertebrate taxa were required to account for >90% of the diet (by proportional abundance). The larger dietary niche breadth of *S. h. holbrookii* compared to *B. fowleri* suggests that the former species may be more of a dietary generalist than the latter. This is generally consistent with results obtained from other studies in other geographic locations comparing individual species of these two families (Anderson et al. 1999; Smith et al. 2004), although one previous study found a similar niche breadth for one *Bufo* and one *Scaphiopus* species (Punzo 1992). The broader dietary niche breadth of *S. h. holbrookii* may be an evolutionary adaptation that enables this species to coexist with ecologically similar, dietary specialists such as *B. fowleri* and/or cope with the highly dynamic conditions of the coastal dune ecosystem in this study area (Anderson et al. 1999).

The importance of ants in the diet of subadult *B. fowleri* and *S. h. holbrookii* in our study is consistent with results reported in several previous studies of *B. fowleri* (Brown 1974; Bush and Menhinick 1962; Clarke 1974; Klimstra and Myers 1965) and *S. h. holbrookii* (Pearson 1955; Punzo 1992). In fact, the percentage of *B. fowleri* diet comprised of ants that we observed (88-90%) is the largest reported value that we are aware of for any *Bufo* species

TABLE 2. Proportion of stomachs containing a particular invertebrate taxon ("P_1"), and proportion of stomach contents based on counts of individual food items ("P_2") in all subadult *Bufo fowleri* and *Scaphiopus h. holbrookii*.

Invertebrate Taxon	*B. fowleri* (N = 76)		*S. h. holbrookii* (N = 18)	
	P1	P2	P1	P2
Araneae	0.26	0.02	0.50	0.13
Opiliones	—	—	0.06	0.01
Isopoda	0.09	0.00	0.22	0.14
Collembola	0.12	0.01	0.22	0.05
Orthoptera	0.01	0.00	0.06	0.01
Blattodea	0.09	0.00	0.17	0.05
Homoptera	0.03	0.00	—	—
Coleoptera	0.41	0.01	0.28	0.11
Coleoptera larvae	0.03	0.00	—	—
Lepidoptera	0.11	0.00	—	—
Lepidoptera larvae	0.09	0.00	—	—
Diptera	0.43	0.04	0.11	0.04
Formicidae	0.88	0.90	0.56	0.47
Hymenoptera (excluding Formicidae)	0.03	0.00	—	—

"—" indicates that there were no individuals of that invertebrate taxon present

worldwide. The ability to eat ants and other noxious and armored invertebrates (e.g., beetles; Coleoptera) may be an adaptation that insures an adequate food supply for these anuran species, as there is little competition for these invertebrate groups from other predators (Clarke 1974). Moreover, consuming large numbers of ants to meet the species' dietary needs may be highly adaptive for these anurans because the ant populations may be capable of sustaining very high predation rates since most of the ants eaten by anurans are workers and not reproductive units. As stated by Toft (1980), "ant specialists are more like grazers or browsers that eat the leaves of a tree rather than like predators that take whole individuals". Consequently, anuran predation may have relatively limited impact on the availability of ants. Additionally, the toxic skin secretions of some anurans (including members of Bufonidae and Pelobatidae) are at least partially sequestered from dietary sources (primarily ants and beetles; Isacch and Barg 2002; Saporito et al. 2004). Therefore, a diet comprised of a relatively large number of ants and/or beetles (as is the case for *B. fowleri* and *S. h. holbrookii* in this study) may be necessary to produce the toxic secretions used as a chemical defense against potential predators. The use of toxic skin secretions as a defense against potential predators is well documented in Bufonidae and Pelobatidae (Duellman and Trueb 1986). In fact, toxic skin secretions of *S. h. holbrookii* can cause symptoms similar to an allergic reaction in humans, including watery irritated eyes, runny nose, sneezing, and strong burning sensation in the nose and eyes during and subsequent to handling of individuals (B.C. Timm, pers. obs.).

Differences we observed between species in the proportion of the diet comprised of ants (*B. fowleri,* 88–90%; *S. h. holbrookii*, 47-56%) may be an indication of differing feeding strategies. Specifically, other investigators have noted that anuran species with a higher proportion of ants (and/or termites) in their diet are more active foragers than those with a comparatively lower proportion of ants (and/or termites) in their diet (Gerritsen and Strickler 1977; Krebs 1978; Toft 1980). These authors suggest that prey species that are patchily distributed in space and time (such as ants and termites) are more likely to be discovered and eaten by actively foraging predators than by sit-and-wait predators. Thus, *B. fowleri* may be more of an active forager while *S. h. holbrookii* may be more of a sit-and-wait predator. While we are not aware of any published studies on the foraging strategy of subadults of either species, our preliminary results from nocturnal radio-telemetry work on adult *S. h. holbrookii* suggest that they are in fact best characterized as sit-and-wait predators (B. C. Timm, unpubl. data).

Results from this study provide the first published account of the diets of subadult *B. fowleri* and *S. h. holbrookii*. In addition to a general understanding of dietary composition, these results also provide insight into potential feeding strategies exhibited by these species as well as potential interspecific competition between these species via dietary overlap. Though we only captured subadult individuals of the two study species, we suggest that future studies examining diets of individual and sympatric amphibian species include an assessment of these attributes for different age classes (e.g., newly metamorphosed juveniles, subadults, and adults) of the focal species of interest. Results from such studies will provide much needed information regarding ontogenetic dietary consistency/shifts, an aspect of amphibian ecology for which there is currently a dearth of scientific information.

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Literature Cited

Anderson, A. M., D. A. Haukos, and J. T. Anderson. 1999. Diet composition of three anurans from the playa wetlands of northwest Texas. Copeia 1999:515–520.

Barbour, R. W. 1953. The amphibians of Big Black Mountain, Harlan County, Kentucky. Copeia 1953:84–89.

Brown, R. L. 1974. Diets and habitat preferences of selected anurans in southeast Arkansas. Am. Midl. Nat. 91:468–473.

Bush, F. M. 1959. Foods of some Kentucky herptiles. Herpetologica 15:73–77.

———, and E. F. Menhinick. 1962. The food of *Bufo woodhousei fowleri* Hinckley. Herpetologica 18:110–114.

Clarke, R. D. 1974. Food habits of toads, genus *Bufo* (Amphibia: Bufonidae). Am. Midl. Nat. 91:140–147.

Duellman, W. E., and L. Trueb. 1986. Biology of Amphibians. McGraw-Hill Book Co.. New York, New York. 670 pp.

Gerritsen, J., and J. R. Strickler. 1977. Encounter probabilities and community structure in zooplankton: A mathematical model. J. Fish. Res. Board Canada 34:73–82.

Hurlbert, S. H. 1978. The measurement of niche overlap and some relatives. Ecology 59:67–77.

Isacch, J. P., and M. Barg. 2002. Are bufonid toads specialized ant-feeders? A case test from the Argentinian flooding pampa. J. Nat. Hist. 36:2005–2012.

Klemens, M. W. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. Connecticut State Geological and Natural History Survey, Hartford, Connecticut. 318 pp.

Klimstra, W. D., and C. W. Myers. 1965. Foods of the toad, *Bufo woodhousei fowleri* Hinckley. Trans. Illinois State Acad. Sci. 58:11–26.

Krebs, J. R. 1978. Optimal foraging: decision rules for predators. *In* J. R. Krebs and N. B. Davies (eds.), Behavioural Ecology: An Evolutionary Approach, pp. 23–63. Sinauer Associates, Sunderland, Massachusetts.

Pearson, P. G. 1955. Population ecology of the spadefoot toad, *Scaphiopus h. holbrookii* (Harlan). Ecol. Monogr. 25:233–267.

Punzo, F. 1992. Dietary overlap and activity patterns in sympatric populations of *Scaphiopus holbrooki* (Pelobatidae) and *Bufo terrestris* (Bufonidae). Florida Sci. 55:38–44.

Saporito, R. A., H. M. Garraffo, M. A. Donnelly, A. L. Edwards, J. T. Longino, and J. W. Daly. 2004. Formicine ants: An arthropod source for the pumiliotoxin alkaloids of dendrobatid poison frogs. Publ. Nat. Acad. Sci. 101:8045–8050.

Schoener, T. W. 1968. The *Anolis* lizards of Bimini: Resource partitioning in a complex fauna. Ecology 49:704–726.

Smith, L. M., M. J. Gray, and A. Quarles. 2004. Diets of newly metamorphosed amphibians in west Texas playas. Southwest. Nat. 49:257–263.

Toft, C. A. 1980. Feeding ecology of thirteen syntopic species of anurans in a seasonal tropical environment. Oecologia 45:131–141.

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The Hemipenis of *Trimorphodon quadruplex*

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Scott and McDiarmid (1984:2) stated that "Most early attempts to clarify the relationships of *Trimorphodon* have been misled by an inadequate description of the hemipenis…" Recently, the *Trimorphodon biscutatus* complex has received some significant attention both in molecular and morphological analyses (Devitt 2006; Devitt et al. 2008) and much of its evolutionary history is becoming better understood. However, these recent studies have not included hemipenial morphology and earlier papers appear to provide inaccurate descriptions (e.g., Klauber 1940; Scott and McDiarmid 1984; Smith 1941). Cope (1895, 1900) dissected the tails of male *Trimorphodon* and noted that their hemipenes possessed calyces. This was later rejected by Scott and McDiarmid (1984) and although Savage (2002) stated that *Trimorphodon* possess calyces, he did not provide a reference or evidence for his statement. In this study we dissect, illustrate, and describe the hemipenis of one of the species in the *Trimorphodon biscutatus* complex, *T. quadruplex*.

Methods

A partially everted left hemipenis from a large adult-male specimen (SVL 1075 mm; tail length 226 mm; 89 divided subcaudals) of *Trimorphodon quadruplex* (UTA R-44978) was measured and then removed at the base. We followed the hemipenial preparation procedures of Myers and Cadle (2003) and Zaher and Prudente (2003) with the addition of blue petroleum jelly, inserted into the base of the hemipenis and resulting in full eversion of the hemipenis. The latter method is further described and illustrated by Smith and Ferrari-Castro (2008). Finally, we examined the retracted left hemipenis of USNM 32274—*in situ*, as originally studied and illustrated by E. D. Cope in 1895 and 1900. The description follows the terminology of Dowling and Savage (1960), Myers and Campbell (1981), and Zaher (1999), as adopted by Savage (2002).

Hemipenis Description

Trimorphodon quadruplex (UTA R-44978); Figs. 1, 2

The specimen comes from the town of Santa Cruz, Guanacaste, Costa Rica, and was collected by M. Sasa in 1997. The everted left hemipenis extends approximately 55 mm in length and is 12.5 mm at its maximum width. The pedicel of the hemipenis is long and narrow, extending approximately 20 mm, and its distal half is covered in minute spines. The spinous truncus occupies approximately 10 mm of the hemipenis. This region possesses about 87 hooks (noticeably large spines), ranging from about 1.0 to 1.6 mm in length. When fully everted the spines start at the beginning of the 8th subcaudal and end at the 13th subcaudal. The calyculate apical region extends to the 21st subcaudal. The single semicentripetal *sulcus spermaticus* extends to the tip of the organ. Following the spines is the spinous and papillate calyx region, extending for about 25 mm and includes 20 rows of calyces on the sulcate side. The calyces bear on their edges minute papilla, distally, or spines, proximally. A unique feature of the hemipenis is the enlargement of the two most proximal calyces on the asulcate side, over part of the truncus and resembling naked or striated pockets. The first and largest calyx extends about 4 mm. At the apex of the hemipenis the final 2–3 rows of ornamentation consist of numerous, small papillae.

Trimorphodon quadruplex (USNM 32274); Fig. 1

The specimen comes from San Juán, Nicaragua, and was collected by M. Oviedo. The SVL could not be taken of this specimen but the tail has a length of 173 mm and has 91 subcaudals, excluding the tip. The left hemipenis was examined uneverted, as illustrated by Cope (1895 and 1900). This hemipenis extends in length to the 25th subcaudal, the first minute spines appear at the level of subcaudal 8, and the first hooks at the level of subcaudal 14.

Discussion

The only illustration of *Trimorphodon* hemipenes we are aware of was presented twice by Cope (1895: plate 30, figure 7; 1900: plate 28, figure 7). Cope (1900, p. 1101) mentioned examining only four specimens of *T. biscutatus* (then including *T. quadruplex*), so his illustration was thought to come from one of them. Cope (1861) mentioned a specimen of *T. biscutatus* (= *T. quadruplex*) from Realejo Nicaragua (USNM 5569) and in 1870 (1869) de-

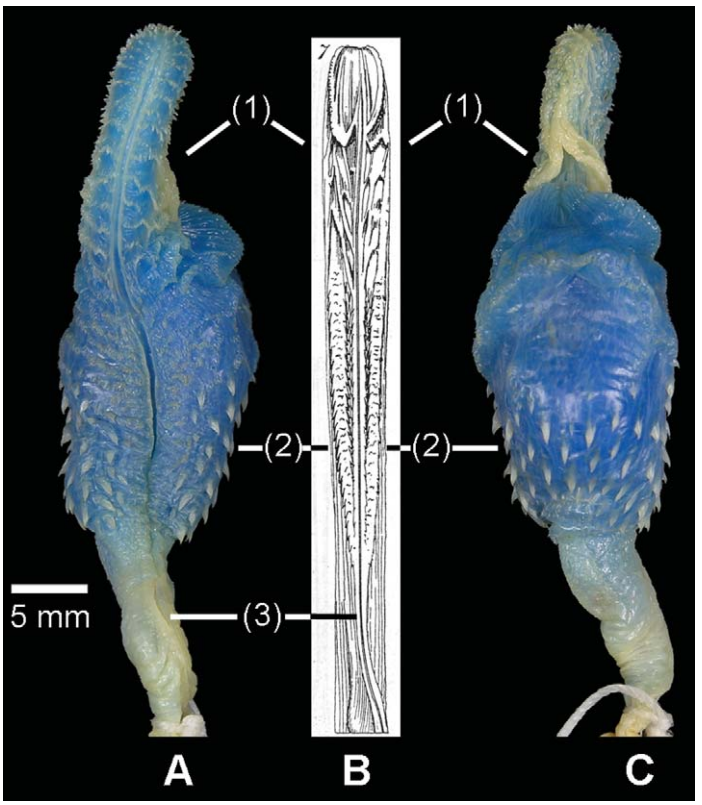

Fig. 1. Hemipenis of *Trimorphodon quadruplex*. Sulcate (A) and asulcate (C) view of the left hemipenis of UTA R-44978, compared to Cope's (1900: plate 28, image 7) *in situ* illustration of the left organ of USNM 32274 (B), showing calyces (1), spines (2), and sulcus spermaticus (3).

FIG. 2. Side view of the hemipenis of *Trimorphodon quadruplex* (UTA R-44978), showing the protruding lower calyces and curvature of the hemipenis.

scribed *T. major* (shortly synonymized by him as *T. biscutatus*, Cope 1876 [1875], p. 131) from Tehuantepec, Oaxaca, based on three specimens (two specimens mentioned by him but three cotypes, USNM 30427–9, are listed by Cochran 1961). However, our examination determined that the hemipenes of none of these specimens were examined by Cope. The illustrated hemipenis belongs to the left hemipenis of a *T. quadruplex* (as currently recognized by Devitt et al. 2008), USNM 32274, a paratype from San Juan, Nicaragua (Smith 1941), which was returned by Cope's estate after his death. Our figure 1 includes an image of Cope's illustration for direct comparison of the retracted and the everted hemipenes. The existence of calyces is quite obvious on the fully everted hempenis (Figs. 1, 2), and as mentioned by Cope (1900), these structures are very unusual.

Although beyond the scope of this study, we examined specimens of *T. biscutatus* (UTA R-51832, from Carretera El Camaron-Mitla Km 106 on Mex 190, Oaxaca) and *T. paucimaculatus* (UTA R-52654, from Arroyo Colorado, Municipio La Huerta, Jalisco) and found these same features (e.g., unusual and extended proximal calyces) on their everted hemipenes. A thorough analysis of the hemipenis of the other species of *Trimorphodon* (*biscutatus*, *lambda*, *lyrophanes*, *paucimaculatus*, *tau*, *vilkinsonii*) is needed to add morphological support to the currently recognized species. King et al. (2009) found that reproductive behavior may correlate with hemipenis morphology. An investigation of the reproductive behavior causing this odd morphological evolution would be interesting.

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LITERATURE CITED

COCHRAN, D. M. 1961. Type specimens of reptiles and amphibians in the U.S. National Museum. Bull. U.S. Natl. Mus. 220:xv + 291 pp.

COPE, E. D. 1861. Contributions to the ophiology of lower California, Mexico and Central America. Proc. Acad. Nat. Sci. Philadelphia 13:292–306.

———. 1870 [1869]. Seventh contribution to the herpetology of tropical America. Proc. Am. Philos. Soc. 11(82):147–169.

———. 1876 [1875]. On the Batrachia and Reptilia of Costa Rica. J. Acad. Nat. Sci. Philadelphia, N. S. 2, 8:93–154.

———. 1895 [1894]. The classification of the Ophidia. Trans. Am. Philos. Soc. 18:186–219+14–33 pls.

———. 1900. The crocodilians, lizards, and snakes of North America. Ann. Rep. U.S. Natl. Mus. 1898:153–1270+36 pls.

DEVITT, T. J. 2006. Phylogeography of the western lyre snake (*Trimorphodon biscutatus*): testing aridland biogeographical hypotheses across the Nearctic-Neotropical transition. Mol. Ecol. 15:4387–4407.

———, T. J. LADUC, AND J. A. MCGUIRE. 2008. The *Trimorphodon biscutatus* (Squamata: Colubridae) species complex revisited: a multivariate statistical analysis of geographic variation. Copeia 2008:370–387.

DOWLING, H. G., AND J. M. SAVAGE. 1960. A guide to snake hemipenis: a survey of basic structure and systematic characteristics. Zoologica 45:17–28.

KING, R. B., R. C. JADIN, M. GRUE, AND H. D. WALLEY. 2009. Behavioural correlates with hemipenis morphology in New World natricine snakes. Biol. J. Linn. Soc. 98:110–120.

KLAUBER, L. M. 1940. The lyre snakes (genus *Trimorphodon*) of the United States. Trans. San Diego Soc. Natur. Hist. 9:163–194.

MYERS, C. W., AND J. E. CADLE. 2003. On the snake hemipenis, with notes on *Psomophis* and techniques of eversion: a response to Dowling. Herpetol. Rev. 34:295–302.

———, AND J. A. CAMPBELL. 1981. A new genus and species of colubrid snake from the Sierra Madre del Sur of Guerrero, Mexico. Am. Mus. Novit. 2708:1–20.

SAVAGE, J. M. 2002. The Amphibians and Reptiles of Costa Rica: a Herpetofauna between Two Continents, between Two Seas. University of Chicago Press, Chicago, Illinois. 934 pp.

SCOTT, N. J., JR., AND R. W. MCDIARMID. 1984. *Trimorphodon*. Cat. Am. Amphib. Reptil. 352:1–2.

SMITH, E. N., AND J. A. FERRARI-CASTRO. 2008. A new species of jumping pitviper of the genus *Atropoides* (Serpentes: Viperidae: Crotalinae) from the Sierra de Botaderos and the Sierra La Muralla, Honduras. Zootaxa 1948:57–68.

SMITH, H. M. 1941. Notes on the snake genus *Trimorphodon*. Proc. U.S. Natl. Mus. 91(3130):149–168.

ZAHER, H. 1999. Hemipenial morphology of the South American xenodontine snakes, with a proposal for a monophyletic Xenodontinae and a reappraisal of colubroid hemipenes. Bull. Am. Mus. Nat. Hist. 240:1–168.

———, AND A. L. C. PRUDENTE. 2003. Hemipenes of *Siphlophis* (Serpentes, Xenodontinae) and techniques of hemipenial preparation in snakes: a response to Dowling. Herpetol. Rev. 34:302–307.

TECHNIQUES

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Effectiveness of Using Burlap Bands to Sample Arboreal Green Salamander Populations in the Blue Ridge Mountains of Georgia and North Carolina

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Green Salamanders, *Aneides aeneus*, occur as two distinct populations in the eastern United States. The more extensive population is located throughout the Cumberland and Allegheny Mountain regions from Pennsylvania to Alabama and northeastern Mississippi. The smaller disjunct population is located in the Blue Ridge Mountains of Georgia, South Carolina, and North Carolina (Petranka 1998). A study conducted in the Blue Ridge Escarpment of western North Carolina, northwestern South Carolina, and northeastern Georgia documented a 98% decline in some populations of Green Salamanders since 1970 (Corser 2001). The U.S. Fish and Wildlife Service currently recognizes *A. aeneus* as a species of concern. The Blue Ridge Escarpment population is listed as rare in Georgia, endangered in North Carolina, and a species of special concern in South Carolina. Corser (2001) attributed declines to climate change, loss and alteration of habitat, a chytrid fungal pathogen, and exploitation through collection by researchers. The issue of forest ecosystem alteration and its importance in understanding Green Salamander arboreality and species declines have recently garnered attention (Pauley and Watson 2005; Waldron and Humphries 2005).

Green Salamanders are generally considered crevice-dwelling species associated with rock outcrops, and only "weakly" arboreal (Pauley and Watson 2005). Green Salamander morphology is consistent with rock-crevice habits, particularly their dorso-ventrally compressed bodies with elongate limbs and toes with expanded square toe tips (Petranka 1998). Most associations with Green Salamanders and non-rock outcrop habitats were reports of large numbers of individuals under the bark of dead and fallen trees, particularly large American Chestnut (Barbour 1949). Contradicting the perception of Green Salamanders as weakly arboreal, Waldron and Humphries (2005) recently documented large numbers of Green Salamanders using arboreal habitats in some Blue Ridge Escarpment populations. Using day and night searches with flashlights, they recorded 345 Green Salamander observations between April and October, of which 43% occurred in trees, 41% in rock outcrops, and only 15% on or in logs. They also reported arboreal nesting. Additionally, Wilson (2003) documented Green Salamanders in woody and arboreal habitats at sites throughout the Blue Ridge Mountains. These studies raise questions about the importance of arboreal habits to Green Salamander populations and highlight the potential need to include methods for searching arboreal habitats as part of Green Salamander monitoring.

Although the technique used by Waldron and Humphries (2005) was successful at discovering many salamanders using arboreal habitats, it was very time consuming (more than 210 h over a 3.5 yr period) and difficult to standardize. Survey success varied widely based on weather conditions and other variables. Further, the effectiveness of the technique is likely to vary greatly among observers who differ in ability to spot salamanders high in trees. A standardized and less labor-intensive technique for studying arboreal habits of Green Salamanders would be useful.

Artificial cover is widely utilized as a technique for standardized monitoring of terrestrial salamanders (Houze and Chandler 2002; Monti et al. 2000). Artificial cover can provide the necessary microclimates to attract salamanders during diurnal retreat, making detection of species less dependent upon the immediate climate. Artificial cover generally involves the application of boards or other materials to the forest floor, or litter bags or baskets along stream banks (Monti et al. 2000). We are not aware of any standardized artificial cover technique for capturing salamanders in arboreal habitats. However, burlap fabric attached to trees (known as burlap bands) has been used to sample arboreal invertebrates and reptiles (Campbell and Sloan 1977; Duguay et al. 2000; Horn and Hanula 2006; Reardon 1976). In addition to attracting invertebrates, these artificial shelters are sometimes occupied by salamanders, including Red-backed Salamanders (*Plethodon cinereus*) and Northern Two-lined Salamanders (*Eurycea bislineata*) (J. Waldron, pers. comm.). Attaching artificial cover to trees at distance and heights determined within the predicted range of Green Salamanders may provide a reliable technique for capturing Green Salamanders occupying arboreal habitats. In 2005, we deployed burlap bands on trees at four study sites in Georgia and North Carolina in order to determine whether Green Salamanders will occupy burlap bands as an artificial cover type.

Methods.—The populations of Green Salamanders surveyed were located in the Nantahala National Forest in Jackson County, North Carolina, and Chattahoochee National Forest in Rabun

County, Georgia. Both populations are located in the Blue Ridge physiographic province. We identified three study sites in the Chattahoochee National Forest and one site in the Nantahala National Forest where Green Salamanders were known to occur (M. Elliott, Georgia Natural Heritage Program, pers. comm.). The vegetation at all sites consists of mixed, uneven-aged conifer/hardwood forest with dense Rhododendron (*Rhododendron maximum*) midstory. The dominant tree species at the sites are Eastern Hemlock (*Tsuga canadensis*), Red Maple (*Acer rubrum*), Tulip Poplar (*Liriodendron tulipifera*), Frasier Magnolia (*Magnolia fraseri*), White Oak (*Quercus alba*), Eastern White Pine (*Pinus strobus*), Pignut Hickory (*Carya glabra*), Northern Red Oak (*Quercus rubra*), Chestnut Oak (*Quercus montana*), and Witchhazel (*Hamamelis virginiana*) (Gordon 1952). Annual precipitation in the area ranges from 215–254 cm (Bruce 1968). The rock outcrops at sites known to be occupied by Green Salamanders are composed of granite. The deep, narrow crevices and asymmetrical walls provided by the granite outcrops offer individuals protection from sunlight (Bruce 1968) and predators. Green Salamanders overwinter, mate, and lay eggs within the outcrops (Pauley and Watson 2005; Petranka 1998). The site in the Nantahala National Forest is located at 950 m elevation (Gordon and Smith 1949) with 15% slope and 75% canopy cover. The three sites in the Chattahoochee National Forest range in elevation from 600–750 m with 10–55% slope and 25–65% canopy cover. Herbaceous understory is dominated by Galax (*Galax aphylla*), Hayscented Fern (*Dennstaedtia punctilobula*), Pansy (*Viola* sp.), Striped Wintergreen (*Chimaphila maculata*), Speckled Wood Lily (*Clintonia umbellata*), and Mountain Laurel (*Kalmia latifolia*) (Gordon 1952).

Burlap fabric was washed with a concentrated liquid detergent formulated for use in laboratories to remove chemicals that aid water resistance and may potentially harm salamanders (Liqui-Nox®). Prior to use, the burlap fabric was tested for anions at U.S. Forest Service, Coweeta Hydrologic Laboratory and results show the fabric contained less than 0.5 ppm of chloride, sulfate, nitrate, phosphate, and bromide. At each site, burlap strips measuring 76.2 cm by 45.7 cm were attached to hardwood trees with hemp rope two meters from the ground on 15 trees with a diameter at breast height (DBH) ≥ 20.3 cm (Fig. 1). Trees ranged from 1-50 m from the rock outcrops. Large hardwood trees were selected because previous research suggested that Green Salamanders are observed on large hardwoods compared to conifers (Waldron and Humphries 2005).

We visited each site three times per month (~1-2 weeks between visits) from June–December 2005. During each visit, we lifted the fabric and searched the entire area under the burlap with a flashlight. For comparative purposes, we also searched crevices for salamanders on each occupied rock outcrop during each visit. We recorded the number and species of salamanders observed, measured individuals (we did not capture and measure salamanders observed in rock crevices), and recorded distance from the nearest occupied rock outcrop. Green Salamanders under burlap were classified as adults (> 44.5 mm total length, TL), sub-adults (29.5–44.4 mm TL), or juveniles (< 29.5 mm TL) (Waldron and Humphries 2005). Salamanders were released at their capture location. Sites were surveyed during the day, at dusk, and after dark.

Results.—Over 16 sample days, we observed 31 salamanders under burlap, only 11 of which were Green Salamanders (Table 1). We also observed Southern Appalachian Slimy Salamanders (*Plethodon chattahoochee*), Southern Gray-cheeked Salamanders (*Plethodon metcalfi*), and a single Ocoee Salamander (*Desmognathus ocoee*). We observed a greater number (16) of juvenile Southern Appalachian Slimy Salamanders under burlap than Green Salamanders. By comparison, we observed 80 salamanders in rock outcrops including 57 Green Salamanders during the same sample period (Fig. 2). Though we did not systematically search for salamanders on non-burlap trees, we did not observe any salamanders on trees outside of burlap covers. Further, while we observed few Southern Gray-cheeked Salamanders under burlap, we did observe them routinely off the forest floor on Rhododendron during wet nights. All Green Salamanders and Southern Appalachian Slimy Salamanders found under the burlap were sub-adults, while the Ocoee Salamander and the Southern Gray-cheeked Salamanders were adults. We determined Ocoee Salamander and Southern Gray-cheeked Salamander adult and juvenile size classes by comparing measurements of each individual to published size classes for the two species (Petranka 1998). Southern Gray-cheeked Salamanders were observed singly, while up to five Southern Appalachian Slimy Salamanders were observed under one piece of burlap at the same time. One Green Salamander was observed under a piece of burlap with three Southern Appalachian Slimy Salamanders. All individu-

FIG. 1. Burlap bands were attached to hardwood trees with hemp rope two meters from the ground on trees with a diameter at breast height (DBH) ≥ 20.3 cm to assess arboreality of Green Salamanders in the Nantahala National Forest, North Carolina and Chattahoochee National Forest, Georgia, 2005.

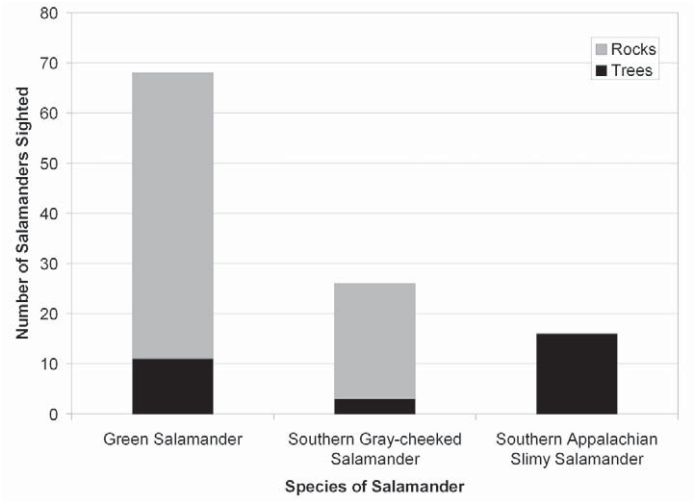

FIG. 2. Number of Green Salamanders, Southern Gray-cheeked Salamanders, and Southern Appalachian Slimy Salamanders in and on rocks versus the number observed under the burlap cover on trees in Chattahoochee National Forest, Georgia, and Nantahala National Forest, North Carolina, 2005.

als were observed between the burlap and tree bark, not between the two layers of the burlap at the top of the band where the burlap was attached to the tree with hemp rope (Fig. 1).

Salamanders were only observed beneath burlap from August–November. However, Green Salamanders and Southern Gray-cheeked Salamanders were observed in the rock outcrops as early as May, when we began establishing transects, until late November. Green Salamanders were found a maximum distance of 10 m from rock outcrops. Southern Gray-cheeked Salamanders were found up to 7 m from rock outcrops. Southern Appalachian Slimy Salamanders were never observed on the rock outcrop; they were only observed under burlap on trees located within 1 m of the rock outcrop.

No salamanders were observed under burlap in surveys conducted before 1600 h and individuals were most abundant under burlap in months with high precipitation (correlation between cumulative monthly rainfall and number of salamanders observed under burlap: $R^2 = 0.87$, $p = 0.067$). Southern Appalachian Slimy and Gray-cheeked Salamanders were common on the forest floor. However, we never observed Green Salamanders on the forest floor, similar to Waldron and Humphries (2005). More Green Salamanders and Southern Gray-cheeked Salamanders were observed in rock crevices than on trees during our surveys.

Discussion.—Our results indicate that Green Salamanders and other terrestrial plethodontid salamanders will occupy burlap as artificial cover during periods of sufficient precipitation. That we did not opportunistically observe any Green or slimy salamanders on trees outside of burlap suggests that despite low captures of salamanders the burlap did improve observation of arboreal habitat use by salamanders. In contrast to the observations of Waldron and Humphries (2005), we did not observe any Green Salamanders on trees during day searches. All arboreal observations of salamanders occurred after dusk following recent rains. This is consistent with other observations of plant climbing behavior in terrestrial *Plethodon* (e.g., Jaeger 1978) and strongly suggests that all salamanders, including Green Salamanders, were moving from forest floor or rock habitats up the trunks of trees to forage on rainy nights. We did observe large numbers of invertebrates under the burlap. We did not capture any Green Salamanders on trees farther than 10 m from the associated rock outcrops, which contrasts sharply with prior observation of Green Salamanders up to 40 m from rock outcrops at one of the same study sites (Waldron and Humphries 2005). This may simply be an artifact of the greater sampling effort of Waldron and Humphries increasing the opportunity to detect Green Salamanders farther from rock outcrops.

One interpretation of our results is they are more consistent with the characterization of Green Salamanders as "weakly arboreal," and their use of trees may be comparable to that of other forest plethodontids. Alternatively, the difference between our results and those of Waldron and Humphries (2005) may be an artifact of the suitability of burlap as refugia. The burlap did not retain much water and the surface under the burlap usually dried within days of a rain. Dry conditions are unfavorable to salamanders, and may explain why we did not observe any individuals under the burlap during the day. Waldron and Humphries (2005) report Green Salamanders in trees, often tucked beneath small flaps of bark, even during dry periods. Burlap apparently did not adequately simulate loose bark that could be used by Green Salamanders; therefore, burlap may be suitable for use if surveying arboreal foraging habits of plethodontids, but unsuitable for measuring other arboreal habits. The effectiveness of burlap might be improved if a strip of foam is attached at the top of the burlap flap to absorb and retain water. Alternately, another substrate such as slabs of real or artificial bark could be attached to trees to provide better microclimates for salamanders.

Further, Waldron and Humphries (2005) found that Green Salamanders prefer American Beech trees and hardwood trees over other tree species. Therefore, conducting a study to determine

TABLE 1. Number of individuals of each species of salamander observed at sites surveyed using burlap bands attached to trees in Chattahoochee National Forest, Georgia, and Nantahala National Forest, North Carolina, 2005. T = Trees, RO = Rock Outcrops.

Salamander Species	Chattahoochee I		Chattahoochee II		Chattahoochee III		Nantahala	
	T	RO	T	RO	T	RO	T	RO
Aneides aeneus	0	2	5	3	4	23	2	31
Plethodon metcalfi	0	0	0	5	0	8	3	9
Plethodon chattahoochee	0	0	16	0	0	0	0	0
Desmognathus ocoee	0	0	1	0	0	0	0	0
Total	0	2	22	8	4	31	5	40

Green Salamander tree species preference is important in assessing arboreality of the species. Trees in this study were chosen because of their size since American Beech trees were scarce at our sites or did not meet size requirements. Tree preference may be because of species of invertebrates found on different species of trees. Future studies include determining if a correlation exists between number of arthropods on trees and number of salamanders present.

Number of salamanders observed under burlap on trees and in the rock outcrops in November 2005 supports earlier findings (Waldron and Humphries 2005) that Green Salamanders as well as Southern Gray-cheeked Salamanders and Southern Appalachian Slimy Salamanders (Petranka 1998) show strong seasonal use of the forest floor and trees. We did not observe any species of salamanders under burlap in trees after November. Most likely Green Salamanders move to rock outcrops where they overwinter, then emerge and disperse in late-March or early-April (Waldron and Humphries 2005). Southern Appalachian Slimy Salamanders are suggested to overwinter in caves in Georgia. Southern Gray-cheeked Salamanders are suggested to overwinter in the ground in extensive burrows. Southern Gray-cheeked Salamanders move to their overwintering habitats and emerge and disperse in the spring at approximately the same time as Green Salamanders (Petranka 1998); therefore, surveys assessing arboreal habitat use should be conducted from August–November or late March–May.

The issue of arboreal habitat use by Green Salamanders and its importance to their population ecology remains unclear. While our results do not disagree with the characterization of Green Salamanders as "weakly arboreal", the results of Waldron and Humphries (2005) suggest that studies of Green Salamander arboreal habits needs greater attention. A 100-m buffer zone around each outcrop containing Green Salamanders has been suggested (Petranka 1998) to maintain cool microclimates on rock outcrops. If arboreal habitats are as important as Waldron and Humphries (2005) observations suggest, then the importance of forest buffers goes beyond maintenance of mild climates on rock outcrops. Though we did not capture large numbers of Green Salamanders under burlap, numerous individuals of other Southern Appalachian Salamanders were found. It should be noted that our study was only conducted during a few months during one season. Just as coverboards used in other reptile and amphibian studies oftentimes need time to "age" before they are successful, burlap or other artificial cover objects may increase in efficiency as they remain in the forest. We suggest the use of numerous sampling techniques for Green Salamanders and other salamander species in the Appalachians, as all methods have their benefits and biases.

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Literature Cited

Barbour, R. W. 1949. A study of the mammals, reptiles, and amphibians of Big Black Mountain, Harlan, Kentucky. Ph.D. Dissertation, Cornell University, Ithaca, New York.

Bruce, R. C. 1968. The role of the Blue Ridge Embayment in the zoogeography of the green salamander, *Aneides aeneus*. Herpetologica 24:185–194.

Campbell, R. W., and R. J. Sloan. 1977. Release of gypsy moth populations from innocuous levels. Environ. Entomol. 6:323–330.

Corser, J. D. 2001. Decline of disjunct green salamander (*Aneides aeneus*) populations in the Southern Appalachians. Biol. Conserv. 97:119–126.

Duguay, J. P., P. B. Wood, and G. W. Miller. 2000. Effects of timber harvests on invertebrate biomass and avian nest success. Wildl. Soc. Bull. 28:1123–1131.

Gordon, R. E. 1952. A contribution to the life history and ecology of the plethodontid salamander *Aneides aeneus* (Cope and Packard). Am. Midl. Nat. 47:666–701.

———, and R. L. Smith. 1949. Notes on the life history of the salamander *Aneides aeneus*. Copeia 1949:173–175.

Horn, S., and J. L. Hanula. 2006. Burlap bands as a sampling technique for green anoles (*Anolis carolinensis*) and other reptiles commonly round on tree boles. Herpetol. Rev. 37:427–428.

Houze, C., Jr., and C. R. Chandler. 2002. Evaluation of coverboards for sampling terrestrial salamanders in South Georgia. J. Herpetol. 36:75–81.

Jaeger, R. G. 1978. Plant climbing by salamanders: Periodic availability of plant-dwelling prey. Copeia 1978:686–691.

Monti, L., M. Hunter, Jr., and J. Witham. 2000. An evaluation of the artificial cover object (ACO) method for monitoring populations of the redback salamander *Plethodon cinereus*. J. Herpetol. 34:624–629.

Pauley, T. K., and M. B. Watson. 2005. *Eurycea cirrigera* (Green, 1830). Southern Two-lined Salamander. *In* M. J. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 740–743. University of California Press, Berkeley, California.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.

Reardon, R. C. 1976. Parasite incidence and ecological relationships in field populations of gypsy moth larvae and pupae. Environ. Entomol. 5:981–987.

Waldron, J. L., and W. J. Humphries. 2005. Arboreal habitat use by the green salamander, *Aneides aeneus*, in South Carolina. J. Herpetol. 39:486–492.

Wilson, C. R. 2003. Woody and arboreal habitats of the green salamander (*Aneides aeneus*) in the Blue Ridge Mountains. Contemp. Herpetol. 2003(2):1–6.

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Monitoring of Stream Salamanders: The Utility of Two Survey Techniques and the Influence of Stream Substrate Complexity

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Stream salamanders are often the most abundant vertebrates in headwater streams (Peterman et al. 2008) and they play an integral role as both predators and prey in these ecosystems (Greene et al. 2008; Resetarits 1997). Because stream salamanders often use both terrestrial and aquatic habitat, they may be vulnerable to the degradation or contamination of either environment (Semlitsch 2000). As a consequence, stream salamanders have proven to be susceptible to terrestrial disturbances such as deforestation (Crawford and Semlitsch 2008; Johnston and Frid 2002) and aquatic disturbances such as siltation (Lowe et al. 2004) and stream acidification (Kucken et al. 1994). Because of this susceptibility to a range of environmental perturbations, it is widely believed that stream salamanders are useful as biological indicators of ecosystem health (Rocco and Brooks 2000; Welsh and Droege 2001). As a result, they have been increasingly incorporated into stream and watershed monitoring efforts (Jung et al. 2000).

A wide range of sampling techniques may be used to study stream salamanders, including active techniques such as dipnetting and visual encounter surveys (Grover 2006; Shaffer et al., 1994), or passive techniques such as funnel trapping or leaf litter bag sampling (Pauley 1995; Willson and Dorcas 2003). In this study, we examine the utility of two common techniques for monitoring stream salamanders: leaf litter bag sampling and nighttime visual encounter surveys (VES). The leaf litter bag refugia technique has long been used to sample aquatic invertebrates (Hilsenhoff 1969; Crossman and Cairns 1974), and has more recently been described as a method for surveying stream salamanders (Pauley 1995). Leaf litter bags may be ideal for many salamander monitoring efforts because they are cheap, non-destructive, easy to employ, and likely result in minimal observer bias (Chalmers and Droege 2002; Jung and Pauley 2003; Pauley and Little 1998; Waldron et al. 2003). Although leaf litter bags have been recommended for developing occupancy estimates for certain aquatic salamanders (Chalmers and Droege 2002; Pauley and Little 1998), this technique may be biased towards the larval and juvenile lifestages (Pauley and Little 1998). Furthermore, larval captures from litter bag sampling may be highly variable and may not demonstrate a clear relationship with actual abundances (Chalmers and Droege 2002; Waldron et al. 2003). Visual encounter surveys require relatively little equipment, are effective for a large range of species, and can be conducted across a wide range of habitats including terrestrial, riparian, and aquatic (Toft et al. 1982; Pough et al. 1987). However, visual encounter surveys may have variable results due to differences in capture rates between researchers (Crump and Scott 1994; but see Marsh 2009) and may yield results that are highly dependent on prevailing stream and weather conditions (Barr and Babbitt 2002; Crump and Scott 1994).

Another potential source of variation in stream salamander captures is the variability in stream substrate complexity that often exists at both a local and regional scale. A number of studies have demonstrated that the species richness of stream organisms is positively correlated with habitat complexity (Gorman and Karr 1978; Reice 1980; Schlosser 1982). In the southern Appalachians, larvae of many stream-dwelling salamander species frequently utilize leaf litter, rock cover, and interstitial spaces in gravel streambeds (Petranka 1998). As a result, we believe that variability in stream substrate complexity may influence both salamander abundance and species richness on a local scale, as well as the accuracy of abundance indices derived from capture data. For example, variability in leaf litter bag captures between sites may be at least partially explained by salamanders preferring litter bags no more than surrounding cover objects in areas of higher substrate complexity (Chalmers and Droege 2002).

Although there are several potential techniques for sampling stream salamanders, researchers may be limited by practical considerations such as time, resources, and the availability of surveyors. The primary objective of this study was to determine how stream substrate complexity influences both capture rates and observed species richness of stream salamanders of two common sampling techniques with the goal of developing monitoring recommendations to optimize capture rates and species detection ability. Specifically, we sought to compare 1) catch-per-unit-effort (CPUE) and observed species richness between sampling techniques and 2) CPUE and observed species richness between stream segments with low and high substrate complexity.

Methods.—We conducted this study at four first to second-order streams in the vicinity of Highlands, North Carolina, USA. The streams sampled were located within 8 km of the Highlands Biological Station (35.0323ºN, 83.1117ºW), (35.0312ºN, 83.1115ºW), (35º0317ºN, 83.1120ºW), (35.0209ºN, 83.1323ºW). At each stream, we surveyed two separate 10-m transects; one with simple substrate and one with complex substrate. Although substrate complexity would typically be considered a continuous variable, we purposefully selected transects with either an extreme abundance or a complete lack of cover objects and treated substrate complexity as a dichotomous variable. Transects with complex substrate had >85% in-stream habitat cover (boulder, cobble, leaf litter, coarse woody debris), while those with simple substrate were entirely sandy or muddy with only sparse leaf litter for cover. At all four streams, the two transects were separated by a minimum of 50 m. Stream segments were selected by systematically searching 13 streams in the area around the Highlands Biological Station. The four streams included in this study were the only streams which met the aforementioned criteria of having: 1) a potential 10-m transect containing exclusively simple substrate and 2) a potential 10-m transect, at least 50 m from the first transect, containing complex substrate.

We constructed 40 leaf litter bags (Pauley and Little 1998) from 1.9 cm^2 polypropylene mesh. To create each leaf litter bag we filled 70 x 70 cm squares of netting with dry leaf litter, twisted the

corners together, and cinched a cable tie around the joined corners. On 18 June 2008, five leaf litter bags were systematically placed throughout each 10-m transect and were covered or surrounded by rocks to keep them in place in the stream. All bags were placed in at least 4 cm of water and were submerged to no more than three fourths of the bag's height.

Leaf litter bags were checked on 2, 16, and 30 July. During sampling, leaf litter bags were removed quickly from the stream and placed in a large white dishpan. As each bag was lifted from the water, a 15 x 20 cm baitnet was swept beneath it to capture any salamanders taking refuge underneath. Bags were held above the dishpan and shaken from side to side, dipped into the stream, and then shaken from front to back for a total of approximately 15 seconds. The water, sediment, and debris collected in the trays were then poured through the baitnet. The sediment and debris from the baitnet was then manually searched for salamanders. All captured salamanders were identified to species and then released within 1 m of the point of capture. We also conducted a time-constrained search (VES) for larval and adult salamanders at each transect in order to compare count data and observed species richness to those obtained with leaf litter bag sampling. Each 10 m transect was searched by two observers for a total of 30 minutes between 2100 h EST on 4 August 2008 and 0200 h EST on 5 August 2008. Salamanders were captured and identified to species and released in the stream.

With the goal of assessing techniques in terms of their ability to optimize capture rates during sampling efforts, we used our count data to compare the catch-per-unit-effort (CPUE) for each sampling technique. This capture rate is reported as the number of salamanders caught per hour of sampling. It is difficult to estimate total sampling time using leaf litter bags because they are in the water "sampling" for days or weeks before being checked. Therefore, the time we used to determine our capture rates is the total time spent by researchers actively sampling in the field. Leaf bags took 20 person-minutes to check per transect, and 60 person-minutes per transect for three days of sampling. One night of visual encounter survey took 60 person-minutes per transect.

We analyzed total CPUE data using the ANOVA procedure of SAS (SAS® Version 9.1 for Windows, SAS Institute, Cary, North Carolina). We conducted a two-way nested ANOVA to examine the effect of substrate type (simple vs. complex) and survey technique (leaf bag vs. VES) on capture rates, while accounting for the fact that our true level of replication was at the stream level. We also conducted a repeated-measures ANOVA to examine the background variability in leaf litter bag capture rates over time. Finally, we ran an independent samples t-test to compare the mean number of species detected in simple and complex substrates.

Results.—We captured a total of 690 salamanders, with leaf litter bag sampling accounting for 54% (N = 374) of total captures and VES accounting for 46% (N = 316) of total salamander captures. Larvae made up a majority of captures from both leaf litter bag sampling (89%) and VES (92%). The two techniques together detected every stream-affiliated salamander species known to be present at our study sites. We found that catch per unit effort (CPUE) did not differ significantly between litter bag sampling and VES ($F_{1,3}$= 0.21, p=0.6769; Fig. 1). Catch per unit effort from both techniques combined did not show a significant relationship with substrate complexity ($F_{1,3}$= 1.61, p=0.2941). With leaf litter bag sampling, CPUE did not significantly differ across sampling occasions ($F_{1,8}$= 1.77, p= 0.2318).

Although CPUE was similar for both sampling techniques, leaf litter bag sampling and VES sampling differed slightly in the species they captured (Table 1). The two sampling techniques each accounted for roughly half of total salamander captures, yet litter bags captured a slight majority of *Desmognathus ocoee* individuals (61%), while nighttime VES captured a majority of *D. quadramaculatus* individuals (77%). In addition, we captured one *Pseudotriton ruber* metamorph and two *Gyrinophilus porphyriticus* larvae in leaf litter bags while neither species was detected at any site during VES. Both sampling techniques captured a large number of *Eurycea wilderae* larvae, while *D. monticola* was not commonly captured using either technique (Table 1).

Overall, we detected significantly more species in transects with complex substrate using both leaf litter bags (T_6= 2.954, p=0.025) and VES (T_6= 3.0, p=0.024). Litter bag sampling detected a mean of 3.75 ± 1.26 SD species in transects with complex substrate and a mean of 1.75 ± 0.50 SD species in simple substrate. Using nighttime VES sampling we found a mean of 3.25 ± 0.96 SD species per transect with complex substrate and a mean of 2.00 ± 0.82 SD species per transect with simple substrate. Overall, surveying in complex transects tended to yield a higher observed species richness primarily because *D. monticola* and *D. quadramaculatus* were

TABLE 1. Total larval and adult salamanders captured by sampling technique and substrate type (Leaf = leaf litter bag, VES = visual encounter survey).

		Desmon	Desoco	Desqua	Eurwil	Gyrpor	Pserub
Leaf							
	larvae	0	0	4	328	2	0
	adults	5	19	1	14	0	1
	total	5	19	5	342	2	1
VES							
	larvae	0	0	13	278	0	0
	adults	7	12	4	2	0	0
	total	7	12	17	280	0	0
Complex							
	larvae	0	0	14	375	1	0
	adults	12	12	5	5	0	1
	total	12	12	19	380	1	1
Simple							
	larvae	0	0	3	231	1	0
	adults	0	19	0	11	0	0
	total	0	19	3	242	1	0

Desmon = *Desmognathus monticola* Desoco = *Desmognathus ocoee* Desqua = *Desmognathus quadramaculatus* Eurwil = *Eurycea wilderae* Gyrpor = *Gyrinophilus porphyriticus* Pserub = *Pseudotriton ruber*

only frequently encountered around complex, rocky substrates (Table 1).

Discussion.—Accurate estimations of amphibian abundances across time, locations, and observers require the use of standardized sampling methods and protocols (Crump and Scott 1994). Because substrate can be highly variable both within and between streams (Inoue and Nunokawa 2002; Vannote et al. 1980), it is important to determine whether this variability influences the efficacy of sampling techniques, particularly when using artificial refugia. Also, because certain sampling techniques may be inherently biased towards particular species or life stages while failing to detect others, any effect of stream substrate complexity on capture rates or observed species richness may significantly affect the utility of many survey techniques (Strain et al. 2008). Although we found no significant difference in CPUE between substrate types and between sampling methods, sampling in areas with greater substrate complexity revealed the presence of more species. For both sampling techniques, fewer species were found in areas of simple substrate than in areas of complex substrate. Stream salamander species have been shown to exhibit different substrate preferences, with *D. quadramaculatus* and *D. monticola* demonstrating a strong preference for rocky substrates (Southerland 1986). Although we found 3 *D. quadramaculatus* larvae in transects with simple substrate, the vast majority of *D. quadramaculatus* (19 of 22) and all *D. monticola* were found in transects with complex substrate (Table 1). These results are consistent with studies of other stream organisms where species richness has been found to be positively correlated with habitat complexity (Gorman and Karr 1978; Reice 1980; Schlosser 1982). Habitat complexity has repeatedly been shown to moderate predatory and competitive interactions (Babbitt and Tanner 1998; Crowder and Cooper 1982; Heck and Crowder 1991), and it has specifically been demonstrated that lotic habitat substrate complexity can decrease the susceptibility of larval salamanders to predation (Barr and Babbitt 2002). As a result, it seems likely that substrate complexity plays a critical role in sustaining high levels of salamander diversity and species richness in these headwater ecosystems.

This study demonstrates that leaf litter bag sampling and VES both have their strengths and weaknesses. Leaf litter bags are cheap, non-destructive, easy to employ, and likely result in minimal observer bias (Chalmers and Droege 2002; Jung and Pauley 2003; Pauley and Little 1998; Waldron et al. 2003). Leaf litterbags also take less time than nighttime VES sampling during repeated surveys and can be particularly useful for large scale inventories and when time-constrained sampling of individual sites is limited (Waldron et al. 2003). Although leaf litterbag sampling was relatively ineffective at capturing large body *D. quadramaculatus*, this technique did capture more *D. ocoee* than the nighttime VES technique. Further, *Pseudotriton ruber* and *Gyrinophilus porphyriticus* were only detected using leaf litter bags, which is consistent with other studies in which leaf bags effectively captured hard to detect species (Waldron et al. 2003). Visual encounter surveys are simple and require relatively little equipment. They are not as biased towards any particular life stage, and they can be implemented over a wide range of habitats. Because different sampling techniques appear to target different ranges of species, we believe the use of more than one sampling technique may allow more accurate estimation of stream salamander abundances and species richness. Following this recommendation, while considering the effects of stream substrate complexity on salamander diversity, can result in more effective stream salamander monitoring.

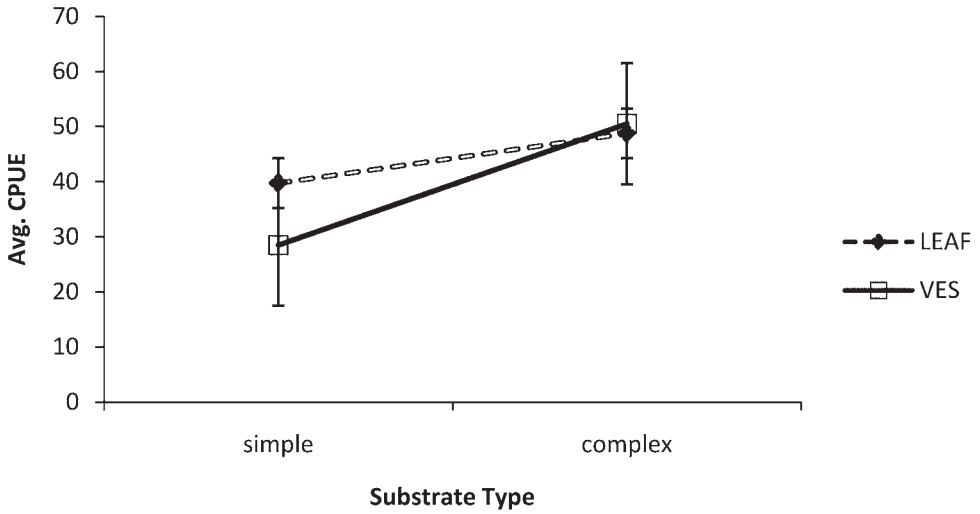

FIG. 1. Average catch-per-unit-effort (CPUE) using leaf litter bags (LEAF) and visual encounter surveys (VES) in simple and complex substrates.

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LITERATURE CITED

BABBITT, K. J., AND G. W. TANNER. 1998. Effects of cover and predator size on survival and development of *Rana utricularia* tadpoles. Oecologia 114:258–262.

BARR, G. E., AND K. J. BABBITT. 2002. Effects of biotic and abiotic factors on the distribution and abundance of larval two-lined salamanders (*Eurycea bislineata*) across spatial scales. Oecologia 133:176–185.

CHALMERS, R. J., AND S. DROEGE. 2002. Leaf litter bags as an index to populations of northern two-lined salamanders (*Eurycea bislineata*). Wildlife Soc. Bull. 30:71–74.

CRAWFORD J. A., AND R. D. SEMLITSCH. 2008. Post-disturbance effects of even-aged timber harvest on stream salamanders in southern Appalachian forests. Anim. Conserv. 11:369–376.

CROSSMAN, J. S., AND J. CAIRNS. 1974. A comparative study between two artificial substrate samplers and regular sampling techniques. Hydrobiologia 44:517–522.

CROWDER, L. B., AND W. E. COOPER. 1982. Habitat structural complexity and the interaction between bluegills and their prey. Ecology 63:1802–1813.

CRUMP, M. L., AND N. J. SCOTT, JR. 1994. Visual encounter surveys. *In*

W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. A. C. Hayek, and M. S. Foster (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians, pp. 84–92. Smithsonian Institution Press, Washington, DC.

Gorman, O. T., and J. R. Karr. 1978. Habitat structure and fish communities. Ecology 59:507–515.

Greene, B. T., W. H. Lowe, and G. E. Likens. 2008. Forest succession and prey availability influence the strength and scale of terrestrial-aquatic linkages in a headwater salamander system. Freshwater Biol. 53:2234–2243.

Grover, M. C. 2006. Comparative effectiveness of nighttime visual encounter surveys and cover object searches in detecting salamanders. Herpetol. Conserv. Biol. 1:93–99.

Heck, K. L., and L. B. Crowder. 1991. Habitat structure and predator-prey interactions in vegetated aquatic systems. *In* S. S. Bell, E. D. McCoy, and H. R. Mushinsky (eds.), Habitat Structure: The Physical Arrangement of Objects in Space, pp. 281–299. Chapman and Hall, New York, New York.

Hilsenhoff, W. L. 1969. An artificial substrate sampler for stream insects. Limnol. Oceanogr. 14:465–471.

Inoue, M., and M. Nunokawa. 2002. Effects of longitudinal variations in stream habitat structure on fish abundance: an analysis based on subunit-scale habitat classification. Freshwater Biol. 47:1594–16.

Johnston B., and L. Frid. 2002. Clearcut logging restricts the movements of terrestrial Pacific giant salamanders (*Dicamptodon tenebrosus*). Can. J. Zool. 80:2170–2177.

Jung, R. E., S. Droege, J. R. Sauer, and R. B. Landy. 2000. Evaluation of terrestrial and streamside salamander monitoring techniques at Shenandoah National Park. Environ. Monit. Assess. 63:65–79.

———, and T. K. Pauley. 2003. Leaf litter bags. Manager's monitoring manual. USGS Patuxent Wildlife Environ Monit Assess Research Center. 01 Feb 2005 <http://www.pwrc. usgs.gov/monmanual/techniques/leaflitter.htm>.

Kucken, D. J., J. S. Davis, J. W. Petranka, and C. K. Smith. 1994. Anakeesta stream acidification and metal contamination: effects on a salamander community. J. Environ. Qual. 23:1311–1317.

Lowe, W. H., N. H., Nislow, and D. T. Bolger. 2004. Stage-specific and interactive effects of sedimentation and trout on a headwater stream salamander. Ecol. Appl.14:164–172.

Marsh, D. 2009. Evaluating methods for sampling stream salamanders across multiple observers and habitat types. Appl. Herpetol. 6:211–226.

Pauley, T. K. 1995. Aquatic salamanders. *In* R. C. Reardon (ed.), Effects of Diflubenzuron on Nontarget Organisms in Broadleaf Forested Watersheds in the Northeast, pp. 14–22. USDA Forest Service. FHM-NC-05- 95. National Center of Forest Health Management.

———, and M. Little. 1998. A new technique to monitor larval and juvenile salamanders in stream habitats. Banisteria 12:32–36.

Peterman, W. E., J. A. Crawford, and R. D. Semlitsch. 2008. Productivity and significance of headwater streams: population structure and biomass of the black-bellied salamander (*Desmognathus quadramaculatus*). Freshwater Biol. 53:347–357.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC.

Pough, F. H., E. M. Smith, D. H. Rhodes, and A. Collazo. 1987. The abundance of salamanders in forest stands with different histories of disturbance. Forest Ecol. Manag. 20:1–9.

Reice S. R. 1980. The role of substratum in benthic macroinvertebrate micro-distribution and litter decomposition in a woodland stream. Ecology 61:580–590.

Resetarits, W. J., Jr. 1997. Differences in an ensemble of streamside salamanders (Plethodontidae) above and below a barrier to brook trout. Amphibia-Reptilia 18:15–25.

Rocco, G. L., and R. P. Brooks. 2000. Abundance and distribution of a stream plethodontid salamander assemblage in 14 ecologically dissimilar watersheds in the Pennsylvania Central Appalachians. Final report. Report No. 2000–4. Penn State Cooperative Wetlands Center, Forest Resources Laboratory, Pennsylvania State University.

Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecol. Monogr. 52:395–414.

Semlitsch, R. D. 2000. Principles for management of aquatic-breeding amphibians. J.Wildl. Manage. 64:615–631.

Shaffer, H. B., R. A. Alford, B. D. Woodward, S. L. Richards, R. G. Altio, and C. Gascon. 1994. Quantitative sampling of amphibian larvae. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians, pp. 130–141. Smithsonian Inst. Press, Washington, D.C.

Southerland, M. T. 1986. The effects of variation in streamside habitats on the composition of mountain salamander communities. Copeia 3:731–741.

Strain, G. F., R. L. Raesly, and R. H. Hilderbrand. 2008. A comparison of techniques to sample salamander assemblages along highland streams of Maryland. Environ. Monit. Assess. DOI 10.1007/s10661-008-0459-3.

Toft, C. A., A. S. Rand, and M. Clark. 1982. Population dynamics and seasonal recruitment in *Bufo typhonius* and *Colostethus nubicola* (Anura). *In* E. G. Leigh, Jr., A. S. Rand, and D. M. Windsor (eds.), The Ecology of a Tropical Forest: Seasonal Rythms and Long-Term Changes, pp. 397–403. Smithsonian Inst. Press, Washington, D.C.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130–137.

Waldron, J. L., C. K. Dodd Jr., and J. D. Corser. 2003. Leaf litterbags: Factors affecting capture of stream-dwelling salamanders. Appl. Herpetol. 1:23–36.

Welsh, H. H., Jr., and S. Droege. 2001. A case for using plethodontid salamanders for monitoring biodiversity and ecosystem integrity of North American forests. Conserv. Biol. 15:558–569.

Willson, J. D., and M. E. Dorcas. 2002. Effects of habitat disturbance on stream salamanders: implications for buffer zones and watershed management. Conserv. Biol. 17:763–771.

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A Functional and Cleanable Substrate for Snake Testing Arenas

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When studying snake behavior in experimental arenas, several considerations must be made when choosing an appropriate substrate. Because of the importance of olfactory information to snakes, and because of their high sensitivity to chemical cues, we often desire an ability to control or eliminate odors in the experimental setting (Ford and Burghardt 1993). This, and the occasional need to reduce unwanted exploratory behaviors such as burrowing, often precludes the use of naturalistic litter substrates. Instead, we opt for a floor surface that is easy to clean or, in the case of paper

substrate, can be discarded and replaced. Many snakes rely heavily on lateral undulation for locomotion (Gans 1986; Gray 1946), which requires a substrate with considerable texture, and the use of smooth, easily cleaned or disposable substrates limits this ability. In experimental arenas with such substrates, snakes often use alternatives to lateral undulation (e.g., concertina and rectilinear motion; Gans 1986; Gray 1946) that may be perfectly acceptable or appropriate depending on the conditions of the study. However, concertina locomotion is apparently far less efficient than lateral undulation (Walton et al. 1990), and under some circumstances the relatively low rate of travel achieved by concertina or rectilinear locomotion can be counterproductive to behavioral studies. Snakes and other legless squamates will also resort to slide-pushing when other methods prove ineffective (Gans 1984; Gasc and Gans 1990), and this often involves vigorous movements of the entire body that might detract from a subject's ability to attend to stimuli important to a given experiment.

Researchers have found alternatives to paper or smooth flooring, such as artificial turf or indoor-outdoor carpeting (Finkler and Claussen 1999; Winne and Hopkins 2006). These provide more texture than many paper substrates and are resilient enough to be washed and reused many times. However, the labor and time required to thoroughly wash and let dry the large number of carpet pieces required to conduct numerous experimental trials seems hardly worth the small improvement in snake locomotion obtained by using these as substrates, particularly the latter (personal observation). Because of this, we have sought and found what we believe to be a better solution.

Perlite is a lightweight, crumb-like material having many applications, the most familiar perhaps being its use as an incubation substrate for reptile eggs and to improve aeration of soils for gardening. It is readily and inexpensively available at garden supply stores worldwide. Another use of perlite, and the one that led to its use here, is as an additive to paints to provide visually pleasing texture to the ceilings and walls in our homes. When sold as a paint texturizer, perlite can have a fine, medium, or coarse grain. By mixing a coarse perlite with animal-safe paint, applying this mixture to an arena floor, and then coating it with several additional paint-only layers, we have obtained a substrate that is easy to clean thoroughly (we wash it with warm soapy water, rinse, and then finish with a microfiber cloth dampened with isopropanol), dries quickly afterward, and is resilient to frequent cleaning. The substrate remains fixed and weighs very little, allowing one to keep the test arena highly portable if desired. During the first few cleanings, a small number of the perlite pieces might become broken or dislodged, but this soon ceases after recoating with paint. The treatment is extremely easy to apply, and it can be used on surfaces of any size, shape, or orientation. Moreover, one can vary the location, amount, and coarseness of texture to suit specific needs. Vermiculite, which is very similar to perlite, is also likely to function well for this purpose, though its more angular nature might inhibit satisfactory paint coverage.

Although we have not empirically tested for effects of this treatment on the chemosensory behavior of snakes, we have noticed no aversive responses (e.g., tongue flicks followed by abrupt evasive motions) from any study subjects in arenas treated in this manner. However, in order to limit the possibility of adverse paint-related chemical effects, all new applications of paint should be subjected

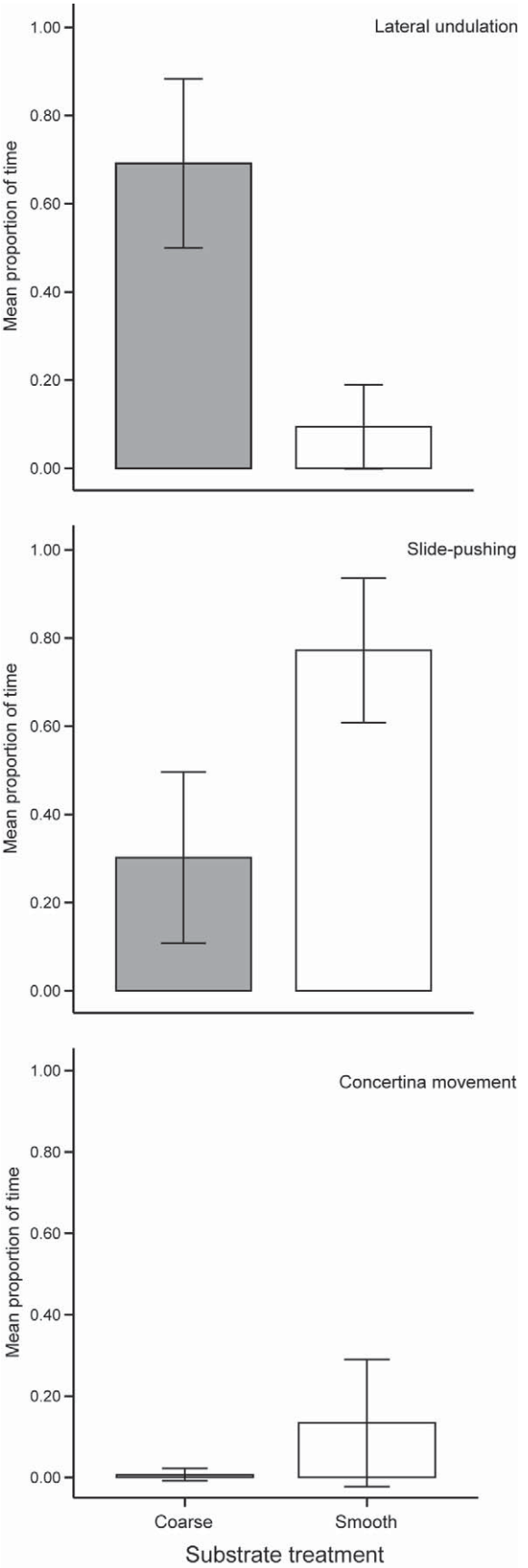

FIG. 1. Mean proportions of time spent by 10 *Nerodia clarkii compressicauda* engaging in three locomotory methods on a smooth painted surface (smooth) and on a surface treated with perlite-infused paint (coarse). Error bars indicate 95% confidence intervals.

to several cycles of washing and drying before use. Furthermore, by preparing arenas well in advance, at least twice the suggested curing time of the paint, one can thoroughly wash newly treated arenas several times as soon as the paint has been allowed to dry for the suggested length of time, dislodging any fragile or poorly anchored pieces of perlite in the process, and still have time to recoat the surface and allow the paint to properly cure prior to experimentation.

In an examination of this substrate's effect on snake locomotion, we observed 10 Mangrove Saltmarsh Watersnakes (*Nerodia clarkii compressicauda*; mean SVL = 21.3 cm) traversing each of two wooden-floored, 13 x 60 cm trackways, one treated in the manner described above (the coarse treatment) and one treated with only paint (the smooth treatment). Data for each subject were the proportions of time spent using lateral undulation, concertina movement, and slide-pushing (the only three locomotory modes we observed), averaged over three trials in each of the two treatments. The proportions of time spent engaged in lateral undulation (Wilcoxon Signed Ranks Test; $Z = 2.67$; $p = 0.008$), slide-pushing (Wilcoxon Signed Ranks Test; $Z = 2.67$; $p = 0.008$) and concertina movement (Wilcoxon Signed Ranks Test; $Z = 2.20$; $p = 0.028$) differed significantly between the coarse and smooth surface treatments (Fig. 1). Subjects primarily used lateral undulation on the coarse surface and slide-pushing and concertina movement on the smooth surface. Thus, the perlite treatment provides a texture that facilitates the use of lateral undulation better than does a surface treated only with paint. In addition to tests involving snakes on dry arena floors, the painted perlite substrate has proved beneficial in experiments involving snakes in shallow-water test arenas and in a study involving terrestrial monitor lizards. Studies involving other squamates, legless or otherwise, may also benefit from such a substrate when more naturalistic materials are not feasible.

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Literature Cited

Finkler, M. S., and D. L. Claussen. 1999. Influence of temperature, body size, and inter-individual variation on forced and voluntary swimming and crawling speeds in *Nerodia sipedon* and *Regina septemvittata*. J. Herpetol. 33:62–71.

Ford, N. B., and G. M. Burghardt. 1993. Perceptual mechanisms and the behavioral ecology of snakes. *In* R. A. Seigel and J. T. Collins (eds.), Snakes: Ecology and Behavior, pp. 117–164. McGraw-Hill, New York, New York.

Gans, C. 1984. Slide-pushing: a transitional locomotor method of elongate squamates. Symp. Zool. Soc. Lond. 52:12–26.

———. 1986. Locomotion of limbless vertebrates: Pattern and evolution. Herpetologica 42:33–46.

Gasc, J. P., and C. Gans. 1990. Tests on locomotion of the elongate and limbless lizard *Anguis fragilis* (Squamata: Anguidae). Copeia 1990:1055–1067.

Gray, J. 1946. The mechanism of locomotion in snakes. J. Exp. Biol. 23:101–120.

Walton, M., B. C. Jayne, and A. F. Bennett. 1990. The energetic cost of limbless locomotion. Science 249:524–527.

Winne, C. T., and W. A. Hopkins. 2006. Influence of sex and reproductive condition on terrestrial and aquatic locomotor performance in the semi-aquatic snake *Seminatrix pygaea*. Funct. Ecol. 20:1054–1061.

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A New Technique for Capturing Burrow-Dwelling Anurans

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Although a substantial proportion of North American frogs and toads will use burrows facultatively, as retreats from stressful environmental conditions (typically cold and/or dry weather; Lannoo et al. 2005; individual species accounts in Lannoo 2005), a handful of species use borrows obligately—relying on them to meet physiological or ecological needs. The Nenirana group of Hillis and Wilcox (2005) contains three species, *Lithobates areolatus* (Crawfish Frogs), *L. capito* (Gopher Frogs), and *L. sevosus* (Dusky Gopher Frogs) that inhabit burrows constructed by other species (predominantly crayfish in the case of *L. areolata*, and Gopher Tortoises [*Gopherus polyphemus*] in the case of *L. capito* and *L. sevosus,* though they are also known to inhabit small mammal burrows and holes in dead or rotting trees; Lannoo 2005). Adults of these three species are secretive and rapidly retreat into burrows when disturbed. Therefore, outside of the breeding season these frogs are rarely seen, and when seen near burrows (as they almost always are) they are next to impossible to capture. All three species are of conservation concern (Jensen and Richter 2005; Parris and Redmer 2005; Richter and Jensen 2005); *L. sevosus* is known from only two populations and is listed as federally endangered (USFWS 2001).

If we are to gather the basic ecological information needed to conserve these species, we must develop techniques for capturing animals year-round, through all life history stages. Once captured, animals can be weighed and measured, assessed for health, marked, and implanted with radiotransmitters. The best techniques for capturing animals retain the integrity of the burrow, because animals are known to use the same burrow throughout the warm season (Richter et al. 2001; JLH, unpubl. data) and perhaps longer. Further, it has been suggested that burrows are a limiting resource (Thompson 1915; Jensen and Richter 2005).

We developed a technique to capture Crawfish Frogs from their burrows, but the technique can be applied to Gopher Frogs and other animals occupying small-diameter burrows. We work on Crawfish Frogs in southwestern Indiana; *L. areolatus* is classified as state endangered in Indiana. Crawfish Frogs spend the majority of their adult lives associated with upland burrows, primarily those created by crayfish. Several different species of crayfish construct suitable burrows; at our study site in southwestern Indiana there are *Cambarus diogenes, Fallicambarus fodiens,* and *Cambarus* (*Tubericambarus*) *polychromatus* (Thoma and Armitage 2008). Crayfish burrows extend from the soil surface down to the water

table, and while chambers and side passages may be common, crayfish burrows are not usually a part of a vast burrow network. Burrows tend to be in clay soils, which create well-defined burrow walls and retain water (Grow and Merchant 1980). Compared with Gopher Tortoise burrows, crayfish burrows are narrow; burrows used by Crawfish Frogs are typically not much wider at the surface than the frog itself.

It follows that methods used to extract crayfish from burrows would be effective at extracting Crawfish Frogs. Published methods of successful crayfish extraction include excavation of burrows (Simon 2001), Norrocky pipe traps (Norrocky 1984), plungers (Simon 2001), motorized pumps (Thoma and Armitage 2008), and burrowing crayfish mist nests (Welch and Eversole 2006). However, several of these methods (excavation, plungers, pumps, and pipe traps) permanently damage burrows and the surrounding area (Ridge et al. 2008), and they all could potentially stress or injure the frog.

In addition to considering the above techniques, we tried securing a collapsible mesh minnow trap over the crayfish burrow. We also tried inserting a piece of PVC pipe at the burrow entrance with the idea that once the frog entered we would remove and cover the burrow end of the pipe (with a spatula) to trap the frog. We tried putting mist netting outside the burrow (similar to the Welch and Eversole [2006] crayfish net) as well as putting variations of a trap door over the burrow opening. Though occasionally successful, all of these methods turned out to be less than ideal for the capture of Crawfish Frogs. The success of some traps (minnow traps and PVC pipe traps) was limited because they did not prevent animals from returning to their burrows and all traps required constant monitoring, potentially for several days, while waiting for the frog to emerge from the burrow.

We were compelled to find a technique that would induce animals to leave their burrows while we were present, and would prevent them from returning to burrows once they were aware of our presence. The key observation (JLH) was that following heavy rains and burrow flooding, Crawfish Frogs surface every 20–40 min to breathe. The technique we introduce here has two basic components: flooding burrows to induce animals to surface, and blocking their retreat with an inflated balloon.

We outfitted a bicycle tire pump with a long (> 2 m) plastic tube (8 mm diameter) and attached a circular-shaped balloon to the end with a rubber band, so that when the bike pump handle was depressed, the balloon inflated (Fig. 1A, B). When inflated, the balloon conforms to the interior contours of the burrow but does not alter the burrow itself. To capture frogs we inserted the deflated balloon into the burrow (~20–30 cm). We then filled the burrow from a 23-liter jug containing water from a nearby lake. It usually took about 12 liters of water to fill burrows, and more water to maintain the water level at the surface of the burrow. Crawfish Frogs take an average of 30 min to surface. When they surface, we inflate the balloon, trapping the frog at the burrow entrance. In response, the frogs typically inflate their bodies and lower their head, tucking their jaws towards their chest. To extract them we gently pull up on the tubing and the balloon, forcing the frog out. For stubborn frogs, we insert a spatula and gently pry them out. This technique does not damage the burrow when done carefully, and we do not use enough force to harm the frog. The vegetation around the burrows gets trampled but recovers. Some frogs come up for air and quickly escape back into the burrow before the balloon can be inflated. In these cases, we repeat the procedure. On a few occasions the balloon ruptured.

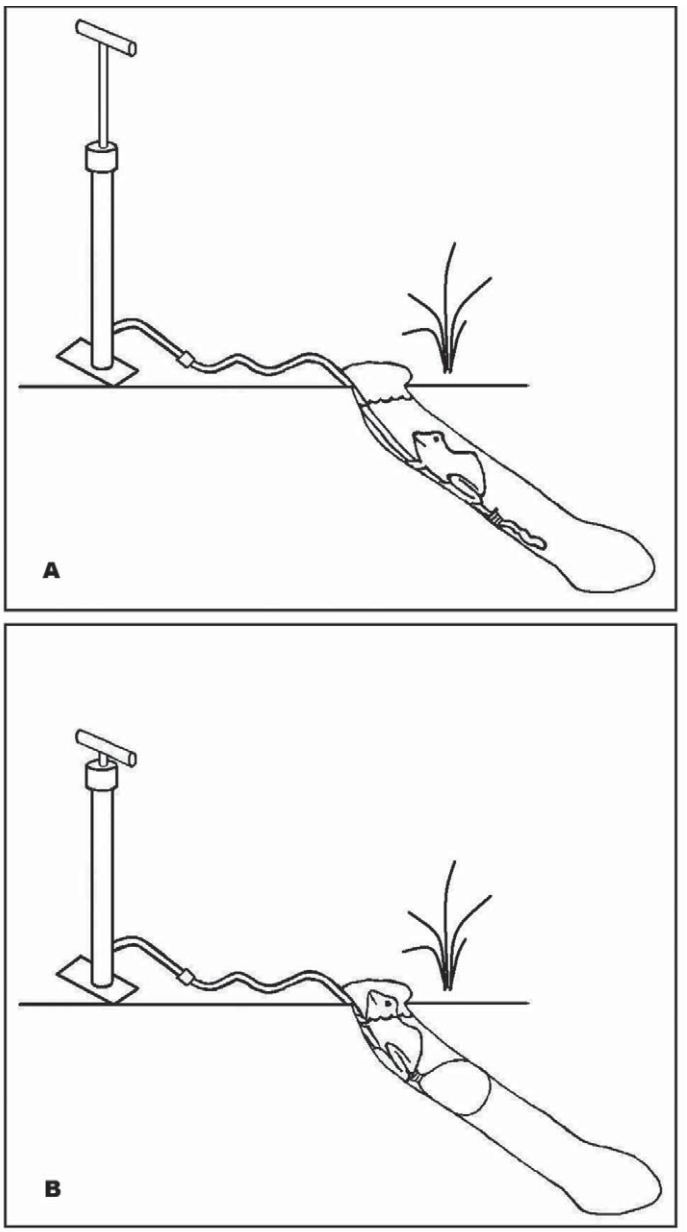

FIG. 1. A) Crawfish Frog in burrow below water surface, balloon deflated, tire pump plunger up. B) Crawfish Frog rises to water surface, balloon inflated, tire pump plunger down.

This method was also successful for retrieval of a Southern Leopard Frog (*Lithobates sphenocephalus*), but it took the frog about 165 minutes to surface. In addition to applying this technique to burrows known to be occupied (most of our known burrow sites were discovered following the implantation of their inhabitants with transmitters (3.8g PD-2 temperature sensing transmitters Holohil Systems Ltd. [Carp, Ontario, Canada]), we have also used this technique with success to determine the occupancy of suspected Crawfish Frog burrows (JLH, unpubl. data). The one time this technique did not work on a burrow known to be inhabited by a Crawfish Frog, the burrow branched uphill and therefore could not be sufficiently filled with water to force the

frog to surface. We suspect a modification of this technique could be used to extract Gopher Frogs and Dusky Gopher Frogs from Gopher Tortoise burrows, small mammal burrows, and other small refugia situated in clay substrates. This technique may be also applied to other amphibian species and perhaps to reptiles and other burrow-dwelling taxa.

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LITERATURE CITED

GROW, L., AND H. MERCHANT. 1980. The burrow habitat of the crayfish, *Cambarus diogenes diogenes* (Girard). Amer. Midl. Nat. 103:231–237.

HILLIS, D. M., AND T. P. WILCOX. 2005. Phylogeny of the New World true frogs (*Rana*). Mol. Phylogenet. Evol. 34:299–314.

JENSEN, J. B., AND S. C. RICHTER. 2005. *Rana capito*. Gopher frog. *In* M. J. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 536–538. University of California Press, Berkeley, California.

LANNOO, M. J. (ed.) 2005. Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

———, A. L. GALLANT, P. NANJAPPA, L. BLACKBURN, AND R. HENDRICKS. 2005. Introduction. *In* M. J. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 351–380. University of California Press, Berkeley, California.

NORROCKY, M. J. 1984. Burrowing crayfish trap. Ohio J. Sci. 84:65–66.

PARRIS, M. J., AND M. REDMER. 2005. *Rana areolata*. Crawfish frog. *In* M. J. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 526–528. University of California Press, Berkeley, California.

RICHTER, S. C., AND J. B. JENSEN. 2005. *Rana sevosa*. Dusky gopher frog. *In* M. J. Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 584–586. University of California Press, Berkeley, California.

———, J. E. YOUNG, R. A. SEIGEL, AND G. N. JOHNSON. 2001. Post-breeding movements of the dark gopher frog, *Rana sevosa* Goin and Netting: implications for conservation and management. J. Herpetol. 35:316–321.

RIDGE, J., T. P. SIMON, D. KARNS, AND J. ROBB. 2008. Comparison of three burrowing crayfish capture methods based on relationships with species morphology, seasonality, and habitat quality. J. Crustacean Biol. 28:466–472.

SIMON, T. P. 2001. Checklist of the crayfish and freshwater shrimp (Decapoda) of Indiana. Proc. Indiana Acad. Sci. 110:104–110.

THOMA, R. F., AND B. J. ARMITAGE. 2008. Burrowing Crayfish of Indiana. Final report to Indiana Department of Natural Resources. Indianapolis, Indiana.

THOMPSON, C. 1915. Notes on the habits of *Rana areolata* Baird and Girard. Univ. Michigan Occas. Pap. Mus. Zool., No. 9.

UNITED STATES FISH AND WILDLIFE SERVICE (USFWS). 2001. Endangered and threatened wildlife and plants; final rule to list the Mississippi gopher frog distinct population segment of dusky gopher frog as endangered. Federal Register 66:62993–63001.

WELCH, S. M., AND A. G. EVERSOLE. 2006. Comparison of two burrowing crayfish trapping methods. Southeast. Nat. 5:27–30.

AMPHIBIAN DISEASES

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Detection of the Chytrid Fungus, *Batrachochytrium dendrobatidis*, on Recently Metamorphosed Amphibians in the North-Central United States

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The pathogenic chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), has been associated with population declines of many amphibian species around the world, including relatively pristine habitats (e.g., Berger et al. 1999; Fellers et al. 2001; Herrera et al. 2005; Skerratt et al. 2007; Lips et al. 2008; Wake and Vredenburg 2008). Chytridiomycosis, the disease induced by *Bd*, likely is the proximate cause of many of these declines (Lips et al. 2006; Rachowicz et al. 2006; Skerratt et al. 2007). While the foci of much current research, we lack a clear understanding of the origin of *Bd*, its distribution and persistence, and the mechanisms by which it spreads across the landscape and ultimately kills amphibians (Longcore et al. 2007; Morgan et al. 2007; Lips et al. 2008; Wake and Vredenburg 2008), although Voyles et al. (2009) recently reported disruption of electrolyte transport and cardiac arrest as potential mechanisms for causing mortality.

Typically, vulnerable individuals die after *Bd* has infected their keratin, but vulnerability varies with life stage and species traits (Ouellet et al. 2005; Rollins-Smith and Conlon 2005; Longcore et al. 2007; Morgan et al. 2007; Bielby et al. 2008; Harris et al. 2009). Some species, such as the African Clawed Frog (*Xenopus laevis*) and American Bullfrog (*Rana catesbeiana*), are known to carry *Bd* without symptoms of the disease whereas diseased individuals have been observed in populations of other species without associated die-offs (Ouellet et al. 2005; Corn 2007; Kriger and Hero 2006; Longcore et al. 2007). As a fundamental first step in understanding these ecological processes and the resultant threats *Bd* poses to amphibian populations in specific areas, we need to know whether populations are exposed to the pathogen (e.g., Retallick et al. 2004; Ouellet et al. 2005; Pearl et al. 2007; Frias-Alvarez et al. 2008). We report here on results of our efforts to produce baseline data on *Bd* detection in US states for which few data have been reported: Minnesota, Wisconsin, and Iowa (Loda and Otis 2009).

We sampled recently metamorphosed amphibians at 75 unique breeding sites across five general areas within the north-central US: 1) Voyageurs National Park, 2) the St. Croix National Scenic Riverway, 3) the Upper Mississippi River National Wildlife and Fish Refuge, 4) northern Iowa, and 5) southwestern Wisconsin

(Fig. 1). We sampled 29 sites during July and August 2006 and 64 sites during June, July, and August 2007, including 18 sites in both years (Table 1). We chose sampling locations based upon our knowledge of species occurrences at these sites gained during previous studies.

We sampled nine amphibian species, including *Bufo americanus, Acris crepitans,* the *Hyla chrysoscelis-versicolor* complex, *Pseudacris triseriata, R. catesbeiana, R. clamitans, R. septentrionalis, R. pipiens,* and *R. sylvatica* (Table 1). Our goal was to sample 20 live, apparently healthy recent metamorphs of each species available per site in 2006 and 30 such metamorphs in 2007. We sampled fewer metamorphs when we captured fewer animals than expected at a site (Table 1). Metamorphs were collected individually by hand capture or net during visual-encounter surveys in littoral or nearby habitat. We only sampled metamorphs with fully resorbed tails. Once captured and swabbed, we retained individuals until we completed all sampling at a site, at which time we released them near the point of capture. We sampled metamorphs of as many species as were available at each site during our sampling windows in a given year.

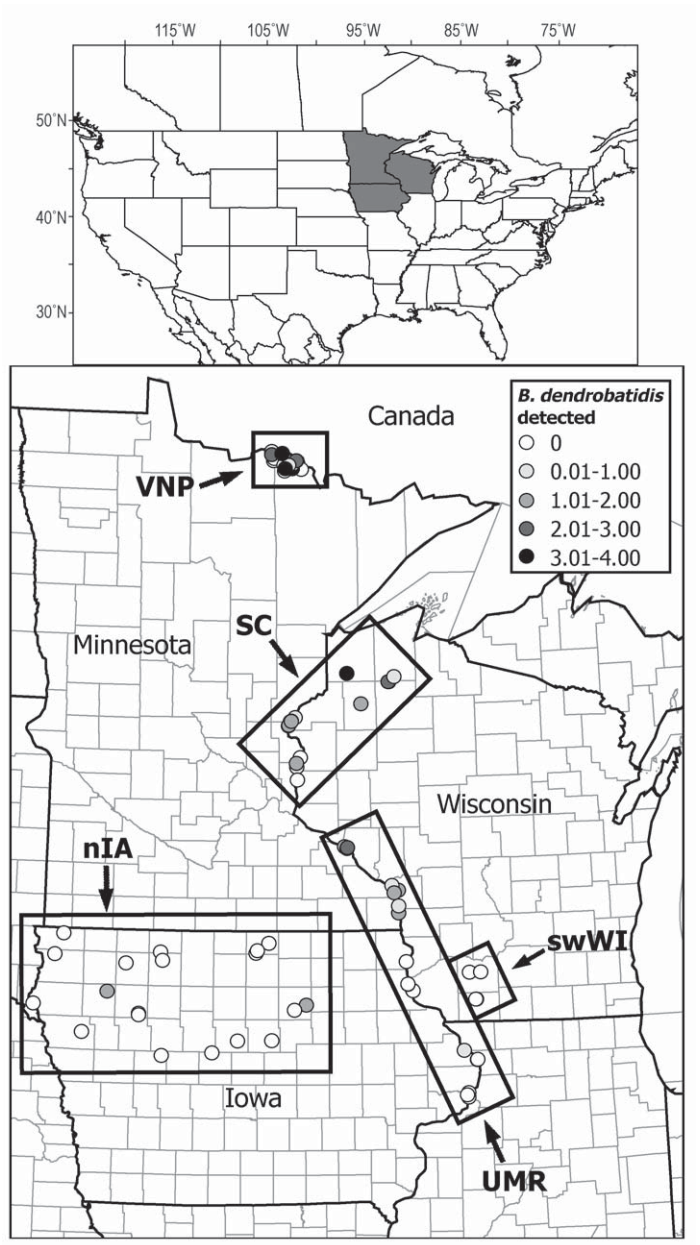

FIG. 1. The locations sampled in the north-central United States and relative quantities of *Batrachochytrium dendrobatidis* (*Bd*) detected across amphibian breeding sites and areas. Quantities are averages across species and years for each site based upon samples scored as 0 = not detected, 1 = weak positive signal, 2 = positive signal, 3 = strong positive signal, and 4 = very strong positive signal, as reported to us by Pisces Molecular LLC. Note that some breeding sites are not easily visible due to overlap at this scale. VNP = Voyageurs National Park; SC = the St. Croix National Scenic Riverway; UMR = the Upper Mississippi River National Wildlife and Fish Refuge; swWI = southwestern Wisconsin; nIA = northern Iowa.

We used decontaminated equipment and fresh disposable gloves to capture and handle each individual specimen and one cotton-tipped swab (Puritan brand, 15 cm, no-glue cleaning sticks) to swab each animal 30 times across the ventral skin on the thighs, abdomen, and hind limbs, including the interdigital webbing, similar to Livo (2004). Typically, we pooled the ten individual cotton-tipped swabs we used to sample ten individual conspecific metamorphs at each site in one sterile vial containing 70% EtOH. This enabled us to limit analytical costs (two samples of pooled swabs per species per site in 2006 and three in 2007) while increasing our chances of detecting *Bd* within a sample simply due to more animals represented in each sample analyzed. We sealed vials on site and sent them to Pisces Molecular LLC (Boulder, Colorado) for PCR analyses as per their instructions. Pisces Molecular LLC used methods described in Annis et al. (2004) and reported results to us as not detected, weak positive signal, positive signal, strong positive signal, or very strong positive signal. According to Pisces Molecular LLC, the detection limit was 0.1 zoospore equivalent DNA per PCR reaction.

Bd was detected on at least one species at 34 of 75 sites (45%) and in 4 of the 5 general areas sampled (Table 1; Fig. 1). *Bd* was detected most often on *R. clamitans* (23 of 27 sites) and *R. septentrionalis* (7 of 9 sites) in relatively moderate to heavy quantities. The remaining detections also were on ranids, in relatively small quantities on *R. pipiens* (5 of 39 sites) and *R. sylvatica* (6 of 9 sites) and in moderate quantities on *R. catesbeiana* (1 of 2 sites). *Bd* was not detected on *B. americanus*, *A. crepitans*, *H. chrysoscelis/versicolor*, and *P. triseriata* (Table 1).

We sampled *R. clamitans* and *R. pipiens* at 11 of the same sites in 2007. *Bd* was detected on *R. clamitans,* but not *R. pipiens*, at six of those sites, and on both species at one other. *Bd* was not detected on either species at the remaining four sites (Table 1).

Our results provide the first baseline information we know of on the detection of *Bd* at our study sites and add to the sparse published *Bd* data for the north-central U.S. (Green et al. 2002; Ouellet et al. 2005; Spatialepidemiology.net/Bd-Maps 2009; Loda and Otis 2009). Although detection varied with year, site, and species, our results are similar to the relatively widespread distribution and variable detection reported for other regions in the U.S. and around the world (Ouellet et al. 2005; Longcore et al. 2007; Pearl et al. 2007; Spatialepidemiology.net/Bd-Maps 2009; Loda and Otis 2009). Our results also support previously reported observations that *Bd* detection can be a function of the species sampled (e.g., Retallick et al. 2004; Ouellet et al. 2005; Longcore et al. 2007; Pearl et al. 2007).

Other researchers have demonstrated *Bd* detection was greater

TABLE 1. Relative quantities of *Batrachochytrium dendrobatidis* (*Bd*) detected on swabs of recent metamorphs by species, year, area, and site in the north-central United States. Ac = *Acris crepitans*, Rcl = *Rana clamitans*, Rp = *R. pipiens*, Rse = *R. septentrionalis*, Ba = *Bufo americanus*, Hc/v = *Hyla chrysoscelis—versicolor* complex, Pt = *Pseudacris triseriata*, Rca = *R. catesbeiana*, and Rsy = *R. sylvatica*. Each number represents the relative quantity of *Bd* DNA detected in the extracts from ten pooled swabs (one swab per individual), unless noted as a different pooled number of swabs via a superscripted number in parentheses. 0 = not detected, 1 = weak positive signal, 2 = positive signal, 3 = strong positive signal, and 4 = very strong positive signal, as reported to us by Pisces Analytical LLC. These different signal strengths represent different relative quantities of *Bd* DNA present in samples (based upon comparisons of results using the 45-cycle, single-round, PCR amplification method used here with results from quantitative PCR; J. Wood, Pisces Molecular LLC; pers. comm.). VNP = Voyageurs National Park; SC = the St. Croix National Scenic Riverway; UMR = the Upper Mississippi River National Wildlife and Fish Refuge; swWI = southwestern Wisconsin; nIA = northern Iowa.

Area & Site	Species and Year Sampled												
	Ac		Rcl		Rp		Rse		Ba	Hc/v	Pt	Rca	Rsy
	2006	2007	2006	2007	2006	2007	2006	2007	2007	2007	2007	2007	2007
VNP													
1DB1	—	—	—	—	—	—	—	—	—	0,0,0	—	—	—
2DF1	—	—	4,4	3	—	—	4,4	3,4,4	—	—	—	—	—
3DAI1	—	—	—	—	—	0,0,0	—	0,0,0	—	0(1)	—	—	0,0,3
3DC1	—	—	—	—	—	—	0,4	0,0,2	—	—	—	—	—
4DC1	—	—	0,3	2,2,3	—	0(7)	3,4	3,3,4	—	—	—	—	—
4DC2	—	—	—	—	—	—	—	—	—	—	—	—	2,2,3
5DA1/2	—	—	—	—	—	—	4,4	2,4,4	—	—	—	—	—
7DE1	—	—	—	—	0,0	0,0,0	—	—	—	0,0,0	—	—	0,0,3
8DB1	—	—	—	—	—	—	0(1)	—	—	—	—	—	—
8DC1	—	—	—	—	—	0,0,0	—	—	—	—	—	—	0,0,4
8DC3	—	—	—	—	—	—	4,4	—	—	—	—	—	—
9DBI1	—	—	—	—	—	—	—	—	—	0	—	—	—
10DC1		—	—	—	—	—	—	—	—	0,0,0	—	—	—
11DA1	—	—	0,2	0,0(1)	—	0(9)	—	—	—	—	—	—	—
11DB4	—	—	3(1)	—	—	0,2,4	4,4	4	—	—	—	—	—
SC													
1DA1	—	—	3,4	0,0,0	—	0,0,0	—	—	—	—	—	—	—
1DE1	—	—	—	0,0,0	—	—	—	—	—	—	—	—	—
2DB1	—	—	—	0,0,0	—	—	—	—	—	—	—	—	—
2DD2	—	—	3,4	0,0,3	—	—	—	—	—	—	—	—	0,0,2
4DA3	—	—	—	0,3,3	—	—	—	—	—	—	—	—	0,0,0
4DB1	—	—	—	0,3,3	—	—	—	—	—	—	—	—	—
4DB2	—	—	2,2	—	—	—	—	—	—	—	—	—	—
4DB9	—	—	—	—	—	—	—	—	—	—	0,0,0	—	0,0,0
4DBI2	—	—	—	—	—	—	—	—	—	—	0,0,0	—	0,0,0
4DC1	—	—	2,4	—	—	—	—	—	—	—	—	—	0,0,3
4DCI2	—	—	—	—	—	—	—	—	—	0,0,0	—	—	—
8DB1	—	—	4,4	—	—	—	—	—	—	—	—	—	—
10DC1	—	—	1,3	—	—	—	—	—	—	—	—	—	—
12DB1	—	—	3,4	0,3,3	0,0	0,0,0	—	—	—	—	—	—	—
12DC1	—	—	—	2,3,3	—	—	—	—	—	—	—	—	—
12DE1	—	—	0,2	0,0,2	—	—	—	0(5),2	—	—	—	—	—
UMR													
P4DA1	—	—	—	0,0(3)	0,0	0,0,0	—	—	—	—	—	—	—
P4DA2	—	—	—	0,3,3	—	—	—	—	—	—	—	—	—
P4DC1	—	—	—	0,0,0	—	0,0,0	—	—	—	—	—	—	—
P4DD1	—	—	—	3,4,4	0,3	0,0,4	—	—	—	—	—	—	—
P7DAI1	—	—	—	2,3,3	—	—	—	—	0,0,0	—	—	—	—
P7DE3	—	—	—	0,2,3	—	0,0,0	—	—	—	—	—	—	—
P7DH1	—	—	—	0,3,4	—	0,0,0	—	—	—	—	—	—	—
P8DB1	—	—	—	3,3,4	0,0	0,0,0	—	—	—	—	—	—	—
P8DG1	—	—	—	—	0,0	0,0,3	—	—	—	—	—	—	—

TABLE 1. Continued.

Area & Site	Species and Year Sampled												
	Ac		Rcl		Rp		Rse		Ba	Hc/v	Pt	Rca	Rsy
	2006	2007	2006	2007	2006	2007	2006	2007	2007	2007	2007	2007	2007
UMR													
P10DA3	—	—	—	0,0,2	—	—	—	—	—	—	—	—	—
P10DA4	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
P10DB3	—	—	—	4	—	0,0,0	—	—	—	—	—	—	—
P10DB4	—	—	—	—	0,0	—	—	—	—	—	—	—	—
P10DD1	—	—	—	—	0,0	0,0,0	—	—	—	—	—	—	—
P13DA1	—	—	—	—		0,0,0	—	—	—	—	—	—	—
P13DA4	—	—	—	—	0,0	—	—	—	—	—	—	—	—
P13DA6	—	—	—	—	—	—	—	—	—	—	—	0[(5)]	—
P13DB3	—	—	—	—	0,2	0,0,0	—	—	—	—	—	—	—
P14DA1	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
P14DB2	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
P14DC1	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
swWI													
CP	0,0	—	—	—	—	—	—	—	—	—	—	—	—
MP	0,0	—	—	—	—	—	—	—	—	—	—	—	—
RG	0,0	—	—	—	—	—	—	—	—	—	—	—	—
TV	0,0	—	—	—	—	—	—	—	—	—	—	—	—
nIA													
A1WRP04	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A1WRP05	—	0,0,0	—	—	—	—	—	—	—	—	—	—	—
A2WRP01	—	0,0,0	—	—	—	—	—	—	—	—	—	—	—
A2WRP07	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A3WRP02	—	—	—	—	—	—	—	—	—	—	—	0,2,2	—
A3WRP03	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A4WRP04	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A4WRP05	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A5WRP02	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A5WRP05	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A6WRP04	—	0,0,0	—	—	—	—	—	—	—	—	—	—	—
A6WRP07	—	0,0,0	—	—	—	—	—	—	—	—	—	—	—
A7SITE05	—	—	—	—	—	0	—	—	—	—	—	—	—
A7WRP03	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A7WRP05	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A8WRP01	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A8WRP05	—	0,0	—	—	—	0,0,0	—	—	—	—	—	—	—
A9WRP01	—	—	—	—	—	0,0,0	—	—	—	—	—	—	—
A9WRP04	—	—	—	—	—	0,2,2	—	—	—	—	—	—	—

on more aquatic species, including several of the species we sampled (e.g., Retallick et al. 2004; Ouellet et al. 2005; Longcore et al. 2007; Pearl et al. 2007). For example, we did not detect *Bd* in relatively small samples of *B. americanus*, *H. chrysoscelis/versicolor*, *P. triseriata*, and *A. crepitans* and we detected it infrequently on *R. pipiens*. These results were similar to those from previous studies showing lower detections or infections in these less-aquatic species (Ouellet et al. 2005; Longcore et al. 2007). As possible further support for such observations, we also detected *Bd* less often on *R. pipiens* than on *R. clamitans* sampled from the same sites. Rollins-Smith and Conlon (2005) demonstrated that *R. pipiens* produces skin peptides that confer *Bd* resistance. This might or might not have affected our detections of *Bd* on *R. pipiens* in this study. Our detections of *Bd* on the largely terrestrial *R. sylvatica* from six of nine sites ran counter to the trend of lower detections on less aquatic species and is a higher frequency than reported previously for this species (Ouellet et al. 2005; Longcore et al. 2007; Reeves 2008). All told, because of variance in detection among species, limited sample sizes, and because we were not able to sample species with apparent higher detection rates, such as *R. clamitans* or *R. septentrionalis*, across all sites, we cannot conclude *Bd* was not present at sites where

we did not detect it. This is especially true for northern Iowa, where we sampled only *A. crepitans* and *R. pipiens* at 18 of the 19 sites, and southwestern Wisconsin, where we sampled only *A. crepitans* at all four sites.

We have conducted call and/or visual-encounter surveys at these breeding sites and many others since 2002 as part of the U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) in ARMI's Midwest Region. While we cannot speak to trends in the demographics of any of these populations or breeding subpopulations, we observed most of the species we expected to be present during our surveys. An exception has been *A. crepitans*, which we did not observe at many potential breeding sites and is known to have declined throughout the northern portion of its range, including much of the area in Iowa we report on here. In addition to observing most of the expected species, we rarely have observed dead postmetamorphic amphibians, although this is not unusual in association with chytridiomycosis (Skerratt et al. 2007). *Rana clamitans* and *R. septentrionalis* from four of the Voyageurs sites we report on here had clinical chytridiomycosis in previous years (D. E. Green, pers. comm.), but we did not observe live animals displaying any behavioral symptoms of chytridiomycosis (Berger et al. 1999) at these sites or elsewhere. Thus, based upon all of our observations, we have no evidence of dramatic recent population declines associated with any of these *Bd* detections, similar to what others have stated for other regions (e.g., Longcore et al. 2007). Clearly, however, we lack a substantive understanding of amphibian population dynamics in relation to *Bd* presence and chytridiomycosis at these sites to comment on this meaningfully. More intensive studies are necessary to understand any impacts of *Bd* exposure on amphibian populations in this region.

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Literature Cited

Annis, S. L., F. D. Dastoor, H. Ziel, P. Daszak, and J. E. Longcore. 2004. A DNA-based assay identifies *Batrachochytrium dendrobatidis* in amphibians. J. Wildl. Dis. 40:420–428.

Berger, L., R. Speare, and A. D. Hyatt. 1999. Chytrid fungi and amphibian declines: overview, implications and future directions. *In* A. Campbell (eds.), Declines and Disappearances of Australian Frogs, pp. 23–33. Environment Australia. Canberra, Australia.

Bielby, J., N. Cooper, A. A. Cunningham, T. W. J. Garner, and A. Purvis. 2008. Predicting susceptibility to future declines in the world's frogs. Conserv. Let. 1:82–90.

Corn, P. S. 2007. Amphibians and disease: Implications for conservation in the Greater Yellowstone Ecosystem. Yellowstone Sci. 15:11–16.

Fellers, G. M., D. E. Green, and J. E. Longcore. 2001. Oral chytridiomycosis in the mountain yellow-legged frog. Copeia 2001:945–953.

Frías-Alvarez, P., V. T. Vredenburg, M. Familiar-López, J. E. Longcore, E. González-Bernal, G. Santos-Barrera, L. Zambrano, and G. Parra-Olea. 2008. Chytridiomycosis survey in wild and captive Mexican amphibians. EcoHealth 5:18–26.

Green, D. E., K. A. Converse, and A. K. Schrader. 2002. Epizootiology of sixty-four amphibian morbidity and mortality events in the USA, 1996-2001. Ann. New York Acad. Sci. 969:323–339.

Harris, R. N., R. M. Brucker, J. B. Walke, M. H. Becker, C. R. Schwantes, D. C. Flaherty, B. A. Lam, D. C. Woodhams, C. J. Briggs, V. T. Vredenburg, and K. P. C. Minbiole. 2009. Skin microbes on frogs prevent morbidity and mortality caused by a lethal skin fungus. Int. Soc. Microb. Ecol. J. 3:818–824.

Herrera, R. A., M. M. Steciow, and G. S. Natale. 2005. Chytrid fungus parasitizing the wild *Leptodactylus ocellatus* (Anura: Leptodactylidae) in Argentina. Dis. Aquat. Org. 64:247–252.

Kriger, K. M., and J. M. Hero. 2006. Survivorship in wild frogs infected with chytridiomycosis. EcoHealth 3:171–177.

Lips, K. R., F. Brem, R. Brenes, J. D. Reeve, R. A. Alford, J. Voyles, C. Carey, L. Livo, A. P. Pessier, and J. P. Collins. 2006. Emerging infectious disease and the loss of biodiversity in a Neotropical amphibian community. Ecology 103:3165–3170.

———, J. Diffendorfer, J. R. Mendelson III, and M. W. Sears. 2008. Riding the wave: Reconciling the roles of disease and climate change in amphibian declines. PLoS Biol. 6:441–454.

Livo, L. J. 2004. Methods for obtaining *Batrachochytrium dendrobatidis* (*Bd*) samples for PCR testing. *In* K. B. Rogers (ed.), Boreal Toad Research Report, pp. 64–68. Colorado Department of Natural Resources, Division of Wildlife. Denver, Colorado.

Loda, J. L., and D. L. Otis. 2009. Low prevalence of amphibian chytrid fungus (*Batrachocytrium dendrobatidis*) in northern leopard frog (*Rana pipiens*) populations of north-central Iowa, USA. Herpetol. Rev. 40:428–431.

Longcore, J. R., J. E. Longcore, A. P. Pessier, and W. A. Halteman. 2007. Chytridiomycosis widespread in anurans of northeastern United States. J. Wildl. Manage. 71:435–444.

Morgan, J. A. T., V. T. Vredenburg, L. J. Rachowicz, R. A. Knapp, M. J. Stice, T. Tunstall, R. E. Bingham, J. M. Parker, J. E. Longcore, C. Moritz, C. J. Briggs, and J. W. Taylor. 2007. Population genetics of the frog-killing fungus *Batrachochytrium dendrobatidis*. Proc. Nat. Acad. Sci. USA 104:13845–13850.

Ouellet, M., I. Mikaelian, B. D. Pauli, J. Rodrigues, and D. M. Green. 2005. Historical evidence of widespread chytrid infection in North American amphibian populations. Conserv. Biol. 19:1431–1440.

Pearl, C. A., E. L. Bull, D. E. Green, J. Bowerman, M. J. Adams, A. Hyatt, and W. H. Wente. 2007. Occurrence of the amphibian pathogen *Batrachochytrium dendrobatidis* in the Pacific Northwest. J. Herpetol. 41:145–149.

Rachowicz L. J., J. M. Hero, R. A. Alford, J. W. Taylor, J. A. T. Morgan, V. T. Vredenburg, J. P. Collins, and C. J. Briggs. 2006. The novel and endemic pathogen hypotheses: competing explanations for the origin of emerging infectious diseases of wildlife. Conserv. Biol. 19:1441–1448.

Retallick, R. W. R., H. McCallum, and R. Speare. 2004. Endemic infection of the amphibian chytrid fungus in a frog community post-decline. PLoS Biol 2:1965–1971.

Reeves, M. K. 2008. *Batrachocytrium dendrobatidis* in wood frogs (*Rana sylvatica*) from three national wildlife refuges in Alaska, USA. Herpetol. Rev. 39:68–70.

Rollins-Smith, L. A., and J. M. Conlon. 2005. Antimicrobial peptide defenses against chytridiomycosis, an emerging infectious disease of amphibian populations. Devel. Comp. Immun. 29589–598.

Skerratt, L. F., L. Berger, R. Speare, S. Cashins, K. R. McDonald, A. D. Phillott, H. B. Hines, and N. Kenyon. 2007. Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. EcoHealth 4:125–134.

Spatialepidemiology.net/Bd-Maps. 2009. *Batrachochytrium dendro-*

batidis. http://www.spatialepidemiology.net/bd-maps/. Accessed 26 October 2009.

VOYLES, J., S. YOUNG, L. BERGER, C. CAMPBELL, W. F. VOYLES, A. DINUDOM, D. COOK, R. WEBB, R. A. ALFORD, L. F. SKERRATT, AND R. SPEARE. 2009. Pathogenesis of chytridiomycosis, a cause of catastrophic amphibian declines. Science 326:582-585.

WAKE, D. B., AND V. T. VREDENBURG. 2008. Are we in the midst of the sixth mass extinction? A view from the world of amphibians. Proc. Nat. Acad. Sci. USA 105:11466–11473.

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Occurrence of the Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*) in Ozark Caves, Missouri, USA

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Amphibian chytrid fungus (*Batrachochytrium dendrobatidis*, hereafter *Bd*) has been documented in a variety of species and habitats across North America, although the full extent of its faunal and geographic distribution is not yet known (Adams et al. 2007; Briggler et al. 2008; Longcore et al. 2007; Ouellet et al. 2005; Pearl et al. 2007; Reeves and Green 2006). To our knowledge, no surveys for the presence of this fungal pathogen have been published on cave amphibian populations. Missouri contains 6200 caves and 927 documented species (Elliott 2007) with eight amphibian species commonly inhabiting Ozark caves and one salamander that is cave restricted (Sutton 1993). The goal of this study was to test for the presence of *Bd* among multiple amphibian taxa found in caves across the lower Missouri Ozarks.

From November 2007 to October 2008 we tested 35 adult and larval amphibians from 12 caves in 5 counties in the Missouri Ozarks for *Bd*. Adults and some larvae were tested for *Bd* by swabbing a cotton-tipped wooden shaft applicator over the ventral surface of each foot, the back, the abdomen, and around the thigh and vent area. The wooden tip end of the applicator was first lightly rubbed on these surfaces followed by the cotton end of the applicator. Both wooden and cotton tip were broken off and placed in a 2.0 ml screw-cap tube with 1 ml of 70% ethanol. Larval salamanders that were too small to swab effectively were collected and placed in a 2.0-ml screw-cap tube with 1 ml of 70% ethanol. All samples were shipped to Pisces Molecular, Boulder, Colorado, for PCR (polymerase chain reaction) assay.

Of the 35 individuals sampled in this study, 11 were infected with *Bd*. Positive *Bd* test results were detected from at least one cave in all 5 counties tested (Fig. 1; Table 1). Adult animals comprised the bulk of our sampling (29 of 35 individuals sampled). Ten adult samples showed positive *Bd* test results. Of the six larval salamander samples collected, one larval *Eurycea spelaea* (Grotto Salamander) tested positive for *Bd*, which is of interest as there are few documented cases of *Bd* in larval salamanders (Brodman and Briggler 2008). Although we tested both salamander and anuran species for *Bd*, more salamander species were tested and *Bd* was more prevalent among anurans; 20% of anurans tested positive for *Bd* while only 11.4% of salamanders tested positive ($\chi^2 = 9.37$; df = 1; P = 0.002). *Bd* samples were collected from amphibians classified as trogloxenes (species that use caves but cannot complete their life cycle entirely within a cave), troglophiles (species that can complete their life cycle within a cave but are also widely seen above ground), and troglobites (species that are cave obligates) (Table 1). The majority of samples were collected from troglophiles (60.0%); trogloxenes, which comprised 25.0% of our samples, showed the highest percent of *Bd* infection (17.1%), followed by troglophiles (11.4%) and troglodytes (2.9%).

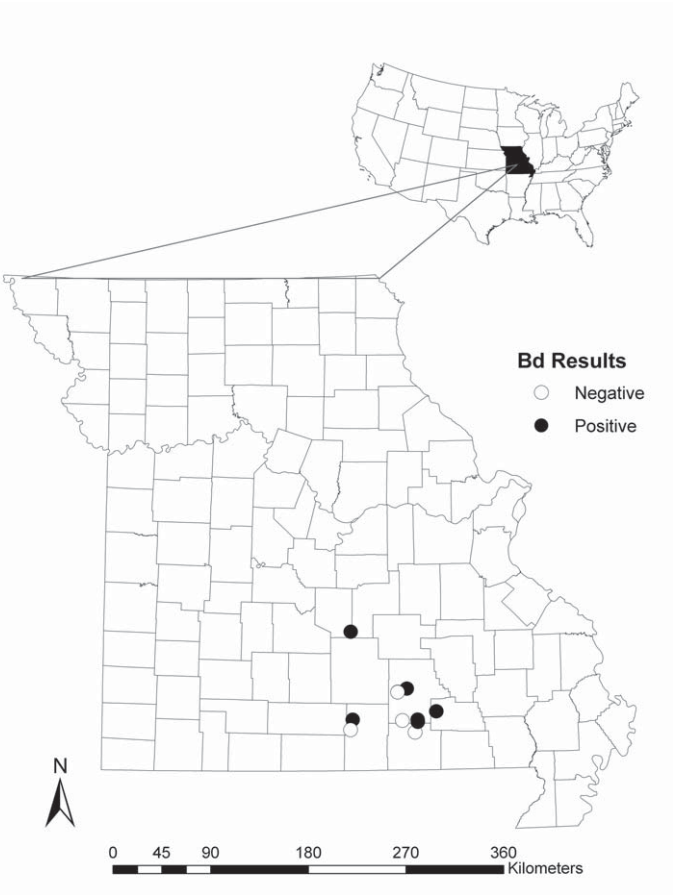

FIG. 1. Cave locations surveyed for *Batrachochytrium dendrobatidis* (*Bd*). Open circles indicate caves where all samples were negative for *Bd*, while closed circles indicate caves that had at least one positive *Bd* test. Proximity of caves led to overlap of symbols for three locations.

Bd grows and reproduces at temperatures of 4–25ºC with maximal growth at 17–25ºC (Piotrowski et al. 2004). The thermal environment of the Ozark caves in this study, while not ideal, is suitable for *Bd* growth with average water temperatures of 11.6ºC.

In this study, anurans were infected with *Bd* in higher proportions than were salamanders, although our relatively modest sample size may not accurately reflect *Bd* prevalence. *Lithobates palustris*, which comprised the bulk of our anuran *Bd* samples, typically seek caves for refuge from hot weather during summer and from cold temperatures during winter, exiting for periods to breed and feed

TABLE 1. Locations and associated species data for all amphibians tested for *Batrachochytrium dendrobatidis* in caves in Missouri, USA. MSS Cave ID = Missouri Speleological Survey cave identification number; TX = trogloxene; TP = troglophile; TB = troglobite; T-R = Township and Range of legal description for cave location.

MSS Cave ID	County	Species	Life Stage	Results	Date	Eco Type	T-R
CTR032	Carter	*Eurycea spelaea*	Adult	Negative	10-Jan-08	TB	27N 2W
CTR033	Carter	*Eurycean spelaea*	Adult	Negative	10-Jan-08	TB	27N 2W
CTR033	Carter	*Eurycea spelaea*	Adult	Negative	10-Jan-08	TB	27N 2W
CTR033	Carter	*Eurycea spelaea*	Larvae	Positive	10-Jan-08	TB	27N 2W
CTR033	Carter	*Lithobates catesbeianus*	Adult	Positive	10-Jan-08	TP	27N 2W
HWL037	Howell	*Eurycea spelaea*	Larvae	Negative	8-Jan-08	TB	26N 10W
HWL037	Howell	*Lithobates palustris*	Adult	Positive	8-Jan-08	TX	26N 10W
HWL037	Howell	*Lithobates palustris*	Adult	Positive	8-Jan-08	TX	26N 10W
HWL023	Howell	*Eurycea longicauda*	Larvae	Negative	27-Feb-08	TP	25N 10W
HWL023	Howell	*Eurycea longicauda*	Adult	Positive	27-Feb-08	TP	25N 10W
HWL023	Howell	*Eurycea longicauda*	Larvae	Negative	27-Feb-08	TP	25N 10W
HWL023	Howell	*Eurycea longicauda*	Larvae	Negative	27-Feb-08	TP	25N 10W
HWL023	Howell	*Eurycea longicauda*	Larvae	Negative	27-Feb-08	TP	25N 10W
ORE014	Oregon	*Lithobates palustris*	Adult	Positive	9-Nov-07	TX	25N 4W
ORE014	Oregon	*Eurycea longicauda*	Adult	Negative	9-Nov-07	TP	25N 4W
ORE014	Oregon	*Eurycea longicauda*	Adult	Negative	9-Nov-07	TP	25N 4W
PUL010	Pulaski	*Eurycea lucifuga*	Adult	Negative	15-Oct-08	TP	34N 10W
PUL010	Pulaski	*Eurycea lucifuga*	Adult	Negative	15-Oct-08	TP	34N 10W
PUL010	Pulaski	*Eurycea longicauda*	Adult	Negative	15-Oct-08	TP	34N 10W
PUL010	Pulaski	*Lithobates palustris*	Adult	Negative	15-Oct-08	TX	34N 10W
PUL010	Pulaski	*Lithobates palustris*	Adult	Positive	15-Oct-08	TX	34N 10W
PUL010	Pulaski	*Eurycea longicauda*	Adult	Positive	15-Oct-08	TP	34N 10W
SHN578	Shannon	*Lithobates palustris*	Adult	Negative	13-Nov-07	TX	29N 4W
SHN578	Shannon	*Eurycea longicauda*	Adult	Positive	13-Nov-07	TP	29N 4W
SHN328	Shannon	*Eurycea lucifuga*	Adult	Negative	27-Nov-07	TP	26N 4W
SHN328	Shannon	*Eurycea longicauda*	Adult	Negative	27-Nov-07	TP	26N 4W
SHN328	Shannon	*Lithobates palustris*	Adult	Positive	27-Nov-07	TX	26N 4W
SHN281	Shannon	*Plethodon serratus*	Adult	Negative	6-Dec-07	TP	26N 4W
SHN281	Shannon	*Eurycea longicauda*	Adult	Negative	6-Dec-07	TP	26N 4W
SHN281	Shannon	*Lithobates catesbeianus*	Adult	Positive	6-Dec-07	TX	26N 4W
SHN591	Shannon	*Plethodon albagula*	Adult	Negative	24-Sep-08	TP	29N 6W
SHN591	Shannon	*Eurycea lucifuga*	Adult	Negative	24-Sep-08	TP	29N 6W
SHN591	Shannon	*Eurycea lucifuga*	Adult	Negative	24-Sep-08	TP	29N 6W
SHN589	Shannon	*Eurycea lucifuga*	Adult	Negative	24-Sep-08	TP	29N 6W
SHN588	Shannon	*Lithobates palustris*	Adult	Negative	26-Sep-08	TX	26N 5W

(Johnson 2000; Prather and Briggler 2001; Resetarits 1986). This life history trait may help to explain the prevalence of *Bd* among the anurans in our samples and also to explain a possible transport mechanism of *Bd* in cave systems. Similarly, trogloxenes had the highest overall rates of *Bd* infection is this study when compared to troglophiles and troglodytes. As with *Lithobates palustris*, which is a trogloxene ecotype, trogloxene species tend to be very mobile and will spend a large amount of time outside of the cave during different life stages or seasons (Briggler and Prather 2006; Mittleman 1950; Petranka 1998). This behavior may serve to move *Bd* into, out of, and among different caves. However, in the Lower Missouri Ozarks, streams, creeks, caves, and springs in watersheds are connected by a system of karst (Elliott 2005) and presence of *Bd* among aquatic hellbenders throughout the Ozarks (Briggler et al. 2008) has been well documented. The karst system itself also may be serving as a conduit to spread *Bd* throughout watersheds and among caves throughout this region.

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care guidelines and appropriate permits were obtained.

Literature Cited

Adams, M. J., S. Galvan, D. Reinitz, R. A. Cole, S. Pyare, M. Hahr, and P. Govindarajulu. 2007. Incidence of the fungus *Batrachochytrium dendrobatidis* in amphibian populations along the northwest coast of North America. Herpetol. Rev. 38:430–431.

Briggler, J. T., K. A. Larson, and K. J. Irwin. 2008. Presence of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) on hellbenders (*Cryptobranchus alleganiensis*) in the Ozark Highlands. Herpetol. Rev. 39:443–444.

———, and J. W. Prather. 2006. Seasonal use and selection of caves by plethodontid salamanders in a karst area of Arkansas. Am. Midl. Nat. 155:136–148.

Brodman, R., and J. T. Briggler. 2008. *Batrachochytrium dendrobatidis* in *Ambystoma jeffersonianum* larvae in southern Indiana. Herpetol. Rev. 39:320–321.

Elliott, W. R. 2005. Caves and karst. *In* P. W. Nelson, The Terrestrial Natural Communities of Missouri, pp. 475–491. The Missouri Natural Areas Committee, Jefferson City, Missouri.

———. 2007. Zoogeography and biodiversity of Missouri caves and karst. J. Cave Karst Stud. 69:135–162.

Johnson, T. R. 2000. The Amphibians and Reptiles of Missouri. 2nd ed. Missouri Department of Conservation, Jefferson City, Missouri. 400 pp.

Longcore, J. R., J. E. Longcore, A. P. Pessier, and W. A. Halteman. 2007. Chytridiomycosis widespread in anurans of northeastern United States. J. Wildl. Manage. 71:435–444.

Mittleman, M. B. 1950. Cavern-dwelling salamanders of the Ozark Plateau. Bull. Natl. Speleol. Soc. 12:12–15.

Ouellet, M., I. Mikaelian, B. D. Pauli, J. Rodrigue, and D. M. Green. 2005. Historical evidence of widespread chytrid infection in North American amphibian populations. Conserv. Biol. 19:1431–1440.

Pearl, C. A., E. L. Bull, D. E. Green, J. Bowerman, M. J. Adams, A. Hyatt, and W. H. Wente. 2007. Occurrence of the amphibian pathogen *Batrachochytrium dendrobatidis* in the Pacific Northwest. J. Herpetol. 41:145–149.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.

Piotrowski, J. S., S. L. Annis, and J.E. Longcore. 2004. Physiology of *Batrachochytrium dendrobatidis*, a chytrid pathogen of amphibians. Mycologia 96:9–15.

Prather, J. W., and J. T. Briggler. 2001. Use of small caves by anurans during a drought period in the Arkansas Ozark. J. Herpetol. 35:675–678.

Reeves, M. K., and D. E. Green. 2006. *Rana sylvatica* (wood frog) chytridiomycosis. Herpetol. Rev. 37:450.

Resetarits, J. W., Jr. 1986. Ecology of cave use by the frog *Rana palustris*. Am. Midl. Nat. 116:256–266.

Sutton, M. R. 1993. Caves and cave wildlife in a mineral prospecting area, Oregon and Shannon counties, Missouri. J. Missouri Speleol. Soc. 33:1–138.

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The Presence of *Ranavirus* in Anuran Populations at Itasca State Park, Minnesota, USA

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Viruses in the genus *Ranavirus* are implicated as a possible contributing factor to global amphibian declines (Daszak et al. 1999). Previous studies have associated ranaviruses with mass amphibian die–offs throughout North America (Chinchar 2002 Greer et al. 2005; Williams et al. 2005) including Minnesota, USA (Green et al. 2002; Vandenlangenberg et al. 2003). However, it is unclear whether ranavirus infections exist in wild anuran populations without causing die-offs. This study investigates the presence of ranavirus in six anuran species at the headwaters of the Mississippi River in Itasca State Park, Minnesota, USA.

Methods.—We collected recently metamorphosed and adult frogs and toads by hand and with nets from twenty-six sites in Itasca State Park, Clearwater County, Minnesota (47.2397°N, 95.2075°W) in June and July 2009. Sites were chosen for maximum species diversity and for accessibility. There have been no reports of mass amphibian die-offs in the park, which has been the site of a University of Minnesota field station since 1909 (D. Biesboer, pers. comm., 30 July 2009; C. Handrick, pers. comm., 3 Aug 2009). Both field-based and lab-based courses are taught during summer months and there are few places in the state that have had such a consistent and thorough presence of biologists during peak periods of amphibian activity. This steady stream of students and faculty provides some level of confidence that amphibian die-offs will be observed and reported. That said, there is no guarantee that amphibian die-offs, particularly of aquatic larvae, went unobserved.

To minimize contamination among sites, nets and waders were rinsed with 5% bleach solution between collecting events. Captured frogs were kept individually in separate plastic bags. Individuals were classified as either young-of-the-year (YOY) or adults by comparing their snout-vent length to published sizes of adult frogs (Oldfield and Moriarty 1994; Wright and Wright 1995). Frogs were returned to the laboratory and humanely euthanized with MS-222 (tricaine methanesulfonate) (Simmons 2002). Liver samples were stored in RNAlater (Ambion, Austin, Texas, USA) or 99% ethanol at 4°C until processing. Vouchers were deposited in the Bell Museum of Natural History, University of Minnesota (JFBM).

We used disposable razor blades to subsample between 15–30 mg of liver tissues for DNA extraction using the Qiagen DNeasy Blood and Tissue Kit (Qiagen, Valencia, California, USA) follow-

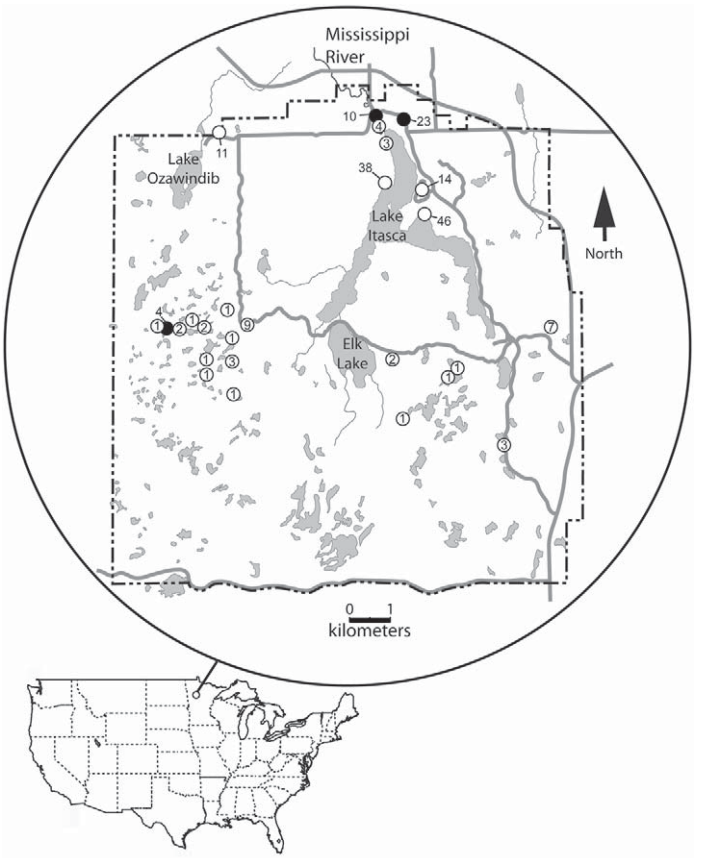

FIG. 1. Collecting locations (circles) of anurans screened for ranavirus at Itasca State Park, Minnesota, USA. Numbers reflect sample size at each site. Sites with ranavirus positive specimens indicated by filled circles, localities with no ranavirus positive specimens indicated by open circles. Park boundaries shown by a dashed line. Light gray areas are water.

ing the manufacturer's protocol. We screened DNA for the presence of ranavirus using polymerase chain reaction (PCR) to amplify a highly conserved ~500-bp fragment of the ranavirus major capsid protein (MCP) using the MCP4 and MCP5 primers (Mao et al. 1997). PCR was carried out in 12.5 μl volumes using conditions described by Greer et al. (2005) and the product visualized by gel electrophoresis on 1% agarose gels stained with ethidium bromide. We ran negative (water in place of genomic DNA) and positive controls (DNA extracted from a specimen verified to be ranavirus positive) with each PCR reaction.

All positive samples were verified by sequencing using Big Dye terminator cycle sequencing on an ABI 3730xl at the Advanced Genetic Analysis Center, University of Minnesota. Sequences were identified as ranavirus using BLAST (Altschul et al. 1990). We gel-purified the positive PCR product from *L. pipiens* prior to sequencing using 3% agarose due to the presence of some non-specific PCR products. Positive PCR products of *L. sylvatica* were purified using Exonuclease I and Shrimp Alkaline Phosphatase (Hanke and Wink 1994).

Results.—We collected and tested 191 YOY and adult frogs of six different species. Four individuals (2%) from two species tested positive for ranavirus (Table 1): three *Lithobates sylvatica* (JFBM 16793, 16923, and 17116) and one *Lithobates pipiens* (JFBM 16932). Four frog species, *Lithobates septentrionalis*, *Pseudacris crucifer, Hyla versicolor*, and *Anaxyrus americanus,* had no positive samples. We captured infected frogs from three different sites within Itasca State Park (Fig. 1); the infected *L. pipiens* shared a site with one of the infected *L. sylvatica* (JFBM 17116). One *L. sylvatica* (JFBM 17116) and the infected *L. pipiens* were adults while the two remaining *L. sylvatica* were recent YOY. Aside from one dead ranavirus-negative *L. pipiens* (cause of death undetermined), all specimens appeared healthy at the time of capture.

DNA sequences (Genbank accession # GQ856477) from the four infected individuals were identical to each other and to other Frog Virus 3 (FV3) sequences from infected North American amphibians (Genbank FJ459783, GQ144408, FJ601916, AY548484, and U36913) and the *Terrapene* Virus 3 (TV3) sequence (U82553) from a turtle (Mao et al. 1997).

Discussion.—FV3 was originally isolated from a Northern Leopard Frog (*L. pipiens*) collected from Minnesota or Wisconsin, and proved to be fairly benign in metamorphosed amphibians in laboratory experiments (Granoff et al. 1966; Tweedell and Granoff, 1968; see Williams et al. 2005 for historical review), but since then, amphibian ranaviruses have been primarily associated with mortality events, especially in larval amphibians (Gray et al. 2009, but see Gray et al. 2007). The presence of ranavirus in apparently healthy metamorphosed frogs at Lake Itasca State Park, an area with no reported amphibian die-offs, suggests that die-offs may not be an inevitable outcome of ranavirus infections and that ranavirus may be more common than previously thought.

There are several possible explanations for our observations of ranavirus in the absence of large-scale mortality events. These include: genetic resistance in these anuran populations (Green et al. 2002; Pearman et al. 2004; Teacher et al. 2009); a less virulent strain of FV3-like virus; the absence of some environmental conditions necessary to cause mass die-offs (Gahl and Calhoun 2008; Greer et al. 2005); or that die-offs occurred but went unnoticed or unreported, particularly since mortality in early, aquatic life history stages would be difficult to observe.

TABLE 1. Ranavirus infections in six frog species collected in Itasca State Park, Minnesota, USA, in 2009.

Species	Family	Adults positive / tested	YOY positive / tested	All individuals positive / tested	Prevalence in all individuals (95% CI)
Lithobates sylvatica	Ranidae	1/21	2/47	3/68	4.4 (2.01–12.69)
Lithobates pipiens	Ranidae	1/68	—	1/68	1.5 (0.01–8.63)
Lithobates septentrionalis	Ranidae	0/27	—	0/27	0 (0–10.85)
Pseudacris crucifer	Hylidae	0/3	0/2	0/5	0 (0–40.10)
Hyla versicolor	Hylidae	0/7	0/2	0/9	0 (0–26.93)
Anaxyrus americanus	Bufonidae	0/3	0/11	0/14	0 (0–19.08)

Other studies have confirmed that five of the frog species we examined are susceptible to ranavirus (Duffus et al. 2008; Green et al. 2002). Although the susceptibility of *A. americanus* to ranavirus remains unknown, ranavirus has been identified in other bufonids such as *Anaxyrus fowleri*, *Bufo bufo*, and *Rhinella marina* (Chinchar 2002; Cunningham et al. 2007; Zupanovic et al. 1998). Given our small sample sizes and the potential for false negatives (Greer and Collins 2007), we cannot eliminate the possibility that species we identified as negative were also infected at low levels.

It is important to document the baseline prevalence of ranavirus infections in amphibian populations in order to understand its epidemiology and transmission in wild populations. In much of the ranavirus literature, amphibians are sampled and tested only after or during die-offs. While this response-based sampling is valuable, it offers a skewed estimate of ranavirus prevalence and perhaps virulence in amphibian populations. Future studies should expand the limited documentation of baseline ranavirus levels in randomly-sampled wild populations and also investigate the factors that may cause sublethal infections to become virulent. Such research would allow scientists to better evaluate the causes and consequences of ranavirus infections in amphibian communities.

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Literature Cited

Altschul, S. F., W. Gish, W. Miller, E. W. Myers, and D. J. Lipman. 1990. Basic local alignment search tool. J. Mol. Biol. 215:403–410.

Chinchar, V. G. 2002. Ranaviruses (family Iridoviridae) emerging cold-blooded killers. Arch. Virol. 147:447–470.

Cunningham, A. A., A. D. Hyatt, P. Russell, and P. M. Bennett. 2007. Experimental transmission of a ranavirus disease of common toads (*Bufo bufo*) to common frogs (*Rana temporaria*). Epidemiol. Infect. 135:1213–1216.

Daszak, P., L. Berger, A. A. Cunningham, A. D. Hyatt, D. E. Green, and R. Speare. 1999. Emerging infectious diseases and amphibian population declines. Emerg. Infect. Dis. 5:735–748.

Duffus, A. L. J., B. D. Pauli, K. Wozney, C. R. Brunetti, and M. Berrill. 2008. Frog Virus 3-like infections in aquatic amphibian communities. J.Wildl. Dis. 44:109–120.

Gahl, M. K., and A. J. K. Calhoun. 2008. Landscape setting and risk of *Ranavirus* mortality events. Biol. Cons. 141:2679–2689.

Granoff, A., P. E. Came, and D. C Breeze. 1966. Viruses and renal carcinoma of *Rana pipiens*: 1. The isolation and properties of virus from normal and tumor tissues. Virology 29:133–148.

Gray, M. J., D. L. Miller, J. T. Hoverman. 2009. Ecology and pathology of amphibian ranaviruses. Dis. Aquat. Org. 87:243–266.

———, ———, A. C. Schmutzer, and C. A. Baldwin. 2007. Frog virus 3 prevalence in tadpole populations inhabiting cattle-access and non-access wetlands in Tennessee, USA. Dis. Aquat. Org. 77:97–103.

Green, D. E., K. A. Converse, and A. K. Schrader. 2002. Epizootiology of sixty-four amphibian morbidity and mortality events in the USA, 1996-2001. Ann. New York Acad. Sc. 969:323–339.

Greer, A. L., M. Berrill, and P. J. Wilson. 2005. Five amphibian mortality events associated with ranavirus infection in south central Ontario, Canada. Dis. Aquat. Org. 67:9–14.

———, and J. P. Collins. 2007. Sensitivity of a diagnostic test for amphibian *Ranavirus* varies with sampling protocol. J. Wildl. Dis. 43:525–532.

Hanke, M., and M. Wink. 1994. Direct DNA-sequencing of PCR-amplified vector inserts following enzymatic degradation of primer and dNTPs. BioTechniques 17:858-860.

Mao, J., R. P. Hedrick, and V. G. Chinchar. 1997. Molecular characterization, sequence analysis, and taxonomic position of newly isolated fish Iridoviruses. Virology 229:212–220.

Oldfield, B., and J.J. Moriarty. 1994. Amphibians and Reptiles Native to Minnesota. Univ. Minnesota Press, Minneapolis, Minnesota. 237 pp.

Pearman, P. B., T. W. J. Garner, M. Straub, and U. F. Greber. 2004. Response of the Italian agile frog (*Rana latastei*) to a *Ranavirus*, Frog Virus 3: A model for viral emergence in naïve populations. J. Wildl. Dis. 40:660–669.

Simmons, J. E. 2002. Herpetological Collecting and Collections Management, revised edition. SSAR, Shoreview, Minnesota. 153 pp.

Teacher, A. G. F., T. W. J. Garner, and R. A. Nichols. 2009. Evidence for directional selection at a novel major histocompatibility class I marker in wild common frogs (*Rana temporaria*) exposed to a viral pathogen (*Ranavirus*). PLoS ONE 4:e4616. doi:10.1371/journal.pone.0004616.

Tweedle, K., and A. Granoff. 1968. Viruses and renal carcinoma of *Rana pipiens*. V. Effect of frog virus 3 on developing frog embryos and larvae. J. Natl. Cancer Inst. 40:407–410.

Vandenlangenberg, S. M., J. T. Canfield, and J. A. Magner. 2003. A regional survey of malformed frogs in Minnesota (USA). Environ. Monit. Assess. 82:45–61.

Williams, T., V. Barbosa-Solomieu, and V. G. Chinchar. 2005. A decade of advances in Iridovirus research. Ad. Virus Res. 65:173–248.

Wright, A. H., and A. A. Wright. 1995. Handbook of Frogs and Toads of the United States and Canada. 3rd ed. Comstock Publishing Associates, Ithaca, New York.

Zupanovic, Z., C. Musso, G. Lopez, C. L. Louriero, A. D. Hyatt, S. Hengstberger, and A. J. Robinson. 1998. Isolation and characterization of iridoviruses from the giant toad *Bufo marinus* in Venezuela. Dis. Aquat. Org. 33:1–9.

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Increasing Detections of *Batrachochytrium dendrobatidis* in Central Florida, USA

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The fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) was first detected in Florida, USA in 2008 in one American Bullfrog (*Lithobates catesbeianus*) and in one Florida Cricket Frog *(Acris gryllus dorsalis)* (Rizkalla 2009). Here, I report the results of further testing on 16 amphibian species in Walt Disney World's Wildlife Management and Conservation Area (WMCA) in central Florida.

The WMCA is a network of primarily forested wetlands with interspersed upland spanning 3380 ha in Orange and Osceola counties designed as a buffer area for Reedy Creek and managed by the Reedy Creek Improvement District. The Reedy Creek basin includes a significant portion of the headwaters of the Kissimmee River. Sampling for this study was restricted to the northern portion of the WMCA, centered approximately at 28.39929703°N, 81.60801927°W. A HOBO data logger (Onset Computer Corporation, Bourne, Massachusetts, USA) recorded weather conditions at approximately 28.398159°N, 81.597216°W. Amphibians were captured using plywood coverboards, minnow traps, and during incidental encounters. Thirty-four coverboard arrays were placed 250-m apart with each array checked once a month. Ten minnow traps were placed in canals, a marsh, and a pond for three days each month. Because the first positive bullfrog was found in an exhibit within Disney's Animal Kingdom® Theme Park, we also sampled native anurans found within the water features of many exhibits. Clean disposable gloves were worn when handling each animal.

As described in Rizkalla (2009), live amphibians were swabbed along the ventral surface and legs 25 times with cotton-tipped swabs (Puritan, Guilford, Maine, USA). Swab tips were stored at room temperature in 2-ml screw cap microcentrifuge tubes (Fisher #02-681-343) containing 1 ml of 70% ethanol. The keratinized regions around the mouths of six tadpoles found dead (American Bullfrog and Southern Leopard Frog, *L. sphenocephalus*) were also submitted for analysis. Sample collection occurred from July 2008 – July 2009. Maximum daily temperature during sample days ranged from 15.2–37.9°C. Samples were sent in August 2008, and June, August 2009 to Pisces Molecular (J. Wood, Boulder, Colorado, USA) for analysis using a polymerase chain reaction to detect *Bd* presence (Annis et al. 2004). For this report, 266 samples from 16 species were analyzed.

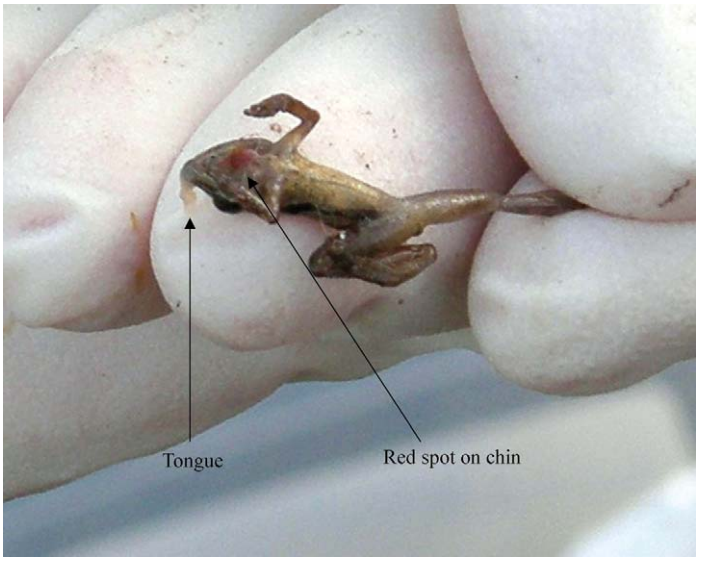

FIG. 1. Symptoms of *Batrachochytrium dendrobatidis* (*Bd*) in a Little Grass Frog (*Pseudacris ocularis*) included lethargy, loss of righting mechanism, a red spot on the chin (arrow), and inability to retract the tongue.

Several species were *Bd*-positive within the WMCA, including five Florida Cricket Frogs, three Greenhouse Frogs (*Eleutherodactylus planirostris*), two Southern Toads (*Anaxyrus terrestris*), and one Little Grass Frog (*Pseudacris ocularis*) (Table 1). Only the Little Grass Frog showed clinical signs of infection. When captured, it appeared lethargic, could not retract its tongue, and had a red spot on its chin (Fig. 1). When released upon swabbing, it did not right itself and died soon after. Infection was also detected in one adult American Bullfrog and one Cuban Treefrog (*Osteopilus septentrionalis*) found within Disney's Animal Kingdom®.

TABLE 1. Prevalence in 2008 (Rizkalla 2009), 2009, and total prevalence (no. animals testing positive/total sampled; "—" indicates none detected) of *Batrachochytrium dendrobatidis* on amphibians in Walt Disney World's Wildlife Management and Conservation Area, Florida, USA.

Species	2008	2009	Total Prevalence
Amphiuma means	0/1	0/1	0/2
Siren lacertina	—	0/4	0/4
Notophthalmus viridescens piaropicola	—	0/2	0/2
Eleutherodactylus planirostris	0/59	3/12	3/71
Anaxyrus terrestris	0/7	2/60	2/67
Acris gryllus dorsalis	1/5	5/70	6/75
Hyla cinerea	0/6	0/36	0/42
Hyla femoralis	—	0/6	0/6
Hyla squirella	—	0/1	0/1
Osteopilus septentrionalis	0/1	1/37	1/38
Pseudacris nigrita	—	0/4	0/4
Pseudacris ocularis	—	1/6	1/6
Gastrophryne carolinensis	—	0/2	0/2
Lithobates catesbeianus	1/2	1/5	2/7
Lithobates grylio	—	0/1	0/1
Lithobates sphenocephalus	—	0/19	0/19

Sample sizes in the previous study (Rizkalla 2009) were too low to assess prevalence. For the well-sampled species in this study (Cuban Treefrog, Florida Cricket Frog, Greenhouse Frog, Southern Toad), prevalence of *Bd* infection appeared low (2.6–8%) or absent (Green Tree Frog). Given the small sample size of American Bullfrogs and Little Grass Frogs, it is premature to determine rates of infection. Although a histological examination was not performed, it appeared that *Bd* was the cause of death for the Little Grass Frog, as symptoms matched those described in a previous report for another species (Todd-Thompson 2009).

Optimal pathogen growth in culture has been reported to occur at 23ºC (Daszak et al. 2003). Further laboratory experiments have indicated that *Bd* does not grow or grows slowly at temperatures above 28°C, suggesting infections at these temperatures may not be fatal (Piotrowski et al. 2004). To increase the probability of detection in the previous study (Rizkalla 2009), sample collection was restricted to the cooler months of the year. In this study, sampling occurred year round to increase the sample size. There were four cases of *Bd* when high air temperatures were above 28ºC, including the Little Grass Frog sampled in April when the air temperature was 31°C and an American Bullfrog sampled in July at 38°C.

It is possible that water temperatures and shaded areas may not have been as warm as the ambient temperature recorded at the weather station. Thus, it could be difficult to attribute the fatality of the Little Grass Frog to *Bd* despite the high temperature. However, species' behavior should also be a consideration. Little Grass Frogs tend to perch in vegetation above the water line (Conant and Collins 1998). Similarly, other *Bd*-positive species in this study, such as Florida Cricket Frog and Southern Toad, exhibit diurnal or terrestrial activity which would expose them to warm temperatures for prolonged periods (which is a recommended treatment for captive species (Piotrowski et al. 2004)). Thus, infection in these species is notable.

The unique patterns of infection observed in central Florida may be an artifact of a particular strain of the fungus. The pathogen is also capable of adapting to changing temperatures (Woodhams et al. 2008), trading fecundity for maturation rate; as temperatures increased, growth rate increased but fewer zoospores were produced per zoosporangium. However, temperatures above 28°C were not tested, and laboratory conditions may not accurately represent the behavior of the pathogen in the wild. Thus, warm temperatures could explain the low prevalence observed in central Florida but it could take a low zoospore load to cause fatality. We should not presume that species in warm climates are less likely to be impacted by *Bd* infection. Sampling should occur throughout the year to improve estimates of prevalence.

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Literature Cited

Annis, S. L., F. P. Dastoor, H. Ziel, P. Daszak, and J. E. Longcore. 2004. A DNA-based assay identifies *Batrachochytrium dendrobatidis* in amphibians. J. Wildl. Dis. 40:420–428.

Conant, R., and Collins, J. T. 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. 3rd ed., expanded. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.

Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2003. Infectious disease and amphibian population declines. Diversity and Distributions 9:141–150.

Piotrowski, J. S., S. L. Annis, and J. E. Longcore. 2004. Physiology of *Batrachochytrium dendrobatidis*, a chytrid pathogen of amphibians. Mycologia 96:9–15.

Rizkalla, C. E. 2009. First reported detection of *Batrachochytrium dendrobatidis* in Florida, U.S.A. Herpetol. Rev. 40:189–190.

Todd-Thompson, M., D. L. Miller, P. E. Super, and M. J. Gray. 2009. Chytridiomycosis-associated mortality in a *Rana palustris* collected in Great Smoky Mountains National Park, Tennessee, USA. Herpetol. Rev. 40:321–323.

Woodhams, D. C., R. A. Alford, C. J. Briggs, M. Johnson, and L. A. Rollins-Smith. 2008. Life-history trade-offs influence disease in changing climates: strategies of an amphibian pathogen. Ecology 89:1627–1639.

HERPETOLOGICAL HUSBANDRY

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Captive Husbandry in the Rocky Mountain Tailed Frog, *Ascaphus montanus*

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The Rocky Mountain Tailed Frog, *Ascaphus montanus,* is a small, semi-aquatic frog found in cold, torrential streams of the northwestern United States. Tailed frogs are the most basal living anurans and possess a number of unusual features as adults including a tail-like intromittent organ, vestigial tail-wagging muscle, nine presacral vertebrae, and free ribs (Duellman and Trueb 1994). In addition, *Ascaphus* tadpoles possess a suctorial mouth which they use to climb rocks amid strong currents in order to feed on periphyton (Altig and Brodie 1972). Tailed frogs are not available commercially and knowledge of laboratory husbandry is limited (Held 1985). Given the increased risk of chytridiomycosis in stream-dwelling frogs (Kriger and Hero 2007), the presence of chytrid fungus in the northwestern United States (Muths et al. 2008; Pearl et al. 2007), and documented infection in another stream-dwelling leiopelmatid frog (*Leiopelma archeyi*; Bell et al. 2004), the development of husbandry techniques for this unique frog is increasingly important. As a torrent species, tailed frogs present a particular challenge because of their unusual habitat requirements.

Our objective was to mimic as closely as possible the first-order streams typically inhabited by adult tailed frogs. Key features of those streams include high flow rates, cold temperatures, slightly acidic pH, and granite cobbles. Herein we present husbandry in-

formation gathered over 2 ½ years (July 2007–December 2009) for a colony of adults (N = 16; 8 male, 8 female) and tadpoles (N = 15; 1–3 years of age; see Metter 1967 for aging criteria).

Individuals were collected by hand from streams in the Payette National Forest, Valley County, Idaho, USA and placed in individual plastic containers (Gladware) filled with stream water. Holes were placed in lids for aeration and containers were stacked and kept cool with a 12-V thermoelectric cooler (Igloo PowerChill). Animals were transported by automobile to the animal care facility at Southern Illinois University Edwardsville. Upon arrival, animals were acclimated by gradual addition of aquarium water to individual containers.

Adults (N = 16) and tadpoles (N = 15) were placed separately in two rectangular aquaria constructed from 1.9 cm × 28.6 cm pine boards (Fig. 1). Inside dimensions were 121.9 cm × 27.9 cm × 26.7 cm. Angle brackets were used to join boards together at corners. The interior surface of the floors and walls of the aquaria were coated with waterproof blue marine paint and sealed with silicone aquarium sealant. Lids were constructed from 0.16 cm thick Plexiglass with 0.5 cm diameter holes spaced approximately 10.0 cm apart for aeration. The floor of each aquarium included a filter-guarded drainage hole at one end. Aquaria were placed adjacent to one another on wooden scaffolding located above a 1.5 m diameter round plastic tub that served as a reservoir tank. The complete setup contained approximately 265 L of deionized water.

Water flow was powered by a 9085 Lph submersible utility pump (Supreme model 24) placed at the bottom of the reservoir. Water was filtered at the intake with a filter canister and sleeve (Marineland Magnum) containing a mixture of activated carbon and ammonia removing media (Aquarium Pharmaceuticals Ammocarb). A 10 cm length of plastic tubing connected the filter canister to 1.9 cm inside diameter schedule 40 PVC pipe. Filtered water was pumped to a ½ hp chiller (Aqua Logic Delta Star) cycled at 20-minute intervals with a plug-in timer to maintain a temperature of 9 ± 1°C, near the temperature recommended by Pough (2007) for cold water amphibians such as *Ascaphus*. Chilled water was directed over each aquarium with additional 1.9 cm PVC with flow controlled via stopcocks. Water flowed into aquaria from above through a 5.0 cm opening in the Plexiglas lid, simulating a cascading stream and providing aeration. A third stopcock directed excess water into the plastic reservoir tank. Water depth was maintained in aquaria at 7 cm with a PVC standpipe attached to the coarse filter. The pH was kept at ~6.8 by placing a nylon mesh bag of sphagnum peat moss in the reservoir tank. Lighting cycles were adjusted monthly to reflect seasonal changes in photoperiod. In addition, a 26 W fluorescent light bulb was used to provide low-level lighting at night for prey detection during feeding (Pough 2007). Room temperature was kept at 20°C.

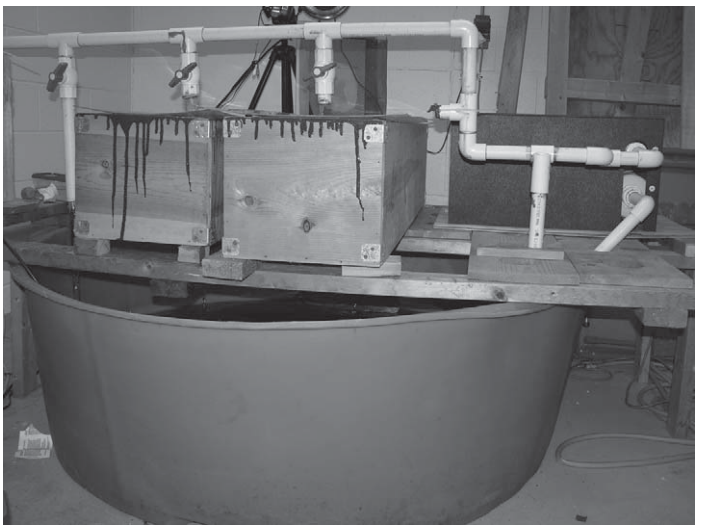


FIG. 1. Husbandry setup for a colony of Rocky Mountain Tailed Frogs, *Ascaphus montanus*. Adult frogs (N = 16) and tadpoles (N = 15) are housed separately in rectangular aquaria containing aquarium gravel and granite cobbles. Deionized water is chilled and circulated into the aquaria and reservoir tank via PVC.

Aquarium substrates consisted of aquarium gravel and granite cobbles of varying diameters (range = 5–30 cm) purchased from a landscape supplier. Cobbles were placed in an overlapping arrangement to provide refugia for adults. Large flat cobbles protruding from the water were used as feeding platforms for adults. Cobbles also served as a feeding surface for tadpoles which moved along them using their suctorial mouths (Altig and Brodie 1972).

Water quality (pH, alkalinity, chlorine, hardness, nitrite, nitrate) was tested twice weekly with test strips (Jungle Quick Dip) or with a pH meter (Hanna HI98103). Increases in nitrite or nitrate levels were controlled with water conditioner (Kordon Amquel Plus). Slight decreases in pH were adjusted as needed with a phosphate-based buffer (Seachem Neutral Regulator). Water levels were checked frequently and any losses due to evaporation were replaced as needed. Aquaria were cleaned and water was changed completely on a bimonthly basis. The health status of adults and tadpoles was monitored weekly by lifting large rocks and visually examining and censusing all individuals. Nitrile gloves were used whenever it was necessary to handle individuals or aquarium contents in order to reduce the likelihood of pathogen transmission.

Adult tailed frogs are known to eat a variety of arthropods, including Orthopterans (Bury 1970; Held 1985; Metter 1964). We fed adults twice weekly with 1.0–1.5 cm gut-loaded crickets purchased from Timberline Fisheries, Inc. (Marion, Illinois). Crickets were maintained on a diet of Timberline Cricket Power Food. Tadpoles were fed periphyton that became established on cobbles from two sources: 1) introduction of original stream water from transport containers; and 2) addition of a colony of living diatoms and desmids from Carolina Biological (Burlington, North Carolina). Once periphyton became established, cobbles developing an algal coat in the adult aquarium were transferred to the tadpole aquarium to provide additional food.

Adult frogs were marked for individual identification by injection with white visible implant elastomer in the webbing between digits of the pes (Northwest Marine Technology, Shaw Island, Washington; Nauwelaerts et al. 2000). Prior to marking, adults were anesthetized by immersion in tricaine methanesulfonate (MS-222) at a dose of 1.0 g/L. Individuals were removed from anesthesia once they lost the righting reflex.

After 18 months individuals were weighed to monitor changes in growth. All individuals experienced growth over this period with the greatest increases in body mass occurring in females. The mean body mass (± SD) at time of capture for 12 surviving adults (from a starting population of N = 16) was 4.37 ± 0.24 g for males (N = 6) and 6.73 ± 0.86 g for females (N = 6; Table 1). The percent increase in body mass over 18 months in captivity was 22.2

± 9.4% for males and 67.4 ± 36.7% for females (Table 1). Initially, 4 out of 8 females were visibly gravid at the time of capture. After 18 months 6 out of 6 remaining females were gravid. During this time period follicles (visible through the skin) became noticeably larger. Presumably, the greater increase in female body mass was due largely to gravidity.

TABLE 1. Change in body mass for a colony of Rocky Mountain tailed frogs, *Ascaphus montanus*, during the first 18 months in captivity.

Males			Females		
Mass 07/01/07	Mass 01/01/09	% Increase	Mass 07/01/07	Mass 01/01/09	% Increase
4.59	5.2	13.3	8.28	9.34	12.8
4.07	4.67	14.7	7.0	10.68	52.6
4.71	5.67	20.4	6.47	9.94	53.6
4.35	5.34	22.8	6.70	11.33	69.1
4.21	5.17	22.8	5.89	12.03	104.2
4.28	5.97	39.5	6.03	12.78	111.9
*4.71	—	—	*6.12	—	—
*3.51	—	—	*8.15	—	—

* indicates mortality

Male nuptial pads began to appear in October 2007 and persisted throughout the observation period. Copulexus *sensu* Sever et al. (2001) was observed on 12 occasions, with the earliest observation occurring on 19 May and the latest on 3 January (Fig. 2). Durations ranged from 1–3 days and no males were observed displacing rivals. Extended copulexus and an absence of male-male combat was previously reported by Stephenson and Verrell (2003) in a laboratory study of reproductive behavior in *Ascaphus*. Of the 12 events observed in our colony, only two involved pairings of the same individuals. Stephenson and Verrell (2003) also determined that there was no significant relationship between body mass and mating success in male *Ascaphus*. Our observations are consistent with this, since males in our colony exhibited similar numbers of copulations regardless of size. Courtship behavior involving males grasping unreceptive females in the absence of copulation occurred throughout the year as described by Metter (1967).

To date, we have not observed oviposition in the laboratory, despite providing conditions similar to those characterizing oviposition sites in *Ascaphus montanus* (see Karraker et al. 2006). Held (1985) had a similar experience with the Coastal Tailed Frog, *A. truei*. Karraker et al. (2006) determined that water temperature explained the greatest amount of variation in the timing of oviposition in *A. montanus*. Our setup maintained a relatively constant water temperature of 9 ± 1°C, within the range 11.4 ± 2.9°C reported by Karraker et al. (2006) for oviposition sites. Gradually increasing water temperature and photoperiod might be a way to stimulate natural oviposition. Alternatively, oviposition could be induced through injection of hormones (Brown 1975; Noble and Putnam 1931).

Four (3-year old) tadpoles metamorphosed from November to December 2007. The temperature range at which metamorphosis occurred (9 ± 1°C) was near the optimum reported for inducing metamorphosis in *Ascaphus truei* (10°C; Brown 1990). The first two individuals to metamorphose were placed in the adult aquarium. These individuals disappeared after several days and were assumed to have been cannibalized. We subsequently added a separate 18.9 L glass aquarium with a similar drainage system and substrate for juveniles. A T-fitting was inserted into the PVC pipe to divert water to a fourth stopcock above the aquarium. The two remaining froglets were fed a diet of flightless *Drosophila melanogaster* from Timberline Fisheries, Inc. (Marion, Illinois) *ad libitum* for approximately 1 month, at which point both stopped eating and died. In retrospect, a diet of flightless *Drosophila* raised on standard fruit fly media was probably insufficient for raising newly metamorphosed froglets. This stage of rapid growth and development might require the addition of supplemental nutrients (e.g. calcium) to *Drosophila* media.

After approximately 8 months in captivity (March 2008), three adult specimens (two males and one female) developed skin lesions and became noticeably lethargic. It was assumed that they had contracted an infection from an unknown pathogen, possibly due to the introduction of food (crickets) or from cross-contamination from a nearby colony of leopard frogs (*Rana pipiens*) maintained in the animal care facility. In response, water was changed completely and a broad spectrum treatment with antibiotics (Mardel Maracyn [tetracycline]), fungicides (Jungle Fungus Clear), and anti-protozoan medication (Aquarium Products Quick Cure) at dosages recommended for sensitive fish, was initiated for a one-week

FIG. 2. Copulexus in a pair of captive Rocky Mountain Tailed Frogs, *Ascaphus montanus*.

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

period. Water temperature was raised to room temperature (20°C) and carbon was removed from the filter to prevent adsorption of medications. All three individuals died, but no further adult mortality occurred at that time. A necropsy was performed on one of the specimens by a veterinary pathologist. Histological sections were prepared by staining with H&E and silver. Upon examination, no evidence of disease or fungal infection was observed and a cause of death could not be determined.

Unfortunately, the antibiotic treatment altered the microbial flora in the tank resulting in a precipitous drop in pH (<5) approximately three weeks after completion of the broad spectrum treatment. This resulted in 100% tadpole mortality. There were no noticeable effects on adults, presumably due to their ability to climb onto rocks. Following the loss of tadpoles, adults were redistributed to take advantage of the additional space (Tank 1: N = 7; Tank 2: N = 6).

A fourth adult frog (gravid female) became lethargic in August 2008 and died. A cluster of ~40 eggs was removed postmortem and placed under a granite cobble directly beneath the inflow pipe to encourage development. However, the eggs soon became enveloped in a coat of filamentous fungus and failed to develop. A necropsy was also performed on this individual using the same methods described earlier, but a cause of death could not be determined.

In conclusion, this husbandry setup represents a good starting point for keeping *Ascaphus montanus* in captivity. The frequency with which they engage in copulexus in the laboratory makes captive breeding a possibility; however, oviposition remains a challenge. The described setup is relatively inexpensive, easily reproducible, and will provide a suitable environment for tailed frogs over an extended period of time.

Acknowledgments.—We thank Gina Bonaminio, Dick Brugam, Paul Brunkow, Bruce Bury, John Cossel, Dave Duvernell, Ana Egnew, Marc Hayes, Brent Matsuda, Brad Moon, Marilyn Nielson, Jake Schaeffer, and Chris Theodorakis for advice with specimen collection and/or husbandry. We thank John Sagartz of Seventh Wave Laboratories for conducting the necropsies. We thank the Idaho Department of Fish and Game and the United States Forest Service/Payette National Forest for granting collecting permits. This study was funded by a Funded University Research grant and a Summer Research Fellowship from Southern Illinois University Edwardsville. All animals were maintained in accordance with Southern Illinois University Edwardsville Institutional Animal Care and Use Committee (IACUC) guidelines.

Literature Cited

Altig, R., and E. D. Brodie, Jr. 1972. Laboratory behavior of tailed frog *Ascaphus truei* tadpoles. J. Herpetol. 6:21–24.

Bell, B. D., S. Carver, N. J. Mitchell, and S. Pledger. 2004. The recent decline of a New Zealand endemic: how and why did populations of Archey's frog *Leiopelma archeyi* crash over 1996–2001? Biol. Conserv. 120:189–199.

Brown, H. A. 1975. Temperature and development of. the tailed frog, *Ascaphus truei*. Comp. Biochem. Physiol. 50A:397–405.

———. 1990. Temperature, thyroxine, and induced metamorphosis in tadpoles of a primitive frog, *Ascaphus truei*. Can. J. Zoolog. 54:552–558.

Bury, R. B. 1970. Food similarities in the tailed frog, *Ascaphus truei*, and the Olympic salamander, *Rhyacotriton olympicus*. Copeia 1970:170–171.

Duellman, W. E., and L. Trueb. 1994. Classification. *In* W. E. Duellman and L. Trueb (eds.), Biology of Amphibians, pp. 516–518. Johns Hopkins University Press, Maryland.

Held, S. P. 1985. Maintenance, exhibition, and breeding of the tailed frog, *Ascaphus truei,* in a zoological park. Herpetol. Rev. 16:48–51.

Karraker, N. E., D. S. Pilliod, M. J. Adams, E. L. Bull, P. S. Corn, L. V. Diller, L. A. Dupuis, M. P. Hayes, B. R. Hossack, G. R. Hodgson, E. J. Hyde, K. Lohman, B. R. Norman, L. M. Ollivier, C. A. Pearl, and C. R. Peterson. 2006. Taxonomic variation in oviposition by tailed frogs (*Ascaphus* spp.): Northwest. Nat. 87:87–97.

Kriger, K. M., and J. M. Hero. 2007. The chytrid fungus *Batrachochytrium dendrobatidis* is non-randomly distributed across amphibian breeding habitats. Divers. Distrib. 13:781–788.

Metter, D. E. 1964. A morphological and ecological comparison of two populations of the tailed frog, *Ascaphus truei* Stejneger. Copeia 1964:181–195.

———. 1967. Variation in the ribbed frog *Ascaphus truei* Stejneger. Copeia 1967:634–641.

Muths, E., D. S. Pilliod, and L. J. Livo. 2008. Distribution and environmental limitations of an amphibian pathogen in the Rocky Mountains, USA. Biol. Conserv. 141:1484–1492.

Nauwelaerts, S., J. Coeck, and P. Aerts. 2000. Visible implant elastomers as a method for marking adult anurans. Herpetol. Rev. 31:154–155.

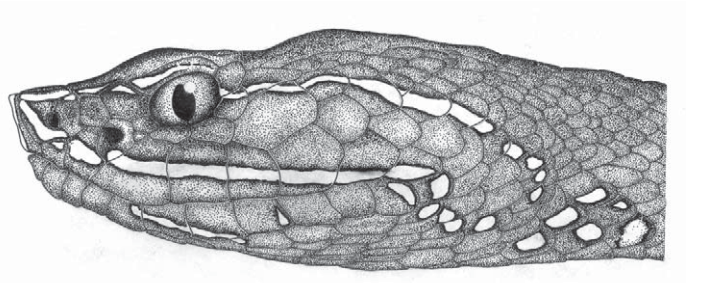
Noble, G. K., and P. G. Putnam. 1931. Observations on the life history of *Ascaphus truei* Stejneger. Copeia 1931:97–101.

Pearl, C. A., E. L. Bull, D. E. Green, J. Bowerman, M. J. Adams, A. Hyatt, and W. H. Wente. 2007. Occurrence of the amphibian pathogen *Batrachochytrium dendrobatidis* in the Pacific Northwest: J. Herpetol. 41:145–149.

Pough, F. H. 2007. Amphibian biology and husbandry. ILAR J. 48:203–213.

Sever, D. M., E. C. Moriarty, L. C. Rania, and W. C. Hamlett. 2001. Sperm storage in the oviduct of the internal fertilizing frog *Ascaphus truei*. J. Morphol. 248:1–21.

Stephenson, B., and P. Verrell. 2003. Courtship and mating of the tailed frog (*Ascaphus truei*). J. Zool. 259:15–22.



Agkistrodon bilineatus (UMRC 88-3), 388 mm SVL. Mexico: Yucatán: 20 km ESE Mérida. Illustration by Julian C. Lee.

NATURAL HISTORY NOTES

The Natural History Notes section is analogous to Geographic Distribution. Preferred notes should 1) focus on observations in the field, with little human intrusion; 2) represent more than the isolated documentation of developmental aberrations; and 3) possess a natural history perspective. Individual notes should, with few exceptions, concern only one species, and authors are requested to choose a keyword or short phrase which best describes the nature of their note (e.g., Reproduction, Morphology, Habitat, etc.). Use of figures to illustrate any data is encouraged, but should replace words rather than embellish them. The section's intent is to convey information rather than demonstrate prose. Articles submitted to this section will be reviewed and edited prior to acceptance.

Electronic submission of manuscripts is requested (as Microsoft Word or Rich Text format [rtf] files, as e-mail attachments). Figures can be submitted electronically as JPG files, although higher resolution TIFF or PDF files will be requested for publication. Please DO NOT send graphic files as imbedded figures within a text file. Additional information concerning preparation and submission of graphics files is available on the SSAR web site at: http://www.ssarherps.org/HRinfo.html. Manuscripts should be sent to the appropriate section editor: **Jackson D. Shedd** (crocodilians, lizards, and *Sphenodon*; jackson.shedd@gmail.com); **Charles W. Painter** (amphibians; charles.painter@state.nm.us); **John D. Willson** (snakes; willson@uga.edu); and **James Harding** (turtles; hardingj@msu.edu).

Standard format for this section is as follows: SCIENTIFIC NAME, COMMON NAME (for the United States and Canada as it appears in Crother [ed.] 2008. *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico*. SSAR Herpetol. Circ. 37:1–84, available from SSAR Publications Secretary, ssar@herplit.com; for Mexico as it appears in Liner and Casas-Andreu 2008, *Standard Spanish, English and Scientific Names of the Amphibians and Reptiles of Mexico*. Herpetol. Circ. 38:1–162), KEYWORD. DATA on the animal. Place of deposition or intended deposition of specimen(s), and catalog number(s). Then skip a line and close with SUBMITTED BY (give name and address in full—spell out state names—no abbreviations). (NCN) should be used for common name where none is recognized. References may be briefly cited in text (refer to this issue for citation format).

Some further comments. The role of the "Standard Names" lists (noted above) is to standardize English names and comment on the current scientific names. Scientific names are hypotheses (or at least represent them) and as such their usage should not be dictated by a list, society, or journal.

Recommended citation for notes appearing in this section is: Medina, P., and R. L. Joglar. 2008. *Eleutherodactylus richmondi*: reproduction. Herpetol. Rev. 39:460.

CAUDATA — SALAMANDERS

AMBYSTOMA MACULATUM (Spotted Salamander). **UNUSUAL MALFORMATION**. Malformations such as missing and extra limbs and digits have been observed in both salamander and frog species at least since the mid-1990s (Johnson et al. 2002. Ecol. Monogr. 72:151–168; Lannoo 2005. Amphibians Declines: The Conservation Status of United States Species. Univ. California Press, Berkeley, California. xxi + 1094 pp.). On 28 March 2009, I captured a female *Ambystoma maculatum* at the Central Kentucky Wildlife Management Area, Madison County, Kentucky, USA (37.6299156°N, 84.1961575°W) that possessed an unusual growth directly adjacent to the cloaca. The growth appeared to be a fully formed toe having the same banding pattern, length, and keratinized tip as the individual's normally placed toes. No other abnormalities were present on this individual. However, this and other malformations involving digits and appendages have been observed in other individuals of this species at this location.

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FIG. 1. Photograph showing an *Ambystoma maculatum* female with a fully formed toe adjacent to the cloaca. Note that all limbs were present and showed no sign of malformation.

AMBYSTOMA OPACUM (Marbled Salamander). **COLORATION**. Color anomalies have been well documented in amphibians, especially albinism (Bechtel 1995. Reptile and Amphibian Variants: Colors, Patterns, and Scales. Krieger Publ., Malabar, Florida. 224 pp.; Hensley 1959. Publ. Michigan State Univ. [Biol.] 1:133–159). Accounts of partial albino Marbled Salamanders are known from Maryland, Mississippi, and Illinois (Dyrkacz 1981. Herpetol. Cir. 11:1–31; Walston 2004. Herpetol. Rev. 35:365). Further, Mitchell (2002. Banisteria 24:67–69) has reported capture of leucistic *A. opacum* larvae in Virginia. However, accounts of darker variants are lacking in comparison to reports of albinism (Richards and Nace 1983. Copeia 1983:979–990). In the family Ambystomatidae, observations of melanistic Spotted Salamanders (*A. maculatum*) are known from Arkansas (Easterla 1972. Herpetologica 24:330–331) and a melanistic Axolotl (*A. mexicanum*) was reported by Humphrey and Bagnara (1979. J. Hered. 58:251–256). Here, we have adapted the term "melanoid," first used by Humphrey and Bagnara (1979, *op. cit.*) and later by Richards and Nace (1983, *op. cit.*), to describe all of our melanistic specimens due to the varying degrees of melanism in each. Thus, we report the first known captures of three melanoid and one hypomelanistic *A. opacum* in Tennessee. A melanoid adult male (63 mm SVL, 7 g) was observed at the Volunteer Army Ammunition Plant (VAAP) site in Hamilton Co., Tennessee (35.10437°N, 85.13053°W) on 9 Oct 2007. The specimen exhibited an overall black coloration, completely lacking the conspicuous white patterns usually present in male *A. opacum* (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.). At the same location, a melanoid female (66 mm SVL, 10 g) was observed on 8 Oct 2008. This specimen exhibited regular patterning on the dorsal surface, although all patterned areas were extremely faint and almost completely hidden. Our third melanoid specimen was a female (72 mm SVL, 7 g) observed at the VAAP site on 11 Dec 2008. Again, remnants of white crossbands were almost entirely undetectable. Lastly, a hypomelanistic

adult female (67 mm SVL, 8 g) was observed at the VAAP site on 8 Oct 2008 during autumn breeding movements. The specimen exhibited an overall pinkish-purple coloration due to the decrease in melanophores, with the white crossbands appearing normal. All specimens were collected under TWRA Permit No. 3082 and UTC AUP No. 0408TPW-04.

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AMBYSTOMA TIGRINUM (Tiger Salamander). **PREDATION**. Birds have been hypothesized to prey upon Tiger Salamander larvae when they are trapped in drying ponds (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C. 587 pp.; Lannoo and Phillips 2005. *In* M. J. Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 636–639. Univ. California Press, Berkeley). However, aquatic predation by birds on Tiger Salamander larvae has not been confirmed. On 4 Aug 2008, at 1230 h, we observed an adult *Ardea herodias* (Great Blue Heron) capture and eat a large larval *Ambystoma tigrinum* at Jasper-Pulaski Fish and Wildlife Area, in Jasper County, Indiana, USA (41.1576111°N, 86.9703333°W). The heron was observed wading in a wetland and struck at prey under the surface of the water. It held a salamander larva in its bill for a few minutes before swallowing it whole. During this time we were able to identify the salamander larva by observation through a 10-power spotting scope. Its size and the presence of four limbs ruled out all other species known at the site.

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AMBYSTOMA TIGRINUM TIGRINUM (Eastern Tiger Salamander). **REPRODUCTION**. Terrestrial salamanders of the family Ambystomatidae typically reproduce through explosive breeding aggregations formed in temporary and permanent water bodies. Among species known to utilize this strategy, breeding is typically associated with precipitation events and occurs at night (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington. 587 pp.). Here, however, I report repeated observations of diurnal breeding activities within populations of *A. t. tigrinum* in southern Illinois.

Between 9 Feb and 15 March 2008, nine individual *A. t. tigrinum* (five females, four males) were observed engaged in diurnal breeding activities within two forested ponds of the Shawnee National Forest, Gallatin and Hardin counties, Illinois, USA (37.60569°N, 88.25950°W and 37.57192 °N, 88.25472°W). Breeding behaviors were observed between 1210–1520 h and consisted of males and females depositing spermatophores and egg masses on submerged tree branches and vegetation. Ponds were characterized by high turbidity at all times during these observations, with Secchi disk transparencies ranging from 0.18–0.41 cm (N = 10 readings/pond). No ice was observed on the ponds' surfaces, and skies were clear.

To my knowledge, this is the first report of diurnal breeding activities by any pond-breeding ambystomatid salamander. These preliminary observations suggest that light cues necessary for the formation of nocturnal breeding aggregations among ambystomatid salamanders are absent or reduced in ponds with high turbidity, resulting in diurnal breeding because individuals are unable to recognize an external photoperiod. In adjacent ponds with clear water (i.e., Secchi disk transparencies exceeding the actual pond depth), breeding activities were only observed at night, though on the same dates as the diurnal activities described above. Many of the permanent fishless ponds within the Shawnee Forest exhibit similarly high turbidity, attributable to substrates composed of well-decomposed organic muck and constant resuspension of particles by precipitation events. Therefore, in these ponds, diurnal breeding activities may be commonplace, and future studies should focus on ponds with high turbidity to determine the prevalence of these behaviors.

All research was conducted in accordance with Southern Illinois University Carbondale IACUC Protocol # 05-036 and with permission of the United States Forest Service. This research was funded by a grant from the Chicago Herpetological Society.

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BOLITOGLOSSA ORESTES (Culata Climbing Salamander) and ***BOLITOGLOSSA SPONGAI*** (NCN). **LIFE HSTORY**. Herein we report information on reproduction, habitat, and diet of two plethodontid salamanders from the cloud forests of Mérida, Venezuela. A removal survey was conducted during June to August 2008, in La Mucuy, San Javier del Valle, and San Eusebio cloud forests. For all specimens, length (SVL, from tip of snout to the anterior edge of vent) was measured. Specimens were dissected to determine sex and reproductive condition; egg number and diameter were measured; testis length and width were measured and surface average was calculated. The stomach contents were washed from the dissected stomach, separated, and identified with a dissecting microscope. All specimens were deposited in the Amphibians and Reptiles Collection of the Universidad de Los Andes (CVULA).

Salamanders were found within logs and moist litter associated with mats of mosses and lichens. The majority of prey items were soil invertebrates including ants, pseudoscorpions, spiders, acari, beetles, and isopods.

Two gravid female *Bolitoglossa orestes* (CVULA 7101, 7108) collected in San Javier del Valle, had enlarged and convoluted oviducts with two rows of 8 light yellow, yolk-filled eggs. Eggs were joined together without pedicels. Female size and average diameter egg are given in Table 1. A small female (CVULA 7099) collected in La Mucuy, had a total of 56 whitish jelly eggs of different sizes and its oviducts were straight. One male (CVULA 7109) collected in San Javier del Valle has small white testes.

An adult female *Bolitoglossa spongai* from San Eusebio Forest (CVULA 7092) with an enlarged and convoluted oviduct had only

TABLE 1. Reproductive characteristics of *Bolitoglossa orestes* and *Bolitoglossa spongai* collected in three cloud forests of the Andes of Venezuela.

Species	CVULA	Date	SVL (mm)	Sex	Oviductal egg number right / left	Mean egg diameter (mm)	Mean testis surface (mm^2) right / left
B. orestes	7101	07/17/08	102.66	F	8/8	1.33 ± 0.25	—
B. orestes	7108	07/17/08	99.81	F	8/8	1.51 ± 0.21	—
B. orestes	7109	07/17/08	70.81	M	—	—	6.73/8.98
B. orestes	7099	06/27/08	74.00	F	31/25	0.42 ± 0.06	—
B. spongai	7092	06/13/08	103.00	F	11/10	1.7 ± 0.54	—
B. spongai	7096	06/13/08	94.00	M	—	—	14.23/13.56
B. spongai	7094	06/13/08	70.00	M	—	—	10.32/9.74

21 large yellow yolk-filled eggs. Two males (CVULA 7096 and 7094) were collected in the same locality with whitish enlarged testes. Despite the small sample size in each species, SVL for females exceeds that of males (Table 1).

The best predictors of salamander presence at these sites were deep ground cover and high humidity. From this field work we concluded that subterranean elements are important components of the salamander environment. Based on egg numbers and egg development they might reproduce throughout the year as other tropical species Chan (2003. J. Linn. Soc. 78[4]:489–496). Many aspects of the biology and natural history of these salamander species remain to be ascertained.

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BOLITOGLOSSA STRIATULA (Striated Salamander). **PREDATION**. *Bolitoglossa striatula* is the only salamander in Costa Rica with paired dorsal and lateral dark longitudinal stripes. This species forages on the leaves of herbaceous vegetation at night and hides during the day in the plants located near ponds. Many aspects of its biology are unknown. This is the first report of predation of *B. striatula*.

On 15 April 2004 at 1100 h, an individual *Micrurus nigrocinctus* (Central American Coralsnake) (300 mm SVL) was captured near an artificial pond at the University of Costa Rica, campus "Sede de Occidente," San Ramón, Alajuela, Costa Rica (10.083°N; 84.467°W; 1070 m elev.). The snake was placed in a glass bottle where it regurgitated a *B. striatula* (55 mm SVL, 65 mm TL) 30 min later. The *B. striatula* was partly digested, and was deposited at the Museo de Zoología, Universidad de Costa Rica (UCR 17581).

In Costa Rica, the diet of *M. nigrocinctus* is primarily colubrid snakes, small lizards, and occasionally members of their own species (Solórzano 2004. Snakes of Costa Rica: Distribution, Taxonomy and Natural History. INBio. Santo Domingo, Heredia, Costa Rica. 792 pp.). This is the first record of a salamander in its diet.

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DICAMPTODON TENEBROSUS (Coastal Giant Salamander). **REPRODUCTION**. Little is known about the nesting habits of *Dicamptodon* spp. Only three observations of *D. tenebrosus* nests have been published (Henry and Twitty 1940. Copeia 1940[4]:247–250; Nussbaum 1969. Herpetologica 25[4]:257–262; Jones et al. 1990. Northwest. Nat. 71:93–94). On 19 Sept 2007, at 1415 h, we observed a terrestrial adult (SVL 158.0 mm, 96.7 g), with eggs and recently hatched larvae. It was located in a first order tributary of Texas Creek, about 16 km NE of Washougal, Washington, USA, in the Cascades Mountains at 447 m elev. When the nest site was disturbed, a terrestrial adult *D. tenebrosus*, presumed to be the female, appeared from under a downed log directly adjacent to the boulder where the nest was located. The presence of the female tending to the nest is consistent with observations made at other nest sites (Henry and Twitty 1940, *op. cit.*; Nussbaum 1969, *op. cit.*). There was at least one embryo and ca. 6 hatchlings. The nest appeared to have originally contained 20–30 eggs, fewer than the 70 eggs observed in other documented *D. tenebrosus* nests (Henry and Twitty 1940, *op. cit.*; Nussbaum 1969, *op. cit.*). The remaining embryo was separated from the other empty egg casings, possibly due to the disturbance. The hatchlings, which still contained their yolk sacs, were in close proximity to one other and the remnants of the nest. The nest was in 5 cm of 10°C water, under a flat boulder with a substrate of fine gravel next to the stream bank. Surrounding vegetation included Salmonberry (*Rubus spectabilis*), Vine Maple (*Acer circinatum*), and Red Alder (*Alnus rubra*). The pedicels of the eggs attached to the rock were indicative of *D. tenebrosus* as compared to *D. copei* (Steele et al. 2003. Herpetol. Rev. 34:227–228). On 20 Sept, JGM returned to the site to retrieve a tail clip for genetic analysis for species confirmation and the adult was still present, but no larvae were found. However, several crayfish (*Pacifastacus* sp.) were at the nest site, suggesting predation of the larvae. Genotyping was performed in the laboratory of Andrew Storfer (School of Biological Sciences, Washington State University) and confirmed that the adult was *D. tenebrosus*.

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EURYCEA JUNALUSKA (Junaluska Salamander). **OCCURRENCE AND REPRODUCTION**. *Eurycea junaluska*, a rare salamander in southwestern North Carolina and southeastern Tennessee, is thought to be extirpated from the Cheoah River in Graham County, North Carolina (Ryan and Sever 2005. *In* M.

J. Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 745–746. Univ. California Press, Berkeley, California). Additionally, it is reported that around mid-May adults attend egg clutches in streams (Ryan and Sever 2005, *op. cit.*) Contrary to these reports, we discovered three adult *E. junaluska* attending their egg clutches on 12–13 April 2005 in the Cheoah River, Graham County, North Carolina, along with one live adult crossing a wet road from deciduous forest toward this river during a nighttime search. All three egg clutches were deposited in cup-shaped depressions on the underside of large cobble or small boulders at the top of small riffle or run areas in the river. We observed one of the clutches hatching out which would further indicate an earlier date of egg deposition than reported in published accounts. Egg counts were ca. 36 from the hatching clutch, with 31 and 58 eggs in the remaining two clutches. On 19 Sept 2005 we observed a large, gilled larva (90 mm TL, 46 mm SVL) in the Cheoah River 200 m upstream from the previous location and one adult under artificial cover in adjacent riparian habitat, and on 14 June 2006 in aquatic searches, we found one adult in this same area. Voucher photos were verified by J. C. Beane, North Carolina State Museum of Natural Sciences (accession numbers 12294 and 12352).

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NOTOPHTHALAMUS VIRIDESCENS (Eastern Newt). **POLYMELIA**. The presence of extraneous limbs (polymelia) is known to naturally occur in both larval and adult salamanders (Sessions and Ruth 1990. J. Exp. Zool. 254:38–47; Cecala et al. 2007. Herpetol. Rev. 38:434). Emergent research suggests that although polymelia in wild salamander populations does occur, it is rare (Williams et al. 2008. Biol. Lett. 4:549–552) and may be associated with trematode parasites (Johnson et al. 2006. Ecology 87:2227–2235). In North America, in situ examples of polymelia are primarily restricted to ambystomatid salamanders (e.g., Johnson et al. 2003. Cons. Biol. 17:1724–1737). For the extant Nearctic salamandrid genera (*Taricha* and *Notophthalamus*), records of polymelia are few and restricted to the hind limbs (North American Reporting Center for Amphibian Malformations [NARCAM] website; via http://www.nbii.gov). Here we report a naturally occurring case of forelimb polymelia in *N. viridescens*. On 29 Sept 2007 we collected an eft stage *N. viridescens* near the city of Lindale (Smith County., Texas, USA) from underneath a fallen log along County Road 4106 (32.57°N, 95.35°W). The specimen (SVL 19.19 mm, TL 15.90 mm) possesses two right forelimbs that coalesce near the midpoint of the humerus (Fig. 1). Based on external examination it appears that the bones comprising each arm include at least a partial humerus in addition to a full radius and ulna. Other than exhibiting polydactyly (two extra digits) and associated brachydactyly, the extraneous appendage (4.28 mm) appears comparable in gross morphology to its natural counterparts (4.92 mm right arm; 4.90 mm left arm) albeit slightly shorter. Although polymelia is known to occur in *N. viridescens* (Record ID 51, NARCAM website), the frequency and geographic distribution of its occurrence are not well documented.

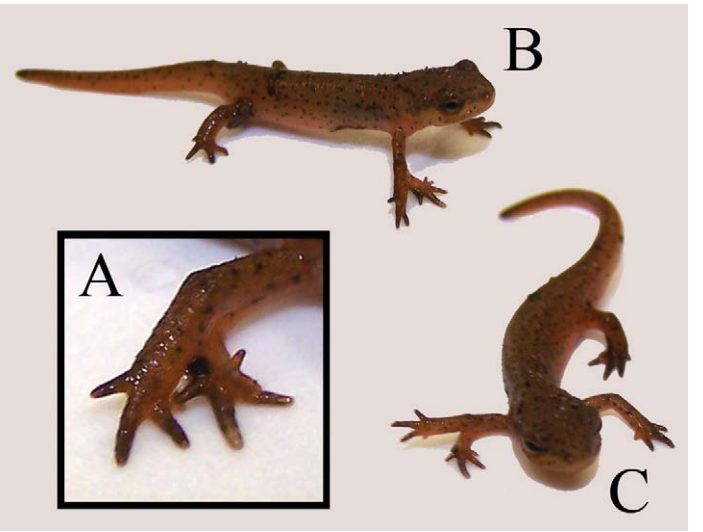

FIG. 1. Close-up (A), lateral (B), and dorso-frontal (C) views of forelimb polymelia in an eft stage *Notophthalamus viridescens* (UTA A-59131) from eastern Texas, USA.

The specimen was deposited at the University of Texas at Arlington Amphibian and Reptile Diversity Research Center (UTA A-59131) and in vivo photographic vouchers were deposited in the UTA Digital Collection (UTADC 3494–3500). All measurements were taken using a digital caliper. Limb measurements were taken distally from the elbow. We thank C. M. Sheehy III for comments on the manuscript. Collecting was conducted under Texas Parks and Wildlife scientific permit number SPR-0707-1387 to CJF.

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NOTOPHTHALMUS VIRIDESCENS (Eastern Newt). **OVERWINTERING BEHAVIOR**. The movements and homing ability of *Notophthalmus viridescens* efts have been previously documented (Healy 1975. Amer. Mid. Nat. 93[1]:131–138; Gill 1978. Evolution 32[4]:839–849). In Virginia, most adults were observed to exit ponds in autumn, presumably to overwinter in terrestrial sites surrounding their resident ponds; however, considerable variation in life history has been reported across the range of this species and regular overwintering of adults in aquatic sites has been reported for other populations (Gill 1978. Ecol. Monogr. 48:145–166). Healy (1975, *op. cit.*) reported that efts were sometimes located near the base of the same tree in successive springs and that the root system of these trees may have served as winter hibernacula. Consequently, he suggested that proximity to trees in April and early May could indicate that efts at this time (in Charlton, Massachusetts) remain close to the site of their winter emergence. Congregation of juvenile *N. viridescens* at winter hibernacula has not been previously reported. Herein I describe the occurrence of such a congregation of *N. viridescens* efts at a terrestrial site believed to have been used for overwintering.

FIG. 1. Aggregation of *Notophthalmus v. viridescens* efts at hibernacula site in Ashtabula Co., Ohio, USA.

On 2 April 2006, I observed a minimum of 19 *N. viridescens* red efts congregated beneath a slab of stone (Fig. 1). The observation was made at ca. 1645 h under partly cloudy conditions with an ambient air temperature of ca. 13.5°C. The stone was not particularly close to the base of any trees, but was located within 30 m of a small woodland pool in Ashtabula County, Ohio, USA. The pool, which currently holds water year-round, was excavated to a depth of ca. 1–2 m about 10 years prior and an adult *N. viridescens* was observed surfacing near the edge of this pool. Beneath the slab were a number of small holes leading to subterranean spaces of unknown depth. At least one eft was observed to escape down one of these holes (Fig. 1). The group of efts encompassed a wide range of sizes and appeared to represent multiple age-classes. Also found beneath the slab was a Red-backed Salamander (*Plethodon cinereus*) and a Leopard Slug (*Limax maximus*) The spaces beneath this slab coupled with the large number of efts and the rapidity with which they moved toward the holes gave the strong impression that this site was used as winter hibernacula. A thorough search of additional cover objects in the surrounding area revealed no additional efts. To the best of my knowledge this is the first report of such behavior by *N. viridescens* efts. However, the utilization of specific sites as winter hibernacula would seem to be congruent with reports of strong homing ability and spatial cognition in this species.

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PLETHODON CINEREUS (Red-backed Salamander). **LEUCISM.** Leucism, a lack of skin pigmentation caused by defective chromatophores (Bartlett and Bartlett 2005. Designer Reptiles and Amphibians. Barron's Educational Series. New York), has been recorded in a number of plethodontid salamanders (Seeliger 1945. Copeia 1945:122; Miller and Braswell 2006. Herpetol. Rev. 37:198). Documented cases of leucism in *Plethodon cinereus* exist for West Virginia (Pauley 1974. Redstart 42:104), Maryland (Harris 1968. Bull. Maryland Herpetol. Soc. 4:57-60; Mitchell and Mazur 1998. Northeast. Nat. 5:367–369), and southern Ontario (Rye 1991. Can. Field Nat. 105:573–574). Here, we report two additional cases of leucism in *P. cinereus*, in Massachusetts and New York.

During August 2007, an adult *P. cinereus* of unknown sex, white in coloration with darkly colored eyes, was discovered beneath a decaying log in the Stony Brook Reservation in West Roxbury, Suffolk County, Massachusetts (WGS84, 42.2652778°N, 71.14°W, elev. 64 m) (E. O'Brien, pers. comm.). The specimen was found within 1 m of a heavily traveled footpath in a forested area comprised predominately of *Pinus strobes* and *Fagus grandifolia* with *Comptonia peregrine*s ground cover, and was left in situ. An abundance of decaying logs was present. Both "red-backed" and "lead-backed" phenotypes of *P. cinereus* are common in the area. Several successive searches of the area were carried out over the next two weeks in an effort to photograph the specimen. On 5 Sept 2007, a leucistic adult of unknown sex measuring ca. 6.5 cm TL was found together with an adult and a neonate of the "red-backed" phenotype beneath a log in the immediate area where the original leucistic specimen was discovered (Fig. 1). Since there is no photographic record from O'Brien's original sighting, it remains unclear whether this second sighting represents the original specimen or a second individual.

On 20 Sept 2008, an adult *P. cinereus* of unknown sex (ca. 7.5 cm TL) lacking skin pigmentation and patterning with dark eyes, was discovered beneath some fallen tree bark among a 2–3 cm layer of moist leaf litter in a wooded area located directly behind the reptile house and service yard of the Wildlife Conservation Society's Bronx Zoo in Bronx County, New York (WGS84; 40.8502583°N, 73.8777417°W, elev. 20 m). The overall coloration of the specimen was white, although its skin was partially transparent, allowing visibility of some visceral organs. The wooded area is situated on a slight 10–15° north-facing incline, is bordered by service yard

FIG. 1. Leucistic *Plethodon cinereus* with "red-backed" adult and juvenile from Suffolk County, Massachusetts.

buildings to the south and a paved public pathway to the north, and is dominated by *Quercus* sp., *Acer* sp., and *Liquidambar styraciflua*. An abundance of felled trees and tree bark litter the area and provide considerable ground cover. *Plethodon cinereus* of the "red-backed" morph are common in the immediate area although no "lead-backed" or additional polymorphic phenotypes have been found.

Plethodon cinereus is considered to be one the most abundant terrestrial vertebrates in deciduous forests of northeastern North America (Burton and Likens 1975. Copeia 1975:541–546), with densities reaching up to 2.8 salamanders/m^2 (Mathis 1991. Oecologia 86:433–440). Likewise, it also has an extensive distribution, ranging from North Carolina to Quebec and westward to Minnesota (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC. 587 pp.). Given these attributes, combined with a general ease of locating them beneath logs, rocks, and leaf litter, it can be expected that occasional specimens exhibiting coloration abnormalities will be found. The fact that there are currently more documented cases of leucism in *P. cinereus* than any other caudate is likely an artifact of the relative abundance of *P. cinereus*, rather than a greater incidence of color anomaly in the species. Given its fossorial and nocturnal terrestrial habits (Petranka 1998, *op. cit.*), leucism as well as other conspicuous phenotypes documented for *P. cinereus* such as albinism (Hensley 1959. Pub. Mus. Michigan State. Univ., Ser. 1:135–139; Dyrkacz 1981. SSAR Herpetol. Circ. 11:1–31; Gilhen 1986. Can. Field Nat. 100:375) may not be as deleterious to *P. cinereus* as they would be for less reclusive amphibian species. Both observed leucistic individuals were adults in good physical condition and were found in close proximity to conspecifics.

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PLETHODON CINEREUS (Red-backed Salamander). **ELEVATION**. On 2 Sept 2008, we observed a single dead, adult red-backed salamander in a granitic seepage at 1173 m elevation on the north headwall of the North Basin, Katahdin, Mount Katahdin Township (T3 R9 WELS), Piscataquis County, Maine, USA (45.931°N, 68.922°W). Red-backed Salamanders are commonly reported from low elevations in the Katahdin region, and have been reported at elevations exceeding 1219 m in the southern Appalachians, but similar elevation records do not exist for the northeastern United States, where tundra communities occur above 1200 m (Hunter et al. 1999. Maine Amphibians and Reptiles. University of Maine Press, Orono, Maine; Taylor 1993. The Amphibians and Reptiles of New Hampshire. Nongame and Endangered Wildlife Program, New Hampshire Fish and Game Department, Concord, New Hampshire). This record provides limited information about the potential elevational distribution of this species and is unusual because the surrounding vegetation is subalpine and arctic-alpine, a vegetation type not present in the southern Appalachians. Dominant vascular plants observed in the surrounding snowbed community included the following unusual subalpine assemblage: *Carex intumescens, Carex flava*, *Carex scirpoidea*, *Glyceria striata, Campanula rotundifolia*, *Dasiflora fruticosa*, *Sibbaldiopsis tridentata*, *Drosera rotundifolia, Arnica lanceolata*, and *Prenanthes trifoliolata*. *Plethodon cinereus* is not the only amphibian occurring at this elevation on Katahdin; 179 m SW of this location at a similar elevation, we observed an adult American Toad (*Anaxyrus americanus*). The amphibian communities of these northern, alpine communities are more diverse than typically acknowledged and are in need of additional, focused research.

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PLETHODON DORSALIS / EURYCEA LUCIFUGA / ANEIDES AENEUS (Zigzag Salamander, Cave Salamander, Green Salamander). **ARBOREALITY**. Salamanders of the genus *Aneides* are found in arboreal habitats in temperate rainforests of northwestern North America (Spickler et al. 2006. Herpetol. Cons. Biol. 1:16–26) and hardwood forests of the eastern United States (Wilson 2003. Contemp. Herpetol. 2003[2]:1–6). However, no studies have reported the use of arboreal habitats by salamanders in the genera *Plethodon* and *Eurycea*. Herein, I report arboreal habitat use in both *Plethodon dorsalis* and *Eurycea lucifuga*. On 12 May 2005 and 15 Oct 2006, I observed *P. dorsalis* (N = 3), *E. lucifuga* (N = 5), and *Aneides aeneus* (N = 2) between 1.5 m and 4 m above ground on tree trunks (dbh greater than 114 cm). All areas of observation were adjacent to small streams. Observations were made in two different old-growth hardwood forest stands of southeastern Tennessee, USA (site 1, Dick's Cove, [35.2199417°N, 85.9599778°W]; site 2, Morgan's Steep, [35.2026833°N, 85.9320167°W]). Both sites were mesic cove forests. Individuals were observed between 2200 and 0100 h. On the two nights of observation the weather was cool with light rain. *Plethodon dorsalis* and *A. aeneus* were both observed on large Black Oak (*Quercus velutina*; site 1) while *E. lucifuga* were observed on Tulip Poplars (*Liriodendron tulipifera*; site 2). One individual *P. dorsalis* was observed foraging (ca. 2 m above ground) on small flies. These observations provide new habitat associations for both *P. dorsalis* and *E. lucifuga*.

I thank J. Berton, C. Harris, and M. Hess for assistance.

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PLETHODON GLUTINOSUS (Northern Slimy Salamander). **REPRODUCTION AND BEHAVIOR.** *Plethodon glutinosus* has an extensive geographic distribution in the eastern United States. Extensively studied accounts of female reproductive behavior in nature remain sparse, leaving gaps in the knowledge of the reproductive behavior of this species. Currently much of what is known about nesting and associated behavior has been gained from observations made during experimental manipulations of brooding female *P. glutinosus*, their clutches, or nesting environments (Peterson 2000. Ethology 106:781–794; Trauth et al. 2006.

Herpetol. Nat. Hist. 9:141–149). To date, reported egg deposition sites for *P. glutinosus* include rotting stumps, logs, and under rocks (Beamer and Lannoo 2005. *In* M. J. Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 808–811. Univ. California Press, Berkeley, California). Here we report a new type of egg deposition site used by *P. glutinosus* in the Appalachian Plateau region of northern Alabama.

On 29 Sept 2008 a female *P. glutinosus* was observed in attendance of a clutch of at least 5 observable eggs attached at a single point to the roof of a crevice, 10.37 mm height, in a sandstone/siltstone bluff along Clear Creek in Winston County, Alabama (WGS84, 34.02759°N, 87.37294°W). The observed eggs were in a late stage of development. The female was positioned partially coiled around and underneath the nest. The female remained motionless while viewing and photographing the nest. A second female *P. glutinosus* was encountered in attendance of a nest in a separate crevice within the same bluff system ca. 30 m from the first nest and female. The second female did exhibit an aggressive response while viewing the nest by moving between the clutch and the crevice opening and exhibiting an all-trunk raised (ATR) posture. This posture is considered an aggressive response in terrestrial salamanders (Jaeger 1984. Copeia 1984:309–314). The placement of the second nest within the crevice prevented a clear photograph and egg count from being taken.

HRC returned 3 Oct 2008 and found the first female still in attendance with five observable hatchlings; no eggs could be observed. The female was positioned coiled around the hatchlings. At the second nest the female was again found in attendance with the nest; no hatchlings were observed. On 23 Oct 2008 we found the female *P. glutinosus* was still in attendance at the first nest with two remaining hatchlings. The second female *P. glutinosus* was also observed in attendance of the second nest although no eggs or hatchlings were observed. Because of the depth of the second crevice it is possible that hatchlings were present but not observed from the crevice opening. We returned on 10 Nov 2008 and found no females or hatchlings in either crevices. To our knowledge this is the first record of this type of habitat use for egg deposition in *P. glutinosus*.

Digital photographs of the female and clutch and female and hatchlings were deposited in Alabama Herp Atlas Project-Digital at Auburn University; AHAP-D 206 and AHAP-D 207.

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PSEUDOEURYCEA NIGROMACULATA (Black-spotted Salamander). **PREDATION**. On 27 Sept 1995 in central Veracruz, México, 6 km. S of Acultzingo (WGS84, 18. 6966°N, 97.3155°W, 2183 m. elev.), Walter Schmidt observed an adult male *Rhadinaea fulvivitis* (258 mm SVL, 119 mm TL), predating a *Pseudoeurycea nigromaculata* (56.5 mm SVL) on the forest floor. These specimens were collected and deposited at the Collection of Museo de Zoologia, Facultad de Ciencias, UNAM (*R. fulvivitis* MZFC 17669; *P. nigromaculata* MZFC 8457). This observation represents the first report of predation on this species (Parra-Olea 1998. Cat. Amer. Amphib. Rept. 664:1–2).

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PSEUDOTRITON RUBER (Red Salamander). **HABITAT USAGE / MOVEMENT**. *Pseudotriton ruber* is found in both aquatic and terrestrial habitats and can occur in relatively dry habitats away from aquatic sites (Mount 1975. The Reptiles and Amphibians of Alabama. Auburn Printing, Auburn, Alabama. 345 pp.). *Pseudotriton ruber* seldom disperses >30 m from overwintering sites (Axtell and Axtell 1948. Copeia 1948:64), however few studies document *P. ruber* migration or dispersal capabilities. In a recent survey of ephemeral ponds (N = 26) on the Cumberland Plateau, Corser (2008. Am. Midl. Nat.159:498–503) identified 18 of a potential 21 known amphibian species to breed in the region, but he did not document *P. ruber*. On 13 and 17 Oct 2006, I found three adult *P. ruber* at two different ephemeral ponds on the Cumberland Plateau (elev. 585 m) in southeastern Tennessee, USA (wetland site 1 [35.2235361°N, 85.9710694°W]; wetland site 2 [35.2361861°N, 85.8928694°W]). The Cumberland Plateau is bounded by moist cove forest, and ephemeral ponds represent the only natural body of water on the plateau. All three individuals were found under moist decaying logs within completely dry ephemeral ponds. The hydroperiod of plateau ephemeral ponds follows an annual cycle in which ponds are typically flooded between November and June and are completely dry for the remainder of the year. Two salamanders were located at a pond (site 1) greater than 388 m from the nearest possible stream habitat and the third salamander was located at a pond (site 2) over 1 km from the nearest stream. The two ephemeral ponds were 7.2 km apart. It is unlikely that *P. ruber* uses ephemeral ponds for breeding, given that the larval period is usually 1.5–3.5 years (Petranka 1998. Salamanders of the United States and Canada, Smithsonian Institute Press, Washington. 302 pp.) and that ephemeral ponds dry each year. It is also unlikely that these individuals use ephemeral ponds as overwintering sites because previous study shows that many individuals, particularly females, move back to stream habitats to overwinter (R. Bruce pers. comm.). Therefore, it is most likely that *P. ruber* has extensive dispersal capabilities that range from 388 m to over 1 km from stream sites and may use ephemeral ponds as an important moist stop over site during migration and dispersal events in an otherwise xeric, drought prone landscape. The present observations confirm that *P. ruber* uses ephemeral ponds on the Cumberland Plateau. My observations suggest that ephemeral ponds may be important to *P. ruber* on the Cumberland Plateau and further highlight the importance of ephemeral ponds in an area where wetlands are declining and federal regulatory oversight is limited (Scheffers et al. 2006. J. Field. Ornthol. 77:178–183).

I thank R. Bruce and J. B. C. Harris for comments on this note.

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ACRIS CREPITANS (Northern Cricket Frog) and ***ACRIS GRYLLUS*** (Southern Cricket Frog). **INTERSPECIFIC AGONISM.** *Acris crepitans* and *A. gryllus* have sympatric ranges in the southeastern United States (Nevo and Capranica 1985. Evol. Biol. 19:147–214). In North Carolina, range overlap occurs in the Coastal Plain and Fall Zone and the species are syntopic (co-occur locally) in a few locations, but they are not known to interbreed, probably because females can recognize conspecific males by vocalizations (Micancin 2008. Ph.D dissertation, Univ. North Carolina). In *A. crepitans*, aggressive interactions between males include complex acoustic signals that include information on the individual's body size and size-independent willingness to physically interact (Burmeister et al. 2002. Anim Behav. 64:715–725). Agonistic encounters among *A. crepitans* can result in the use of an alternative mating tactic by subdominant males (i.e., satellite behavior, Wagner 1989. Behav. Ecol. Sociobiol. 25:429–436). We have observed two prominent behaviors, leg extension and grappling, in observations of both species of *Acris* in North Carolina. These behaviors are exhibited by calling males in high-density choruses or when a satellite male is in close proximity to the calling male. In leg extension, the individual repeatedly extends and contracts a hind leg in an exploratory fashion. When the foot or leg contacts another male, the individual turns to face the opponent before grappling until one male hops free. Physical interactions continue until either male moves away from the immediate area.

On 8 June 2007 at 2403 h, in an area of Merchants Millpond State Park (Gates County, North Carolina, USA) with an extensive mixed chorus of *Acris* (36.4261°N, 76.6770°W; NAD83 datum), we found an *A. crepitans* male and *A. gryllus* male interacting aggressively. We video recorded the interaction with a Canon Powershot A80 digital camera with light from two Petzl Duobelt halogen headlamps. We recorded for two 3-min periods. The aggressive interaction included leg extensions, grappling, and vocalizations by both males. The vocalizations allowed us to conclusively identify the males as *A. crepitans* and *A. gryllus* without capturing them (and thus interrupting their interaction).

Despite the exceptionally large populations of *A. crepitans* and *A. gryllus* at this location and our extensive work at the site in 2006 and 2007, this is the only case in which we have observed such prolonged physical agonism within or between the species, and we know of no previous reports of this behavior. Since conspecific recognition occurs by females at Merchants Millpond, interspecific agonism in males is likely a product of competition for calling space on aquatic macrophytes and woody debris, not competition for mates. Because male competition is mediated by vocalizations in *A. crepitans*, it is possible that the prolonged interaction we observed resulted from the inability of the two males to mediate their spacing acoustically. Future investigations of male competition in mixed choruses of *Acris* could include an analysis of the aggressive thresholds of both species toward intrusion by conspecific and heterospecific males.

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ACRIS GRYLLUS (Southern Cricket Frog). **DISPERSAL**. On 8 July 2004 around 0300 h at Cliffs of the Neuse State Park (Wayne County, North Carolina, USA), I observed a female Acris gryllus feeding on insects under the lights of a building (35.2412°N, 77.8873°W). If the female originated or bred at the nearest chorus of *A. gryllus* (35.2362°N, 77.8867°W), then she moved at least 562 m through forested habitat and up a hill to reach the location where I observed her.

Acris crepitans (Northern Cricket Frog) and *A. blanchardi* (Blanchard's Cricket Frog) have declined near northern range margins. In North Carolina, *A. gryllus* has also declined near the northern edge of its range and the Cliffs of the Neuse population is adjacent to that area (Micancin and Mette 2009. Zootaxa 2076:1–36). An important consideration in the conservation of cricket frogs is the extent of nonbreeding or upland habitat use. This observation indicates that the population of *A. gryllus* at Cliffs of The Neuse State Park can use upland habitat far from breeding wetlands during the breeding season. The well-known jumping ability of *Acris* apparently allows them to move far from wetlands in search of food.

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BUFO BUFO (Common Toad). **DAVIAN BEHAVIOR.** Misdirected copulation with dead conspecific or other species is known as Davian behavior. It was described in mammals (Dickerman 1960. J. Mammal. 41:403), and birds (Lehner 1960. Wilson Bull. 100:293–294; Moeliker 2001. Deinsea—Annual of the Natural History Museum Rotterdam 8:243–247). In anurans it has been reported, although not as Davian behavior, in the Cane Toad (*Bufo marinus*) (Lewis 1989. Cane Toads: An Unnatural History. Doubleday. New York, New York. 98 pp.), and the Cuban Treefrog (*Osteopilus septentrionalis*) and Southern Toad (*Bufo terrestris*) (Meshaka 1996. Florida Sci. 59[2]:74–75). The first report of Davian behavior in the study area was described for *Bufo bufo* (Ayres 2008. Podarcis 9:11–12). Here I present new observations about this unusual behavior.

Field observations were made at clay pits in the Gandaras de Budiño e Ribeiras do Louro (GBRL) wetland, municipality of Porriño, NW Spain (42.1023°N, 8.6301167°W) on 6 Jan 2009. GBRL wetland consists of a complex of gallery forests, flooded areas, and artificial ponds created by the extraction of clay. Abandoned clay pits have been colonized by aquatic vegetation, and constitute an important breeding area for *B. bufo*, which are an important food resource for Eurasian Otters (*Lutra lutra*) during winter. I monitored clay pits by walking along the shore and banks, looking for anuran reproductive activities, or remains of toads predated by otters.

On 6 Jan 2008 I found three female *B. bufo* predated by otters in an area with shallow water (<20 cm deep), but in a deeper area (to 1 m deep) I found another predated female. When I recovered the corpse from the bottom of the pond, I noted a live male attached to the remains of the female (Fig. 1).

FIG. 1. Male *Bufo bufo* (top) in amplexus with a dead female conspecific that had been partially consumed by a Eurasian Otter.

This behavior is unusual, as it seems that it represents an ecological trap for male toads. The absence of sex recognition by *B. bufo* has been studied by Marco and Lizana (2002. Ethol. Ecol. Evol. 14:1–8) who reported the lack of a release call in the Iberian Green Frog (*Pelophylax perezi)* leads male *B. bufo* to amplex with this species, wasting time and energy, and missing opportunities to mate with gravid conspecific females. They also reported amplexus with the Fire Salamander (*Salamandra salamandra*), dead fishes, or pieces of wood.

Males detected in amplexus with dead females in winter 2008 were located in shallow areas and females lacked hind legs (Ayres and Garcia 2007. Galemys 19:45–50), so it seems that body shape does not affect male choice. But the pair in amplexus detected in 2009 were in deep water. This increased the risk of the male being predated by otters, and the depth did not allow the male to breath without leaving the dead female. Males in amplexus with dead females could pass several days attached to the body, which increases the risk of predation and results in a loss of mating opportunities.

It is unclear why male toads perceive corpses as suitable mates. It has been suggested that movement is a factor that leads males to grasp individuals or objects, even observer's toes (Ayres, pers. obs.; Meshaka 1996, *op. cit.*). Nevertheless, dead females remain motionless in the bottom of the ponds, which suggests that chemical factors may influence this unusual behavior. Further studies will be necessary to assess if this hypothesis is true.

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BUFO HOUSTONENSIS (Houston Toad). **PREDATION**. Few predators of the federally endangered *Bufo* (=*Anaxyrus*) *houstonensis* have been recorded: snakes (*Nerodia erythrogaster*, *Thamnophis proximus*) predate on tadpoles (Freed and Neitman 1988. Texas J. Sci. 40:454-456), snakes (*Heterodon* sp., *N. erythrogaster*) on adult toads (USFWS 1984. Houston Toad Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico), and red imported fire ants (*Solenopsis invicta*) on newly metamorphosed toadlets (Freed and Neitman. 1988, *op. cit.*). Here, we report the first record of predation of an adult *B. houstonensis* by another anuran, the American Bullfrog, *Rana catesbeiana*.

On 28 Mar 2008 at 2312 h, an adult female *R. catesbeiana* (158.8 mm SVL) was observed on the shoreline of a pond on the Boy Scouts of America's Griffith League Ranch in Bastrop County, Texas, where *B. houstonensis* had been and were actively breeding. American Bullfrogs are reported to eat anything they can swallow, from insects to mammals (Bolek and Janovy 2007. Herpetol. Rev. 38:325-326; Dixon 2000. Amphibians and Reptiles of Texas. 2nd ed. Texas A&M Univ. Press, College Station, Texas. 421 pp.; Frost 1935. Copeia 1935:15–18), and hence, they are potential predators of all life stages of this endangered toad. The *R. catesbeiana* was collected and later dissected to determine if predation on *B. houstonensis* had occurred. An adult male *B. houstonensis* (50.3 mm SVL) was discovered in the stomach, along with an *Acris crepitans* and three *Hyla versicolor*. We have determined this was predation rather than scavenging due to the well-preserved nature of the *B. houstonensis*. While this toad was partially digested, its cranial crests and parotids remain apparent, and spotting may be seen on its venter. Additionally, we compared its D-loop mitochondrial sequence to other sequences we generated from sympatric *Bufo* species, which support its identification as *B. houstonensis*. This record represents the first published account of *B. houstonensis* as a diet component of another anuran.

Specimens were deposited at the Texas Cooperative Wildlife Collection, Texas A&M University, College Station, Texas, USA (TCWC 93562 includes *R. catesbeiana* and its stomach contents: *B. houstonensis*, *A. crepitans*, 3 *H. versicolor*). Identification were verified by T. Hibbitts. We thank D. J. Brown and L. M. Villalobos for field and lab assistance.

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BUFO PARITALIS (Forest Toad). **DIURNAL RETREAT**. *Bufo paritalis* is a large, rare, and little-known, endemic toad that lives in the tropical rainforests of the Western Ghats (Molur and Sally 1998. Zoo's Print 13[12]:29). Little information on the distribution and natural history of the species exists (Daniels 1992. Hamadryad 17:40-42; Krishna and Krishna 2004. Herpetol. Rev. 35:156-157; Krishna and Krishna 2001. J. Bombay Nat. Hist. Soc. 98:456-457). From 18 Feb to 17 March 1999, I studied the breeding behavior and reproduction of *B. paritalis* at the Bisle Reserve Forests of the Western Ghats (12°15'N; 75°37'E, 150 m elev.). During the day, *B. paritalis* retreats inside tree crevices or buttresses of live trees and dead wood ca. 0.3–0.6 m above ground. During the first hours of the night it emerges from this retreat to feed and mate. Between 1900–1930 h the toads emerge from the crevices adjacent to a stream and either enter the water or perch on rocks in the flowing stream. A few males arrive early and began calling, afterwards

many males emerge from the hideouts and join the calling group. This retreat habitat and calling behavior has not been reported for *B. paritalis*.

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COCHRANELLA ALBOMACULATA (White-spotted Cochran Frog). **PREDATION**. Predation on adult anuran amphibians by invertebrates, especially by spiders (e.g., Blackburn et al. 2002. Herpetol. Rev. 33:299; Formanowicz et al. 1981. Herpetologica 37:125–129; Jansen and Schulze 2008. Herpetol. Rev. 39:459; Pontes et al. 2009. Herpetol. Rev. 40:71), but also by crabs (Duellman and Trueb 1986. Biology of Amphibians. The Johns Hopkins University Press. Baltimore and London), or bugs (Toledo 2003. Phyllomedusa 2:105–108) have been reported several times. Herein we report, to our knowledge, the first account of a whip scorpion (Amblypygi) feeding on a glass frog.

At 2200 h on 31 March 2009, at Cerro Negro, Veraguas Province, Panama (08.569°N, 81.097°W; 770 m elev.), we detected a large whip scorpion holding an almost digested female *Cochranella albomaculata* between its chelicerae. The whip scorpion was sitting on a rock, amidst a small mountain stream. At the time of observation all that remained of the frog were one leg and a clutch of eggs that poured out of the frogs remains (Fig. 1).

Amblypygi are not frequently reported as predators of frogs (Armas 2001. Revista Ibérica de Aracnología 3:87–88), nevertheless they might play an important role as predators of glass frogs. White-spotted Cochran Frogs are known to call from rocks in the stream during drier periods, whereas they prefer riparian vegetation during wet periods (Kubicki 2007. Glass Frogs of Costa Rica. Editorial INBio. Santo Domingo de Heredia, Costa Rica). Therefore the dry season is when whip scorpions might encounter these frogs frequently, as both seek out humidity on rocks near streams.

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FIG. 1. Large whip spider (Amblypygi) holding the remains of a female *Cochranella albomaculata* between its chelicerae.

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DENDROBATES PUMILIO (Strawberry Poison-dart Frog). **COLORATION.** *Dendrobates pumilio* of Central America is noted for its exceptionally high level of color polymorphism (Savage 2002. The Amphibians and Reptiles of Costa Rica. Univ. Chicago Press, Chicago and London. 954 pp.). For decades this species has been the focus of numerous studies to elucidate the function, evolution, and maintenance of this color variation (Wang and Shaffer 2008. Evolution 62:2742–2759). An integral aspect of this research is to develop a detailed knowledge of the geographical range and description of all the color morphs.

The purpose of this note is to expose the existence of a previously unknown population of *D. pumilio* that differ from previously described populations. The existence of this population is based on numerous individuals that were consistently encountered during the years of 2005–2007, while the author was conducting unrelated research in the region. This new color morph is all blue, similar to the previously described morph found in the Cerro Brujo region, but has the large black spotting on the dorsum like those morphs found on Bastimentos (Fig. 1).

Individuals from this population were encountered on the mainland of the Bocas del Toro Province, Panama in the foothills between the Rio Changuinola and the Rio Risco within the vicinity of 9.218863°N, 82.460632°W. Although individuals of the nominate color morph were often encountered in adjacent areas along the Rio Changuinola, the two morphs were never seen within the area.

FIG. 1. The newly discovered color morph of *Dendrobates pumilio* differs from the nominate color form in being uniformly dark blue with large black spots on the dorsum.

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DENDROPSOPHUS MICROCEPHALUS (Yellow Treefrog). **PREDATION.** Many frog species group together in a chorus to increase their mating success; however a significant risk they face in doing so is an increased detection by predators (Ryan et al. 1981. Behav. Ecol. Sociobiol. 8:273–278; Wells and Taigen 1989. Behav. Ecol. Sociobiol. 25:13–22) as olfactory, auditory, and vibratory signals are substantially increased in choruses. Anuran chorus behavior is prevalent due to the high probability of attracting a mate relative to calling alone (Ryan et al. 1981, *op. cit.*). Herein we report observations of predation on *D. microcephalus* by the Cat-eyed Snake *Leptodeira septentrionalis* in the vicinity of Las Cuevas Research Station (16.71667°N 88.9833°W), within the Chiquibul Forest Reserve, Belize. The advertisement call of this frog is generally described as a "creek-eek-eek" (Duellman 1970. The Hylid Frogs of Middle America Vol. 1. Monograph Mus. Nat. Hist., Univ. Kansas). On 6 Aug 2008 at ca. 2100 h, we heard a squeak-like repetitious call, differing substantially from the advertisement call: this call was higher pitched and although not analyzed, call rate seemed constant. Additionally, these calls were not triggered by conspecific call bouts as is generally observed in *D. microcephalus* (Schwartz and Wells 1985. Copeia 1985:27–38). Upon locating the source in the pond vegetation (a mixture of sedges and shrubs), we discovered that a male *D. microcephalus* had been attacked by a *L. septentrionalis* from the rear and was vocalizing what was most likely a distress call. The frog did not physically struggle as the snake consumed it, but did continue to vocalize until it was completely ingested. Ingestion took ca. seven minutes. Despite general knowledge of distress calls in anurans (Gerhardt 1994. Annu. Rev. Ecol. Syst. 24:293–324), this type of call remains undescribed in *D. microcephalus*. Moreover, little is known about predators of this species.

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DENDROPSOPHUS MINUTUS (NCN). **PREDATION**. Dragonfly larvae are commonly known to prey on small frogs and tadpoles (Caldwell et al. 1980. Oecologia 46:285–289), including species of Hylidae (McCollum and Leimberger 1997. Oecologia 109:615–621). On 28 Sept 2008 (ca. 2100 h), at Poço Azul, Brasília National Park, Federal District, Brazil (15°30'S, 47°50'W), we found a larval female odonate *Castoraeschna longfieldae* (50.5 mm length, catalogued at Museu Nacional do Rio de Janeiro [MNRJ]) preying on a tadpole of *Dendropsophus minutus* during a night of hard rainfall. This observation took place in a grassy pond where numerous anurans were heard calling. When captured, the odonate larva continued to grasp the tadpole. This is the first record of *C. longfieldae* preying on tadpoles. To accurately identify the dragonfly, we maintained the larva in the laboratory until metamorphosis (77.26 mm length). Other anurans in the area include *Rhinella schneideri*, *Phyllomedusa azurea*, *Hypsiboas lundii*, *Bokermannohyla pseudopseudis*, *Odontophrynus salvatori*, *Leptodactylus ocellatus*, and *L. furnarius*. Tadpoles of all these species may be potential prey to *C. longfieldae* and other larval odonates.

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ELEUTHERODACTYLUS JOHNSTONEI (NCN). **MICROHABITAT**. *Eleutherodactylus johnstonei* has exhibited exceptional colonizing abilities, and exploits a wide variety of macro- and microhabitats, including outbuildings and shower stalls (Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. University Press of Florida, Gainesville). At 1930 h on 11 June 2009 at Lazy Lagoon Guest House in St George's, St. George Parish, Grenada, an adult *E. johnstonei* was found utilizing the top inside rim of a porcelain indoor toilet (Titon, 6.1 liters/flush). Its presence became known when the toilet was flushed, and the force of water from inside the upper rim caused the frog to descend into the bowl of the toilet; from there it vacated the toilet and escaped to the outside under a door. As business had been slow at Lazy Lagoon and this occurred at the end of the dry season, the frog was likely exploiting a convenient moist microhabitat. I am unaware of any previous report of *E. johnstonei* using the interior of an indoor toilet as a retreat.

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HADDADUS BINOTATUS (Clay Robber Frog). **EGG CLUTCH**. *Haddadus binotatus* has direct development and a hatchling egg tooth (Hedges et al. 2008. Zootaxa 1737:1–182). During May 1987 in the Parque Nacional da Tijuca, an egg clutch of *H. binotatus* was found containing 14 eggs (Fig. 1). The eggs were collected, taken to the laboratory, and kept until hatching for identification. After hatching the material was fixed in 10% formalin and included in the amphibian collection of the Zoology Department of the Universidade Federal do Rio de Janeiro (ZUFRJ 3083). The egg clutch was found under a rotten tree trunk on the ground of the forest. The eggs were separated from each other in an area of 4.5 cm. A thin layer of substrate was stuck to the outer membrane of the egg. The eggs were large, ca. 10 mm, and two membranes were observed surrounding the embryo (Fig. 2). The embryos were a clear beige color when alive, they were all at the same stage of development,

FIG. 1. Egg clutch of *Haddadus binotatus* with 14 eggs found in the Parque Nacional da Tijuca.

FIG. 2. Egg and embryo of *Haddadus binotatus* (about 10 mm).

and had a lot of yolk and a large, highly vascularized tail covering almost its entire body (Fig. 2). Near hatching, the characteristic egg tooth of the embryo could be observed. This tooth is keratinized and black in its distal portion as reported by Townsed and Stewart (1985 Copeia 1985:423–436) in *E. coqui* and *E. antillensis*, the egg tooth falling off shortly after hatching. The hatchling left the egg at ca. 9 mm SVL. The embryo tail of *Haddadus binotatus* covers almost its entire body, different from that of *Ischnocnema venancioi* (Izecksohn and Albuquerque 1972. Arq. Univ. Fed. Rur. Rio de Janeiro 2[1]:13–15), *I. guentheri* (Lynn and Lutz 1946. Bol. Mus. Nac. Zool. 71:1–46), *I. parva* (Lutz 1944. Bol. Mus. Nac. Zool. 15:1–30), and *E. coqui* (Townsed and Stewart 1985, *op. cit.*) which covers only part of the body. The tail is very vascularized, which suggests, as observed by Izecksohn and Albuquerque (1972, *op. cit.*), to be the main respiratory organ. Pombal (1999. Rev. Bras. Zool. 16[4]:967–979) observing the oviposition of *Brachycephalus ephipium*, showed that this species had parental care. The female rolled the eggs on the substrate to stick particles of substrate on its membrane to better camouflage them, to protect them from parasites, and to keep the embryos hydrated. It is possible that this behavior is the same in *H. binotatus* because the eggs were found covered by particles of substrate as observed by Pombal (1999, *op. cit.*). This is the first report of an egg clutch of *H. binotatus*.

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HYLARANA LEPTOGLOSSA (Long-tongued Frog). **DEFENSIVE BEHAVIOR.** *Hylarana leptoglossa* is an aquatic frog, inhabiting subtropical lowland forests and forming breeding aggregations on the edges of permanent, macrophyte-dominated

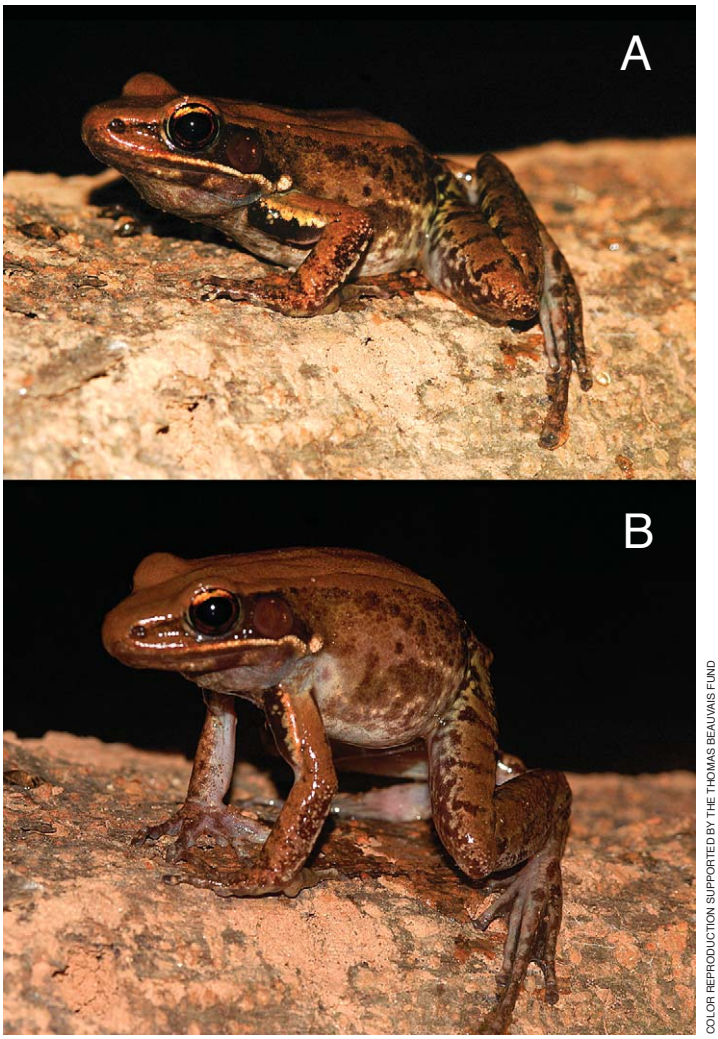

FIG. 1A. *Hylarana leptoglossa* in typical resting position. 1B. *Hylarana leptoglossa* in defensive posture.

waterbodies during the early monsoons (between the months of March to May). An adult male (Museum of Arya Vidyapeeth College, AVC 0943; SVL 60.5 mm) collected from near Lailad village (25.9320278°N, 91.7756944°E; 225 m elev.), Nongkhyllem Wildlife Sanctuary, East Khasi Hills, Meghalaya State, northeast India on 25 March 2009 displayed the following behavior as a response to handling during a photography session: all four limbs were planted on the substratum, while the body was greatly elevated, till the forelimbs were nearly vertical to the ground with the knee raised, the body raised > 50% depth of body (Figs. 1A–B). It maintained the position for ca. 10 secs each time.

Defensive postures are familiar methods of defense in anuran amphibians (review in Dodd 1976. Smithson. Herpetol. Inf. Serv. [37]:1–10), and were previously unreported in this species. The described posture results in elevated body position, presumably confusing potential predators. Another behavioral defense mechanism noticed was puffing of the body and of the gular region, although no glandular secretions or odor were detected.

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LITHOBATES AREOLATUS CIRCULOSUS (Northern Crawfish Frog). **PREDATION.** The Eastern Hog-Nosed Snake, *Heterodon platyrhinos,* is generally considered to be specialized for eating toads (Bufonidae); it has been suggested that their enlarged posterior maxillary teeth assist in holding and deflating these prey (Edgren 1955. Herpetologica 11:105–17; Minton 2001. Amphibians and Reptiles of Indiana. Indiana Academy of Science. Indianapolis, Indiana. 404 pp.). However, *H. platyrhinos* is also known to consume other anuran species including several species of ranids (Edgren 1955, *op. cit.*; Platt 1960. Univ. Kansas Pub. Mus. Nat. Hist. 18:253–420). Here, we report predation by *H. platyrhinos* on *Lithobates areolatus circulosus*. To our knowledge, this is the first documentation of this snake species preying upon this frog species, which is in decline across portions of its northern range, including Indiana (Parris and Redmer 2005. *In* Lannoo [ed.] Amphibian Declines: Conservation Status of United States Species, pp. 526–528. Univ. Calif. Press, Berkeley, California).

On 14 May 2009 at 0750 h, an adult *H. platyrhinos* was observed at Hillenbrand State Fish and Wildlife Area in Greene County, Indiana (USA), regurgitating a recently consumed adult female *L. a. circulosus*. This frog was one of 19 implanted with transmitters (Model PD-2 Holohil Systems Ltd. [Carp, Ontario, Canada]) for a study of the movements and habitat use of this state endangered species. The snake (SVL 48.5 mm, TBL 62.1 mm, mass 130 g) was observed and captured near the frog's burrow. Upon being caught, the snake immediately performed a defensive display that included defecation and regurgitation; stomach contents included the frog implanted with the transmitter.

The *L. a. circulosus* (108 mm SVL) was first observed on 4 April 2009 in gravid condition (mass 134 g) while entering a semi-permanent breeding wetland. She left the wetland on 19 April 2009 after depositing her eggs (weight 90 g; Kinney, unpubl. data). After breeding, the frog traveled, over the course of 10 days, 730 m (straight line distance) NE to a burrow, which it inhabited for 14 days prior to being eaten. The regurgitated carcass was missing a portion of its head, suggesting the snake took the frog head on (and that there was resistance), a position consistent with occupancy of a burrow (JLH, pers. obs.), not an animal fleeing. The frog had been in the burrow the previous morning, and the carcass was fresh, suggesting that the frog had been eaten within the past 24 hours. Toads are uncommon at our study site. Only two *Anaxyrus fowleri* have been observed, another was heard calling (JLH; pers. obs.). None have been collected along 1100 m of drift fencing (184 buckets; four wetlands encircled; Kinney, unpubl. data). Low toad densities at our study site may result in *H. platyrhinos* predation on ranids.

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LITHOBATES AREOLATUS CIRCULOSUS (Northern Crawfish Frog). **BREEDING.** *Lithobates a. circulosus* is declining throughout parts of its range and listed as state endangered in Indiana (Parris and Redmer 2005. *In* Lannoo [ed.] Amphibian Declines: Conservation Status of United States Species, pp. 526–528. Univ. Calif. Press, Berkeley, California.). We have been studying the breeding biology of this species in an attempt to understand factors contributing to recent declines (Minton 2001. Amphibians and Reptiles of Indiana. Indiana Academy of Science. Indianapolis, Indiana. 404 pp.).

Here we report an instance of atypical, perhaps satellite-like, breeding in *L. a. circulosus*. On 1 May 2009 at 0803 h, one of us (VCK) found an amplexed pair (Fig. 1) in a drift fence pit fall trap located at our study site, Hillenbrand State Fish and Wildlife Area in Greene County, Indiana, USA. The female was gravid. Both animals were pit-tagged prior to their release—still in amplexus—in the wetland, and were individually weighed and measured after separating and upon exiting. The male was 86 mm SVL, 74 g; the female was 101 mm SVL, 96 g, and was spent. There were three unusual components to these field observations: 1) This pair arrived 25 days after the end of peak breeding at this wetland, which occurred from 2 April 2009 through 5 April 2009 (VCK, unpubl. data). This was 26 days later than the previous last female, 20 days later than the previous last male. 2) The pair was in amplexus when found. While males and females occasionally occurred in the same bucket over the course of the breeding season, at no other time were *L. a. circulosus* (97 breeding animals total observed at our drift fences encircling two wetlands) found in amplexus before entering breeding wetlands. 3) The animals left the pond separately, a week apart (the female on 6 May 2009, the male on 14 May 2009), and upon exiting were found at the same bucket on the opposite side of the wetland where they had entered.

Explosive breeding in temperate amphibians such as *L. a. circulosus* typically involves males arriving early (Smith et al.

FIG. 1. Amplectant pair of *Lithobates areolatus circulosus* entering a breeding wetland. The female is gravid. Photograph by Vanessa C. Kinney.

1948. Amer. Midl. Nat. 39:608–614), and calling for competitive reasons (to establish dominance among males or access to favorable breeding sites) and to attract females. Once in the wetland, females are generally thought to exercise choice in determining mates or breeding sites (Wells 2008. The Ecology and Behavior of Amphibians. Univ. Chicago Press, Chicago. 1148 pp.). Alternately, satellite males, which tend to be smaller and younger, may sneak matings by remaining silent and intercepting females, avoiding competitive interactions with males and not affording females choices (Krebs and Davies 1978. Behavioural Ecology: An Evolutionary Approach. Sinauer, Sunderland, Massachusetts. 494 pp.; Wells 2008, *op. cit.*).

It is likely that neither male competition nor female choice occurred with this amplexed pair of *L. a. circulosus*. They came from a direction (east) with no known breeding wetlands (indeed, the wetland where they were found may be the easternmost extant breeding wetland for this species at this latitude). The next closest wetland in any direction is > 1 km away. It is possible that they coupled in this distant wetland and traveled overland in amplexus to the wetland where they were found; this would account for their tardiness. But at least eight other females bred at this second wetland, and there were no features of this wetland such as drying or the presence of fish that appeared to us to make it unfavorable. It seems more likely that the male intercepted the female on the way to the wetland where they were found—perhaps at some distance away, which, again, would account for their tardiness. If so, there was likely no calling involved in attracting this female and little opportunity for female choice. At 86 mm SVL, this male was not small (Parris and Redmer 2005. *op. cit.*); nevertheless, this observation suggests some form of previously undescribed alternate mating tactic, perhaps a satellite-type male behavior, in this species.

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LITHOBATES NEOVOLCANICUS (Transverse Volcanic Leopard Frog). **DIET**. *Lithobates neovolcanicus* inhabits lakes and low streams in open areas surrounded by oak-pine forest and mesquite prairies throughout the Transverse Neovolcanic Belt (1500–2500 m elev.) across the states of Guanajuato, Jalisco, Michoacán, and México in central México. On 1 Dec 2008 at 1935 h we observed and photographed a *Lithobates neovolcanicus* (IBH-RF 027; 51 mm LHC), eating an *Anaxyrus punctatus* (Red-spotted Toad) in a small pond situated at Rio Las Lajitas (21.4932333°N, 99.961°W; 947 elev.), in the Tortugas locality at Xichú Municipality, Guanajuato, México. Other reports on the diet of *Lithobates zweifeli, L. catesbeianus, L. vaillanti,* and *L. brownorum* (Field and Beatty 2003. Herpetol. Rev. 34:228; Ramírez-Bautista and Lemos-Espinal 2004. Southwest. Nat. 49[3]:316–320; Mendoza-Estrada et al. 2008. Acta Zool. Mex. [n.s.] 24[1]:169–197) indicate that most species feed on invertebrates and terrestrial and aquatic vertebrates, including fish and tadpoles of *Lithobates* sp. *Lithobates vaillanti* was reported eating *Agalychnis callidryas* (Vaughan 2003. Herpetol. Rev. 34:238), but no reports on feeding habits of *L. neovolcanicus* occur in the literature.

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LITHOBATES ONCA (Relict Leopard Frog). **CANNIBALISTIC OOPHAGY**. Oophagy, the consumption of eggs, is not uncommon among anurans (Crump 1992. *In* Elgar and Crespi [eds.], Cannibalism: Ecology and Evolution Among Diverse Taxa, pp. 256–276. Oxford University Press, New York; Alford 2009. *In* McDiarmid and Altig [eds.], Tadpoles: the Biology of Anuran Larvae, pp. 240–278. Univ. Chicago Press, Chicago, Illinois; Gunzburger and Travis 2005. J. Herpetol. 39:547–571). It is one of many forms of cannibalism exhibited by amphibians, most commonly by the larval stages (Crump 1992, *op. cit*). The larvae of a number of hylids and dendrobatids that occur in various phytotelmons eat heterospecific and homospecific (trophic) eggs. The larvae of two species of *Lithobates* have been reported to be oophagous (*L. sylvatica* and *L. temporaria*), but cannibalistic oophagy has only been reported for *L. temporaria* (Alford 1999, *op. cit.* and Gunzberger and Travis 2005, *op. cit.*).

Homospecific oophagous activities by tadpoles of *Lithobates onca* were observed in two different canyons within Black Canyon, Clark Co., Nevada, USA. On the morning of 25 April 2008, I observed two large (7–9 cm total length, estimated Gosner [1960. Herpetologica 18:183–190] stages 34–36) tadpoles that initially appeared to be resting on a 1–2 day old egg clump of *L. onca* (terminology from Altig and McDiarmid 2007. Herpetol. Monogr. 21:1–32). The egg clump was within 20 cm of the shore, about 5 cm below the water surface, and attached to overhanging Bermuda Grass (*Cynodon* sp.). As I observed for about 7 min, it became evident that the tadpoles were eating the eggs. The tadpoles wriggled and tore at the eggs at the top and sides of the clump. There was a second, recently-laid clump within 30 cm of the feeding tadpoles that was also attached to overhanging grass. The permanent pool was in a natural warm-water spring system; the pool measured 6 × 4 m with a maximum depth of about 1 m. The substrate was

silt over bedrock. There was no emergent or submergent aquatic vegetation, but the bottom did have visible algal growth. Water temperature was 22° C. Five *L. onca* tadpoles of similar size to those seen on the eggs were in the pool. When I returned to the site on 27 April 2008, there was no evidence of either egg clump, and no hatchlings were seen in the pool. Hatchlings were not expected to have already hatched because it takes about 5-7 days for embryos of *L. onca* to hatch at this temperature (personal observation).

At about 1900 h on 28 April 2008, in a second canyon off Black Canyon, *L. onca* tadpoles were observed eating a later stage egg clump (Gosner Stages 15–18) of *L. onca*. In a permanent pool filled by flow from warm-water springs in the system, three *L. onca* tadpoles about 7–9 cm total length, at Gosner stages 34-36, were tearing at the eggs. The pool measured about 2 x 3 m with a maximum depth of 0.4 m. Pool substrate was cobble, silt and bedrock with visible algal growth. Water temperature was 21° C. There was a smaller, more recently oviposited egg clump of *L. onca* in the pool about 20 cm from the eggs being consumed. Both egg groups were attached to *Typha* sp. at 10 and 5 cm below the water surface. On 1 May 2008, the first egg clump was absent; the majority of the jelly of the second group remained, but the embryos were absent. The egg membranes were torn and appeared partially consumed. The observations of the state of the egg masses and absent embryos were consistent with those described by Petranka and Thomas (1995. Anim. Behav. 50:731-739). There were no hatchlings seen in the pool, but as seen at the previous site, these also were not expected to have hatched in such a short period. In both cases, no other predators were seen in the pool, nor were there tracks or prints seen around the shoreline of the pool.

Typically, cannibalism is expected to occur under conditions including high density and low food availability (Caldwell and Carminoza de Araujo. 1998. Biotropica 30:92-103). Potential benefits of oophagy include elimination of potential competitors, increasing resources available for survivors, and energy-rich nutrients from the eggs in the form of calcium and phosphorus, necessary components for proper skeletal development (Crump 1983. Am. Nat. 121:281-287). Neither high density nor low food availability appeared to be factors in the two pools in which I observed cannibalistic oophagy exhibited by *L. onca*. It has been suggested that explosive breeding in amphibians is a response to cannibalism by reducing differences in developmental stages and therefore reducing the opportunity for cannibalism to occur. *Lithobates onca* is not an explosive breeder, but rather has a prolonged breeding season extending for several months (Bradford et al. in Lannoo (ed) 2005. Amphibian Declines. Univ. California Press: Berkeley, pp. 567-568; personal observation). While Fox (2008. Herpetol. Rev. 39:151-154) reported only early stage *Spea intermontana* tadpoles fed on conspecific hatching tadpoles, the observations reported here were more in line with the reports from Crump (1983. *op. cit.*) that no tadpoles of *Hyla pseudopuma* under Gosner 35 were observed to be cannibalistic. There was no apparent fungal or algal growth on the eggs or developing embryos of *L. onca* that were being cannibalized, unlike those of *Spea* (Fox 2008. *op. cit.)*. Unlike most other oophagous tadpoles, the tadpoles of *L. onca* are not morphologically specialized for eating eggs. The mouth is relatively small with well developed keratinized jaw sheaths that have only small serrations; oophagous larvae typically have powerful jaws, enlarged jaw sheaths and broad oral labia. The tadpoles of *L. onca* also lack the modified, shortened intestinal tract found in other oophagous larval anurans, suggesting that the tadpoles of *L. onca* are only opportunistically oophagous.

Crump (1990. Copeia.1990:560–564) and Wildy et al. (1998. J. Herpetol. 32:286–289) reported that cannibalism resulted in enhanced growth of larval treefrogs and larval salamanders. We currently have no data to indicate that this is the case for tadpoles of *L. onca*. Several species of *Lithobates* have been reported to consume heterospecific eggs (Gunzberger and Travis 2005, *op. cit.*). *Lithobates onca* currently co-occur with *Bufo woodhousii*, *B. punctatus,* and *H. arenicolor* (unpubl. data). It would be interesting to observe whether the opportunistically cannibalistic oophagous tadpoles of *L. onca* are also opportunistically heterospecific oophagous.

These observations were made while conducting conservation efforts supported by Lake Mead National Recreation Area, National Park Service. I thank R. Altig for helpful comments on this note.

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LITORIA CAERULEA (Green Treefrog). **SAUROPHAGY**. *Litoria caerulea* is a large hylid frog from northeastern Australia (Cogger 2000. Reptiles and Amphibians of Australia. 6th edition. Ralph Curtis Publishing, Sanibel, Florida. 808 pp.). *Litoria caerulea* are known to be opportunistic predators, even capable of eating small rats (Tyler 1994. Australian Frogs: A Natural History. Cornell Univ. Press, 51 pp.). Reports of reptiles being eaten in the field by *L. caerulea* are rare. During the evening of 16 Sept 2006 I observed a gecko (*Hemidactylus frenatus*) at ca. 2 m height in a palm tree on the campus of James Cook University in Townsville, Queensland, Australia. *Hemidactylus frenatus* is native to Southeast Asia and is introduced into Australia (Wilson 2005. A Field Guide to Reptiles of Queensland. New Holland Publishers, 45 pp.). While observing the gecko, I watched a *L. caerulea* jump from a higher location in the palm and attack the gecko. The gecko was grabbed near its hind legs and bit the frog before being eaten. Photographs were taken during the event and deposited in the digital image collection at the Amphibian and Reptile Diversity Research Center at the University of Texas at Arlington (UTADC 4007). This is the first record of saurophagy in *L. caerulea*.

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LITORIA CYCLORHYNCHA (Spotted Thighed Frog). **SALINE HABITAT**. With some rare exceptions (e.g., Balinsky 1981. J. Exp. Zool. 215:335–350) anurans are generally intolerant of salt water, particularly in the larval stage. For example, recent studies in Australia reported upper conductivity tolerance limits in the field for tadpoles between 10^3 and 10^4 μS cm^{-1} (2–10% sea water)

for six common frog species found in waters affected by secondary salinisation in western Victoria, Australia (Smith et al. 2007. Freshwater Biol. 52:75–84). During a recent survey of the water quality and biodiversity values of the rivers of the South Coast Region undertaken by the Centre of Excellence in Natural Resource Management, University of Western Australia, tadpoles were collected in waters with comparatively high salt loads at sites on the Twertup Creek system, Fitzgerald River: 20.7 mS cm^{-1} (salinity of 12.4 ppt, 35% seawater: site C2, Mum's Creek, 33.780617°S, 119.2975767°E, 15 Jan, 21 tadpoles) and 22.2 mS cm^{-1} (salinity of 13.37 ppt, 38% seawater: site JC8, on Jacup Creek, 33.749267°S, 119.209667°E, 12 Jan, 1 tadpole). Tadpoles were identified as *Litoria cyclorhyncha* using Main (1965. Frogs of Southwestern Australia. Western Australian Naturalists' Club, Perth, Australia. 73 pp.) and Anstis (2002. Tadpoles of South-eastern Australia. Reed New Holland, Sydney, Australia. 281 pp.). At C2 tadpoles were at Gosner Stages 24 (1), 25(14), 26 (4), 28 (1) and 37 (1). At JC8 the single tadpole collected was at Gosner Stage 37 and had a total length of 64 mm. The late stage of development for some tadpoles at both sites suggests an extended period exposed to high salinities. The cluster of tadpoles at early post-hatching stages at C2 might indicate a recent breeding event—presumably also in relatively saline water. There is variation in salinity at these sites. In late spring sampling at the same sites (11 and 12 Nov 2008) salinities were much higher at 51.32 mS cm^{-1} (C2) and 48.79 mS cm^{-1} (JC8) (33.79 and 31.7 ppt, 86 and 91% seawater). Local rainfall and runoff reduce salinities and there was rainfall in the period November to January: November, 89.8 mm, 19 rain days, maximum daily fall 17.4 mm; December, 65 mm, 12 rain days, maximum daily fall 23.4 mm; January, 16.4 mm, 4 rain days, maximum daily fall 10.0 mm (rainfall data for Jacup, ca. 5 km WNW of sampling sites, from http://www.bom.gov.au/climate/dwo/IDCJDW6058.latest.shtml, accessed 16 April 2009).

On 8 Sept 2008 an adult frog jumped into a pool on Twertup Creek (site TWE03, 33.9156°S, 119.19808°E). The frog was captured in the pool and identified as *L. cyclorhynca*. Water in the pool had a salinity of 56.9 mS cm^{-1} (salinity of 37.4 ppt, 107% seawater). The frog jumped back into the pool again when released on granite rocks on the bank. The sound made when the frog jumped into the pool was frequently heard along this hypersaline creek system suggesting *L. cyclorhyncha* may commonly and voluntarily enter highly saline waters.

Salt levels in these tributaries of the Fitzgerald River system are partly elevated due to secondary salinity generated by clearing of native vegetation but the streams also have naturally high salinities as this region has a long, geological history of primary, natural salinity in a variety of water bodies (e.g., at least 3 million years; George et al. 2008. Aust. J. Soil. Res. 46:751–767). Our data suggest these sites might be highly saline when this species breeds in spring and summer (Tyler et al 2001. Frogs of Western Australia. WA Museum, Perth, Western Australia). Anurans can have well-developed capacities to distinguish salinities (Haramura 2008. Copeia 2008:64–67) so the use of saline waters is unlikely to be a mistake and, both adults and tadpoles of *L. cyclorhyncha* can clearly tolerate elevated salinity levels. Tadpoles of a closely related species, *L. aurea* from eastern Australia (Burns and Crayn 2006. Mol. Phylog. Evol. 39:573–579), have been reported in water between 5 and 15% seawater (Christy and Dickman 2002. Amphibia-Reptilia 23:1–11) but not in salinities as high as reported here.

If this truly is a high salinity tolerance in *L. cyclorhyncha* this might reflect natural tolerance evolved during extended exposure to naturally saline waters (George et al. 2008, *op. cit.*) which may have been accentuated during earlier periods of lower rainfall in south-western Australian (e.g., in the Plio-Pleistocene; Byrne 2008. Quaternary Sci. Rev. 27:2576–2585). Secondary salinization has generally been seen as having a negative impact on amphibians in the field (e.g., Smith et al 2007, *op. cit.*) but our observations suggest that one Australian frog species may have a much higher salinity tolerance than anticipated. More extensive field work is required to clarify how generally *L. cyclorhyncha* uses saline waters and what life history stages can persist in saline water.

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MELANOPHRYNISCUS MOREIRAE (Maldonado Red-bellied Toad)**. DEFENSIVE BEHAVIOR.** When threatened, many amphibians show a defensive behavior called unken reflex (Duellman and Trueb 1994. Biology of Amphibians. McGraw Hill, New York. 670 pp.). In this behavior, the individual arches its back, lifting the head and the posterior part of the body while remaining motionless. The forelegs are brought forward and upward and the hind legs are flexed upward, showing the aposematic coloration of the throat and limbs as described and figured by Noble (1951. Biology of the Amphibia. McGraw Hill, New York; p. 381, fig. 131). However, nontoxic and drab colored species may also exhibit this posture (Noble 1951, *op. cit.;* Firschein 1951. Copeia 1951[1]:74).

The bufonid genus *Melanophryniscus* contains 25 species, all distributed in southeastern South America (Frost 2009. Amphibian Species of the World. An Online Reference. Version 5.3 <http://research.amnh.org/herpetology/amphibia/index.php>. 15 Nov 2009; Céspedez 2008. Facena 24:35-48). *Melanophryniscus* species are arranged in three phenetic groups: *M. stelzneri* group, *M. tumifrons* group, and *M. moreirae* group (Cruz and Caramaschi 2003. Bol. Mus. Nac. [N.S.] Zool. 500:1–11). All species have aposematic coloration (e.g., Cruz and Caramaschi 2003, *op. cit.*; Kwet et al. 2005. Salamandra 41[1/2]:3–20). Fernández (1927. Bol. Acad. Nac. Cienc. Córdoba, 29:271–320) was the first to report unken reflex for *Melanophryniscus* (*M. stelzneri*) and this behavior has been observed in nine other species—six in *M. stelzneri* group and three in *M. tumifrons* group: *M. dorsalis, M. montevidensis, M. cupreuscapularis* and *M. pachyrhynus* (Kwet et al. 2005, *op. cit.*), *M. krauczuki,* and *M. atroluteus* (Baldo and Basso 2004. J. Herpetol. 38:140–150), *M. rubriventris* (Laurent 1973. Acta Zool. Lilloana 26[23]:319–334), *M. devincenzii* (Manzano et al. 2004. Inst. Sup. Correl. Geol. Miscellánea 12:271–290), and *M. orejasmirandai* (Kolenc et al. 2003. Aquamar, Madrid 5[30]:16–21).

During a long-term study carried out at the plateau of Parque Nacional do Itatiaia (between 22.3095278°S, 44.6739444°W and 22.38975°S, 44.6723611°W), 1950–2400 m elev., states of Minas

Gerais and Rio de Janeiro, Brazil, nine adults of *Melanophryniscus moreirae* (seven males and two females) were observed exhibiting unken reflex in potentially threatening situations such as fall (N = 2), handling (N = 6), and accidental trampling (N = 1), exposing the bright red coloration of limbs and throat. All nine individuals also exhibited the posture when their backs were pressed with a finger against our hands, vegetation, or other substrate, as shown in Fig. 1. The observations were made between September–December (Spring–Summer) during 2005–2008 and in October 2009. The individual observed in 2009 was a male and displayed the behavior during amplexus (Fig. 2), persisting even when the female moved. After a few minutes the male released his hold but still displayed the unken reflex behavior. This is the first report of unken reflex in *M. moreirae* group and, as far as we know, the first record for unken reflex behavior in a paired amphibian.

FIG. 1 (top). Adult male *Melanophryniscus moreirae* (SVL = 26.6 mm) exhibiting unken reflex after being pressed by a finger against the substrate (photo: P. Almeida-Santos).

FIG. 2 (bottom). Adult male *Melanophryniscus moreirae* exhibiting unken reflex behavior during axillary amplexus. Photo: P. Almeida-Santos.

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ODONTOPHRYNUS cf. AMERICANUS (NCN). **PREDATION** Despite the great variety of taxa known to prey on amphibians, records from Argentina are scarce. Current information on predation of *Odontophrynus* spp. is lacking. Here we provide with the first report of *Liophis vanzolinii* (Colubridae) predating *Odontophrynus cf. americanus*. On 12 Oct 2008 at 1520 h at Estancia Las Verbenas, Valle de Pancanta (WGS84, 32.8666667°S, 66.1°W; 1650 m elev.), Central Ranges of San Luis Province, Argentina, we observed an adult *L. vanzolinii* (460 mm TL) predating an *O. cf. americanus* (43 mm SVL). This interaction was observed in a pasture near a rocky stream bordered by *Cortaderia selloana* grass. These specimens were collected and immediately after capture, the snake released the frog, which died within a few minutes.

These specimens are deposited in the Herpetological Collection of Universidad Nacional de San Juan (UNSJ-1000 *Odontophrynus cf. americanus*; UNSJ-1002 *Liophis vanzolinii*). Both species are common in this area and it is possible that this interaction occurs on a regular basis. This observation suggests that *L. vanzolinii* is a natural predator of *O. cf. americanus* and that the "blue" skin toxins (unreported blue coloration of toxin secretion; Laspiur and Buff, pers. obs.) of *O. cf. americanus* might not be an effective defense against *L. vanzolinii*. We thank Sol Acosta for help with field work and review of this note.

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PHYLLODYTES LUTEOLUS (Yellow Heart-tongued Frog) **PREDATION**. Spiders and invertebrates are well known predators of frogs (Formanowicz et al. 1981. Herpetologica 37:125–129; Prado and Borgo 2003. Herpetol. Rev. 34:238–239; Toledo 2005. Herpetol. Rev. 36:395–400; Menin et al. 2005. Phyllomedusa 4[1]:39–47). On 13 April 2006 at 2015 h we observed predation of *Phyllodytes luteolus* by the spider *Phoneutria* cf *bahiensis* (Fig. 1). This observation occurred on a terrestrial bromeliad in the coastal ecosystem at Belmonte Municipality, Bahia, Brazil. This is the first

FIG. 1. *Phyllodytes luteolus* being predated for spider. Photo by Thais Silva.

report of spider predation on *Phyllodytes* sp. in Brazil (Menin et al. 2005, *op. cit.* and Toledo 2005, *op. cit*).

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PHYSALAEMUS BILIGONIGERUS (NCN). **PREDATION.** As amphibians undergo ontogeny, their relative vulnerability to predators can shift with their life stage (Wells 2007. Ecology and Behavior of Amphibians. Univ. Chicago Press, Chicago, Illinois. 1148 pp.). Herein I document two predation events of *Physalaemus biligonigerus* at two different life stages; the first by a giant water bug (Belostomatidae) on an adult frog, and the second by a domestic pig (*Sus scofra domestica*) on a nest.

Giant water bugs are known to be major invertebrate predators of post-metamorphic anurans (Toledo 2005. Herpetol. Rev. 36:395–400). On 21 March 2009 at 2045 h, I observed a large belostomatid (body length ca. 75 mm) consuming a *P. biligonigerus* in a temporary pond in the Isoceño community of Yapiroa, Provincia Cordilleria, Departmento Santa Cruz, Bolivia (WGS 84, 19.6000°S, 62.5667°W). The giant water bug and the *P. biligonigerus* were ca. 200 mm from the shore of the pond. When I approached the pair, the belostomatid released the frog and swam into deeper water and I was unable to identify it to species. I retrieved the dead frog from the surface of the water (adult male; SVL 39 mm) and observed a puncture wound on its venter. Male *P. biligonigerus* call from the shallows close to the edge of a pond or from the middle of temporary pools (up to 20 cm deep; Schalk, unpubl. data). As with other *Physalaemus* species, male *P. biligonigerus* call from the surface of the water and generate waves that may attract aquatic predators (Toledo 2003. Phyllomedusa 2:105–108; pers. obs.).

Physalaemus biligonigerus construct foam nests to protect eggs from desiccation and predators (Prado et al. 2005. Amphibia-Reptilia. 26:211–221). These nests float on the water's surface and are generally deposited near emergent vegetation close to the pond's shore (pers. obs.). On 24 March 2009 at 1430 h, I observed an adult domestic pig eat a foam nest of a *P. biligonigerus* in the same temporary pond described above. The pig took the entire nest in its mouth and proceeded to chew it with smaller pieces of foam falling out of its mouth. After swallowing the large piece, it proceeded to eat the smaller pieces of foam floating in the water. There were no other *P. biligonigerus* nests in the pond. After consuming the nest, the pig walked into the surrounding forest. It is uncertain whether foam nests are regularly consumed by pigs in this region. My observations of 55 nests from February to March 2009 indicate that many, if not most, foam nests are not consumed or disrupted by pigs.

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PSEUDACRIS REGILLA (Northern Pacific Treefrog). **CAVITY USE.** Frogs of the family Hylidae use a variety of natural refuges, such as interstices among rocks (*Hyla macrocephala*, McIntyre 2003. Herpetol. Rev. 34:51) and cavities in standing trees (*H. japonica*, Kojima and Osawa 2003. Bull. Herpetol. Soc. Japan 2003:1–2; *H. cinerea* and *H. versicolor/chrysocelis*; McComb and Noble 1981. Wildl. Soc. Bull. 9:261–267). In the Pacific Northwest, *Pseudacris regilla* have been found in arboreal nests of tree voles (*Arborimus* spp.; Forsman and Swingle 2007. Herpetol. Cons. Biol. 2:113–118). Besides anecdotal reports of use of cover objects (Jameson 1957. Copeia 1957:221–228; Weitzel and Panik 1993. Great Basin Nat. 53:379–384) and "log crevices" (Nussbaum et al. 1983. Amphibians and Reptiles of the Pacific Northwest. Univ. Idaho Press, Moscow. 332 pp.), we found little information on use of natural cavities by *P. regilla*. Here, we report extensive use by *P. regilla* of pre-existing cavities in logs around a breeding pond in northeastern Oregon, USA.

We made our observations at a shallow pond 20.5 km SSW of Baker City, Oregon (44.6165°N, 117.9583°W; elev. 1597 m). This pond hosts large breeding populations of *P. regilla* and *Ambystoma macrodactylum*. The pond is within an opening in a forest comprised mainly of Ponderosa Pine (*Pinus ponderosa*). The understory is sparse grasses with an abundance of downed branches and logs. The pond fills with water in spring to reach ca. 1 m deep and 40 m × 40 m in surface area. By late summer, the

pond was reduced to ca. 0.2 m deep (8 m × 10 m surface area) when we made our observations. Vegetation on the exposed, shallowly sloping benches ringing the summer pool was grasses and sedges matted by livestock use. The receded water left 28 large logs (> 2m long) stranded around the exposed benches and concentrated in the NW quadrant of the pond. Most logs had little to no bark, and met the definition of decay Structure Class 2 (on ground, missing some limbs and bark, minor decay; Bull et al. 1997. Trees and logs important to wildlife in the interior Columbia River basin. USDA Forest Service Report PNW-GTR-391, 55 pp.).

During a morning (0930–1100 h) survey on 12 August 2005, we observed at least 80 small *P. regilla* wedged into cracks and hollows in one of the larger logs (hereafter 'Log A'; ca. 5 m long × 0.5 m diam.). Our visual assessment was that all of these *P. regilla* were between 17 and 21mm SVL, which is consistent with them having transformed in July and August of that same summer. Log A was in the NW quadrant and had its long axis running NE/SW so it received direct morning insolation along its length by the end of our survey. Log A was the closest (ca. 0.75 m) of the logs to the water. We observed at least 15 cases where 2–4 frogs were packed together in the same cavity (Fig. 1). We noted 4 occasions at Log A where a partially exposed frog emerged from a deep cavity followed by a second frog that emerged from an obscured position further inside the log. Over the course of our survey, frogs moved progressively out of cavities and dispersed over the southeast-facing surface of the log. By the time we departed, frogs had emerged from almost all the cavities occupied previously, and we observed several frogs on the ground around the log where we had not observed frogs previously.

We saw one *P. regilla* emerge from a cavity in a second log ('Log B', 0.6 m long, 0.4 m diam.) located 24 m NE of the small pool. Attached bark confirmed this log as *P. ponderosa*. We counted 10 holes in this log, all of which had sharp edges and were roughly oval in shape (mean diam.= 14 ± 1.6 SE mm). We were able to insert a finger into a few of the holes and determine that they enlarge a little below the surface.

Close inspection revealed *P. regilla* emerging from cavities in 3 of 10 other logs along the ponds northern benches near Log A and Log B. Of the logs we inspected, Log A appeared to have the most cavities. The hollows, grooves, and holes that were occupied in Log A appeared to be cracks and insect cavities whose size and shape had been altered by natural decay and possibly fire. Cavities in Log A measured 8–15 mm in diameter and of the 6 we probed with twigs, most extended at least 110 mm into the log. Cavities occupied by frogs in other logs typically had entries that were oval and measured 10–15 mm in diameter.

FIG. 1. Recently metamorphosed *Pseudacris regilla* clustered into, and emerging from, cavities in a decaying log.

The use of pre-existing burrows for moisture regulation, predator avoidance, aestivation, and thermoregulation has been documented for many amphibians (Duellman and Treub 1986. Biology of Amphibians. J. Hopkins University Press, Baltimore, Maryland. 670 pp.).

Our observations suggest that cavities in downed wood can be used extensively by recently-transformed *P. regilla* near their breeding sites. Retreats such as those we describe could be valuable for a number of reasons, including serving as refuges near water sources for rehydration during the dry season, thermally buffered retreats during cold nights, or protection from some predators.

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PSEUDACRIS REGILLA (Northern Pacific Treefrog)**. PREDATION.** Mallards (*Anas platyrhynchos*) are omnivorous ducks which have been observed eating a number of frog species, including *Rana aurora, R. boylii, R. sylvatica,* and *R. temporaria* (Hayes and Rombough 2004. Herpetol. Rev. 35:375–376; Rombough et al. 2005. Herpetol. Rev. 36:438–439). However, *Pseudacris regilla* has not been reported as prey.

On 17 Jan 2009, while hunting ducks on the Willamette River near St. Paul, Marion County, Oregon, we shot a hen mallard as it flew into our decoys on a flooded gravel bar. Immediately after death, an adult *P. regilla* (44.5 mm SVL, 5.5 g, gravid female) emerged from the duck's mouth and hopped across the floor of our boat. The frog was collected, examined, and found to have no visible injuries. It was placed in a container for observation and was still alive the next day. The crop and digestive tract of the duck was removed and examined; it contained sand and a small amount of plant matter.

Pseudacris regilla in the northern Willamette Valley typically gather for spawning during late January and early February, and mallards in this area have been observed feeding on *P. regilla* life stages (eggs, adult frogs) at spawning sites (C. Rombough, unpubl. data). The mallard hen described here was collected at 0930 h, when air temperature was –2.2° C, and the surfaces of still and slowly flowing waters in the area were frozen. *Pseudacris regilla* in this area had begun breeding a week before this observation (10 Jan 2009). We speculate that the frog had been in a torpid state, possibly under ice at the edge of a breeding pool, when the duck consumed it, and that the post-mortem spasms of the duck assisted in its escape from the bird's crop.

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RANA CASCADAE (Cascades Frog). **NECROGAMY.** Necrogamy has been previously documented in *Rana boylii* (Bettaso et al. 2008. Herpetol. Rev. 39:462). Herein we report a similar mating observation in *R. cascadae* while conducting egg mass surveys at Deep Creek Basin, Trinity Alps Wilderness, Trinity County, California, USA. On 18 May 2009 at 1326 h, an adult male *R. cascadae* (60.6 mm SVL) was observed in amplexus with a deceased gravid female *R. cascadae* (77.3 mm SVL) ca 20 cm underwater in a shallow stream alcove (Fig. 1). The deceased female *R. cascadae* was partially decomposed and a film of fungal hyphae covered both sides of the body. The male *R. cascadae* appeared to be in good condition upon inspection after removal from the deceased female. This behavior could allow negative population effects for *R. cascadae* by reducing overall male courtship availability during their brief and explosive breeding seasons. Additionally, this behavior could have negative implications with direct transmission of diseases.

FIG. 1. Male *Rana cascadae* in amplexus with deceased conspecific in Deep Creek basin, Trinity Alps Wilderness, California.

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RANA CATESBEIANA (American Bullfrog)**. PREDATION.** The Osprey, *Pandion haliaetus*, is a large (to 1.8 m wingspan) raptor whose breeding range includes western North America (Udvardy 1997. National Audubon Society Field Guide to North American Birds. Chanticleer Press, New York. 822 pp.). The osprey's diet consists almost exclusively of fish, although other vertebrates, including amphibians, are occasionally taken as prey (Birds of North America, Cornell Lab of Ornithology: http://bna.birds.cornell.edu/BNA/). However, taxon-specific accounts of amphibians as items of osprey diet are lacking. I here provide an account of osprey predation on *Rana catesbeiana*.

At 1300 h on 15 May 2007, I was watching male *R. catesbeiana* call and defend territories along the banks of a small (0.4 ha) farm pond in western Oregon, USA (WGS84, 50.08761°N, 51.6528°E). Frogs were calling while floating at the water's surface; their bright yellow throats were highly visible. Periodically, one would rush an intruding male from several meters away, grabbing at it and driving it out of its territory. At 1310 h, an adult osprey circled the pond; it passed over the frogs at between 10 and 15 m height. At this, the frogs immediately became silent and disappeared under cover. No amount of calling by me (normally a successful technique at this pond) could coax them to emerge or continue. The osprey, meanwhile, had landed ca. 15 m up in a fir tree overlooking the pond; it remained there, almost motionless. At 1317 h, after seven minutes of silence, the osprey leapt from its perch, flapped up into the air, and made a swift glide toward the far end of the pond. Stooping low over the water, it snatched a (ca. 150 mm SVL) *R. catesbeiana* from the surface with its talons, circled the pond once (with the frog), then flew away.

Besides the identity of the prey, an interesting aspect of this observation is the fact that the osprey made a long swoop at the prey. Typically, when capturing fish (Rainbow Trout, *Oncorhynchus mykiss*; Black Crappie, *Pomoxis nigromaculatus*; and Bluegill, *Lepomis macrochirus*) in this and adjacent ponds, ospreys hover over the target and make a swift, often vertical dive. Additional observations of osprey capturing frogs may reveal whether different capture methods are used for fish versus amphibian prey.

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RANA DRAYTONII (California Red-legged Frog). **DISPERSAL.** Very little information is available regarding dispersal of post-metamorphic juvenile *R. draytonii* from perennial ponds, although mass emigration in response to receding water has been documented for other pond-breeding anurans (Paton et al. 2000. Northwest. Nat. 7[3]:255–269, Pilliod et al. 2002. Can. J. Zool. 80[11]:1849–1862). During the 2003–04 and 2004–05 rain seasons, we captured *R. draytonii* incidentally in pitfall traps while conducting studies for *Ambystoma californiense* at five perennial ponds on the ca. 8094 ha Santa Lucia Preserve near Carmel, Monterey County, California, USA. The study area consisted primarily of a mosaic of grassland, coastal scrub, oak woodland, and redwood forest habitats in four watersheds (Potrero, Robinson Canyon, Las Garzas, San Clemente) that drain into the Carmel River and Pacific Ocean. The property was historically used to graze cattle, and the manmade stock ponds, which ranged in size from 0.08–0.53 ha, were situated in relatively open areas in or near grassland or oak savanna. The purpose of this note is to document mass dispersal of *R. draytonii* metamorphs from perennial ponds, which has conservation and land management implications given that the species is listed as Threatened by the federal government.

We initiated drift fence studies on 15 Oct in 2003 and 2004, prior to the first significant rain each season, and completed them by 1 April. Every pond was partially enclosed with 20 m lengths of 0.914 m high silt fence (Enge 1997. Herpetol. Rev. 28:30–31) buried at least 15 cm and situated 2–10 m from the high water line. Two to 10 m gaps were left between lengths of drift fence to allow free movement of amphibians on nights when the pitfall traps were shut. Each of the five study ponds were ≥ 65% enclosed by drift fence spaced equidistant around the entire perimeter. Paired pitfall

traps (7.6 L) were installed 10 m apart at the ends and middle of each length of fence and covered with an elevated plywood shade. On evenings when rain was forecast (>50% likelihood), traps were opened and checked on the following morning; after each rain event traps were left open for one additional night. We recorded length measurements snout–urostyle length (SUL) from a subset of captured *R. draytonii* and released them in the nearest dense, moist vegetation on the opposite side of the drift fence (outward-bound) or at the edge of the pond (inward-bound).

Pitfall traps were open 57 nights in 2003-04 and 49 nights in the 2004–05 winter seasons. We recorded 308 captures of *R. draytonii* in both years combined, of which 220 were metamorphs (73%). Metamorphs were captured at all ponds although the number varied considerably by location (Table 1). Average size (SUL) of dispersing metamorphs was 30.7 mm (range 22–42 mm; N = 213). The actual number of metamorphs, sub-adults (ca. 45–75 mm) and adults (>75 mm) recaptured was unknown because individuals were not marked. Since there were gaps in the drift fence arrays, any metamorphs captured in outside traps at the end of a drift fence section were still considered to be dispersers; those captured in interior outside traps (N = 15) were excluded from analysis. Therefore, 93% of captured metamorphs were assumed to be dispersers. Given that no inward-bound individuals captured from Dec through March measured < 57 mm SUL (N = 32), there was no indication that any metamorphs returned to the ponds.

In 2003–2004, 95% of all metamorphs were captured by 25 Dec (Fig. 1). Only three metamorphs were captured after 1 Jan, in spite of heavy rains from Jan through March. In 2004–05, 95% of metamorphs were captured by 12 Nov. Similar to the previous year, despite frequent rain from Jan through March, no metamorphs were captured after 30 Dec. In both years, the highest capture frequency occurred during the first significant precipitation of the rain season, even though the magnitude of these events differed markedly (8 mm on 1 Nov 2003 vs. 24 mm on 17 Oct 2004). Precipitation during 2003-04 was 88% of normal while precipitation in 2004-05 was 143% of normal for Carmel Valley, California. These results suggest that the first rains of late summer/early fall, regardless of magnitude, incite dispersal and that most *R. draytonii* metamorphs have left by the end of the calendar year.

The number of captured metamorphs varied considerably between seemingly productive *R. draytonii* breeding ponds. Comparisons of relative abundance to estimate potential recruitment should be viewed with caution, since this study did not target *R. draytonii*. Furthermore, over-wintering *R. draytonii* tadpoles (Fellers et al. 2001. Herpetol. Rev. 32:156–157) were observed at two of the five ponds, and individuals may therefore transform and disperse

TABLE 1. Number of *Rana draytonii* captured in 2003–04 and 2004–05 on the Santa Lucia Preserve, Carmel, California, USA.

Pond #	Season	Metamorphs	Subadults	Adults	Total
2	2003-04	31	0	4	35
3	2004-05	16	2	38	56
13	2003-04	27	1	5	33
17	2004-05	42	12	11	65
27	2004-05	110	0	9	119

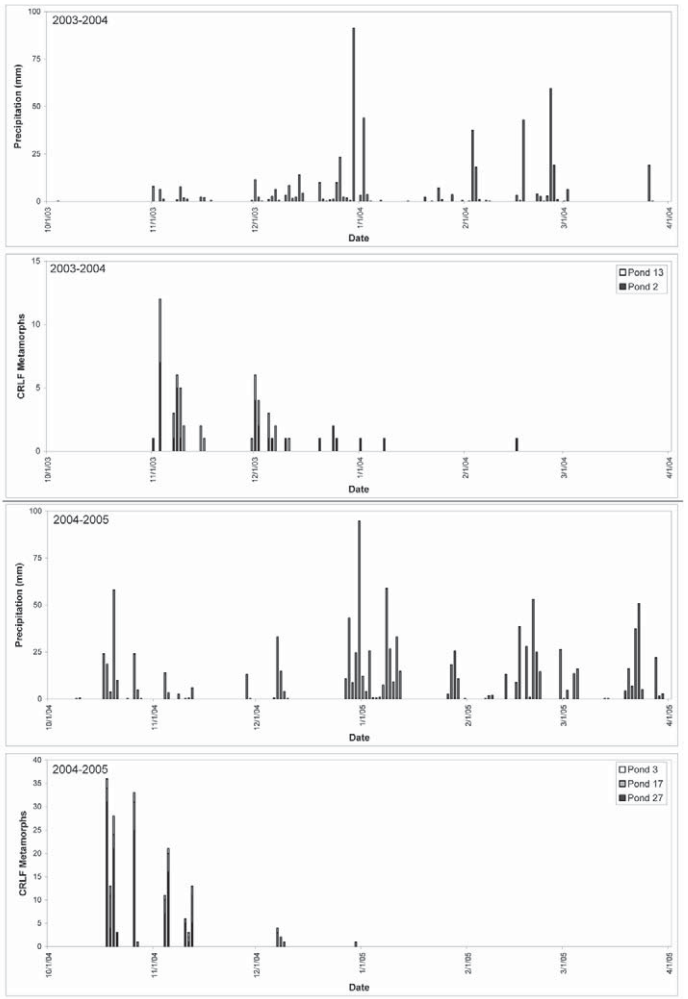

FIG. 1. Precipitation and number of *R. draytonii* metamorphs captured in 2003–04 and 2004–05, Santa Lucia Preserve, Carmel Valley, California, USA.

at nearly anytime of the year when environmental conditions are appropriate. Nevertheless, our data indicates that the first several precipitation events of the fall season incite mass dispersal of *R. draytonii* metamorphs, even at perennial ponds that may appear to provide the appropriate habitat requirements for all age classes. In addition to avoiding predators (including conspecifics), metamorphs presumably disperse to seek appropriate non-breeding habitat until they reach reproductive age and either return or colonize new locations. Our data supports the contention that core-habitat conservation models, which are often symmetrical, may be insufficient for *R. draytonii* and other pool-breeding amphibians that require appropriate movement corridors to ensure connectivity between breeding and non-breeding habitat across a varied landscape (Baldwin et al. 2006. J. Herpetol. 40:442–453; Fellers and Kleeman 2007. J. Herpetol. 41:276–286).

This work was conducted under the authority of U. S. Fish and Wildlife Service Endangered Species Recovery Permits and California Department of Fish and Game scientific collecting permits. The Western Regional Climate Center (Reno, Nevada) provided precipitation data from the Carmel Valley station (#041534). We are grateful to the Santa Lucia Preserve for access to the ponds and assistance with installation of the drift fences, and to the Rancho San Carlos Partnership for partial funding of this study.

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RANA DRAYTONII (California Red-legged Frog). **PREY.** Although ranid frogs generally have indiscriminant diets, data regarding vertebrate food items taken by *Rana draytonii* are sparse. Vertebrates documented as prey include *Gasterosteus aculeatus* (Three-spined Stickleback), *Pseudacris regilla* (Pacific Chorus Frog), *Peromyscus californicus* (California Mouse) (Hayes and Tennant 1985. Southwest. Nat. 30:601–605), *Microtus californicus* (California Vole), and *Reithrodontomys megalotis* (Western Harvest Mouse) (Hayes et al. 2006. Herpetol. Rev. 37:449). Although expected, snakes have not been reported as dietary items.

On 13 Aug 2008, at 0030 h, while conducting surveys for *R. draytonii* at a pond in the Sierra Nevada foothills in northern California (Placer Co.), an adult frog (ca. 100 mm) was observed grabbing and quickly devouring a juvenile (ca. 20 cm SVL) *Thamnophis sirtalis* (Common Gartersnake). The *T. sirtalis* had been slowly moving across a flat, muddy bank covered with *Eleocharis* sp., and the *R. draytonii* was situated at the water/mud bank margin, quiescent, facing into ponded open water. Consistent with other feeding observations of ranid frogs (Anderson 1993. J. Exp. Biol. 179:1–12), the *R. draytonii*, upon lunging and grabbing the snake, used its forelimbs to manipulate the snake farther into its mouth. The capture and swallowing of the snake occurred within a period of five to seven seconds and the snake was entirely engulfed within that time. The temperature at the time of observation was 23°C, water temperature was 23.5°C, humidity was ca. 50%, and moon phase was waxing, approaching full.

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RANA PIPIENS (Northern Leopard Frog). **WINTER ACTIVITY**. On 10 Dec 2006 at ca. 1200 h, a *Rana pipiens* was observed on the north shore of Lake Winter located in Northern Wisconsin (45.8°N, 91.1°W). The lake was covered with approximately 2–3 inches of ice, except the occasional narrow opening near the shore. The south-facing shoreline was somewhat undercut from erosion and about 30.5 cm of soil was exposed. While walking out onto the ice from the shoreline a *R. pipens* was observed jumping away from shore and out onto the ice and snow. The *R. pipens* appeared to be rather torpid and its skin appeared rather dry and leathery.

The previous weather was cold, often with maximum temperatures well below the average maximum temperature for those days. On 9 Dec 2006 the temperature increased to a maximum of 1.7°C and then continued to climb to around 4–5°C during the day of the observation, which was mostly sunny. 5.6°C was the maximum temperature that day; two degrees below the 6.7°C record set in 2002 and well above the typical average maximum temperature of -1.6°C (temperature data accessed on-line from www.undergroundweather.com).

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RANA SYLVATICA (Wood Frog). **EGG MASS SURVEYS.** Egg mass counts have become an increasingly popular method for estimating reproductive effort of Wood Frogs in seasonal breeding pools in the northeastern United States. Scientists, conservation organizations, and regulatory agencies use egg mass counts to determine population size and track population trends over time, to identify breeding pools in need of protective measures, and to develop indices based upon biological significance (Couch and Paton 2000. Wildl. Soc. Bull. 28[4]:895–901; Oscarson and Calhoun 2007. Wetlands 27[1]:80–95). Wood Frog ovipositioning typically occurs in communal rafts attached to submerged vegetation at or near the water surface (Couch and Paton, *op. cit.*; Egan and Paton 2004. Wetlands 24(1):1–13; Seale 1982. Copeia 1982[3]:627–635). In many northeastern states, citizen scientists are being trained to assess the ecological value of vernal pools through egg mass counts. Using snorkel equipment for one such survey in Maine, I found that the subsurface view of a large raft of Wood Frog egg masses revealed numerous masses on the pool bottom. Between 0.5 and 1 m below the communal aggregation of egg masses attached to *Ilex verticillata* at the water surface, some masses were clearly attached to submerged vegetation at the pool bottom while others were merely resting on a substrate of leaf litter. During 2009 springtime assessments (27 April–5 May), three pools (Penobscot County, Maine, USA; 44.884°N, 68.688°E; NAD 1983) were found to contain Wood Frog egg masses directly below and around the margins of rafts attached to vegetation near the water surface. There was no lack of attachment sites near the water surface in any of the three pools. Whether they were originally deposited in situ or were secondarily dislodged and came to rest on the pool bottom is unknown. In deep or tannic pools where visibility is poor, egg mass counts may have the potential to underestimate the true number of masses that occur within a pool.

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RHINELLA ARENARUM (Common Toad). **MORTALITY**. Car traffic often results in high amphibian casualties when roads are encountered during breeding or other movements. *Rhinella arenarum* is the common toad in Argentina (Cei 1980. Amphibians of Argetina. Monitore Zoologico Italiano [NS]. Monogr. 2, 609 pp.). In San Juan Province this species is distributed in all wetted areas including the watering systems of towns. On 23 Nov 2008, we counted the toads dead on the streets in Valle Fértil Departament. This region belongs to the Chaco Seco Phitogeografical Province (Cabrera 1994. Enciclopedia Argentina de agricultura y ganadería. Editorial ACME S.A.C.I., 81 pp.). During this time 84 dead toads were encountered on the road in 900 m. All toads were 89 ± 18.8 mm, typical of adult reproductive *R. arenarum*. This is

the first report of the extent of toad mortality on the roads of San Juan Province, Argentina.

We thank L. Quiroga for review of this note.

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SCAPHIOPUS HOLBROOKII (Eastern Spadefoot). **PREDATION**. *Scaphiopus holbrookii* is an aquatic breeding terrestrial amphibian which, with exception to several days in any year when the species may breed, is predominantly nocturnal in its habits; diurnal hours are spent underground in burrows (Pearson 1955. Ecol. Monogr. 25:233–267). This activity pattern is believed primarily to be an adaptation to avoid desiccation (Bragg 1961. Anim. Behav. 9:178–186), though may also act to reduce predation risk.

Known predators of *S. holbrookii* include various species of mammals, snakes, and birds, though we are not aware of any reports of raptor predation on *S. holbrookii*. During a pilot radiotelemetry investigation of adult *S. holbrookii* movement patterns at Cape Cod National Seashore in Provincetown, Massachusetts (USA), we observed indirect evidence of owl predation on an adult *S.. holbrookii*. Specifically, during 25 August 2005 we found a radio-transmitter from an adult male *S. holbrookii* (SVL 5.4 cm, mass: 19.25 g) inside a small owl pellet on the ground surface. While we were unable to identify the owl species the pellet was from, there are only three species of owl known to inhabit the study area during the late-August time period including: Great Horned Owl (*Bubo virginianus*), Barred Owl (*Strix varia*), and Northern Saw-whet Owl (*Aegolius acadicus*).

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SCINAX LITTORALIS (Snouted Treefrog). **PREDATION**. Amphibians and reptiles are commonly preyed upon by spiders (Neill 1948. Herpetologica 4:158). In the Atlantic Forest, the spider *Ancylometes* spp. (Araneae, Ctenidae) has been reported as an anuran predator (Bernarde et al. 1999. Biociências 7:199-203; Serafim et al. 2007. Herpetol. Rev. 38:437; Haddad et al. 2008. Atlantic Forest Amphibians: Guide for the Atlantic Forest Anurans. Editora Neotropica, São Paulo. 244 pp.). Herein, we report predation of an adult *Scinax littoralis* in Ubatuba, São Paulo, southeastern Brazil (23º30'02.4''S, 45º05'01.4''W, 40 m elev.). On 21 Sept 2008 at 2000 h, one of us (PJPC) observed an adult male *Scinax littoralis* (27.3 mm SVL) that was being consumed by the spider *Ctenus medius* (Araneae, Ctenidae) (46 mm SVL) (Fig.1).

This frog was collected and deposited in the Coleção Jorge Jim, UNESP, Botucatu, SP. We thank A.D. Brescovit for identification of the spider.

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FIG. 1. The spider *Ctenus medius* preying on an adult *Scinax littoralis*.

SMILISCA BAUDINII (Mexican Treefrog). **DIET.** *Smilisca baudinii* is a moderate to large (55–65 mm SVL) nocturnal treefrog (Savage 2002. The Amphibian and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. University of Chicago Press, Chicago, Illinois. 934 pp.). Mexican Treefrogs are known invertivores feeding mostly on insects and spiders (Lee 2000. A Field Guide to the Amphibians and Reptiles of the Maya World: The Lowlands of Mexico, Northern Guatemala, and Belize. Cornell University Press, Ithaca, New York), with grasshoppers reported in the stomachs of specimens collected from Nicaragua (Noble 1918. Bull. Amer. Mus. Nat. Hist. 38[10]:311–347). Here we report the first vertebrate prey item for *S. baudinii*.

At 1015 h on 7 Jan 2007 we located a female *S. baudinii* (6.0 cm SVL, 13.0 g) ca. 2.0 m high on the trunk of an oak tree (*Quercus oleoides*) in Cayo Cochino Pequeño, Cayos Cochinos Archipelago, Islas de la Bahia, Honduras. The frog contained a large food item in its gut and appeared to have a lizard tail protruding from its mouth. After capturing the frog and forcing it to regurgitate the prey item, we identified the partially digested lizard as an adult male (6.5 cm SVL, 12 cm tail, 5.0 g) *Norops lemurinus*. The lizard represented a 38.5% meal by mass and a 108.3% prey item by SVL length. Our observation represents the first report of *N. lemurinus* in the diet of *S. baudinii*, as well as the largest reported meal by mass or length for *S. baudinii*.

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SMILISCABAUDINII (Mexican Treefrog) and ***PACHYMEDUSA DACNICOLOR*** (Mexican Leaf Frog). **REPRODUCTION**. Interspecific mating interactions are known to occur when the reproductive activities of amphibian species overlap temporally and spatially (Höbel 2005. Herpetol. Rev. 36:55–56; Höbel 2005. Herpetol. Rev. 36:439–440; Waterstrat et al. 2008. Herpetol. Rev. 39:458). In some cases, it has been suggested that these encounters may act as reproductive interference leading to negative demographic consequence (Pearl et al. 2005. Am. Midl. Nat. 154:126–134). Herein we report an instance of interspecific amplexus between two hylid species. On 11 June 2008 at ca. 0100 h near the city of Uruapan, Michoacán, México (19.24277°N, 102.05228°W, 931 m elev.) we encountered an extremely large (>1500 individuals) multiple-species breeding chorus of anurans. The chorus included five species: *Pachymedusa dacnicolor*, *Leptodactlyus melanonotus*, *Tlalocohyla smithii*, *Rhinella marina*, and *Smilisca baudinii*. The most frequently encountered species were *P. dacnicolor* and *S. baudinii*. Amidst this majestic euphony we located an amplectant pair consisting of a male *S. baudinii* and a female *P. dacnicolor* (Fig. 1). Although cross-species amplectant behavior has frequently been reported among anurans and can be inferred for a number of temperate hylid species known to hybridize (e.g., Lamb et al. 1990. J. Evol. Biol. 3:295–309), there are few published reports of mating errors in tropical hylids or of amplectant interaction between hylid subfamilies.

FIG. 1. Male *Smilisca baudinii* in amplexus with female *Pachymedusa dacnicolor*, found during large multi-species breeding chorus in western Michoacán, México (UTADC 4000).

We thank J. A. Campbell for assistance. Identifications were verified by E. N. Smith. A photographic voucher of this pairing was deposited in the University of Texas at Arlington Digital Collection (UTADC 4000).The National Science Foundation (DEB-0613802 to J. A. Campbell) provided financial support.

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SMILISCA PHAEOTA (Masked Tree Frog). **UNILATERAL MYDRIASIS**. Excessive dilation of the pupil is known as mydriasis. In anurans, fixed mydriasis has been reported during local population declines in conjunction with the presence of the fungal pathogen *Batrachochytrium dendrobatidis* (Hale et al. 2005. USDA Forest Service Proc. 36:407–411). The condition of unilateral mydriasis (excessive dilation of a single pupil) in frogs, defined as an abnormality by the U.S. Fish and Wildlife Service (USFWS Abnormality Classification SOP website via http://www.fws.gov), is rarely reported outside of North America and Europe. Here we report the in situ occurrence of fixed unilateral mydriasis in a tropical hylid species. On 16 March 2008 we made a small collection of anurans near the town of San Lorenzo in Esmeraldas, Ecuador (1.26219°N, 78.79528°W, 40 m elev.). Part of the collection was an adult *Smilisca phaeota* (48.5 mm SVL) that possessed an uneven dilation of its pupils (Fig. 1A). When exposed to daylight, the right pupil of the specimen (Fig. 1B) was excessively dilated whereas the left pupil (Fig. 1C) appeared to respond normally. Most unilateral ophthalmic abnormalities documented in frogs are suggestive of

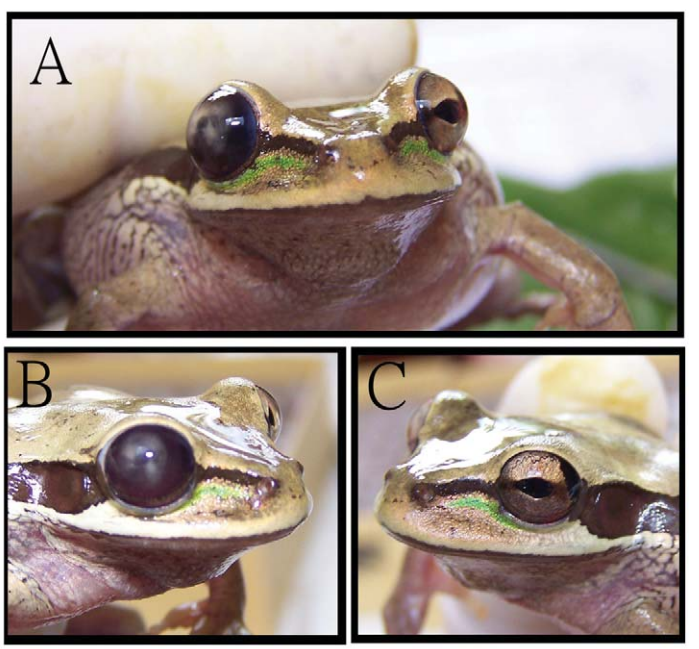

FIG. 1. Unilateral mydriasis in a *Smilisca phaeota* (UTA A-58905) from western Esmeraldas, Ecuador.

trauma or focal disease (Ballard and Cheek 2003. Exotic Animal Medicine for the Veterinary Technician. Blackwell Publishing. 379 pp). Stimulation or damage of sensory nerves is known to cause pupil dilation (Klopper 1951. Acta. Physiol. Pharmacol. Neerl. 2:8–13) as are subcutaneous drug injections and direct exposure to certain chemicals (Meltzer and Auer 1904. Am. J. Physiol. 11:449–454; Wright and Whitaker 2001. Amphibian Medicine and Captive Husbandry. Krieger Publishing, Malabar, Florida. 449 pp.). Based on examination in the field and a subsequent assessment of the preserved animal, there are no obvious external injuries to the specimen. However, it remains unclear whether the condition reported herein resulted from traumatic injury or an association with disease. Additionally, tropical hylids possessing ocular anomalies have been reported to survive in the wild for at least short periods of time (Carvaho et al. 2008. Herpetol. Rev. 39:211), so it is difficult to assess if this case of mydriasis was of relatively recent origin or a longer held affliction.

The specimen was deposited in the herpetological collection of the University of Texas at Arlington (UTA A-58905, Field ID: ENS 12598) and was collected under permit N 001-08 IC-FAU-DN-BAPVS/MA. In vivo images of the frog were deposited in the UTA Digital Collection (UTADC 3718–3720). Financial support was provided to ENS by the Instituto Bioclon (Mexico), UTA (start-up funds), and the National Science Foundation (DEB-0416160).

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SPEA MULTIPLICATA (Mexican Spadefoot). **PREDATION.** The fact that spiders prey on anurans is well documented. Much of the literature on the subject was reviewed and summarized by McCormick and Polis (1982. Biol. Rev. 57:29–58) and Toledo (2005. Herpetol. Rev. 36:395–400) and subsequent to the latter, multiple new accounts have appeared in every volume of this journal. Considering the diversity of the two orders however, the extent of published examples specifically identifying the species involved is relatively limited. Toledo (2005, *op. cit.*) recorded 68 post-metamorphic species of anuran preyed upon by 30 species of Araneae documented in the literature. This amounts to only 1.2% of the 5602 anuran species currently listed by Frost (2008. Amphibian Species of the World: an Online Reference. Version 5.2 (15 July 2008). http://research.amnh.org/herpetology/amphibian/index.php) and 0.07% of the 40,462 Araneae species listed by Platnick (2008. The World of Spider Catalog, ver. 9.0 http://research.amnh.org/entomology/spiders/catalog/index.htm/). Jackman et al. (1983. Science 222:515–516) recorded the larvae of the fly *Tabanus punctifer* preying on recently metamorphosed *S. multiplicata*. Pomeroy (1981. Ph.D. thesis. Univ. California, Riverside. *fide* McCormick and Polis 1982, *op. cit.*) identified the nymphs of dragonflies (Odonata), backswimmers (*Notonecta undulata*), dung beetles (Scarabaeidae), and larvae of diving beetles (*Thermonectes* sp.) as predators of *S. multiplicata* tadpoles, and a tiger beetle (*Cicindela sedecimpunctata*) as predators of adults.

This appears to be the first record of an Araneae, in this instance an unidentified tarantula (Theraphosidae), preying on *S. multiplicata*, although Toledo (2005, *op. cit.*) included eight examples of Theraphosidae preying on other species of frogs. The observation occurred at 1819 h on 14 Oct 2006 in the state of Tamaulipas, Mexico, in the municipality of Miquihuana, 1 km SW of the remote village of Aserradero, located on a dirt road 12.5 km. N of the town of Miquihuana (WGS84, 23.6791667°N, 99.7563889°W; 2473 m elev), Temperature was 21°C; barometric pressure 31.33. The habitat at this locality in the Sierra Madre Oriental is pine-oak forest with madrone (*Arbutus xalapensis*) and agaves (*Maguey americana* and *M. asperrima*). It is generally a semiarid environment with surface water limited to a few arroyos and washes that seldom support more than a few isolated shallow pools although afternoon rains occur almost daily throughout the summer. A few distantly located cattle tanks and seasonally active seeps are present in the region. In the immediate area where the observation took place, ca. 2 or 3 hectares had been cleared of the smaller trees and undergrowth, presumably for livestock grazing, leaving only some of the larger trees in a pasture with occasional bunchgrass and an abundance of fallen logs. An arroyo delineates the north side of the pasture.

The event was observed while turning over rocks in the pasture. The initial attack was not witnessed. The tarantula was first seen holding the *S. multiplicata* after a moderately large stone was turned. We observed the spider, which remained motionless for ca. 2–3 minutes, seemingly disturbed from feeding by the rock having been moved. When attempts were made to take photographs, the spider dropped the toad and retreated ca. 10–20 cm and did not return to its prey. The *S. multiplicata* was alive but appeared to be paralyzed, presumably from the effect of the spider's venom. The toad was whole, intact, with no obvious wounds or necroses, suggesting that it had only very recently been caught and the spider had not begun consuming its prey. The elytra and some other body parts from a Beetle (Tenebrionidae), presumably preyed on earlier by the same spider, where found in a small tunnel excavated under the rock, the rock its self providing the ceiling of the chamber before it was turned over. Toledo (2005, *op. cit.*) reported that almost 90% of recorded instances of invertebrates preying on post-metamorphic anurans take place in or at the water's edge, when either recently metamorphosed frogs are leaving the water, or when adults congregate and enter the water for breeding, all circumstances which are not applicable to this case. The *S. multiplicata*, a small adult (2.4 cm SVL; 1.25 g), was weighted and measured in the field before being preserved. It was deposited in the collection of the Universidad Autónoma de Nuevo Leon, UANL 6500 along with a second specimen UANL 6501, measuring 2.6 cm. found under a nearby rock. The spider was left in the field where found. Fieldwork was conducted under SEMARNAT permit no. 00800/06 and funded by HZI.

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STEREOCYCLOPS INCRASSATUS (Brazilian Dumpy Frog). **DEFENSIVE BEHAVIOR.** *Stereocyclops incrassatus* is a Brazilian microhylid, found in humid coastal forests in eastern Brazil from Espírito Santo to Bahia (Frost 2009. Amphibian Species of the World: an Online Reference. Version 5.3; http://research.amnh.org/herpetology/amphibia/. American Museum of Natural History, New York). Ecological or behavioral information for this genus is scarce, but includes a description of feeding habits in *S. incrassatus* (Teixeira et al. 2006. Bol. Mus. Biol. Mello Leitão 19:53–58) and a description of defensive behavior in *S. parkeri* (Sazima 1978. Biotropica 10:158). Herein, we describe an unreported defensive behavior for *S. incrassatus*.

At ca. 1700 h on 12 March 2009, we observed the defensive behavior of an adult male *S. incrassatus* (44 mm SVL) against a predation attempt by an adult colubrid snake, *Liophis milliaris merremi* (559 mm SVL. 127 mm TL). The animals were found in the vicinity of the municipality of Itacaré, Bahia state, Brazil (WGS84, 14.2888128°S, 38.984219°W; elev. ca. 10 m). The snake was trying to swallow the frog headfirst. With the head already inside of snake's mouth, the frog was displaying the following defensive position: the head was pressed against the ground, the back was raised, the body inflated, and the fore and hind limbs were strongly retracted against the body, giving the frog a solid and round shape. When we approached, the snake regurgitated the frog and we noticed that its mouth and a small part of the frog's body was covered by a glue-like secretion produced by the frog. The secretion was visibly sticky, as it adhered sand grains to both animals. It was not apparently whitish, but the adhered sand might influence our perception of the color of the secretion. The secretion made it difficult for the snake to open its mouth for approximately a minute. After several unsuccessful attempts, the snake was finally able to open its mouth by itself. During that time, the frog remained in the position described above until, in the hands of one of us, it flattened its body and stretched out its four limbs. When placed on the ground it raised its head and remained in this flattened position for more than a minute (Fig. 1).

This is the first description of defensive behavior for *S. incrassatus*. This is the first time that a defensive posture with all the limbs pressed against the body and the head pressed against the ground has been reported for a Brazilian microhylid. Flattening the body and stretching all the limbs at the same time has also not been previously described for any Brazilian microhylid. We did not see any color in the *S. incrassatus* secretion. Secretion of sticky substances is a useful defensive tactic, as it causes almost immediate liberation of the prey (Evans and Brodie. 1994. J. Herpetol. 28:499–502). All these data support the idea that many anurans may combine secretions with different body positions to increase defense success.

FIG. 1. Posture maintained by a *Stereocyclops incrassatus* after being handled by one of the observers.

The specimens are deposited in the herpetological collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, Brazil (*Liophis miliaris merremi*, MZUSP 17732, and *S. incrassatus*, MZUSP 141343). We thank IBAMA for collection permits (14555-1).

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CROCODYLIA — CROCODILIANS

CROCODYLUS ACUTUS (American Crocodile). **NESTING ECOLOGY.** *Crocodylus acutus* is widely distributed in the Atlantic and Pacific coasts of Mexico, Central America, and northern South America, many Caribbean islands, and southern Florida (Ernst et al. 1999. Cat. Amer. Amph. Rept. 700:1–17). Information on nesting ecology has been documented in Caribbean atolls and coast habitat (Ogden 1978. J. Herpetol. 12:183–196; Platt and Thorbjarnarson 2000. Copeia 2000:869–873; Casas-Andreu 2003. Acta Zool. Mex. [n.s.] 89:111–128; Mazzotti et al. 2007. Herpetol. Rev. 38:285–289; Charruau et al. 2010. J. Nat. Hist., *in press*). However, there is a paucity of information on nesting ecology of *C. acutus* in mainland and man-made habitat. Hence, here we present observations on its nesting ecology in El Cajon Reservoir in central Honduras.

We searched for nests around the main rivers and secondary tributaries of El Cajon Reservoir (15.01078ºN, 87.71149ºW, datum: WGS84, elev. 285 m) in February–April 2005. We found 30 nests of *C. acutus*: two on the Yure River, 16 on the Humuya River, and 12 on the Sulaco River. Nest holes were constructed by *C. acutus* that were found in the shoreline vegetation and elevated areas away from shoreline and creeks. The nest areas were characterized by very steep slopes and the presence of sandy and rocky soil.

We observed hatchlings at each nest site during May and June. The number of hatchlings varied from 10 to 21 per nest on the Yure River, 10 to 27 on the Humuya River, and 10 to 33 on the Sulaco River. Successful nests were determined by the presence of eggshell membranes indicating the nests were excavated by the nesting female. Platt and Thorbjarnarson (2000, *op. cit.*) observed that females defend nests from predators but parental care was minimal or non-active. In El Cajon Reservoir, we observed active parental care during our surveys.

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RYNCHOCEPHALIA — TUATARA

SPHENODON PUNCTATUS (Tuatara). **FRUGIVORY.** The unique assemblage of plants and limited animal species in New Zealand, as on many isolated islands, has allowed novel seed dispersal relationships to evolve (Valido and Olesen 2007. *In* Dennis et al. [eds.], Seed Dispersal: Theory and its Application in a Changing World, pp. 124–147. CAB International, Wallingford). Seed dispersal is essential for gene flow and maintaining ecological structure in plant communities. Our understanding of these systems and their dispersal vectors are vital for the conservation of native ecosystems with nearly 70% of woody species in New Zealand possessing fruit suitable for vertebrate seed dispersal (Clout and Hay 1989. New Zealand J. Ecol. 12:27–33). Some New Zealand plants exhibit growth forms that are thought to be conducive to lizard-mediated seed dispersal (Lord and Marshall 2001. New Zealand J. Bot. 39:567–576). Twelve species of frugivorous lizards in New Zealand have been identified as potential seed dispersers (Whitaker 1987. New Zealand J. Bot. 25:315–328). New Zealand's largest lepidosaurian, *Sphenodon punctatus*, has been characterized as a generalized opportunistic carnivore that subsists primarily on beetles, insect larvae, arachnids, and weta (Ussher 1999. New Zealand J. Zool. 26:117–125; Walls 1981. New Zealand J. Ecol. 4:89–97). Seeds in tuatara scat and stomach contents (Ussher 1999, *op. cit.*; Walls 1981, *op. cit.*; Southey, cited in Whitaker 1987, *op. cit.*) have been dismissed as instances of reptile frugivory and seed dispersal because they were thought to be indirectly or accidentally consumed (Valido and Olesen 2007, *op. cit.*). Here we provide the first evidence for intentional frugivory by the tuatara and report on its implications for effective seed dispersal.

During fieldwork on Stephens Island (40.67°S, 174.00°E) in March 2009, two *Sphenodon punctatus* scat samples were discovered that contained a large number of seeds. The first sample (Sample 1) was freshly deposited on 11 March inside the collection bag of an adult male tuatara (SVL = 230 mm, mass = 370 g) and the second sample (Sample 2) was discovered on 23 March deposited by an unknown tuatara on a concrete pathway roughly 75 meters from Sample 1. The distance between these samples make it unlikely to be the same individual, as this species is highly territorial (Moore et al. 2009. J. Herpetol. 43:570–578).

Dissection of Sample 1 and Sample 2, revealed a few arthropod body fragments, identified as common small beetle species with the majority of the sample being comprised of seeds and several stems. Comparison with collected seed samples identified the seeds as Kawakawa (*Macropiper excelsum*), and thorough counts yielded at least 407 intact seeds in Sample 1 and 1343 intact seeds and 41 seed fragments in Sample 2. Seed fragments were considered any seed that had sustained damage that exposed the endosperm. Kawakawa is a common understory shrub in the regenerated and degraded original forest patches on Stephens Island (Mulder and Keall 2001. Oecologia 127:350–360), and was fruiting in abundance in March 2009. Kawakawa possess bright orange, aromatic, aggregate fruit spikes which can contain up to 150 seeds per spike (Burrows 1995. New Zeal J Bot**.** 33:131–140). When Sample 1 was collected it had a distinct orange-tinge aiding in the plant's identification. Comparison with fresh fruit spikes shows that the stems found in the fecal samples were the central stems of the aggregate fruit with three and nine stems found in Sample 1 and Sample 2, respectively. The fruit spikes can fall intact to the ground when the plant is agitated and fruit are ripe (K. C. Burns, pers. comm.) making them available to terrestrial animals. The presence of the fruit spike stems in the scat samples provides evidence for direct consumption of several whole fruit spikes since other frugivores (e.g., geckos and Weta) with smaller mouths remove the fruit flesh from the central stem (pers. obs.). In order to ingest the large number of seeds found in each sample, the number of whole fruit spikes that would need to be consumed is at least two and nine, respectively, for Sample 1 and Sample 2. The absence of large prey remains, the presence of fruit spike stems and the large number of seeds all suggest the direct consumptions of fruit spikes by tuatara.

To examine the viability of these seeds, germination trials were performed on two subsets of seeds that were deemed intact under 10× magnification from fecal Sample 1 (N = 53, 50) and Sample 2 (N = 65, 50), along with two sets of controls comprising defleshed seeds from ripe Kawakawa fruit spikes (N = 66, 50). Once removed from the island, seeds were stored in plastic petri dishes in a cool refrigerator. For the trials, seeds were placed in glass Petri dishes with a saturated filter paper substrate and placed under 12-h light: dark timer controlled fluorescent grow lights. The first sets were started on 16 April 2009 with the second sets beginning on 30 June 2009. Seeds were checked weekly over the following seven weeks by performing counts of radicle and cotyledon emergence. The control, Sample 1, and Sample 2 average percent emergence rates of radicle (93.2%, 79.1%, 99.1%, respectively) and cotyledon (49.5%, 31.3%, 43.1%, respectively) were roughly similar between samples. Critically, this indicates that many seeds passed by the tuatara are still viable.

Excretion of viable seeds provides the possibility of seed dispersal by tuatara regardless of the method of consumption or germination rate. Other examples of seed dispersal by traditionally carnivorous animals have been documented in recent years (Calviño-Cancela et al. 2007. Écoscience 14: 529–534; Otani 2002. Ecol Res. 17:29–38). It has even been suggested that a carnivore's dentition lend them to be more effective seed dispersers than herbivores because they cause less damage to seeds during mastication (Otani 2002, *op. cit.*). Tuatara should not be disregarded as a potential seed dispersal vector because of their primary diet.

A whole suite of potential questions raised by this observation can be divided into two general groups. The first group is those questions about the biology of tuatara: How frequent is this behavior? What implication does this have for the diet of tuatara? With the dense population of tuatara on Stephens Island (Moore et al. 2007. Biol Conserv. 135:181–188), could frugivory be an alternative feeding strategy due to intense resource competition? These fecal samples were found during the mating season of the tuatara; could a high caloric demand be leading to fruit consumption? If tuatara are intentionally eating the Kawakawa fruit, are

they locating them by olfaction, color, or ultraviolet vision? The second group involves questions about the ecological implication for this frugivory: How does the deposition pattern and microhabitat, e.g. clumped or scattered on sunny open soil or down a burrow, of deposited seeds impact germination (Williams et al. 2000. Austral Ecol. 25:523–532; Wotton 2002. New Zealand J. Bot. 40:639–647)? Stephens Island only has a subset of New Zealand plants; could the tuatara's historical range have included access to other fruiting plants they would consume? Does the territorial tuatara move over enough area to effectively disperse seeds? Further research is needed to understand this occurrence of tuatara frugivory and its implications for their diet and seed dispersal in remnant and historical New Zealand ecosystems.

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TESTUDINES — TURTLES

ACTINEMYS* (= *EMYS*) *MARMORATA (Western Pond Turtle). **PREDATION**. The Western Pond Turtle is in decline over 80% of its historical range in California, primarily due to habitat loss and competition from introduced species (Stebbins 2003. A Field Guide to Western Reptiles and Amphibians, 3rd ed., Houghton Mifflin, Boston, Massachusetts). Wild pigs *(Sus scrofa)*, hybrids of feral domestic pigs and European wild boars, are a purposely introduced species rapidly increasing in range and population throughout the state (Waithman et al. 1999. J. Wild. Manag. 63[1]: 298–308). Wild pigs are omnivores, and forage for and consume a wide variety of vertebrate prey (Wilcox and Van Vuren 2009. J Mammal. 90[1]:114–118). Worldwide, feral pigs have been documented to consume eggs and young of four chelonian species, including Green Sea Turtles *(Chelonia mydas)*, giant tortoises *(Chelonoidis nigra [=Geochelone elephantopus])* in the Galapagos (Coblentz and Baber 1987. J. Appl. Ecol. 24:103–118), Spur-thighed Tortoises *(Testudo* spp.*)* in Sardinia (Corbett [ed.], 1989. The Conservation of European Reptiles and Amphibians. C. Helms, London), and Texas Tortoises *(Gopherus berlandieri)* (Taylor and Hellgren 1997. Southwest. Nat. 42[1]:33–39). I report below on the first documented case of wild pig predation on the eggs of Western Pond Turtles.

Early on the morning of 21 October 2003, I went to check the progress of a pond-draining project at Cabin Pond (37.37953°N, 121.73146°W) on the Blue Oak Ranch in Santa Clara County, California, USA. In the heat and aridity of the California autumn, the moist basin of the receding pond had attracted wild pigs. Overnight, they had wallowed in the deep mud and thoroughly rooted for earthworms in the moist soil around the shallow end of the pond basin. Three pigs were in the basin when I arrived. Two were rooting beyond where the soil moisture ended in the grass-covered uplands on the slope, ca. 20 m above and beyond the pond. The pigs bolted for cover as soon as they saw me. Moments later, while inspecting the area, I discovered remnants of three turtle eggs in the mounds of soil and dried plant matter where the pigs had rooted. There was a moist, viscous fluid still clinging to the inside of the shells. In the hard earth just below the mound of soil that held the eggs was an elliptical depression about 5 cm across and 3 cm wide. The exact dimensions were difficult to judge due to the rooted conditions.

A number of morphological and behavioral traits make wild pigs ideal predators of turtle nests and eggs. Nest sites of Western Pond Turtles typically are within close proximity of streams and ponds; riparian areas are likewise favored resting and foraging places for wild pigs. Turtle nests typically are no more than 8 cm in depth (Rathbun et al 1992. Southwest. Nat. 37[3]:319–324); wild pigs often root to depths much greater than 8 cm, depending on the soil depth and moisture. Wild pigs' excellent sense of smell may help them detect turtle nests (though they also may encounter turtle eggs in the course of routine rooting). Pigs also have remarkable oral dexterity, which allows them, for example, to detect and swallow earthworms without ingesting soil and may allow them to do the same with small eggs.

In the incident described above, wild pigs were interrupted in the act of predating on turtle eggs—but wild pigs normally swallow their prey whole, leaving no evidence on the ground. The behavior observed serendipitously on the Blue Oak Ranch may therefore happen more often than is witnessed. The spread of wild pigs throughout California could be exacerbating the decline of Western Pond Turtles where these species occur together.

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CHELONIA MYDAS (Green Seaturtle). **DISEASES**. Infectious agents such as fungi and bacteria are known pathogens in marine turtles. Derivative of these kinds of diseases, external and internal tumors may be generated and mainly affect immature animals (Herbst 1994. Annu. Rev. Fish. Dis.4:389–425). In *Chelonia mydas*, *Vibrio harveyi* and *Bacillus* sp. have been described as infectious agents (Work et al. 2003. Dis Aquat Org. 53:41–46). Fungi like *Fusarium oxysporum, Fusarium solana* and *Pseudallescheria boydii* are found in the eggs of *Chelonia mydas*, *Eretmochelys imbricata*, *Caretta caretta*, and *Natator depressus* and can cause death of embryos (Phillott and Parmenter. 2001. Aust. J. Zool. 49:713–718; Phillott 2004. Herpetologica. 34:44–47). There are reports of *Colletotrichum acutatum* in juvenile *Lepidochelys kempii*, with infection in lungs and kidneys (Manire et al. 2002. J. Clin. Microbiol. 40:4273–4280).

There are apparently no published studies on the incidence of infectious agents in marine turtles and nests in Mexico, even though these agents may be important causes of mortality in embryos and hatchlings. Here we document the presence of fungi and bacteria in nests of *C. mydas* on a beach in Veracruz, Mexico.

We took 26 vitello samples from the beach of the "Centro de Protección y Conservación de Tortugas Marinas" in Santander, Veracruz, Mexico. The eggs tested did not appear damaged or show visible signs of infection. For each nest, we counted living and dead hatchlings. The samples were obtained using sterile cotton applicator and cultured on potato dextrose. The samples were kept at 21°C to 23°C during 72 h of incubation. To identify the differences among the infectious agents we used a Cochran Q test, using a 1-0 matrix.

In the samples of *Chelonia mydas* eggs we found *Candida albicans* fungi in 20 samples, and *Staphylococcus aureus* and *Escherichia coli* bacteria were found in eight and five samples, respectively. Ninety-six per cent of all nests presented with at least one of the three infectious agents, although none of the 26 nests presented with the three agents at the same time.

In nests with *Escherichia coli,* mortality was 100%, even when all the embryos were completely developed. In the nests with *Candida albicans* and *Staphylococcus aureus*, mortality was 15% and 20%, respectively. Some individuals showed malformations, including blindness, absence of anterior flippers, and notable differences in size and weight.

The presence of the infectious agents was similar in all nests ($Q = 12.53$; $P>0.05$), nevertheless, for each agent, significant differences were found ($Q = 15.12$: $P< 0.05$).

The source of bacteria and fungi in the Green Seaturtle nests on Santander beach is unclear. Nest invasion by domestic animals such as dogs and pigs, or the disruption of older nests by later nesting females could be a possible source for infectious agents. When the eggs are broken, protein concentration increases in the sand, stimulating bacterial and fungal proliferation (Acuña et al. 1999. Appl. Environ. Microbiol. 65:336–338). Nesting female turtles can carry infectious agents. For example, *Vibrio mimicus* has been reported from marine turtle vents in Costa Rica. This infectious agent could be picked up during nesting, when the female has contact with the sand, and later dispersed into the sea water (Phillott et al. 2002. Aust. J. Zool. 50:687–695).

Humans can transport the bacteria and fungus as well. In Costa Rica, Bangladesh, India, and United States there have been reports of human infections due to the ingestion of turtle eggs (Campos et al. 1996. Appl. Environ. Microbiol. 62:1141–1144). Human transport of pathogens during the handling of eggs may occur if hygiene protocols in the conservation centers are inadequate.

The most damaging nest pathogen was *Escherichia coli* and is an important cause of infection in captive animals (George 2005. *In* Lutz and Musick [eds.], The Biology of Sea Turtles, pp. 363–385). *Candida albicans* fungus is a common cause of respiratory infections (Hernandez and Stephen 2001. J. Zoo. Wild. Med. 32:352–359), and *Staphylococcus aureus* causes skin and gastrointestinal infections (Bennett et al. 1986. J. Food Sci. 51:1337–1339). However, there are no previous reports of these bacteria and fungi in turtle nests in Mexico.

In conclusion, this is the first record of infectious bacteria in *Chelonia mydas* nests in the state of Veracruz. The proximity of human communities to the nesting sites as well as poor hygiene in the marine turtle protection centers are possible sources for infective agents in turtle nests.

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CHELYDRA SERPENTINA (Snapping Turtle). **DEFORMITY.** To our knowledge, there are no previous reports of a wild adult *Chelydra serpentina* found completely lacking a tail. Here we report an adult female *C. serpentina* observed on 23 July 2009 on the Marsh Trail at Rondeau Provincial Park (Ontario, Canada; 42.27830°N, 81.87108°W; 178 m elev.) with no tail. We have examined many Snapping Turtles with partial tail loss but none to this extent. The vertebrae could be felt down from the base of the tail to just past the cloaca and the skin cleanly covered the end. The cloaca was not distorted and was fully intact and there were no signs of scar tissue or wounds from amputation. There were no other deformities through injury or scarring and the turtle appeared to be a healthy adult female. Photographs available from Christina Davy (contact information below).

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GOPHERUS POLYPHEMUS (Gopher Tortoise). **GROWTH**. On 3 January 2009 a large adult female Gopher Tortoise was captured at Jonathan Dickinson State Park, Martin County, Florida, USA (JDSP; 27.0061°N, 80.1288°W). This tortoise had been previously captured nearly 20 years (7134 days) earlier on 23 June 1989. At the time of first capture this animal weighed 7995 g and had a carapace length (CL) of 358 mm. Upon recapture this animal weighed 9163 g and had a CL of 375 mm. Both CL measurements were performed using calipers and each is the average of 10 replicate measurements (Timmerman and Roberts 1994. Herpetol. Rev. 24:64). The average growth rate of the recaptured tortoise was 0.87 mm CL/year. There exists a substantial literature on growth rates in Gopher Tortoises across the species' range (Ernst and Lovich 2009. Turtles of the United States and Canada. John Hopkins University Press, Baltimore, Maryland. 827 pp). Ashton and Burke (2007. J Wildl. Mgmt. 71:783–787) report an average growth rate of 1.8 ± 1.9 mm CL/year for adult female tortoises from the Lake Wales Ridge of Florida, a habitat similar to JDSP.

The age of the JDSP tortoise was estimated based on counts of abdominal growth rings. At the time of first capture in 1989 age was estimated to be >29 years. Although this aging method has been shown to be unreliable in adults of some turtle species (Wilson et al. 2003. Herpetologica 59:178–194), we are unable to estimate age using growth models based on tortoise populations from central Florida (Mushinsky et al. 1994. Herpetologica. 50:119–128) or southcentral Alabama (Aresco and Guyer 1999. Herpetologica 55:499–506) because the JDSP tortoise exceeds the asymptotic limit of CL for both the 1989 and 2009 captures.

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GRAPTEMYS OUACHITENSIS SABINENSIS (Sabine Map Turtle). **COLORATION**. In 2005, six spotting scope observations of aberrantly colored *Graptemys ouachitensis sabinensis* of both sexes (as determined by tail length and head size) were made in the Old Sabine Bottom Wildlife Management Area (OSBWMA) in Lindale, Texas, USA (J. L. Coleman, pers. obs.). Although the striping pattern was typical for *G. o. sabinensis*, the yellow color was replaced with bright red throughout the body and carapace. These individuals were not reported due to a lack of sufficient photographic evidence. A similarly aberrant female *G. o. sabinensis* was trapped along the same stretch of river on 1 July 2009 while sampling using a fyke net and carphorn (Vogt 1980. Copeia 1980[2]:368–371) (Fig. 1). This female was within the documented size range (i.e., carapace length and mass) for *G. o. sabinensis* and bears the typical markings of the subspecies, with the exception of the red coloration and gold colored eyes (Institute of Natural Resource Sustainability at the University of Illinois at Urbana-Champaign, Illinois Natural History Survey photo voucher INHS 2009r). In addition, several other *G. o. sabinensis* captured during the 2009 field season had similar red patterning on their carapaces but lacked the red facial and limb markings.

The only *Graptemys* species reported to exhibit any level of hypererythrinism (increased red pigmentation) are Gibbon's Map Turtle (*G. gibbonsi*), the Ringed Map Turtle (*G. oculifera*), and the Texas Map Turtle (*G. versa*) which are described as having yellow to red carapace markings (Buhlman et al. 2008. Turtles of the Southeast. University of Georgia Press, Athens, Georgia. 251 pp.). No record of a completely hypererythristic map turtle of any species has been reported, nor have red carapace markings been reported for *G. o. sabinensis*. Here we note several different individuals of both sexes over a four-year period, indicating that the trait is not restricted to one sex despite its rarity. Although integumental staining due to environmental influences, such as substrate iron deposits, is possible (J. Harding, pers. obs.), it seems unlikely in the instances reported here, given that our observations were species-specific despite the presence of two other *Graptemys* species and other aquatic turtle species utilizing the same habitat. Additionally, the coloration is not patchy as might be expected in integumental staining and aberrant coloration extends to the iris. We hypothesize that this coloration has a genetic basis; however further validation of this hypothesis is needed.

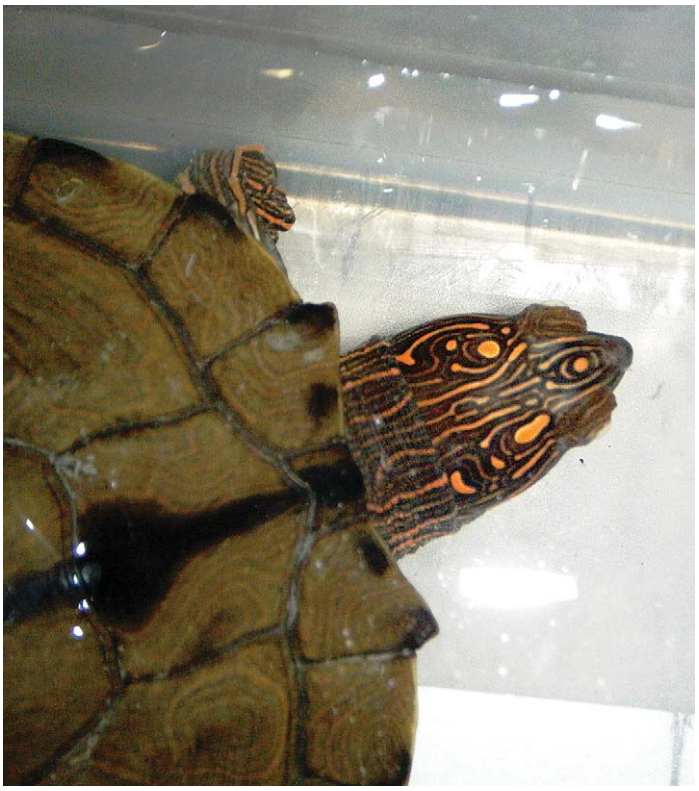

FIG. 1. Aberrent red coloration of a *Graptemys ouachitensis sabinensis* female caught in the Old Sabine Bottom Wildlife Management Area, Lindale, Texas.

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KINOSTERNON SONORIENSE (Sonoran Mud Turtle). **HATCHLING BEHAVIOR**. For many turtle species, little is known about the behavior of hatchlings in the wild. On 14 August 2009, we observed an interaction between two hatchling *Kinosternon sonoriense* in the Peloncillo Mountains, Coronado National Forest, New Mexico, USA (31.503°N, 109.016°W, NAD83, elev. 1706 m). The interaction lasted ca. 2 min and occurred in a rain-filled rock pool (0.23 m^2) approximately 3.5 cm maximum depth. The water temperature was 25.5°C, and the pool was exposed to full sun. We recorded the last minute of the interaction with a camera, which provided durations of behaviors. When we approached the pool, one hatchling (T1) was on top of the other hatchling (T2), holding onto the carapace of T2 with all 4 limbs. Both turtles were underwater, and it appeared that T2 was attempting to swim away from T1. T1 repeatedly bit at the head and anterior carapace of T2. After 80 sec, T1 bit and held fast to the head of T2 for 4 sec while releasing the carapace of T2. T2 then swam away, and T1 followed and eventually perched on the carapace of T2 for 6 sec. T1 then turned and swam to the opposite end of the pool and attempted to bite a water beetle. At this point we retrieved both hatchlings to determine if they were recaptures and record shell measurements. The midline carapace lengths for T1 and T2 were 22.7 and 22.9 mm, respectively, and the yolk scar and caruncle were still present on both hatchlings.

The context of the behavior we observed is unclear. Most likely we observed precocious courtship or social play, which has been described in hatchling turtles (Cagle 1955. Copeia 1955:307; Morris 1976. Herpetol. Rev. 7:111; Kramer and Burghardt 1998. Ethology 104:38–56). The interaction we observed is similar to the description of courtship behavior for other kinosternids (Mahmoud 1967. Copeia 1967:314–319; Lardie 1975. J. Herpetol. 9:223–227). However, Kramer and Burghardt (1998, *op. cit.*) discussed the possibility of social play instead of courtship. Although we were unable to identify the proper context of the behavior, our observation adds to the limited knowledge about the behavior of hatchling kinosternid turtles in the wild.

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(SUP0080-01).

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LEPIDOCHELYS OLIVACEA (Olive Ridley). **EGG SCAVENGING BY FISH.** Sharks and fin-fishes have been documented as significant predators on hatchling sea turtles (Carr 1986. NOAA Tech. Memo. NMFS-SEFC-190, pp. 3–9; Stancyk 1982. *In* K. A. Bjorndal [ed.], Biology and Conservation of Sea Turtles, pp. 139–153. Smithsonian Institution Press, Washington, D.C.). To date, however, there are apparently no reports of fish consumption of sea turtle eggs, presumably because the eggs are buried in a terrestrial nest.

We are studying the ecology of *Lepidochelys olivacea* in the Gahirmatha Marine Wildlife Sanctuary, Orissa, India. The Gahirmatha site is the largest known mass nesting rookery for the Olive Ridley in the world at peak nesting in March and April (Bustard 1976. Tiger Paper 3:3). The Gahirmatha rookery is on a lagoon backed by the Brahmani and Maipura rivers. This mangrove dominated area has notably high fish diversity and productivity (Dash and Kar 1990. The Turtle Paradise: Gahirmatha. Interprint, New Delhi. 295 pp.). Olive Ridleys arrive offshore of Gahirmatha in November and nesting peaks in March and April and continues to May (Dash and Kar 1990, *op. cit.*; Pandav 2000. Conservation and Management of Olive Ridley Sea Turtle Population along the Orissa Coast. PhD. thesis. Utkal University, Bhubaneswar, Orissa. 77 pp.). During the same period, human fishing activities are intensive in the area. In February 2009, three eggs of the Olive Ridley were found in the gut of a catfish, *Arius arius,* which was caught in the Gahirmatha. Diameters of turtle eggs found in the gut ranged from 37.5–37.9 mm.

Unregulated intensive offshore fishing activity has been reported as a major cause for large-scale seaturtle mortality in Orissa (Pandav and Choudhury 1999. Marine Turtle Newsl. 83:10–12). Several thousand dead, gravid Olive Ridleys were found floating on the sea surface during February 2009, possible victims of fishing activities. Therefore, it is presumed that the catfish might have scavenged the eggs from floating dead turtles. Years of research show that Olive Ridleys congregate in small and specific offshore areas of the Orissa Coast, but management programs have failed to provide adequate protection to these congregations from intensive fishing.

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SQUAMATA — LIZARDS

AMEIVA AMEIVA (Giant Ameiva) **DIET**. *Ameiva ameiva* is a medium sized teiid lizard found naturally over a wide range at low elevations from Costa Rica (Savage 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. University of Chicago Press, Chicago, Illinois. 934 pp.) to northern South America, and a few Caribbean islands. Introduced populations occur in Florida (Uetz et. al., The JCVI/TIGR Reptile Database, http://www.reptile-database.org, accessed 21 January 2010; Schwartz and Henderson 1985. A Guide to the Amphibians and Reptiles of the West Indies Exclusive of Hispanola. Milwaukee Public Museum, Milwaukee, Wisconsin. 165 pp.). They are active, diurnal foragers known to feed primarily on insects (Duellman 1978. The Biology of an Equatorial Herpetofauna in Amzonian Ecuador. University of Kansas, Lawrence, Kansas. 352 pp.). Lizards and frogs are also known prey items (Duellman *op. cit.*;Vitt and Colli 1994. Can. J. Zool. 72:1986–2008; Pianka and Vitt 2003. Lizards: Windows to the Evolution of Diversity. University of California Press, Berkeley. 346 pp.). Other vertebrate remains have consisted of lizard and frog eggs (Duellman 2005. Cusco Amazonico. Cornell University Press, Ithaca, New York. 433 pp.) The following observations add mammals to the vertebrate taxa eaten by this species.

On 21 November 2003 at 1430 h in the village of Apoteri (confluence of the Rupununi and Rewa rivers), Region 9, Guyana, an adult *Ameiva ameiva* was observed consuming the phalanges of an unidentified species of bat. The lizard had some difficulty swallowing the extended, stiffened but still articulated bones. About 30 minutes later, ca. 5 m distance from where the first observation was made, an *A. ameiva* was observed carrying a bat carcass that was intact, fully furred and appeared relatively fresh. The lizard bit and held the bat in the head/neck region while repeatedly scratching the body with its forefeet. In this manner small pieces of flesh were removed and immediately swallowed. Eventually a hole ca. 1 cm in diameter was created in the bat's skin. At 1520 h the lizard carried the carcass out of view.

These observations were made in the vicinity of a rarely occupied house that supported a large colony of bats. The *A. ameiva* may have been exploiting the natural mortality of this colony as a food source. Alternatively, the lizard could have opportunistically killed a bat that had fallen from its roost.

I thank Peter Taylor for the opportunity to travel in Guyana.

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ANOLIS PORCATUS (Cuban Green Anole, Caguayo). **SAUROPHAGY**. *Anolis porcatus* is a Cuban endemic that has also been introduced to Hispaniola (Powell et al. 1990. Amphibia-Reptilia 11:421–425) and Florida (Meshaka et al. 1997. Herpetol. Rev. 28:101–102). It is polytypic (Pérez-Beato 1996–1997. Rev. Biol. Trop. 44/45:295–299), widely distributed in the Cuban Archipelago, and abundant in the gardens associated with homes. Principally in Western Cuba, it is sympatric with several other widely distributed lizards that occur in houses, namely *Anolis sagrei sagrei* and *A. homolechis homolechis, Gonatodes albogularis fuscus*, *Hemidactylus haitianus*, *Sphaerodactylus elegans elegans*. Previously published reports on saurophagy in *A. porcatus* include a juvenile *A. homolechis* and younger conspecifics (Socarrás et al. 1988. Misc. Zool. 38:4). Here I provide a second observation of saurophagy in *A. porcatus*, and the first published account of predation on a *Gonatodes a. fuscus*.

At 1630 h on 24 August 2004, an adult (estimated at 50 mm

SVL) female *A. p. porcatus* was observed in the garden of a house in Bejucal (22.925°N, 82.3915°W, elev. 111 m; WGS84), Havana Province, Cuba, devouring a juvenile (~10 mm SVL) *G. a. fuscus*. The *Anolis* lizard was observed with the live juvenile gecko inside its open mouth. The specimen was swallowed poster end first. The *A. porcatus* exhibited some difficulties in swallowing the gecko, probably because of the relatively large size of the juvenile gecko. The posterior part of the gecko body was swallowed quickly but the head was swallowed very slowly. The culmination of the predation was not observed since the animal moved out of view. This episode lasted ca. 15 min.

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ANOLIS STRATULUS (Saddled Anole). **DIET**. *Anolis stratulus* is commonly found throughout the Puerto Rico Bank, including the British Virgin Islands (BVI; Powell and Henderson 2009. Natural History of West Indian Reptiles and Amphibians. University Press of Florida, Gainesville.). It is generally considered a trunk-crown species, although in the BVI it is often found closer to the ground than in other parts of its distribution (Lieht 1974. Copeia 1974:215–221; Perry 2005. *In* J. Lazell, Island: Fact and Theory in Nature, pp. 187–188. University of California Press, Berkeley). *Anolis stratulus* is a sit-and-wait predator of small invertebrates, but has also been known to occasionally drink nectar from flowers (Perry and Lazell 1997. Herpetol. Rev. 28:150–151; Powell and Henderson, *op. cit.*) .

In October 2009 we conducted a study of nectivorous bird food preferences on Guana Island, BVI. As part of this study, a sugar water feeder was placed on a small wooden platform hung from a tree. The platform held a bowl of granulated sugar for attracting Bananaquits (*Coereba flaveola*), small local nectivorous bird. Anoles were often observed on the tree and occasionally basked on the platform. On three separate occasions (occurring once on 16 October 2009, and two observations recorded within 30 minutes of each other on 18 October 2009), we observed at least one adult *A. stratulus* drinking from the feeder located on the platform. The feeder contained 10% and 40% sugar solution during the days of observations, respectively. All observations were recorded between 0830 h and 0930 h. In one case, the lizard was feeding along with a Bananaquit. Although another sympatric nectivorous bird, the Antillean Crested Hummingbird (*Orthorhyncus cristatus*), has been reported to sometimes attack Saddled Anoles (Boal 2008. Carib. J. Ornithol. 21:48–49), Bananaquits have not been reported to show such aggression. Over several years, we have also noted *A. stratulus* licking droplets containing dissolved sugar from the bowl following rain, but have never seen them eat granulated dry sugar.

Reptiles capable of utilizing human habitats such as artificial night-lights have an increased potential for such species to become invasive (Perry et al. 2008. *In* Jung and Mitchell [eds.], Urban Herpetology, pp. 239–256. Herpetological Conservation Vol. 3, Society for the Study of Amphibians and Reptiles, Salt Lake, Utah). Although we have never seen *A. stratulus* at night-lights, observations of them supplementing their diet from artificial feeders suggest they have some potential to become invasive, if introduced outside their native range. To date, however, the only record of introduction of this species is associated with a research project (Kraus 2009. Alien Reptiles and Amphibians. Springer, New York).

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ASPIDOSCELIS SONORAE (Sonoran Spotted Whiptail). **SCAVENGING BEHAVIOR.** *Aspidoscelis sonorae* is a moderately large (to 91 mm SVL), parthenogenetic teiid that occurs in northern Sonora, Mexico, southeastern Arizona, and extreme southwestern New Mexico, and known to be an active foraging insectivore (Sredl et al. 2009. *In* Jones and Lovich [eds.], Lizards of the American Southwest: A Photographic Field Guide, pp. 386–389. Rio Nuevo Publishers, Tucson, Arizona). On 24 April 2009 at 0838 h, in the Saguaro National Park East (Rincon Mountains), southeast Arizona, USA, I observed an adult *A. sonorae* scratching in organic litter at the base of a rock outcrop beneath a large saguaro cactus in bloom. As I observed the lizard forage, it tongue-flicked and scratched the substrate with its forefeet and poked the litter with its rostrum. During this foraging process, a dead honeybee (*Apis millifera*) was uncovered. The *A. sonorae* continued to scratch at the litter in the same area glancing over towards the dead honeybee twice, even moving the dead insect with its front right foot once while continuing to dig for a few more seconds (Fig. 1A). However, upon tongue-flicking the bee the *A. sonorae* turned its full attention

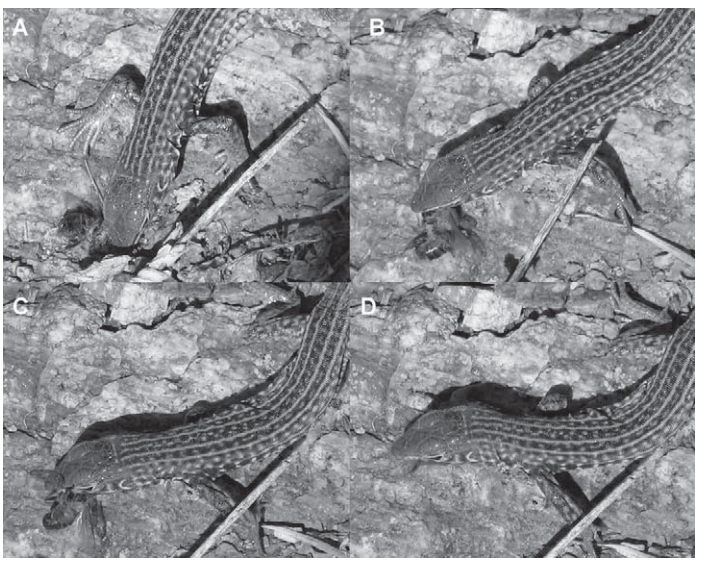

FIG. 1. *Aspidoscelis sonorae* consuming scavenged honeybee at Saguaro National Park East, Arizona, USA.

onto the unresponsive honeybee and after two successive tongue-flicks bit the bee on the head (Fig. 1B) and proceeded to consume the dead honeybee (Fig. 1C–D). To my knowledge, this is the first recorded observation of scavenging by *A. sonorae in situ*.

I thank Wade Sherbrooke for positive identification of the whiptail and comments, and Danny Martin for configuration of the photographs. I would also like to thank Mike Nolan for sharing some of his photographic expertise and hospitality during my trip to Tucson.

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BARISIA CILIARIS (Northern Imbricate Alligator Lizard). **ANTIPREDATOR BEHAVIOR**. The defensive loop posture has been observed in other anguid lizards including *Elgaria kingi* (Bowker 1987. Herpetol. Rev. 18:73–75), and *Barisia imbricata planifrons* (Bille 1997. Herpetol. Rev. 28:202). Here we document this defensive behavior in another anguid lizard, *Barisia ciliaris*. This behavior has sequences of occurrence with the following phenotypic categories, as defined by Greene (1988. *In* Gans and Huey [eds.], Biology of the Reptilia, Vol. 16, Ecology B, pp. 1–152. Academic Press, New York), the following models were recognized: 1) locomotory escape (attempting to avoid capture by hiding in forest litter); 2) head hiding (attaining a loop posture, the head is hidden under the tail); and 3) eversion of hemipenes. This behavior is common in most lizards.

Barisia ciliaris is distributed in the mountainous regions of the northern Mexican Plateau, from extreme southern Coahuila to Guanajuato, east to San Luis Potosi, Zacatecas, Durango, and Nuevo Leon (Smith and Taylor 1950. An Annotated Checklist and Key to the Reptiles of Mexico Exclusive of Snakes. Smithsonian Institution, Washington, D.C. 253 pp.; Lemos-Espinal and Smith 2007. Anfibios y Reptiles del Estado de Coahuila, México. Universidad Nacional Autónoma de México y Comisión Nacional Para El Conocimiento y Uso de la Biodiversidad. 550 pp.).

On 28 May 2007 an adult female *Barisia ciliaris* was caught on Cerro El Potosí in the municipality of Galeana, Nuevo Leon, (24.8675°N, 100.248338°W, elev. 3270 m, NAD27). The specimen was found at 1650 h, and was basking on top of a dry log. Upon detection of our presence, it immediately took refuge in a crevice within the log. The lizard was extracted from the log for data collection using a pair of forceps. Immediately after being captured, it rolled its body into a tight coil, attempting to hide its head under its tail. This posture was maintained until the lizard was released a half hour later.

The specimen was 104.9 mm SVL, with 147.2 mm TL, weight 31.5 g, with 17°C dorsal temperature, and 15°C substrate temperature. Surrounding habitat consisted of pine forest with *Pinus hartwegii* as the dominant species.

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CNEMIDOPHORUS OCELLIFER (Spix's Whiptail). **CANNIBALISM.** *Cnemidophorus ocellifer* is a widely distributed neotropical lizard, occurring in Argentina, Bolivia, Paraguay, and throughout Brazil, excluding Amazonia (Vanzolini et al. 1980. Répteis das Caatingas. Acad. Bras. de Ciênc., Rio de Janeiro, Brazil. 161 pp.). The diet of this lizard is composed mainly of arthropods, in which termites, insect larvae, orthopterans, spiders, and beetles are the main food items (Mesquita and Colli 2003. J. Herpetol. 37:498–509; Vitt 1995. Occas. Pap. Oklahoma Mus. Nat. Hist. 1:1–29). Here, we report the first recorded case of cannibalism in a population of *C. ocellifer* from the Caatinga of northeast Brazil.

During an ecological study of a population of *C. ocelllifer* in the Ecological Station of Seridó, Rio Grande do Norte state (06.5767°S, 37.2558°W; datum: WGS84; elev. 192 m), a sample of 70 individuals was collected between September 2008 and August 2009. The stomach contents of an adult female (70.7 mm SVL), collected on 26 June 2009, revealed conspecific ingestion. An undigested juvenile, indicative of recent ingestion, was found whole (32.5 mm SVL, volume = 1170.9 mm^3)(Fig. 1). The juvenile exhibited bite marks on the head, which was pointed toward the distal portion of the predator's stomach. This evidence indicates that the conspecific was captured in an attack and ingested head first, characteristic of a cannibalistic event.

To date, cases of cannibalism in Brazilian lizards have been recorded in nine species belonging to the families Gekkonidae, Liolaemidae, Scincidae, and Tropiduridae (see Siqueira and Ro-

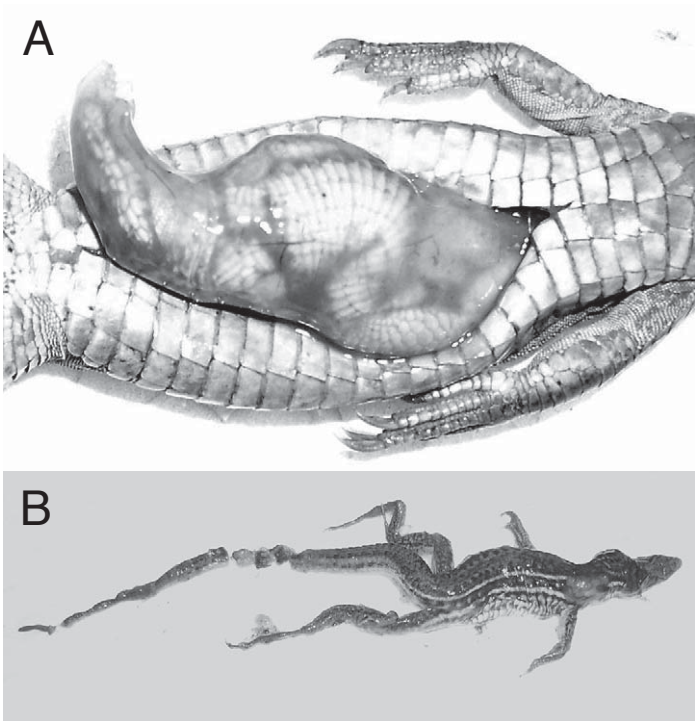

FIG. 1. Cannibalism in *Cnemidophorus ocellifer*: (A) stomach being removed; (B) young conspecific; note signs of bite marks on the head.

cha 2008. S. Am. J. Herpetol. 3:82–87). In the cases involving lizards with sexual dimorphism in body size, and when the sex of the cannibal was reported, the cannibalistic act was always committed by the sex with the larger body size (Siqueira and Rocha 2008, *op. cit.*). In our study, the opposite occurred; cannibalism was practiced by a single female, the sex with the smaller body size in this species.

The frequency of cannibalism occurrence in the population was low (1.4%), a finding consistent with the other reported cases of cannibalism in populations of Brazilian lizards (frequency ranged from 0.7 to 3.8%; Siqueira and Rocha 2008, *op. cit.*). According to Vitt (2000. Herpetol. Monogr. 14:388–400), lizards that capture large prey, such as vertebrates, may not need to forage for several days, owing to the large amount of nutrients provided by the ingested prey. Thus, what seems to be a "rare" event may be an event rarely recorded by investigators.

During the time we recorded the cannibalistic event, we observed an increased number of juveniles in the study area, reflecting a recruitment period. Relatively small body size, lack of experience in detecting potential predators, and the still inefficient recognition of habitat structure make juveniles potential prey for various types of predators (Siqueira and Rocha 2008, *op. cit.;* Vitt 2000, *op. cit.*). The elevated density of juveniles, along with the fact that a predator obtains greater nutritional benefits by capturing conspecifics or phylogenetically similar prey (Mayntz and Toft 2006. J. Anim. Ecol. 75:288–297; Pfennig 2000. Am. Nat. 155:335–345), might have been the main factors that led to the occurrence of this cannibalistic event.

The female specimen of *C. ocellifer* was deposited in the herpetological collection of the Universidade Federal do Rio Grande do Norte, Natal, Brazil (CHBEZ 2681). We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financing the PELD-Caatinga Program entitled Structure and Functioning, and for the research scholarship granted to RFDS (process 127543/2008-2), LBR (process 141993/2006-5), and EMXF (process 304077/2008-9); IBAMA provided a permit (Permit 206/2006 and Process 02001.004294/03-15).

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COLEODACTYLUS NATALENSIS (NCN). **PREDATION.** *Coleodactylus natalensis*, described from the Parque Estadual Dunas de Natal (Freire 1999. Bol. Mus. Nac. 399:1–14), is a gecko considered to be endemic to Atlantic forest remnants in Rio Grande do Norte State, Brazil (Sousa and Freire, *in press*). Considered the smallest lizard in South America, it is a denizen of leaf litter within shaded forests (Capistrano and Freire 2009. PublICa 4:48–56; Freire 1999, *op. cit.*; Sousa and Freire, *op. cit.*). Aside from the description of the species (Freire, *op. cit.*), few ecological studies have been performed. Only some aspects of its diet, reproduction, and habitat preference have been published (Capistrano and Freire, *op. cit*; Lisboa et al. 2008. Herpetol. Rev. 39:221; Sousa and Freire, *in press*, Herpetol. Rev.). Few studies are available regarding prey-predator relationships between reptiles and arthropods within Brazilian communities, due to the time required for sampling and the elusive habits of many reptile species (Rocha and Vrcibradic 1998. Ciência e Cultura 50:364–368). Given the limited distribution of this species within remnant forests, additional information on its ecological relationships are essential to understanding its life history. Here, we report on an observation of predation on *Coleodactylus natalensis* by the ant, *Dinoponera quadriceps*.

The ant genus *Dinoponera* contains species with body sizes varying from 3–4 cm (Paiva and Brandão 1995. Ethol. Ecol. Evol. 7:297–312). *Dinoponera* ants are described as solitary foragers with predominantly carnivorous habits, ranging from humid forest soil to dry savannas (Fourcassié and Oliveira 2002. J. Nat. Hist. 36:2211–2227). The neotropical ant *D. quadriceps* is a typical queenless species of the subfamily Ponerinae, found in the isolated forest range (known locally as "Brejos de Altitude") in the semiarid Caatingas, Cerrado, and Atlantic Forest (Paiva and Brandão, *op. cit.*).

During a study of behavioral ecology on 7 March 2009, in the Parque Estadual Mata da Pipa (PEMP), municipality of Tibau do Sul, State of Rio Grande do Norte, Brazil (6.24861ºS, 35.05750°W; datum WGS84; elev. 63 m), PAGS saw an adult male *C. natalensis* (18.3 mm SVL) in the leaf litter of dense forest at 1100 h. The gecko crossed paths with a *D. quadriceps* (~3 cm from the anterior tip of the head to the posterior end of the abdomen) that was foraging in the near vicinity. The ant immediately grabbed the gecko by the neck with its jaws and proceeded to carry it to the nest. The animals were intercepted in order to collect the lizard.

This is the first record of a known predator for *C. natalensis*. We deposited the specimen (CHBEZ 2518) in the herpetological collection of the Universidade Federal do Rio Grande do Norte, Natal, Brazil. We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the research scholarship granted to PAGS (process 127543/2008-2) and EMXF (process 304077/2008-9).

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COLEODACTYLUS NATALENSIS (NCN). **DIET.** *Coleodactylus natalensis*, described from the Parque Estadual Dunas de Natal (Freire 1999. Bol. Mus. Nac. 399:1–14), is considered endemic to Atlantic Forest remnants in Rio Grande do Norte State, Brazil (Sousa and Freire, *in press*). Considered the smallest lizard in South America, it is a shaded forest leaf-litter dweller (Capistrano and Freire 2009. PublICa 4:48–56; Freire 1999. Bol. Mus. Nac. 399:1–14; Sousa and Freire, *op. cit.*). The diet of *C. natalensis* in Parque Estadual Dunas de Natal is mostly arthropods. Isopods and spiders are the most frequent prey based on numbers, volume, and frequency, implying a preference for large prey that is less abundant in leaf litter (CMCAL, pers. obs.). *Coleodactylus meridionalis* has a similar diet, differing only in its relatively larger prey (Dias et al.

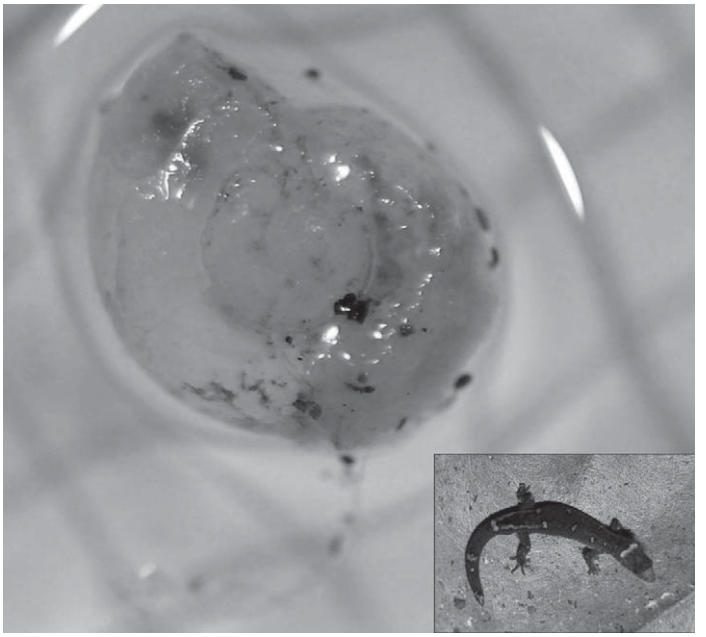

FIG. 1. The *Streptaxis* sp. snail taken from the stomach of *Coleodactylus natalensis* (inset).

2003. Herpetol. Rev. 34:142–143). *Coleodactylus septentrionalis* feeds mainly on termites (Isoptera) and earwigs (Dermaptera) (Vitt et al. 2005. Herpetol. Monogr. 19:137–152). *Coleodactylus amazonicus* seems to prefer collembolans (Collembola) and mites (Acari) (Ramos 1981. Acta Amaz. 11:511–526; Vitt et al., *op. cit.*). Though members of the genus *Coleodactylus* consume a relatively diverse assemblage of invertebrate prey, records of mollusk consumption are lacking. Hence, here we provide the first report of mollusk ingestion in the genus.

During a study of the structure of lizard assemblages in the Parque Estadual Mata da Pipa (PEMP), municipality of Tibau do Sul, State of Rio Grande do Norte, Brazil (6.24861ºS, 35.05750°W; datum WGS84; elev. 63 m), we examined the stomach contents of 16 *C. natalensis*. During this examination, we found a snail of the genus *Streptaxis* (Gastropoda, Streptaxidae) (2.1 mm long, 1 mm width, 10.99 mm^3 volume; Fig. 1), in the stomach of an adult female (20.3 mm SVL, 0.14 g) captured at 1230 h on 13 March 2009 (dry season) in the leaf litter of dense forest.

We deposited the *C. natalensis* (CHBEZ 2509) in the herpetological collection of the Universidade Federal do Rio Grande do Norte, Natal, Brazil. We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the research scholarship granted to PAGS (process 127543/2008-2) and EMXF (process 304077/2008-9). We thank Marc Hayes for helpful comments on this note and Roberto Lima for identifying the snail.

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DIPLOGLOSSUS DELASAGRA (Cuban Pale-necked Galliwasp). **REPRODUCTION AND PARENTAL CARE.** Three endemic species of the subfamily Diploglossinae occur in Cuba, including *Diploglossus delasagra*, *D. garridoi,* and *D. nigropunctatus* (Thomas and Hedges 1998. Copeia 1998:97–103), however, information available on the natural history of these species is scarce. This is probably due to the cryptic and elusive habits exhibited by members of this genus, as observed in most anguids. For this reason, we feel that any attempt to gather and provide information on these species may be relevant to the current knowledge and understanding of their biology.

On 15 June 2007, a gravid female *D. delasagra* was collected in the leaf litter of a woodland patch by an unpaved road connecting the Las Palmas rural community (22.200889°N, 78.8394861°W, WGS84) and the town of Enrique Varona (Falla) (22.172875°N, 78.2002889°W), Chambas municipality, Ciego de Avila province, Cuba. These localities are separated from one another by ca. 6.4 km. The animal was brought to the Centro de Investigaciones de Ecosistemas Costeros (CIEC), and kept in captivity in order to collect data on its reproductive biology.

The individual was kept alive in a plastic bucket placed in a dark room for about 48 h from the time it was collected until it was brought to CIEC. Afterwards, the lizard was placed into a 170 × 190 mm plastic terrarium. One sample of the nearby semideciduous forest leaf litter was taken, allowing us to have a 3–4 cm depth layer at the bottom of the container. It was kept at room temperature, avoiding direct sunlight and thus excessive dehydration. Every two days, the leaf litter was sprayed with tap water to maintain relatively constant moisture.

The animal was periodically fed by providing forest soil-dwelling invertebrates, taking into consideration the feeding preferences for this species (Martínez Reyes and Moreno 2003. *In* L. Rodríguez Schettino [ed.], Anfibios y Reptiles de Cuba, pp. 90–97. UPC Print, Vaasa). The invertebrates were mostly spiders, ants, termites, and small mollusks. Around the mouth of the container, a thick mesh was firmly tied up to keep prey from escaping, and provide the lizard access to fresh air.

Behavioral observations were conducted during daylight hours in 90 min intervals for four days, 5–8 July 2007, between 0730 to 1900 h. The observations also comprised one 24 h cycle, but only on 9 July. Each observation period lasted 15 min, which totalled 12 h of direct observations. During the behavioral experiment, leaf litter temperature ranged between 27.5 and 30.6°C.

The female measured 96.0 mm SVL and 8.58 g body mass, and laid six eggs, which coincided with Schwartz and Henderson (1991. Amphibians and Reptiles of the West Indies. Descriptions, Distributions, and Natural History. University of Florida Press, Gainesville. xvi + 720 pp.); however, Cuban species of this genus may have up to nine eggs per clutch (Martínez Reyes and Moreno, *op. cit.*). Oviposition took place between 19 and 25 June; the clutch size was six eggs and after four days (29 June) measurements were made. Three eggs were chosen to be measured because they were laid at a shallow depth of 10 mm. The resulting egg measurements were slightly lower than those obtained by Barbour and Ramsden

FIG. 1. Female *Diploglossus delasagra* protecting its clutch with the body bent around one egg (arrow).

(1919. Mem. Mus. Comp. Zool. 47:69–213) (8.1 × 14.3 mm, 496.0 mm^3 vs. 9 × 17 mm, 720.6 mm^3).

In this study, the female was observed with her body coiled around one of the eggs 11–12 h post-laying (Fig. 1), which coincides with observations made on a female *D. nigropunctatus* (Barbour and Shreve 1937. Bull. Mus. Comp. Zool. 80:377–387). We noticed that the female remained indifferent to several kinds of stimuli such as camera flash and handling of the container. We also observed the female to rest her snout on one egg. Similar behavior has been described by Savage (2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. Univ. Chicago Press, Chicago, Illinois. 934 pp.) for a female *D. bilobatus* (Costa Rica).

On some occasions, when the female was completely hidden in the leaf litter layer, we searched the top layer to be certain of her position relative to her clutch. She never showed any evasive behaviors. A few times, she slowly buried herself into deeper levels of the leaf litter, but always stayed close (30–50 mm) to her eggs. Similar behavior was also observed in *D. nigropunctatus* by Barbour and Ramsden (*op. cit.*). The female did not display any aggressive behavior while we poked gently around the eggs, contrary to observation for *D. monotropis* (Central and South America) by Solórzano (2001. Fauna 2:8–12). In our case, the female remained indifferent to this kind of stimulus, but always kept an alert posture during disturbance.

No active feeding behavior was observed during the period in captivity, although food was always available. We interpret this as an indication that nest attendance was a priority, and which might be an energetically low-cost activity. However, during nocturnal cycles of observations, the female spent most of the time under the leaf litter, such that foraging might have gone undetected given that this species is thought to exhibit nocturnal habits (Martínez Reyes and Moreno, *op. cit.*).

Our observations on captive *D. delasagra* indicate that the adult female maintains a close and persistent physical proximity to its clutch, which is supported by observations by Greene et al. (2006. S. Am. J. Herpetol. 1:9–19). Other descriptions dealing with the parental care in this group of reptiles such as ingestion of embryonic remains and the closeness to the neonates by the female parent were not possible in this study, as the female was found dead on the morning of 11 July 2007. The cause of death is unknown.

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DRACO BECCARII (Beccar's Flying Dragon). **NESTING**. Nesting is often little-known in secretive animals such as reptiles, and lizards are no exception (Perry and Dmi'el 1994. Amphibia-Reptilia 15:395–401). Anecdotal observations can pave the way for quantitative studies that uncover behaviors associated with nesting and their evolutionary history, and the influence of nest site choice on reproductive success. Little information exists on the nesting habits of flying dragons, genus *Draco*.

On 9 July 2009 at 1245 h we discovered a nesting flying lizard (*Draco beccarii*) near Lapago Base Camp, ~7 km from Labundo Bundo, on the island of Buton in Sulawesi, Indonesia. The mother was on the ground with her head over an open chamber with three visible eggs in the bottom (Fig. 1). The eggs were not dimpled and were arranged in one layer (egg sizes, length followed by width: #1 = 12.6, 7.1; #2 = 12.2, 7.1; #3 = 12.7, 7.2). The mother (SVL = 76.4 mm, TL = 147.2 mm, mass = 5.5 g) was captured for photographs and measurements, palpated and found to contain no other eggs, and released at the nest site the following day. We backfilled the nest (depth to the top egg = 1.8 cm; chamber depth = 3.1 cm; chamber diameter ~3 cm). The nest site was in a small (~10 × 10 cm) spot of bare ground in an area with scattered leaf litter, on a scarcely used trail in rainforest. There was a sparse understory but

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

FIG. 1. A female *Draco beccarii* sits over her nest cavity with three eggs she just laid.

no shrubs near the nest site. The overstory was >95% canopy cover and was not visibly different than the surrounding area. The distance to the nearest tree was 1.5 m and there were several other trees within 10 m. The soil was luvisol and was moist but not saturated. Weather conditions during the observation were mostly sunny and ~27ºC, and followed a day of similar conditions but with some patchy, light rainfall.

Two nesting *D. beccarii* were similarly observed in July, 2000 (Table 1). Nine additional individuals were recorded as gravid females due to palpation, dissection, or terrestrial behavior (Table 1). The mean body sizes of gravid or nesting *D. beccarii* were SVL = 72.2 ± 9.99 mm SD; TL = 148.7 ± 9.94 mm SD; mass = 7.0 ± 1.29 g SD. Based on our observations the nesting season in *D. becarrii* spans (at least) all of July and August on Buton (Table 1).

TABLE 1. Female *Draco becarrii* observed or captured during the nesting season on Buton, Sulawesi. 1 = range for the previous 24 hrs (minimum-maximum); 2 = discovered while nesting, captured and palpated; 3 = captured by hand and palpated; 4 = captured in pitfall trap and palpated; 5 = discovered while nesting, not captured; 6 = sighted on ground but not captured 7 = found dead, dissected; S = sunny, C = cloudy, R = rainy; numbers after weather indicate rainfall amounts over the previous 24 hrs. * Sex determined by lack of colorful dewlap.

Date	time (h)	(ºC)$_1$	SVL (mm)	TL (mm)	mass (g)	reproductive condition	observation
10 Aug 00	~1200	n/a	75.0	n/a	n/a	laid 1 egg	2,S,0
28 Aug 00	~1200	n/a	79.0	n/a	n/a	laid 2 eggs	2,S,0
9 Jul 09	1245	~27	76.4	147.2	5.5	laid 3 eggs	2,S,0
19 Jul 09	1330	22.5-26.0	80.7	154.0	8.5	gravid (N = 4)	3,R,0
31 Jul 09	n/a	22.0-25.0	75.0	163.5	9.0	gravid (N = 4)	4,C,40
1 Aug 09	0945	22.0-24.5	n/a	n/a	n/a	digging nest	5,S,0
4 Aug 09	0900	22.5-26.0	47.3	153.8	6.5	gravid (N = 4)	3,C,0
4 Aug 09	1230	22.5-26.0	n/a	n/a	n/a	female*	6,S,0
6 Aug 09	1330	22.5-26.0	n/a	n/a	n/a	female*	6,S,0
11 Aug 09	1100	23.0-26.5	76.3	137.9	6.5	gravid (N = 3)	7,S,0
11 Aug 09	n/a	23.0-26.5	71.1	149.9	7.0	gravid (N = 3)	4,S,0
13 Aug 09	n/a	23.0-26.0	69.4	134.6	6.0	gravid (N = 2)	4,S,0

We are unaware of any published observations of this or other *Draco* species nesting in the wild, although there may be published information in non-indexed regional journals. The nesting behavior of *D. volans* and *D. spilopterus* in captivity was described by Magdefrau (1992. The Vivarium 4:13–15) and Card (1994. Herpetol. Rev. 25:65), respectively. It appears that *D. beccarii* does not seek out sunny places for nesting like most agamids, but rather nests more or less randomly with respect to canopy openness like many other rainforest-inhabiting tropical agamids (Greer 1989. The Biology and Evolution of Australian Lizards. Surrey Beatty and Sons, Chipping Norton, New South Wales). However, *Draco* appears to conform to the agamid pattern of nesting in the substrate on the forest floor (Greer 1989, *op. cit.*), despite its highly arboreal nature. In fact, it is possible that *Draco* only leaves the trees for nesting. Clutch size in the present observation fell between that reported for *D. melanopogon* (mean = 2, N = 14 and N = 90) and *D. volans* (mean = 4, N = 20) by Hendrickson (1966. Bull. Raffles Mus., Singapore 34:53–71) and Shine et al. (1998. J. Zool. Lond. 246:203–213).

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ENYALIUS PERDITUS (NCN) and ***ENYALIUS BILINEATUS*** (NCN). **PREDATION.** *Enyalius perditus* and *E. bilineatus* are typical Brazilian Atlantic forest species. However, *E. perditus* inhabits areas with humid vegetation and closed canopies, whereas *E. bilineatus* has a preference for more open areas (Jackson 1978. Arq. Zool. 30:1–79). Nevertheless, both species are sympatric with the leaf-litter spider, *Ctenus ornatus* (Ctenidae). This spider is nocturnal, spends most of its time hidden inside cracks or holes, has a preference for areas with dense vegetation, and avoids antropized areas (Almeida et al. 2000. Rev. Brasil. Biol. 60[3]: 503–509). We observed two separate predation events involving this spider on the young of two different *Enyalius* species—the first on *E. bilineatus* and the second on *E. perditus*. We believe these observations to be the first records of this spider predating on these respective lizard species.

On 14 October 2008, in the Municipal Park of Lajinha, in the municipality of Juiz de Fora, state of Minas Gerais, Brazil (21.792417°S, 43.380889°W; WGS84, 893 m elev.), we observed a young *E. bilineatus* (31.3 mm of SVL) being consumed by a *C. ornatus* spider with a cephalothorax length of 28.2 mm during the inspection of a funnel trap used in a reptile survey study. This animal had already been captured by the spider and was held by the neck region at the moment of the initial observation, with no signs of necrosis, which suggests that the capture probably occurred a short time before it. On 22 October, 2008, a young *E. perditus* (31.8 mm of SVL) was found being ingested by a spider of 21.8 mm (cephalothorax length). Upon intial observation, the spider was present inside the trap together with the lizard, with no signs of a predation event. As we initially attempted to take the lizard out of the trap, it evaded capture and approached the spider. It was then captured by the spider, also being held at the neck region. The observation of the necrosis evolution in both animals was carried out and, after about 7 h they were totally consumed, with the exception of a part of each animal's tail.

Because they inhabit the same environment, we believe that this kind of predation may commonly occur in the area. The spiders were deposited in the collection of terrestrial invertebrates of Universidade Federal de Juiz de Fora (CIUFJF 002–003). We thank the Cordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for financial support and also IBAMA for issuing collection permit 16895-1.

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GEKKO GECKO (Tokay Gecko). **PREY.** *Gekko gecko* is an introduced species to Florida from SE Asia (King and Krakauer 1966. Quart. J. Florida Acad. Sci. 29:144–154). Known to be a highly aggressive predator (Smith 1935. The Fauna of British India. Reptilia and Amphibia Vol. II. Taylor and Francis, London. xiii + 440 pp.), *G. gecko* preys on a wide variety of food items in Florida (Meshaka et al. 1997. Florida Field Nat. 25:105–107; Love 2000. Herpetol. Rev. 31:174) and in SE Asia (Aowphol et al. 2006. Amphibia-Reptilia 27:491–503). *Romalea guttata* (Eastern Lubber Grasshopper), native to SE United States, is a chemically defended arthropod, which produces a highly complex defensive secretion when stressed (Whitman et al. 1991. Can. J. Zool. 69:2100–2108). Yosef and Witman (1992. Evol. Ecol. 6:527–536) reported that *Lanius ludovicianus* (Loggerhead Shrike) was the only species of 21 birds and lizards observed during laboratory and field studies to successfully feed on *R. guttata*. Common reactions by various species having ingested *R. guttata* are gagging, regurgitation, and death (Yosef and Witman 1992, *op. cit.*). Here we report the observation of an adult *G. gecko* successfully predating on an adult *R. guttata*.

On 6 June 2008 at ca. 0945 h (DST), an adult *G. gecko* was observed on the eastern-facing wall of a house in a residential community in Broward County, Florida, USA (26.0490°N, 80.3984°W). After turning to leave the area where the gecko was observed, a rustling sound followed by a crunching sound was heard. Upon investigation, the adult *G. gecko* was observed to have seized an adult *R. guttata* cross ways in its jaws. The gecko then moved to another wall of the house where it finished eating the grasshopper. The entire process took approximately ten minutes and at no time did the gecko flinch, gag, or regurgitate the grasshopper. Repeated examinations (1, 3, and 24 h) afterwards of the gecko and feeding locations produced no evidence of regurgitation.

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GERRHOSAURUS NIGROLINEATUS (Black-lined Plated Lizard). **ENDOPARASITES.** *Gerrhosaurus nigrolineatus* is known from Uganda, Rwanda, Tanzania, northeastern South Africa, west to Congo-Brazzaville, southwest to Angola (Spawls et al. 2002. A Field Guide to the Reptiles of East Africa. Academic Press, San Diego. 543 pp.). We established an initial helminth list for *G. nigrolineatus* by examining three specimens (two females, one male) (SVL = 160, 132, 143 mm) collected in February 1968 from Rakai District, Uganda and deposited in the Natural History Museum of Los Angeles County, Los Angeles, California USA (LACM 39470, 39474, 39483). The lizards were opened by a mid-ventral incision. The digestive tract was removed and examined for endoparasites using a dissecting microscope. The body cavity was also searched. Six cestodes were found, three in the small intestines of LACM 39474 and 39483. The cestodes were cleared in xylol, regressively stained in haematoxylin, mounted in balsam, studied under a compound microscope and identified as *Oochoristica truncata* (prevalence, lizards infected/lizards examined × 100 = 67%). Cestodes were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, USA as *Oochoristica truncata* (USNPC 102415).

Oochoristica truncata is likely the most common tapeworm in reptiles in southern Africa and has been reported from agamid, chamelonid, gekkonid and scincid lizards and boid and colubrid snakes (Spasskii 1951. Anoplocephalate Tapeworms of Domestic and Wild Animals. Acad. Sci. USSR, Moscow. 783 pp.; Goldberg and Bursey 2004. Afr. Zool. 39:111–114; Goldberg et al. 1999. Comp. Parasitol. 66:78–80). Although the life cycle of *O. truncata* is not known, Conn (1985. J. Parasitol. 71:10–16) reported beetles acted as intermediate hosts for the congener, *O. anolis*. *Oochoristica truncata* in *Gerrhosaurus nigrolineatus* represents a new host record and the Gerrhosauridae represents a new host family record for *O. truncata*.

We thank Christine Thacker (LACM) for permission to examine specimens and Cecilia Nava (Whittier College) for assistance with dissections.

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GONATODES ATRICUCULLARIS (Cajamarca Gecko). **ENDOPARASITES.** *Gonatodes atricucullaris* is known only from Bellavista, Cajamarca Department, Peru (Uetz and Hallermann 2009. www.reptile-database.org. Accessed 2 February 2010). To our knowledge there are no reports of helminths from this species. The purpose of this note is to establish the initial helminth list for *G. atricucullaris*.

Four *G. atricucullaris* (mean SVL = 31.5 mm ± 1.3 SD, range: 30–33 mm SVL) collected in November 1968, from Bellevista, (7.06667°S, 76.5333°W, datum WGS84; elev. 295 m) Cajamarca Department, Peru, were borrowed from the herpetology collection

of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California: LACM 49352, 49355, 49358, 49359.

The body cavities were opened and the digestive tracts were removed. Contents were examined under a dissecting microscope. Found in the stomachs of LACM 49355 and 49359 were 5 and 21 mature nematodes, respectively. In the large intestine of LACM 49352 was one 3rd stage larva. These were each placed in a drop of glycerol on glass slide, cover-slipped and identified using a compound microscope as *Physaloptera retusa*. Prevalence (number infected lizards/total lizards examined × 100) was 75%. Mean intensity (mean number of worms/infected host ± SD) was 9.0 ± 10.6 SD, range: 1–21. Voucher helminths were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, USA as USNPC 102885.

Physaloptera retusa is widely distributed in lizards in the western hemisphere and is known from North and South America, the Caribbean and Mexico (Goldberg et al. 2007. Comp. Parasitol. 74:327–342). Species of *Physaloptera* utilize insects as intermediate hosts; lizards become infected by ingesting insects that contain infective larvae (Anderson 2000. Nematode Parasites of Vertebrates: Their Development and Transmission 2nd ed. CABI Publishing, Oxfordshire, UK. 650 pp.) *Gonatodes atricucullaris* represents a new host record for *Physaloptera retusa*.

We thank C. Thacker (LACM) for permission to examine specimens and O. Mac (Whittier College) for assistance with dissections.

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GYMNODACTYLUS GECKOIDES (Naked-toed Gecko). **ENDOPARASITES.** *Gymnodactylus geckoides* is known from northeastern Brazil to Central Brazil (Vanzolini 2004. An. Acad. Brasil. Cien. 76:663–698). Three subspecies are recognized (Vanzolini, *op. cit*.). Kossack (1910. Centralbl. Backteriol. Parasit. 56:114–120) found a digenean in a liver cyst of *G. geckoides*. Herein we add to the helminth list for this species.

Thirty-five *G. geckoides amarali* (mean SVL = 38.8 mm ± 9.7 SD, range = 22–49 mm) collected in Brazil, Tocantins State, Caseara (09.2111111°S, 49.8369444°W; WGS 84; elev. 210 m) in September–October 2005 by LJV and deposited in the Sam Noble Oklahoma Museum of Natural History, Norman, Oklahoma as OMNH 42362–42396 were examined for helminths.

The body cavity was opened and the digestive tract was removed and examined under a dissecting microscope. Stomachs had been previously removed and were not available for examination. Eight female nematodes were found in the large intestine of OMNH 42366. Prevalence (infected lizards/lizards examined × 100) was 3%. Nematodes were cleared in glycerol, studied under a compound microscope and identified as *Spauligodon oxkutzcabiensis*. They were deposited in the United States National Parasite Collection, Beltsville, Maryland, USA as USNPC 102694.

Spauligodon oxkutzcabiensis is known from lizards in Mexico, Central and South America. Records are listed in Goldberg and Bursey (2009. Herpetol. Rev. 40:224). To this list should be added: *Microlophis occipitalis* from Peru (Goldberg and Bursey 2009. Salamandra 45:125–128); *Phyllodactylus inaequalis, P. johnwrighti, P. microphyllus* from Peru (Goldberg and Bursey 2010. Comp. Parasitol. *in press*) and *P. unctus* from Mexico (Goldberg and Bursey 2010. Herpetol. Rev. 41:84–85). The life cycle of *S. oxkutzcabiensis* is not known, however, infection of the congener *S. giganteus* occurs by ingestion of eggs in fecal contaminated substrate (Goldberg and Bursey 1992. J. Parasitol. 78:539–541). *Spauligodon oxkutzcabiensis* in *G. geckoides* is a new host record. Brazil is a new locality record.

We thank Cecilia Nava (Whittier College) for assistance with dissections.

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HEMIDACTYLUS MABOUIA (Tropical House Gecko). **CANNIBALISM**. Intraspecific predation of juveniles by adult lizards has been reported in some species (Polis and Myers 1985. J. Herpetol. 19:99–107; Germano and Williams 1994. Herpetol. Rev. 25:26–27; Siqueira and Rocha 2008. S. Am. J. Herpetol. 3:82–87). Among 67 stomachs examined of *Hemidactylus mabouia* specimens, only a single adult stomach contained a conspecific juvenile (Zamprogno and Teixeira 1998. Herpetol. Rev. 29:41–42). Herein, we report the second observation of cannibalism in this gecko.

At ca. 0100 h on 4 January 2010, outside of a house in an urban area (22.9091667°S, 47.0477778° W, 680 m elev.), municipality of Campinas, State of São Paulo, southeastern Brazil, we observed an adult *H. mabouia* with the head of a conspecific juvenile inside its mouth (Fig. 1). The adult gecko had a SVL of ca. 120 mm and the smaller lizard was ca. 50 mm SVL. However, ingestion of the

FIG. 1. An adult *Hemidactylus mabouia* preying upon a conspecific juvenile in municipality of Campinas, State of São Paulo, Brazil.

juvenile was not successful by the adult gecko and the juvenile escaped. We do not know if the unsuccessful predation is result of photographer disturbance. JPP thanks CNPq for financial support.

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HOLBROOKIA APPROXIMANS (Speckled Earless Lizard). **PREDATION.** This phrynosomatid lizard has a wide distribution throughout the southwestern United States and much of the northwest central portion of Mexico (Conant and Collins 1998. A Field Guide to the Reptiles and Amphibian of Eastern and Central North American, 3rd ed. Houghton Mifflin, Boston, Massachusetts. 450 pp.; Stebbins 2003. A Field Guide to Western Reptiles and Amphibians, 3rd ed. Houghton Mifflin, New York. 533 pp.). Smith (1979. Handbook of Lizards. Comstock Publishing Associates, Cornell University Press, Ithaca, New York. 557 pp.) mentioned that a specimen of this species had been consumed by a large *Bufo alvarius* (=*Incilius alvaria*), and another by a "small hawk" but did not provide any specific species. The Burrowing Owl (*Athene cunicularia*) has a wide distribution throughout much of North and South America including the Caribbean (American Ornithologists Union 1983.Check-list of North American Birds, 6th ed. Allen Press, Inc. Lawrence, Kansas. 877 pp.; Wellicome and Holroyd 2001. J. Raptor Res. 35:269–273). This species has been the focus of extensive study in the last twenty years (McDonald et al. 2004. The Burrowing Owl (*Athene cunicularia*): A Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region. http://www.fs.fed.us./r2/projects/scp/assessments/burrowingowl.pdf). Reports of its food habits have been documented (Coulombe 1971. Condor 73:162–176; Grant 1965. Loon 37:2–17; Marti 1974. Condor 76:45–61; Valdez-Gómez 2003. Dieta del tecolote llanero occidental *Athene cunicularia* [Bonaparte 1825], durante su estancia invernal en el bajío mexicano. Las Agujas Zapopan, Universidad de Guadalajara. Licienciatura 41 pp.) but most predation records are for mammals, birds, and invertebrates, with a limited number of herpetofaunal species (Moulton et al. 2006. J. Wildl. Manag. 70:708–716). Here, we add *Holbrookia approximans* as prey to this owl's diet.

On 12 December 2002, during analysis of regurgitated owl pellets collected during a survey on the winter ecology of *A. cunicularia*, a skull (14.3 mm) of an adult *H. approximans* was discovered in one of 128 pellets examined from Llano de la Soledad (25.0958111°N, 100.8104056°W; datum WGS84, elev. 1850 m), in the municipality of Galeana, Nuevo Leon, Mexico. Native vegetation of the study area consists of open grassland bordered by an association of *Larrea tridentata, Flourensia cernua, Rhus microphylla*, *Prosopis* sp., and *Acacia* sp. The study area has been modified by extensive potato culture.

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IGUANA IGUANA (Green Iguana). **PREDATION.** Both juvenile and adult Green Iguanas are preyed on by a wide variety of avian, mammalian, and reptilian predators (Greene et al. 1978. J. Herpetol. 12:169–176; Rivas et al. 1998. Herpetol. Rev. 29:238–239). In general, juvenile Green Iguanas suffer higher mortality from birds while larger size classes are taken more frequently by reptilian and mammalian predators (Rivas et al. 1998, *op. cit*). Here we report a nocturnal predation event on a subadult *Iguana iguana* by an avian predator at the Iguana Verde Foundation (IVF) located in the Gandoca-Manzanillo Wildlife Refuge (09.63818°N, 82.70496°W; datum WGS84), Limón, Costa Rica. The IVF is an education and conservation breeding facility with several natural iguana open-air exclosures (up to 2000 m^2) of mixed male and female age classes.

At 1830 h on 28 May 2009, we observed an adult Spectacled Owl, *Pulsatrix perspicillata,* flying overhead with a subadult (ca. 20 cm SVL) *I. iguana* in its talons. Nocturnal predation events are observed rarely and to our knowledge this is the first account of predation on *I. iguana* by any avian species in the family Strigidae and augments our knowledge of nocturnal predators of Green Iguanas.

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JAPALURA SWINHONIS (Swinhoe's Tree Lizard). **SPINAL DEFORMITY**. Scoliosis and kyphoscoliosis have been recorded in lizards, snakes, and a few chelonians and crocodilians, and may appear at birth or hatching, or after some period of apparent normal skeletal growth and development (Frye 1991. Biomedical and Surgical Aspects of Captive Reptile Husbandry. Krieger Publ. Co., Malabar, Florida. 637 pp.). As for the latter, the etiologies may be due to an expression of sub-lethal genetic defects, or may be caused by some acquired environmental condition such as thermal or physical trauma, metabolic bone diseases, or osteomyelitis (Frye, *op. cit*.).

At ca. 1000 h on June 4 2008, JHW observed two male *Japalura swinhonis* engaged in a territorial dispute next to a paved road in Yunlin County, Taiwan (23.6092ºN, 120.5784ºE; TWD97, elev. 178 m). After capturing one of them as part of a study of internal parasites, we noted that it had a deformed spine and base of tail (Fig. 1). The lizard had a SVL, tail length, and mass of 66 mm,

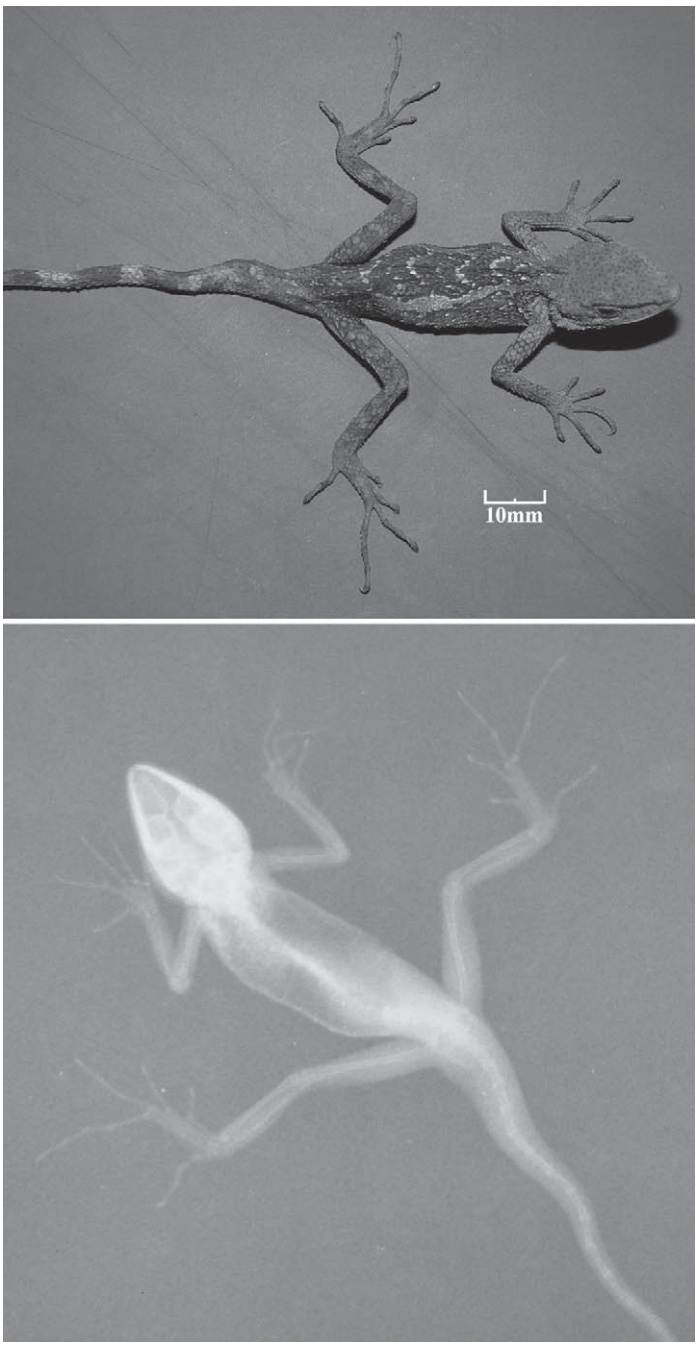

FIG. 1. The dorsal view (top), and radiograph (bottom) of the Swinhoe's Tree Lizard (*Japalura swinhonis*), illustrating the deformed spine.

159 mm, and 6.9 g, respectively. A radiograph was taken, but we observed no fractures or other abnormalities (Fig. 1). The common symptoms of osteodystrophy—fractured limbs or hindlimb paresis, swollen limbs and digits, swollen mandibles, dull coloration, anorexia and lethargy, and/or hypocalcaemic tetany and seizures (O'Malley 2007. Irish Vet. J. 60:303–309)—were not observed, and the lizard appeared healthy. After flushing its stomach for internal parasites, the animal was maintained in captivity for a month, and was then released back into the wild at the same location where it was collected. During the period of captivity, the condition of the lizard did not visibly deteriorate or improve, and since the animal was free-living, we believe that this condition is due to a sub-lethal genetic defect. To our knowledge, this appears to be the first reported instance of such a condition in *J. swinhonis* in the wild.

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KENTROPYX VANZOI (NCN). **ENDOPARASITES.** The poorly known teiid *Kentropyx vanzoi* is a medium-sized lizard that inhabits open habitats along river systems in central Brazil (Gallagher and Dixon 1980. Copeia 1980:616–620). To the best of our knowledge no reports on endoparasites have been published for this species. Herein, we provide information on helminth parasites of *K. vanzoi* from two localities of Mato Grosso state, Central Brazil.

Three *K. vanzoi* specimens were examined for endoparasites from the Coleção Zoológica de Vertebrados da Universidade Federal de Mato Grosso. The lizards were collected from two localities dominated by Cerrado (savanna-like vegetation) in the Mato Grosso state in the municipality of São José do Rio Claro (13.8122°S, 56.6900°W; datum: SAD69); and in the municipality of Primavera do Leste (15.2267°S, 54.0469°W; datum SAD69). The specimen (UFMT 398) from São José do Rio Claro was an adult female collected from a pit-fall trap on 27 May 2001. The specimens (UFMT 1757, 1758) from Primavera do Leste were an adult female and an adult male, respectively, also collected from pitfall traps between 10–14 July 2008. We opened and separately examined the specimens for helminths in the body cavity, esophagus, stomach, lungs, and small and large intestines under a stereomicroscope. Helminths were cleared in phenol, identified, and deposited in the Coleção Helmintológica do Instituto de Biociências da Unesp de Botucatu. The nematode *Physalopteroides venancioi* was found in the body cavity of the female specimen from São José do Rio Claro. Larvae of the cestode *Oochoristica* sp. were recovered from the body cavity and two females of the nematode *Parapharyngodon senisfaciecaudus* were recovered from the large intestine of the female specimen from Primavera do Leste. The male specimen from Primavera do Leste was uninfected.

Reports on endoparasites from *Kentropyx* species in Brazil are scarce and restricted to *K. calcarata*, and include *Kentropyxia sauria* (Baker 1982. Proc. Helminthol. Soc. Washington 49:252–257; Goldberg et al. 2007. Comp. Parasitol. 74:327–342), *Oswaldocruzia* sp. (Ávila and Silva 2009. J. Helminthol. 83:267–269), *Piratuba shawi* (Vicente et al. 1993. Rev. Bras. Zool. 10:19–168), *P. digiticauda* (Ávila and Silva, *op. cit.*), *Physalopteroides venancioi* (Ávila and Silva, *op. cit.*), and *Physaloptera retusa* (Ávila and Silva, *op. cit.*; Goldberg et al., *op. cit.*). Thus, *K. vanzoi* represents a new host record for *Oochoristica* sp., *P. senisfaciecaudus,* and *P. venancioi*. To the best of our knowledge, Brazil represents a new country record for *P. senisfaciecaudus* and Mato Grosso state represents a new locality record for *Parapharyngodon senisfaciecaudus*.

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LEIOSAURUS CATAMARCENSIS (NCN). **CLUTCH SIZE**. *Leiosaurus catamarcensis* is an inhabitant of the Monte phytogeographical province (Cei. 1993. Mus. Reg. Sci. Nat. Torino Monogr. 14:1–949). The biology of this species is poorly known. Blanco and Acosta (2003. Herpetol. Rev. 34:145) reported on clutch size for one female of this species, observing 10 eggs. Villavicencio et al. (2006. Actas de Congreso Argentino de Herpetología, Corrientes. 15 pp.), established the thermal parameters for this species. In this note we report the clutch size for one lizard under laboratory conditions in order to contribute to the limited knowledge of this species' reproductive biology.

During December 2008, a basking female *L. catamarcensis* (84 mm SVL, 21 g) was hand-captured in the field at 0930 h, in San Juan Province, Calingasta Department, on Nacional Route Nº 149 (31.14°S, 69.01°W; datum WGS 84, elev. 2500 m).

Six days after capture on 11 December 2008, this lizard laid a clutch of seven eggs in the laboratory (25ºC and 30% relative humidity). Total egg mass was 6 g, 28.5% of the female mass. Mean egg length was 17.67 ± 0.53 mm and mean egg width was 10.97 ± 0.45 mm. Mean egg volume was estimated (114.5 ± 7.07 mm^3), using the equation [V= 4/3π (L/2) $(W/2)^2$] for an elliptical sphere (Dunham 1983. *In* Huey et al. [eds.], Lizard Ecology, pp. 261–280. Harvard University Press, Cambridge, Massachusetts). To our knowledge, this is the second report of clutch size for this species.

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PHRYNOSOMA BRACONNIERI (Short-tailed Horned Lizard). **DEFENSIVE BLOOD-SQUIRTING BEHAVIOR.** On 6 June 2007, one of us (CR) picked up an adult *Phrynosoma braconnieri* (sex unknown) at 1400 h in hills 8.0 km NW of Cacaloapan, Municipio de Tepanco de López, Puebla, México. The lizard was carried by hand up the trail a short way until it was realized that it had ejected blood from its right eye. Blood on the lizard's eyelids, face, and lower jaw was photographed. It may have been the result of a single or a few squirts. There were no canids in the field with the collector. Six other encounters (CR) involving hand collection of the same species failed to elicit blood-squirting behavior: (N = 1) 5.3 k further west of Cacaloapan (later the same day; 1600 h); (N = 1) at (San Juan Bautista) Cuicatlan, Oaxaca, México (17 June 2006); and (N = 4) at Rancho Tejas (near Ixtlan de Juarez), Oaxaca, México (27 September 2009). All animals were of subadult to adult size (sexes 0.2.2). Similar encounters with *P. braconnieri* (N = 5) in Puebla, México, in 2003 all failed to elicit blood-squirting during hand-capture by humans (Sherbrooke and Mendoza-Quijano 2005. Herpetol. Rev. 36:65–66). Combining our similar encounters (human capture-by-hand), 8% (1 of 12) of the lizards squirted blood.

In the first recognition of the possibility of differences in the occurrence of anti-predator blood-squirting responses between living species of horned lizards (*Phrynosoma* spp.) Sherbrooke and Middendorf (2001. Copeia 2001:1114–1122) predicted, based on purported phylogenetic relationships, that *P. braconnieri* would be determined to be a species utilizing a blood-squirting defense. That prediction was based solely on *P. braconnieri* being a sister taxon of *P. taurus*, a species previously reported to be capable of blood-squirting (Ruthling 1919. Copeia [72]:67–68). Subsequently, following reevaluation of the occurrence of blood-squirting in *P. taurus* that involved both field collection by humans and canid (dog-bioassay) trials, the earlier report (Ruthling 1919, *op. cit.*) of blood-squirting by *P. taurus* was questioned (Sherbrooke et al. 2004. Herpetol. Rev. 35:345–347). With that apparent reversal of designation of *P. taurus* (from a blood-squirting to an apparent non-blood-squirting species) it was suggested that *P. braconnieri* might also have lost its defensive blood-squirting. This attribute appears to be plesiomorphic in the genus (Sherbrooke and Middendorf 2001, *op. cit.*; Leaché and McGuire 2006. Mol. Phylogen. Evol. 39:628–644). The conclusion that *P. braconnieri* may have lost its blood-squirting defense was further supported by negative results during limited dog-bioassay trials (Sherbrooke and Mendoza-Quijano 2005. Herpetol. Rev. 36:66–67). It had also been noted that the earlier prediction that *P. braconnieri* might be a blood-squirting species (Sherbrooke and Middendorf 2001, *op. cit.*), based on its sister-taxon relationship with *P. taurus*, was premature. In addition, Hodges (2004. Southwest. Nat. 49:267–270) reported no blood squirting in response to human hand-capture of *P. braconnieri* (N = 6) and *P. taurus* (N = 20). The negative results, from field encounters by humans and from dog-bioassay trials, and the apparent reversal in status of *P. taurus* did not fully resolve the blood-squirting status of *P. braconnieri*. Confounding factors such as the occurrence of eyelid puffiness during dog trials (a precondition to blood ejection; Middendorf and Sherbrooke 1992. Copeia 1992:519–527) and the inherent difficulty in establishing negative conclusions from negative results remained.

Shortly thereafter a field report of an apparent single squirt of blood during human hand-capture of a *P. taurus* (Garcia-Vazquez and Canseco-Marquez 2006. Herpetol. Rev. 37:347) brought into question the earlier suggestion that *P. taurus*, and, by implication, possibly *P. braconnieri* were non-blood-squirting species (Sherbrooke et al. 2004, *op. cit.*). In a similar apparent "reversal" in evaluation of blood-squirting status for a species (see discussion below), we here report the first evidence of a blood-squirting response (to human handling) by *P. braconnieri,* the other member of its sister-taxon pair *braconnieri-taurus*.

This report leaves unresolved questions surrounding the natural conditions under which a horned lizard's defense of squirting blood from ocular blood-sinuses may be employed by *P. braconnieri*, with canids or other predators (Middendorf and Sherbrooke 1992, *op. cit.*; Sherbrooke and Mason 2005. Southwest. Nat. 50:216–222; Sherbrooke and Middendorf 2004. Copeia 2004:652–658). In addition, our report, with that of Garcia-Vazquez and Canseco-Marquez (2006, *op. cit.*) for *P. taurus*, suggests the need for cau-

tious revisions to interpretations of the phylogenetic history of blood-squirting presented by Sherbrooke and Middendorf (2001, *op. cit.*) and by Leaché and McGuire (2006, *op. cit.*). The *braconnieri-taurus* lineage can probably no longer be considered as one in which blood-squirting has been "lost," certainly not completely. Can such decisions regarding evolutionary trends/changes in a species be based on a one-time observation of a single individual? The frequency of occurrence, effectiveness, and taxonomic range (of target predators) (natural: coyotes, foxes, etc.; unnatural: humans) of horned lizards utilizing this defense remain largely unknown (but see Middendorf and Sherbrooke 1992, *op. cit.*; Sherbrooke and Middendorf 2001, 2004, *op. cit.*). And, in both cases, the "reversals" in blood-squirting status of *P. braconnieri* and *P. taurus* are based on single observations with humans. Under stress of capture by a human other lizards may rarely exhibit ocular bleeding (*Sceloporus jarrovii* and *Urosaurus ornatus*, Sherbrooke 2000. Herpetol. Rev. 31:243; *Sceloporus occidentalis* Klauber 1939. Bull. Zool. Soc. San Diego 14:80–100, and J. Shedd, pers. comm.).

Without the presentation of a proper stimulus or stimuli, and other possibly unknown conditions, we should not expect to elicit a defensive blood-squirting response from a horned lizard even if it is capable of the response. One species, *P. ditmarsi,* was evaluated in two series of dog-bioassay trials before it was shown to squirt ocular-sinus blood (Sherbrooke and Middendorf 2001, *op. cit.*; Hodges 2004, *op. cit.*).

The history of evaluations of *P. braconnieri* and *P. taurus* as blood-squirting or non-blood-squirting serves as a cautionary tale for those trying to come to conclusions regarding the occurrence, presence or absence, of blood-squirting in species of horned lizards. Note should be made that the "nonblood-squirting" designation used by Sherbrooke and Middendorf (2001, *op. cit.*) called attention to the low frequency of blood squirting (relative to *P. cornutum*, *P. hernandesi*, and *P. solare*) within the clade *mcallii-modestum-platyrhinos* of horned lizards, not to its complete absence (two of the three species within this clade were reported to have squirted blood on rare occasions). Without knowing more about the frequency of occurrence of blood squirting within and between geographic populations of a species and under a broader array of potential predator-prey encounters, it remains difficult to conclude that a species has lost blood squirting as a defense, even if it has never been recorded. Conclusions based solely on an absence or reduced frequency of blood-squirting during limited field encounters with humans (probably not representative of evolutionarily determined predator-threat stimuli) and on dog-canid trials (as in the cases of *mcallii-modestum-platyrhinos* and *braconnieri-taurus*) may be suggestive of evolutionary trends but may also lead to confusion. This could be due to their limited scope and subtleties in the nature of the evolved role(s) of blood-squirting in horned lizard species. Lower frequencies of occurrence in some species may be influenced by lack of appropriate elicitation stimuli (type of predator), the physiological condition of lizards, or factors such as individual, population or species dietary history (types and predominance of ants; a potential source of anti-predator chemical compounds [Sherbrooke and Middendorf 2004, *op. cit.*; Sherbrooke and B. A. Kimball, unpubl. data]).

Thus, we are left with questions; are species of horned lizards in which blood squirting remains unreported (*P. douglassi* and *P. mcallii*; also *P. coronatum, P. cerroense, P. wigginsi*, *sensu* Montanucci 2004. Herpetologica 60:117–139, and Leaché et al. 2009. PNAS 106:12418–12423) or has been reported at low frequencies to humans and canids (*P. braconnieri, P. goodei*, *P. modestum*, *P. platyrhinos, P. taurus*) "non-blood squirting" species? Are these species in some stage of losing the defense, or is their apparent "non-blood squirting" designation the result of our own restricted insights into its frequency and distribution of occurrence under varied conditions in nature? We hope that awareness of these issues can help us formulate and test hypotheses that may lead to a better understanding of this fascinating defense.

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PHRYNOSOMA HERNANDESI (Greater Short-horned Lizard). **PREDATION**. Although arthropods are well known predators of vertebrates (review in McCormick and Polis 1982. Biol. Rev. 57:29–58), the impact of arthropod predation on lizards has received little attention (Vitt 2000. Herpetol. Monogr. 14:388–400). Among arthropods, spiders are often reported to prey on vertebrates, especially anurans (review in Toledo 2005. Herpetol. Rev. 36:395–400), although they infrequently include lizards (Cokendolpher 1977. J. Arachnol. 5[2]:184; Corey 1988. J. Arachnol. 16[3]:391–392). Blondheim and Werner (1989. Brit. Herpetol. Soc. Bull. London 30:26–27) reported the lacertid lizard, *Mesalina guttulata*, predated by the widow spiders (*Latrodectus pallidus* and *L. revivensis;* Theridiidae), Schwammer and Baurecht (1988. Herpetozoa, Wien 1[1/2]:73–76) reported the lacertid, *Podarcis melisellensis*, as prey of the widow spider (*L. mactans*), and Hodar and Sanchez-Piñero (2002. J. Zool. Lond. 257:101–109) reported the lacertids, *Acanthodactylus erythrurus*, *Psammodromus hispanicus*, and *P. algirus,* and the gekkonid, *Tarentola mauritanica* as prey of the widow spider, *L. lilianae*. Large arthropods incapable of capturing adult lizards are likely significant predators of neonatal lizards, especially those < 50 mm SVL (Vitt 2000, *op cit*.).

On 21 July 2009 one of us (LKK) discovered a subadult female Western Black Widow Spider (*Latrodectus hesperus*; ca. 9 mm body length) that had completely ensnared a neonate *Phyrnosoma hernandesi* (SVL 21 mm; TL 9 mm) that was caught in a large funnel trap set for terrestrial snakes in grassland habitat. The observation occurred in New Mexico, Bernalillo County, Albuquerque, Kirtland Air Force Base, USA. The *P. hernandesi* was dead and was being attended by the Black Widow as if feeding on the lizard. Both were collected and are deposited in the Museum of Southwestern Biology Division of Arthropods (*L. hesperus* MSBA 23492) and Division of Herpetology (*P. hernandesi* MSB 76339). To our knowledge this is the first report of *P. hernandesi* being preyed upon by the Western Black Widow Spider.

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PHRYNOSOMA MODESTUM (Round-tailed Horned Lizard). **BLOOD-SQUIRTING**. *Phrynosoma modestum* was heretofore thought to be a member of a "non-blood-squirting" clade including *P. mcallii* and *P. platyrhinos* (Sherbrooke and Middendorf III. 2001. Copeia 2001:1114–1122). Here we report blood-squirting by *P. modestum*.

At 1530 h on 14 August 2009 we collected an adult male (50 mm SVL, 6.4 g) Round-tailed Horned Lizard (*Phrynosoma modestum*) ca. 7 km SE of Fowler in Otero County, southeastern Colorado, USA. When first captured, the specimen squirmed and ultimately wriggled out of DW's hand. The animal darted several meters while evading capture, and was subsequently pinned to the ground with more pressure than normal to prevent a second escape. At this time the specimen squirted a small amount of blood (ca. 0.025 ml) from an ocular sinus of the right eye. Blood was also visible surrounding the right eye, which was still swollen and engorged a few moments following the blood-squirting event when photos were taken (Fig. 1A). While photographing this individual at close range (<1 m) following its release, DM noted rapid swelling and subsequent rapid dissipation of swelling of the upper and lower lids around the left eye (Fig. 1B–1D). It is presumed that the lizard was preparing to squirt blood again, this time from the other eye, but found it unnecessary.

Blood-squirting is thought to be primarily a defense against predation attempts by canids (Middendorf and Sherbrooke 1992. Copeia 1992:519–527); potential canid predators in the area include Coyotes (*Canis latrans*), Domestic Dog (*C. lupus familiaris*), and Swift Fox (*Vulpes velox*), but can also be elicited by human contact (Hodges 2004. Southwest. Nat. 49:267–270). To our knowledge this is the first substantiated incidence of *P. modestum* squirting blood (confirmed by W. Sherbrooke, pers. comm.). Field work was conducted under Colorado Division of Wildlife scientific collection license 09HP927 and with permission of the landowner.

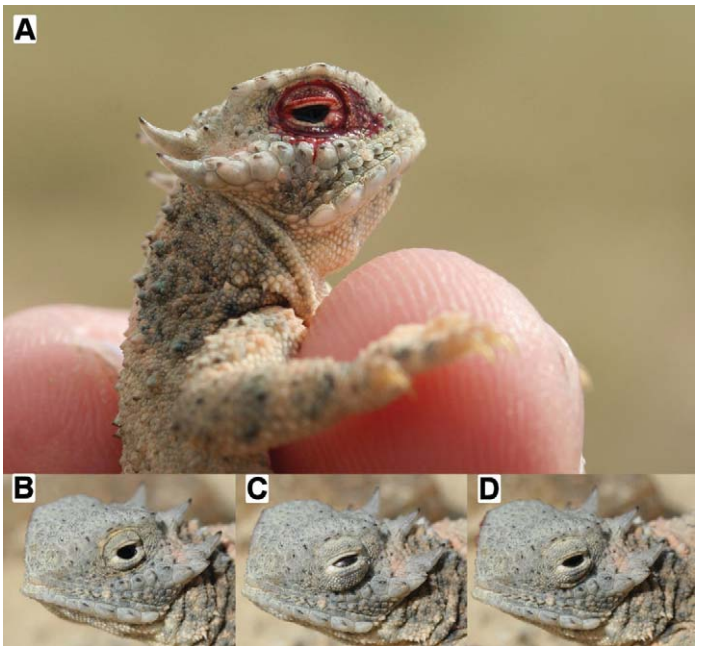

FIG. 1. A) Adult male *Phrynosoma modestum* after squirting blood from the ocular sinus of the right eye. B–D) The same individual after release at 15:43 h, apparently preparing to squirt blood from the left eye, demonstrating the lizards eye before swelling (B, 15:44:55 h), during swelling (C, 15:45:07 h), and after dissipation of swelling (D, 15:45:10 h). Photographed in the field in Otero County, Colorado, 14 August 2009.

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PLESTIODON FASCIATUS (Five-lined Skink). **PREDATION**. Few reports document spider predation on small squamates, and most involve larger spiders, i.e. wolf spiders or orb weavers. Cokendolpher (1977. J. Arachnol. 5:184) observed an orb weaver (*Argiope aurantia*) eating a Broad-headed Skink (*Plestiodon laticeps*); Corey (1988. J. Arachnol. 16:392–393) observed a wolf spider (*Lycosa ammophila*) feeding on a Green Anole (*Anolis carolinensis*); and Hampton et al. (2004. Herpetol. Rev. 35:269–270) observed a wolf spider (*Hogna carolinensis*) feeding on a Ground Skink (*Scincella lateralis*). To our knowledge, no prior records exist of predation of lizards by cobweb spiders (Family Theridiidae), a family of spiders with relatively small body sizes (cephalothorax length range: 1–8 mm; Craig 1987. Am. Nat. 129:47–68). Here we provide an observation of predation by an American House Spider, *Achaearanea tepidariorum,* on a juvenile *Plestiodon fasciatus*.

At ca. 1000 h on 11 August 2006, we observed an *A. tepidariorum* with its fangs deployed in a juvenile (36.0 mm SVL) *P. fasciatus* inside a building at the Tennessee Aquarium Conservation Institute at Cohutta Springs, ca. 1.2 km S of Red Clay, Georgia (34.9739°N, 84.9503°W; datum: WGS84, elev. 259 m). The skink was near death and struggling listlessly. After photographing the scene, we preserved both the spider and the skink. The skink had lost a portion of its tail. As the spider appeared to be actively feeding on the skink at the time of capture, we discount the possibility that the spider was merely investigating a disturbance in its web.

Specimens are deposited in the California Academy of Sciences collections (*Plestiodon*, CAS 235426; *Achaearanea,* CASENT 9024310). We thank J. Miller and J. Vindum for confirming identifications and accessioning the specimens.

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PODARCIS MURALIS (Common Wall Lizard). **CONTROL.** *Podarcis muralis* is a medium-sized European lizard that has been introduced into at least three states/provinces (Ohio, Kentucky, and British Columbia; Burke and Deichsel 2008. *In* Jung and Mitchell [eds.], Urban Herpetology, pp. 347–353. Herpetol. Conserv., Vol. 3, SSAR). Walker and Deichsel (2005. Herpetol. Rev. 36:202) report

the discovery of this exotic species at The Falls of the Ohio State Park, Indiana. Werner Mayer (Museum of Natural History, Vienna, Austria) determined the subspecies as *Podarcis muralis maculiventris*, western clade based on mtDNA sequences. This form is identical to that of specimens observed within Cincinnati, Ohio for over 50 years now. Here we report on measures of controlling this alien species in Indiana and its impact on a native one.

Concerns regarding the presence of *Podarcis muralis* in Indiana resulted in the Indiana Department of Natural Resources (IDNR) enacting an executive order to control this species. The executive order was designed to address two concerns regarding the presence of this species. The first concern was that *Podarcis muralis* might displace native Five-lined Skinks (*Plestiodon fasciatus*) where both species are sympatric. The second concern was to act quickly before the lizards became established and spread to adjacent habitats. The control program was first conducted from 7 July to 15 August 2005 by Nick Burgmeier, and subsequently by two contractors in 2006 and 2007. A total of ca. 30 *P. muralis* were removed from the park and euthanized, most of which were discarded. Two specimens were deposited at the Purdue University Biology collection in West Lafayette, Indiana (25.021, 25.022). One specimen from the Falls of the Ohio State Park is in the Field Museum collection (FM 265504).

The control program was accompanied by visual surveys inside and outside the State Park. As sightings of *Podarcis* decreased, there were increased observations of *P. fasciatus*. However, there were fewer *Podarcis* observed and subsequently captured than predicted. This might be attributed to the flooding of the Falls of the Ohio State Park during the winter of 2004–2005. During this time, the riprap below the interpretative center's observation deck (the focus of *Podarcis* occurrence) was submerged. This flood event possibly drowned many of the *Podarcis* hibernating there. Additionally, local predators might have helped to reduce the *Podarcis* population. Feral Cats (*Felis silvestris catus*) and Mockingbirds (*Mimus polyglottos*) were seen preying upon *Podarcis* within the state park.

After control programs were concluded, GD inspected the area from 11–13 October 2007. Surveys were performed under excellent weather conditions but no *Podarcis* were observed. However, two *P. fasciatus* were seen during this same time period. In the summer of 2008, park personnel and visitors reported additional sightings of juvenile and adult *P. muralis* as well as several *P. fasciatus* (Sarabeth Klueh, pers. comm.). During 2009, park personnel reported only sightings of *P. fasciatus*, but no sightings of *Podarcis* as of 18 September (Bett Etenohan, pers. comm.)

We conclude that the return of *P. fasciatus* after *Podarcis* removal is a good indication that the exotic species likely has had a negative impact on natives. However, the quick recovery of the *Podarcis* population during 2008 might indicate that there is a flow of lizards into the park from illegal release and/or from rafting on driftwood originating from places upriver from Clarksville and as far as Cincinnati. We suggest that the population dynamics of both species be further observed. We would further recommend that land managers take appropriate measures to control the introduced species as necessary.

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SCELOPORUS SPINOSUS SPINOSUS (Spiny Lizard). **BROOD**. *Sceloporus spinosus* is distributed along the central plateau of Mexico. Three subspecies are recognized: *spinosus* is the most widely distributed, while two others—*apicalis* and *caeruleopunctatus*—are endemic to the state of Oaxaca (Bell et al. 2003. Acta Zool. Mex. [n.s.] 90:103–174; Sites et al. 1992. Bull. Am. Mus. of Natl. Hist. 213:1–110; Smith 1939. Zool. Ser. Field Mus. Nat. Hist. 26:59–172; Smith and Taylor 1950. U.S. Natl. Mus. Bull. 199:1–253). Here we report record egg size and dimensions for the species and incubating time under laboratory conditions.

Mean size of sexually mature females varies among populations (69–106 mm SVL), courtship occurs in early spring, and eggs are laid mainly during middle or late summer (Calderón-Espinosa et al. 2006. Herpetol. Monogr. 20:47–158). Females of some populations lay a single clutch per season while females in other populations may lay more than one (Castro-Franco 2002. M.Sc. dissertation, Facultad de Ciencias, Universidad Nacional Autónoma de México; Valdéz-Gonzáles and Ramírez-Bautista 2002. J. Herpetol. 36:36–43). Oviposition is asynchronous within populations as females at all stages of gravidity are found at any one time during the reproductive season (Calderón-Espinosa. et al. 2006, *op. cit*).

On 23 June 2007, a gravid female *S. spinosus spinosus* was obtained from Los Reyes La Paz, Estado de Mexico, Mexico, (19.3543°N, 98.9403°W, 2633 m elev.), and brought into the laboratory and assigned collection number 4401-E. The lizard weighed 50.55 g before oviposition, and was maintained in a plastic box measuring 32 × 20 × 14 cm, with newspaper as substrate, fresh water in a dish, and ambient temperature at 26–28ºC.

On the morning of 4 July 2007, the female laid a clutch of 13 eggs (female weighed 35.74 g post-oviposition), which were placed in plastic boxes with agrolite substrate. An incubator was used to provide a 28–30ºC thermal gradient and relative humidity fluctuated between 50–70%. Mean measurements of the eggs were as follows: length 16.2 ± 01.5 mm and width 10.8 ± 00.7 mm, mean mass 1.13 ± 0.12 g.

Four hatchlings emerged on 28 August 2008 and the remaining nine the next day. The mean incubation time was 55.5 ± 0.5 days at 28–30ºC. Mean measurements were as follows: 27.6 ± 01.7 mm SVL, 34.1 ± 01.2 mm tail length and the neonates weighed 0.86 ± 0.03 g. Hernández-Ibarra et al. (2001. XVI Congreso de Zoología, Memorias, Zacatecas, p. 43) reported that this species lays clutches ranging from 10 to 30 eggs, and Valdez-González (1998. Graduate dissertation, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México) reported clutch numbers of 15.3 ± 1.2 eggs; mean measurements of the eggs were as follows: length 15.1± 0.65 mm and width 8.8 ± 0.3 mm, with mean weight of 1.69 ± 0.808 g.

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TRACHYLEPIS PLANIFRONS (Tree Skink). **REPRODUCTION.** *Trachylepis planifrons* is known from Kenya, Tanzania, Somalia, eastern Ethiopia, northern Zambia, and southeastern Democratic Republic of Congo (Spawls et al. 2002. A Field Guide to the Reptiles of East Africa, Kenya, Tanzania, Uganda, Rwanda and Burundi. Academic Press, San Diego, California. 543 pp.). Other than a report that *T. planifrons* is oviparous (Spawls et al., *op. cit.*), I know of no information on the reproduction of this species. The purpose of this note is to report information on the reproduction of Kenya *T. planifrons* from a histological examination of gonadal material.

A sample of 11 *T. planifrons* consisting of four adult males (mean SVL = 87.0 mm ± 14.0 SD; range: 70–90 mm) and seven adult females (mean SVL = 98.4 mm ± 5.4 SD; range: 90–104 mm) collected 1971 or 1973 were examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California (by Kenya District): Lamu: LACM 93191–93196; Samburu: 65770–65772, 65899, 65902. The left testis was removed from males and the left ovary was removed from females for histological examination. Tissues were embedded in paraffin and cut into sections at 5 μm. Slides were stained with Harris hematoxylin followed by eosin counterstain. Slides of testes were examined to determine the stage of the spermatogenic cycle. Slides of ovaries were examined for the presence of yolk deposition. Histology slides are deposited in LACM.

The only stage noted in the testicular cycle was spermiogenesis (= sperm formation) in which the seminiferous tubules are lined by clusters of sperm or metamorphosing spermatids. Spermiogenesis was noted in one male from February and three from June. The smallest reproductively active male (spermiogenesis in progress) measured 70 mm SVL (LACM 65772) and was from June. Ovaries were classified (sample size in parentheses) as to their reproductive state: quiescent (no yolk deposition): February (1); early yolk deposition (yolk granules in the cytoplasm): February (2), June-July (1); oviductal eggs: February (2), 8 and 9 oviductal eggs, respectively; corpora lutea: June-July (1). Eight and nine eggs are the first clutch sizes reported for *T. planifrons*. The smallest reproductively active female (corpora lutea present) measured 90 mm SVL (LACM 65902) and was from June–July. The presence of reproductive activity in February and June-July suggests *T. planifrons* exhibits a prolonged period of reproduction.

I thank Christine Thacker (LACM) for permission to examine specimens.

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TRACHYLEPIS SULCATA (Western Rock Skink). **REPRODUCTION.** *Trachylepis sulcata* is viviparous and occurs from karroid areas of the Cape and adjacent Free State of the Republic of South Africa through Namibia to southern Angola (Branch 1998. Field Guide to Snakes and Other Reptiles of Southern Africa. Ralph Curtis Books, Sanibel Island, Florida. 399 pp.). Information on its reproduction in the Republic of South Africa was summarized by Bates (1995. Afr. Herp News 24:23–25). The purpose of this note is to compare information on *T. sulcata* reproduction from the Republic of South Africa with data from Namibia taken from a histological examination of museum specimens.

A sample of eight females from Namibia collected in 1972, 1976, 1977 (mean SVL = 64.3 mm ± 8.4 SD, range: 57–83 mm) was examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California USA. Specimens examined by the Namibia region are: Erongo LACM 127496, 127497; Karas LACM 77017; Khomas LACM 77432, 77433, 77435, 77437, 77439. For histological examination the left ovary was removed from females to check for vitellogenesis (yolk deposition). Counts were made of oviductal eggs/embryos or enlarged ovarian follicles (> 5 mm length). Tissues were embedded in paraffin, sections cut at 5 μm, and stained with Harris hematoxylin followed by eosin counterstain. Histology slides are deposited in LACM.

One October female (LACM 77437) contained corpora lutea from a previous litter and concomitant yolk deposition for a subsequent litter verifying *M. sulcata* may produce multiple litters in the same reproductive season as stated by Bates (*op. cit*) and Branch (*op. cit.*). Mean litter size for four females was 3.5 ± 2.4 SD, range: 2–7. Seven embryos is a new maximum litter size for *T. sulcata* and was recorded from LACM 127497, collected in May. It is not known when these embryos would have completed development. Another October female of the same size (LACM 77433) had quiescent ovaries (no yolk deposition). It was not possible to count litter sizes for two females from October with enlarged follicles that had been shot (LACM 77017, 77439). The smallest reproductively active female from Namibia (enlarged follicles > 5 mm) measured 57 mm (LACM 77439) and was from October. In contrast, Bates (1995, *op. cit.*) reported the smallest reproductively active female *T. sulcata* from the Free State Province of South Africa to measure 63 mm SVL and that parturition occurred from November to March. The presence of two October females from Namibia reported herein, one with two full-term embryos (LACM 77432) and one with corpora lutea (LACM 77437) from a previous litter October suggests there may be geographic variation in the ovarian cycle of *T. sulcata*.

I thank Christine Thacker (LACM) for permission to examine *T. sulcata*.

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TROPIDURUS ITAMBERE (Rock Lizard). **HAEMOPARASITES.** *Plasmodium* (*Sauramoeba*) *tropiduri* (Apicomplexa: Plasmodiidae) is a malaria parasite that can infect lizards of the genus *Tropidurus*. This parasite was described by Aragão and Neiva (1909. Mem. Inst. Oswaldo Cruz 1:44–50) in individuals of *T. torquatus* from Minas Gerais state, southeastern Brazil. Carini (1941. Arq. Biol. São Paulo 235:46–47) subsequently reported it in *T. torquatus* from Goiás state, central Brazil. Later, its presence was reported in *Tropidurus* species from other Brazilian states (Pessoa and Souza Lopes 1963. Inst. Med. Trop. São Paulo 5:133–139; Rocha-Silva and Rodrigues 1974. Rev. Saúde. Publ. São Paulo 8:163–170) and from Venezuela (Scorza 1971. J. Protozool. 18:403–410). During our literature review, we could not find any reports of *P. tropiduri* infecting *Tropidurus* lizards after the 1970s. Considering that the taxonomy of this genus was later

revised (Rodrigues 1987. Arq. Zool. São Paulo 31:105–230; Frost et al 2001. Mol. Phylogenet. Evol. 21:352–371) and consequently new species were described, one of which was *Tropidurus itambere*, new studies regarding the presence of this haemoparasite in the *Tropidurus* genus are important.

Herein, we provide the first report of *Plasmodium* (*Sauramoeba*) *tropiduri* in the blood of the lizard *Tropidurus itambere*. It is a medium-sized lizard (mean adult SVL = 71.8 mm) (Rodrigues 1987, *op. cit.*) belonging to the *torquatus* group (Frost et al. 2001, *op. cit.*). It commonly occurs in open, and sometimes rocky, areas in central and southeastern Brazil (Rodrigues 1987, *op. cit.*).

This study was accomplished with 12 adult individuals of *T. itambere* (eight males and four females) collected in a rocky outcrop area located at Ibitipoca State Park (21.696667°S, 43.889167°W; elev. 1200 m), Minas Gerais state, southeastern Brazil, between February and May 2007. We made sanguine smears of collected circulating blood from the abdominal vein of the lizards. The parasitemia was calculated through the number of parasites found in 100 homogeneous microscopic fields of each sanguine smear (parasite density), and the value found was multiplied by 100 and divided by 10.000 (×*100/10.000).

We identified the parasite *P. tropiduri*, with a low parasitemia (mean = 0.16%), in three lizards (two females and one male) of the 12 examined. The low parasitemia of this lizard species was also reported by other authors (Carini 1941, *op. cit.*; Laison and Shaw 1969. Parasitology 59:163–170; Rocha-Silva and Rodrigues 1974, *op. cit.*). The diagnosis of *P. tropiduri* was based on the following characters: all the intraerythrocytic stadia (trophozoites, schizonts, and gametocytes) were identified and usually located in the polar or lateropolar region of the erythrocyte (host cell); rounded gametocytes; schizonts with about 18 merozoites; hypertrophied and lightly deformed erythrocytes.

The morphological analysis of the intraerythrocytic stadia of *P. tropiduri* revealed circular, rounded, prolonged, and ellipsoidal forms. The same was reported by Aragão and Neiva (1909, *op. cit.*), Carini (1941, *op. cit.*), Gahram (1966. Malaria Parasites and Other Heamosporidia. Blackwell Scientific Publications, Oxford. 1114 pp.), Laison and Shaw (1969, *op. cit.*) and Rocha-Silva and Rodrigues (1974, *op. cit.*).

The lizard specimens are deposited in the herpetology collection of the Department of Zoology of the Federal University of Juiz de Fora (numbers: 466, 467, 489, 491, 506–508, 515–517, 614, 618).

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TROPIDURUS OREADICUS (Neotropical Ground Lizard). **PREDATION**. Many arthropods are predators of lizards (McCormick and Polis 1982. Biol. Rev. 57:29–58). Lizards of the genus *Tropidurus* (Tropiduridae) are widely distributed in Brazil and species of the *torquatus* group are abundant in savanna and semi-arid vegetation (Rodrigues 1987. Arq. Zool. 31:105–230).

Tropidurus oreadicus is generally abundant in openly vegetated habitats (Colli et al. 1992. J. Herpetol. 26:66–69) and common in Cerrado areas and open enclaves in the Amazon forest (Rodrigues 1987, *op. cit.*). Carvalho-Filho (2008. Herpetol. Rev. 39:230) observed a juvenile *T. oreadicus* predated by a Guira Cuckoo (*Guira guira*) in Belém, Pará state. However few predation events have been recorded involving this species by other vertebrates or arthropods. Herein, we report predation of *T. oreadicus* by a spider in Cerrado area.

At 1116 h on 16 April 2008, we found an adult of *T. oreadicus* (783 mm SVL, 127 mm tail) in Fazenda Floryl (14.04670ºS, 45.89124ºW; datum: SAD69, elev. 900 m), municipality of Jaborandi, Bahia, Brazil. This lizard had been captured and eaten by an adult wolf spider *Lycosa erytrognata* (Lycosidae, Aranae) in a 60-liter bucket pitfall trap in cerrado. In their review, McCormick and Polis (*op. cit.*) considered wolf spiders as predators of amphibian and fish. This is the first record of predation by this wolf spider on a lizard.

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TROPIDURUS OREADICUS (NCN). **CANNIBALISM AND PREY.** *Tropidurus oreadicus* belongs to the *torquatus* group (Frost et al. 2001. Mol. Phylogenet. Evol. 21:352–371) and is distributed in the states of Mato Grosso, Mato Grosso do Sul, Minas Gerais, Goiás, Maranhão, Bahia, and Piauí, from the margins of the lower Tocantins River to Belém. It usually occurs in open areas (Rodrigues 1987. Arq. Zool. 31:105–230). Species of the *torquatus* group are, in general, heliothermic, diurnal, and mostly insectivorous (Rodrigues 1987, *op. cit.*), though sometimes they may also consume small vertebrates (Kiefer and Sazima 2002. Herpetol. Rev. 33:136; Dias and Rocha 2004. Herpetol. Rev. 35:398–398). Here, we report on cannibalism in *T. oreadicus* and on the predation of the gymnophtalmid lizard *Cercosaura schreibersii* by this same tropidurid.

The observations were carried out in the municipality of Porto Velho, state of Rondônia, northern Brazil (08.7619°S, 63.9038°W). The cannibalism was observed in an urban area on 4 August 2009 at 0950 h. An adult male *T. oreadicus* (93 mm SVL, 23 g after prey removal) was standing on a wall, when it noticed the movement of a conspecific juvenile (34 mm SVL, 1.2 g) near the ground; it approached and ate the juvenile. The predator lizard was captured four hours later and its stomach was examined, from which the

smaller lizard was removed pre-digested. The two specimens were deposited as vouchers in the herpetological collection of Universidade Federal do Acre - Campus Floresta (UFACF 2632, UFACF 2633).

The observation of predation on *Cercosaura schreibersii* took place on the 6 August 2009 at 1140 h, in an open area next to a forest edge in a city park in Porto Velho. A juvenile female *T. oreadicus* (35 mm SVL, 1.8 g after prey removal) was caught after ingesting a juvenile gymnophtalmid lizard *C. schreibersii* (19 mm SVL, 0.3 g). The *C. schreibersii* had still been struggling to free itself from the mouth of the *Tropidurus* when first encountered by the observer. The *T. oreadicus* specimen was collected after a few minutes and the prey was removed from its stomach, which accounted for 16.6% of its body mass. The two lizards were deposited as vouchers in the herpetological collection of Universidade Federal do Acre – Campus Floresta. (*T. oreadicus* UFACF 2634; *C. schreibersii* = UFACF 2635).

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TROPIDURUS TORQUATUS (NCN). **AVIAN ATTACK.** *Tropidurus torquatus* is distributed throughout west-central, northeastern (south of the Bahia state), and southern regions of Brazil (Rocha 2000. Ecologia de Restingas e Lagoas Costeiras. NUPEM/UFRJ, Macaé, Rio de Janeiro, Brazil, pp. 99–116; Rodrigues 1987. Arq. Zool. São Paulo 31:105–230). It is active throughout the year and is easily found in open areas and in environments altered by anthropogenic action, such as "roçados," back yards, and gardens. They are seen mainly on rocks, termite mounds, fallen logs, and on the forest floor, and can climb easily on walls and logs (Araújo 1987. Anais de Etologia 5:189–197).

The House Sparrow (*Passer domesticus*) originates from the Middle East. However, this bird spread throughout Europe and Asia reaching the Americas around 1850 (Silva et al. 2007. Anais do VIII Congresso de Ecologia do Brasil, 2 pp.). It was introduced to Brazil early in the 20th century in the city of Rio de Janeiro and spread throughout the south, southeast, west-central, and northeast portions of of Brazil (Sick 1985. Ornitologia Brasileira, uma Introdução, v.II. Brasília: Editora UnB). Today this bird occurs in almost all countries of the world, and is often characterized as an exotic and bioinvasive species (Silva et al. 2007, *op. cit.*). Bioinvasion is defined as the arrival, establishment, and expansion of an exotic species into a region that is outside its known natural distribution, resultant of accidental or intentional dispersion through human activities (Carlton 1996. Biol. Cons. 78:97–106). Introduced exotic species are adaptive not only by their ability to easily establish new populations, but also by becoming invasive, affecting native communities in their respective ecosystems, altering the structures and function of those ecosystems (Reusch and Williams 1998. Oecologia 113:428–441). Here we report the attack of a juvenile lizard *Tropidurus torquatus* by an adult female *Passer domesticus*.

On 22 Nov 2008 at 1800 h, in a residential garden in the city of Araçatuba, state of São Paulo, Brazil, a juvenile *T. torquatus* was observed exhibiting escape behavior from a House Sparrow. The lizard climbed down from a tree, crossed a street, and climbed a residence wall by a garden. The lizard stayed immobile in alert position. At this time, a female House Sparrow that was nesting in the tree from which the lizard had descended flew down in an apparent aggressive attack. The bird pecked at the lizard's head several times. The lizard fled into the vegetation of the garden.

Female House Sparrows are more aggressive than males around nesting sites due to the lack of rivalry between males (which do not establish territories around the nest) (Sick 1997. Ornitologia Brasileira. Nova Fronteira, Rio de Janeiro, 912 pp.). We believe that the female House Sparrow displayed this aggressive behavior in response to the lizard's presence near the bird's nest.

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TUPINAMBIS MERIANAE (Common Tegu). **FEEDING BEHAVIOR.** Tegus are diurnal, terrestrial, actively foraging omnivores that often feed on fruit, invertebrates, and small vertebrates (Vanzolini et al. 1980. Répteis das Caatingas. Acad. Bras. Ciências, Rio de Janeiro, RJ, Brazil. 161 pp.; Mercolli and Yanosky 1994. Herpetol. J. 4:15–19; Vitt 1995. Occ. Pap. Oklahoma Mus. Nat. Hist. 1:1–29). Although tegus are known to commonly consume vertebrate eggs (e.g., alligators: A. Lima, pers. comm.; turtles: Gonçalves et al. 2007. Rev. Bras. Zool. 24:1063–1070), eggs are poorly represented (birds: Mercolli and Yanosky, *op. cit.*) or absent (Kiefer and Sazima 2002. Amphibia-Reptilia 23:105–108) in systematic studies of tegu diet. However, this bias might result from the methods typically used to describe lizard diets. For instance, soft or quickly digested food items might not be present or distinguishable in stomach content analysis, a method commonly employed to assess lizard diets. Therefore, the poor representation (or absence) of eggs in tegu diet may simply reflect lizard feeding behavior. Here, I report on an opportunistic observation of predation of an egg of the Solitary Tinamou *(Tinamus solitarius)* by a *Tupinambis merianae* (locally known as *teiú*) that puts perspective on this bias.

At 1245 h on 17 October 2002, I witnessed an adult tegu (ca. 40 cm SVL) eat the egg of a *Tinamus solitarius* at the margin of an old dirt road (19.71°S, 41.825°W; elev. 430 m), in the northern part of the Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala (RPPN-FMA), eastern Minas Gerais, Brazil. I encountered the lizard apparently just after it had begun eating the egg. As soon as it became aware of my presence, the lizard took the egg in its mouth and moved about one meter away. The tegu then placed the egg on the ground, and after a few seconds of watching me, resumed eating. Following this initial movement, it was not disturbed again, a pattern unlike that commonly observed during other encounters with basking tegus in this reserve. My presence may not have further disturbed the tegu because I became immobile at a distance of approximately six meters as soon as I saw it. To access the inside of the egg (62 mm length, 46 mm width), the lizard made a small (25 mm radius) hole on its side through which it lapped up the entire contents. This process lasted approximately two minutes. The tegu then abandoned the eggshell and disappeared into the forest. I collected the eggshell and took it to the RPPN-FMA field laboratory for examination.

It may be that eggs are a resource that tegus often consume, but are rarely recorded because only the egg contents are typically eaten and the eggshell is discarded. As a consequence, soft portions of eggs are unlikely to be recognized in stomach content analyses. This observation emphasizes the importance of direct observations to complement studies of lizard diets in order to fully understand the food resources they use.

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VARANUS MITCHELLI (Mitchell's Water Monitor). **DIET AND FORAGING BEHAVIOR**. The diet of *Varanus mitchelli*, a small arboreal and terrestrial monitor lizard inhabiting tropical Australia, was summarized by Shultz and Doody (2005. *In* Pianka and King [eds.],Varanoid Lizards of the World. Indiana University Press, Bloomington). The species is considered a generalist predator, consuming a wide range of small vertebrates and large invertebrates (Shine 1986. Herpetologica 42:346–360; Losos and Green 1986. Biol. J. Linn. Soc. 35:379–407). However, our knowledge of its diet is based almost solely on dissections of limited museum specimens (but see one account of foraging behavior in Vincent and Wilson 1999. Australian Goannas. Reed New Holland, Sydney). The foraging habits and diet of this species have been little studied in nature.

At 1345 h on 7 June 2009 we observed a pair of Crimson Finches (*Neochmia phaeton*) vocalizing and assuming defensive postures near their nest on a tree limb (*Pandanus aquaticus*) overhanging the water, on the Ord River, ~20 km upstream of Kununurra, Western Australia (15.968611°S, 128.743056°E). Closer inspection revealed a juvenile *V. mitchelli* inside the nest. Our presence flushed the goanna from the nest and it fled along the tree limb to the shore. Inspection of the nest revealed one broken egg and two intact eggs. We were unable to return to the nest site to determine if further predation occurred on the eggs. The weather was partly cloudy with an air temperature of 29.3ºC.

At Mornington Wildlife Sanctuary (MWS), approximately 340 km WSW of the Ord River site, one of us (OM) has monitored Crimson Finch nests for three consecutive breeding seasons between 2006 and 2009. During that study, 397 nests were found that had begun clutch initiation, and of these 237 (59.7%) were preyed upon either during the egg stage or nestling stage. Due to competing objectives, systematic data on predation events were not collected. However, some observations were made that are relevant to the abovementioned predation attempt. *Varanus* species were found in four Crimson Finch nests, of which three were identified as *V. mitchelli*, and the fourth was unidentified. Also, *V. mitchelli* were found within two meters of three additional active finch nests. For comparative purposes, we list the observations of other (potential) predators: An Olive Python (*Liasis olivaceus*) was found in one nest, two unidentified snakes were within 2 m of two nests, and one nest was infested with Green Ants (*Oecophylla smaragdina*). One additional nest preyed upon had a hole opened up in the back of the nest, and seven other nests were 'destroyed' or 'torn apart' by unknown predators (possibly avian predators or monitor lizards).

The three confirmed cases of *V. mitchelli* predation on Crimson Finch nests occurred during the egg stage. However, nestlings may also be taken. Both Crimson Finches and *V. mitchelli* are riparian habitat specialists (Higgins et al. 2006. Handbook of Australian, New Zealand & Antarctic Birds (HANZAB): Boatbill to Starlings Part B. Oxford University Press, South Melbourne; Schultz and Doody, *op. cit.*). Between 55% and 98% of Crimson Finch nests are found in Pandanus (Todd 2002. Austral. Bird Watcher 19:161–171; O. Milenkaya, unpubl. data), a microhabitat often used by *V. mitchelli* (Schultz and Doody, *op. cit.*). It is possible that *V. mitchelli* is a major predator of Crimson Finch nests due to their shared microhabitat. It is also likely that *V. mitchelli* prey upon nests of other riparian bird species nesting in the *Pandanus* such as Purple-crowned Fairy Wrens, *Malurus coronatus* (Rowley and Russell 1993. Emu 93:235–250). At MWS, Purple-crowned Fairy Wrens are obligate-Pandanus nesters, and Bar-shouldered Doves, (*Geopelia humeralis*) and Double-barred Finches (*Taeniopygia bichenovii*) occasionally nest in Pandanus (M. Hall, unpubl. data; O. Milenkaya, unpubl. obs.). Finally, while *V. mitchelli* may prey heavily on bird eggs during the wet season, this may constitute a smaller portion of their diet during the dry season. Crimson Finches, for example, nest mainly during the wet season (December to early June; Todd, *op. cit.*).

The Cane Toad (*Bufo marinus*) is moving rapidly toward the Kimberley region. In the Northern Territory invasive toads caused 71–97% declines in *V. mitchelli*, which die after attempting to ingest the toxic toads (Doody et al. 2008. Anim. Cons. 12:46–53). It is likely that toad-induced declines in *V. mitchelli* at Ord River and MWS will occur, and will greatly reduce *V. mitchelli* predation on nests of Crimson Finches and Purple-crowned Fairy Wrens. Studies are underway to determine the importance of *V. mitchelli* as nest predators on those species, and thus to determine the indirect impact of cane toads on nest success of these Pandanus-nesting birds as cane toads invade.

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XANTUSIA WIGGINSI (Wiggins' Night Lizard). **DEFENSIVE BEHAVIOR**. With recent morphological and molecular work on the genus *Xantusia*, the number of recognized species in the state of California has grown from three to six in the last decade (Bezy et al. 2008. J. Herpetol. 42:680–688; Leavitt et al. 2007. Mol. Ecol. 16:4455–4481; Lovich 2001. Herpetologica 57:470–487; Sinclair et al. 2004. Am Nat. 163:396–414). The more isolated and geographically restricted of these species (e.g., *X. gracilis, X. sierrae*, and *X. wigginsi*) remain poorly known and in need of study. The purpose of this note is to add to the limited knowledge of the behavioral biology of one of these species, *X. wigginsi*.

On 2 January 2010 at 1355 h, an adult *X. wigginsi* was uncovered beneath a decaying *Agave deserti* ca. 7.2 km E of Jacumba, San Diego County (32.636178°N, 116.114167°W; datum WGS84). Once grasped by hand, the night lizard immediately defecated on the captor and initiated mouth-gaping behavior, threatening to bite. The mouth-gaping behavior lasted for ca. one to two minutes while the lizard was in hand and initially positioned for photographs. The mouth-gaping was not elicited by high temperatures as a means of panting, as air temperature at the time of capture was ca. 21°C and the temperature (not taken) within the decaying *Agave* refuge was substantially cooler and damp. The gaping behavior ceased soon after the lizard was placed on a dead piece of *Agave* for the photographs.

Mouth-gaping is a common threat display among Lacertilia, including the much larger congeneric *Xantusia riversiana* (Mautz et al. 1992. Herpetologica 48:271–279). However, this behavioral observation involving *X. wigginsi* is of interest because of the incredibly small size of the species (44 mm maximum snout–vent length; Bezy 2009. *In* Jones and Lovich [eds.], Lizards of the American Southwest: A Photographic Field Guide, pp. 440–443. Rio Nuevo Publishers, Tucson, Arizona), in that the lizard's diminutive mouth appeared incapable of inflicting a bite to a human finger. An attempt to bite was never made by the lizard.

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SQUAMATA — SNAKES

BOTHROPS JARARACA (Jararaca). **ALTITUDINAL RECORD.** *Bothrops jararaca* is a generalist species that inhabits several environments in Brazil (from Bahia to Rio Grande do Sul states), Argentina, and Paraguay, from sea level to 1200 m elevation (Sazima 1992. *In* Campbell and Brodie Jr. [eds.], Biology of the Pitvipers, pp. 199–216. Selva, Tyler, Texas; Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Cornell University Press, Ithaca, New York. 870 pp.). On 15 October 2006, a *B. jararaca* (SVL = 500 mm) was found in a high altitude field (elevation ca. 1565 m) at the Caraíbas Farm (13.118664°S, 41.381491°W; datum: SAD 69), Chapada Diamantina, municipality of Mucugê, state of Bahia, Brazil. This record increases the altitudinal range of the species by ca. 365 m from previous reports (Sazima, *op. cit.*). The specimen is deposited in Zoological Museum of Universidade Estadual de Santa Cruz (MZUESC 6326).

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BOTHROPS LEUCURUS (Jararaca/Bahia Lancehead). **DIET.** *Bothrops leucurus* is a medium-sized terrestrial viperid snake, widespread in the Atlantic Forest of northeastern and eastern Brazil (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Cornell University Press, Ithaca, New York. 870 pp.). The diet of the species consists of small vertebrates with an ontogenetic shift from frog and lizard prey as juveniles to rodents as adults (Freitas 2003. Serpentes Brasileiras. Malha-de-Sapo Publicações, Lauro de Freitas, Bahia, Brazil. 160 pp.). On the morning of 10 November 2002, we collected a juvenile *B. leucurus* (ca. 400 mm SVL) on the ground of the forest at Palmeira farm (15.950833°S, 39.627778°W; datum: SAD 69), municipality of Itapebi, state of Bahia, Brazil. The snake subsequently regurgitated a Marbled Swamp Eel, *Symbranchus marmoratus* (Pisces, Actinopterygii, Synbranchidae). To our knowledge, this is the first record of *B. leucurus* preying on a fish. The specimen is deposited in the Zoological Museum of Universidade Estadual de Santa Cruz (MZUESC 4119).

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CAUSUS RHOMBEATUS (Rhombic Night Adder). **PREY SIZE**. Snakes are well known for their ability to consume large prey relative to their body size. In particular, viperids are documented to have high prey to predator mass ratios, with prey exceeding 100% of the snake's mass in some cases (Greene 1983. Am. Zool.

23:431–441). Reports of maximum prey size are important for understanding a species' foraging ecology and the evolution of gape size throughout the evolutionary history of snakes. Yet, detailed records of maximum prey sizes are lacking in many snake clades, particularly those from the Old World. The African viper *Causus rhombeatus* commonly consumes frogs and toads. Herein I report a large prey item for *C. rhombeatus*.

I examined a specimen of *C. rhombeatus* at the Field Museum of Natural History in Chicago (FM 74241). The specimen was collected from Huila, Angola and contained a fully intact toad (probably *Amietophrynus* sp.). The snake measured 566 mm SVL, 20.27 mm head length, 17.21 mm head width and weighed 79 g. The prey item was 95.67 mm SVL, 183 mm total length, 37.59 mm maximum width and weighed 64 g. The prey to predator mass ratio was 81.0% and the prey width to head width ratio was 218.4%. To my knowledge this is the largest prey to predator weight ratio reported for this species.

I thank A. Resestar and the staff at the Field Museum of Natural History in Chicago for their assistance and financial support.

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CROTALUS HORRIDUS (Timber Rattlesnake). **HABITAT USE**. *Crotalus horridus* is threatened or endangered throughout much of its range due largely to human alteration of habitat (Brown 1993. SSAR Herpetol. Circ. 22, 78 pp.). An understanding of habitat use in relation to human impacts will be important in conservation of this species. In the southern Appalachian Mountains, extensive logging and fire suppression in the 20th century resulted in large areas of even-aged closed canopy forest and a reduction in canopy gaps which can be important for reptile species (Greenburg 2001. For. Ecol. Manage. 148:135–144). More recently, rapid suburban development is fragmenting forest habitats across this region (Turner et al. 2003. Landscape Ecol. 18:449–464). Although *C. horridus* are highly dependent on winter dens and summer gestation sites, males and non-gestating females in summer have been reported to favor closed canopy forests with few fallen logs or rocks (Reinert and Zappalorti 1988. Copeia 1988:964–978; Reinert and Rupert 1999. J. Herpetol. 33:45–61). This note describes varying degrees of selection for open canopy sites among four adult *C. horridus* in Jackson County, North Carolina, USA during spring–fall of 2007 and 2008.

In 2007, two adult female *C. horridus* (020 and 040) were captured in early June gestating on a rock dam within a municipal watershed, and two adult males (060 and 081) were captured in early July within an active housing development. Both areas have been extensively logged and are dominated by second growth, closed canopy forests with dense understory shrubs in many areas. Both sites have numerous roads from past logging with road use highly restricted in the watershed and increasing in the development. In the watershed, female 040 remained on the dam until parturition in early September while female 020 left the dam in late July 2007, presumably due to a failed pregnancy. Of the 16 non-gestation locations for 020, three occurred in open canopy sites (Fig. 1). Two of these locations were directly on a seldom used road and one occurred in a natural tree fall opening. After parturition, 040

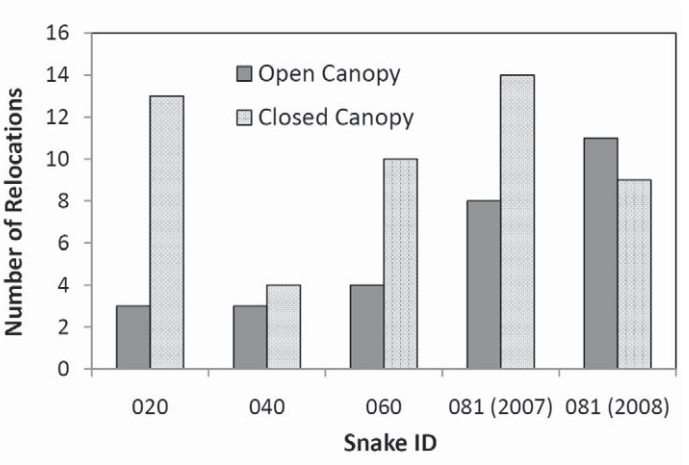

FIG. 1. Use of open vs. closed canopy habitats by four *Crotalus horridus* at two southern Appalachian study sites during Spring–Fall 2007–2008.

moved immediately into adjacent forests using a secondary road as a corridor before moving to a natural tree fall opening. Both snakes used natural log piles while in open sites, and on one occasion 020 used a sapling tree which overhung a log pile.

Within the housing development, male 060 moved onto adjacent private residential lands by August 2007 and used open areas in 4 of 16 of his summer-fall locations (Fig. 1). Three of these locations occurred at road edges (thick grass or shrub cover but no trees) with the remaining location in an old field with thick grass but no tree cover. Male 080 was captured and released within a commercially thinned forest and had eight of 22 locations in 2007 distributed between two such forest stands (Fig. 1). In 2008, 11 of 20 locations for 080 occurred in the same thinned stand in which he was captured. The other thinned stand was avoided entirely in 2008, presumably because of home construction. Of the remaining open canopy locations, one occurred at a road edge just before hibernation in 2007 and the other two occurred in natural openings in the spring of 2008. This male used both natural log piles (spring 2008) and a slash pile from thinning (4 locations in August 2007).

With the predominance of even-aged closed canopy forest in this region, natural and human induced canopy gaps provide benefits to some reptile species and appear to be used to some extent by *C. horridus*. Given limited data, it is unclear if snakes were responding to increased sunlight, shelter from logs and thick shrubs, potential food sources, or other factors. Future investigations should assess the use of open canopy sites, particularly thinned forests, in order to inform potential habitat management for this species.

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CROTALUS LEPIDUS (Rock Rattlesnake). **DIET**. The diet of *Crotalus lepidus* reportedly includes arthropods, frogs, small rodents, and reptiles, especially lizards (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 668 pp.). The species has also been shown to feed on *Gyalopion canum* (Chihuahuan Hook-nosed Snake) in the wild and on a *Virginia striatula* (Rough Earthsnake) in captivity (Milstead et al. 1950. Texas J. Sci. 2:543–562; Wright and Wright 1957.

FIG. 1. Adult *Crotalus lepidus* ingesting a freshly killed *Hypsiglena jani* at Indio Mountains Research Station, Hudspeth Co., Texas, USA.

Handbook of Snakes of the United States and Canada. Comstock Publ. Co., Ithaca, New York. 1105 pp.). In addition, Williamson (1971. Herpetol. Rev. 3:18) described cannibalism on two neonate *C. lepidus* born in captivity; one was eaten by a brood mate that five days later was itself consumed by the mother. From the scant information on feeding behavior in the wild, it is assumed that *C. lepidus* consumes nearly any small animal that it can subjugate, although lizards, because they are usually abundant in habitats used by this rattlesnake, are probably the primary diet item (Beaupre 1995. Herpetologica 51:45–56). We report the first known record of *C. lepidus* preying on *Hypsiglena jani* (Chihuahuan Nightsnake), a small colubrid commonly found in the Chihuahuan Desert.

On 27 June 2008, at 2020 h, an adult male *C. lepidus* (SVL = 565 mm; tail length = 60 mm; 175 g), fitted with a 5.0 g temperature-sensitive radio-transmitter (Holohil Systems Ltd, Ontario, Canada), was tracked on Indio Mountains Research Station (IMRS), Hudspeth Co., Texas, USA (30.4635°N, 105.0055°W; datum: WGS84; elev. 1215 m). IMRS is controlled by the University of Texas at El Paso and situated in an area containing rocky mountainous substrates covered by Chihuahuan Desert scrub vegetation. The snake was positioned in a loose coil within an arroyo next to a Prickly Pear (*Opuntia engelmannii*) and was ingesting a freshly killed adult *H. jani* (Fig. 1). The *H. jani* was being swallowed head first in a folded position, which allowed easily identification of the prey item. When the rattlesnake became aware of our presence, it stopped swallowing for about one minute, but then continued on for approximately 20 more minutes until the entire snake was consumed.

We thank A. Rocha, A. Gandara, L. Miranda, and C. Tweedie for their help in the field. Partial funding for field work was supplied by a grant from T&E Inc., the Joseph Family Trust Fund, a G. A. Krutilek Fellowship, and a F. B. Cotton Trust Scholarship to V. Mata-Silva.

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DRYMARCHON CORAIS CORAIS (Yellowtail)**. DIET.** *Drymarchon corais corais* is known to prey upon a wide range of vertebrates, including other snakes (Beebe 1946. Zoologica 31:11–52; Cunha and Nascimento 1978. Publ. Avul. Mus. Par. Emílio Goeldi 31:1–128). On 2 February 2006 at 1000 h, while conducting fieldwork in riparian forest at the Acangaú Reserve (17.181389°S, 47.070278°W; datum: Córrego Alegre; elev. 665 m) in the municipality of Paracatu, Minas Gerais, Brazil, one of us (AS) found an adult *D. c. corais* (total length ca. 1250 mm) preying on an adult *Liophis miliaris* (ca. 700 mm total length) on the leaflitter of the forest floor. The snakes were left undisturbed and the *D. corais* swallowed the *L. miliaris* head first over the course of approximately 20 minutes. To the best of our knowledge, this is the first published description of a wild *D. corais* preying upon a snake in Brazil and documents a novel prey species for *D. corais*.

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HETERODON NASICUS (Plains Hog-nosed Snake). **DIET AND PREY SIZE.** At 1650 h on 20 September 2007, a juvenile female *Heterodon nasicus* (SVL = 178 mm; tail length = 34 mm; 7.6 g without prey item) was collected in the Assiniboine Corridor Wildlife Management Area, Manitoba, Canada (49.6667ºN, 99.5676ºW; datum = NAD83, elev. 348 m). The *H. nasicus* had an enlarged mid-body and after gentle palpation the snake regurgitated an adult *Plestiodon septentrionalis* (Prairie Skink; Fig. 1) that had been recently swallowed tail first (SVL = 77 mm; tail length = 105 mm; 3.9 g). The skink had damage to its tail with punctures at the base of its tail, presumably a consequence of the struggle with the snake. After being scale-clipped for future identification the snake was released at the capture site.

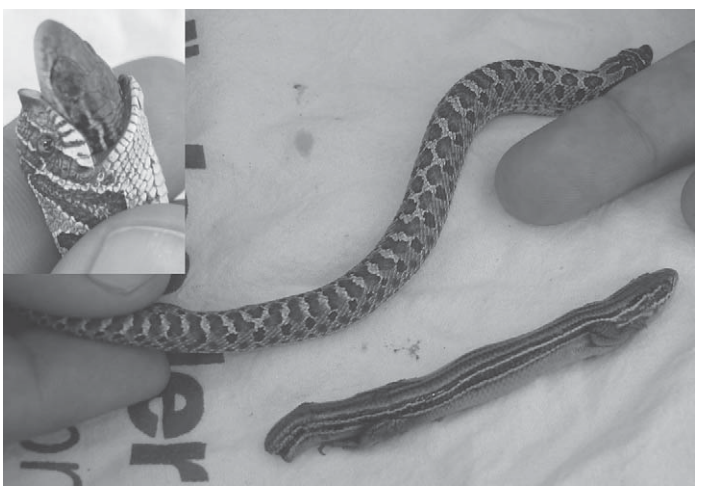

FIG. 1. Juvenile *Heterodon nasicus* with recently regurgitated adult *Plestiodon septentrionalis*. The prey item is also evident in the mouth of the snake prior to regurgitation (inset).

Heterodon nasicus is known to frequently feed on amphibians with a preference for toads, although they also prey upon small mammals, nestlings of ground nesting birds, small lizards, reptile eggs, and snakes (Pendlebury 1976. Can. Field Nat. 90:416–422; Platt 1969. Univ. of Kansas Publ. 18:253–420). *Plestiodon septentrionalis* have been reported in the diet of *H. nasicus* (Oldfield and Moriarty 1994. Amphibians and Reptiles Native to Minnesota. University of Minnesota Press, Minneapolis. 237 pp.), although this the first detailed description. Of considerable note is the size of the prey item (prey/predator mass ratio of 0.51), which is well above the typical meal size for a colubrid snake. Similarly, large anuran prey items (prey/predator mass ratio of 1.06–1.33) recently have been reported for *H. platirhinos* (Steen et al., *in press*. Herpetol. Rev.)

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LEPTODEIRA CUSSILIRIS (Duellman's Cat-eyed Snake). **DIET, CANNIBALISM**. On 26 August 2007 we collected an adult female *Leptodeira cussiliris* (SVL = 220 mm; tail length = 170 mm), in tropical dry forest habitat in Copala, Guerrero, México (16.555975ºN, 98.89425ºW; datum WGS84). When the specimen was examined by dissection, we discovered a partially digested male *L. cussiliris* (verified by Rubén Castro Franco) in the stomach. Duellman (1958. Bull. Amer. Mus. Nat. Hist. 114:1–150) reports that this genus prefers anurans (e.g., Bufonidae, Hylidae, and Ranidae) and lizards (e.g., *Anolis*, *Ctenosaura*, *Ameiva*) as prey. To our knowledge, this represents the first record of cannibalism in *Leptodeira*. Both specimens were deposited in the Colección de Anfibios y Reptiles de la Universidad de Morelos (CARUM).

We thank Rubén Castro Franco for assistance.

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PHILODRYAS PATAGONIENSIS (Parelheira). **FEEDING BEHAVIOR**. *Philodryas patagoniensis* is a medium to large terrestrial colubrid that feeds on a wide variety of prey, including mammals, birds, frogs, lizards and other snakes (including conspecifics) (Rocha and Vrcibradic 1998. Ciência e Cultura 50:364–368; Hartmann and Marques 2005. Amphibia-Reptilia 26:25–31; França et al. 2008. Copeia 2008:23–38; López and Giraudo 2008. J. Herpetol. 42: 474–480). Nevertheless, limited information is available on its predatory behavior, particularly in the wild.

On 19 November 2007 the first author observed two events of predation on lizards (*Ameiva ameiva*) by *P. patagoniensis* in the restinga habitat of Massambaba (22.937111ºS, 42.292056ºW; datum WGS 84), Praia Seca district, municipality of Araruama, state of Rio de Janeiro, Brazil. The first event occurred at the border of a trail at 1026 h. An adult *P. patagoniensis* was seen close to the base of a ground bromeliad. Startled by the presence of the observers, the snake started to move away and it was then seen that it was carrying an adult *A. ameiva* in its mouth. The lizard was being held by the side of the body and was apparently alive. Unfortunately, the snake moved into vegetation and disappeared from view before the outcome of the event could be observed.

The second observation occurred about 18 min later, 150 m from the first encounter. This time, the snake was seen moving towards the lizard and capturing it as it ran. During the ensuing struggle, the snake threw two coils of its body around the lizard, bit its head, and then slowly moved its jaws forward until they completely engulfed the immobilized lizard's head (Fig. 1). They remained in that position for about 22 min, during which the lizard occasionally struggled and the snake responded by quickly jerking its head to the side and/or moving its jaws, presumably using its rear fangs to inject toxic secretions into its prey. After the lizard had stopped moving, the snake let it free of its coils and started to swallow it, a process that was completed in about 6 min. It is also noteworthy that, in spite of being venomous (Araújo and Santos 1997. Rev. Soc. Bras. Med. Trop. 30:517–519), *P. patagoniensis* may use a combination of constriction and envenomation to subdue relatively large prey. *Ameiva ameiva* has been reported as prey of many snake species, including *P. patagoniensis* (França et al., *op. cit.*). This medium-sized teiid is one of the most widely distributed lizard species in South America and is probably a frequent component of the diet of *P. patagoniensis*.

FIG. 1. Adult *Philodryas patagoniensis* immobilizing its prey, an adult *Ameiva ameiva*.

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SISTRURUS CATENATUS EDWARDSII (Desert Massasauga). **DIET, PREY SIZE, AND FEEDING RELATED MORTALITY**. *Sistrurus catenatus edwardsii* feeds on lizards, small mammals, small snakes, centipedes, and anurans (Holycross and Mackessy 2002. J. Herpetol. 36:454–464). Whiptails of the genus *Aspidoscelis* have been reported to be in the diet of *S. c. edwardsii*, however *A. marmorata* (Marbled Whiptail) has not yet been identified as prey (Holycross and Mackessy, *op. cit.*). This is rather intriguing, given the overlap that exists for both species' known geographic ranges (Degenhardt et al. 1996. Amphibians and Reptiles of New Mexico. Univ. New Mexico Press, Albuquerque. 431 pp.). Furthermore, little published information exists regarding prey size for *S. c. edwardsii*. Here, I report feeding related mortality of an *S. c. edwardsii* following consumption of an adult *A. marmorata*.

At 1018 h on 7 August 2008, I discovered a deceased female *S. c. edwardsii* (TCWC 93556) lying in the bottom of a large sand dune blowout in Lea County, New Mexico, USA (32.7847°N, 103.8089°W; datum: WGS 84, elev. 1173 m). The individual was lying dorsum up, appeared bloated, and had recently died. Both lizard and snake tracks were observed near the dead snake. The individual was collected and dissected to determine what was causing the large bulge in the snake's mid-section. Upon dissection, I discovered that the snake had consumed a female *A. marmorata* (TCWC 93557). The lizard's girth had caused a 35 mm long rupture in the snake's stomach which was likely the cause of death for the snake.

The *S. c. edwardsii* measured 310 mm SVL and 18 g mass post mortem and the *A. marmorata* measured 100 mm SVL and 21 g mass post mortem. This indicates that the snake attempted to ingest a prey item 1.17 times its own mass. This measurement is slight in comparison to the record for snakes (relative prey mass = 1.72; Mulcahy et al. 2003. Herpetol. Rev. 34:64). However, perhaps it illustrates a differential consumption/mortality threshold exists among species or individuals.

This observation is noteworthy for two reasons. First, although the ranges of *S. c. edwardsii* and *A. marmorata* overlap, their trophic relationship had not yet been clarified. Second, it indicates the consumption of large prey items may result in increased energy stores for *S. c. edwardsii*, but the potential threat of death due to a ruptured stomach exists.

Submitted by **DANIEL J. LEAVITT**, Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Science, Texas A&M University, College Station, Texas 77843-2258, USA.

THAMNOPHIS MARCIANUS (Checkered Gartersnake). **DIET**. *Thamnophis marcianus* hunt in a variety of habitats and are known to feed on a more diverse group of prey items than many of their congeners (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, D.C. 668 pp.). During a two-week survey in the state of Coahuila, Mexico, on 31 July 2007 between 2100 and 2200 h, we found a foraging adult *T. marcianus* near Mota de Corona (27.41528ºN, 101.17090ºW; datum: WGS84, elev. 353 m). When captured, the individual immediately regurgitated a partially digested adult *Coleonyx brevis* (Texas Banded Gecko). The prey item was deposited in the herpetological collections of the University of Texas at Arlington (UTA R-55494) along with a photographic voucher of its predator (UTADC 2055). Only three genera of lizards, *Cophosaurus*, *Holbrookia,* and *Aspidoscelis* have been documented as prey for *T. marcianus* (Hampton and Fontenot 2007. Herpetol. Rev. 38:94–95). This is the first report of predation on *C. brevis* or any gecko by *T. marcianus* in the wild.

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THAMNOPHIS SIRTALIS INFERNALIS (California Red-sided Gartersnake). **DIET.** *Thamnophis sirtalis* is a terrestrial-aquatic generalist predator that feeds on a wide variety of prey groups (Fitch 1941. California Fish and Game 27:1–32). Although the diet is broad, amphibians often constitute a major component of their prey (Cunningham 1959. Herpetologica 15:17–19; Fitch, *op. cit.*; Fox 1952. Herpetologica 8:4–8). *Thamnophis sirtalis* can shift prey species in response to temporal availability of prey (Fitch, *op. cit.*) and due to gape limitation, may exhibit ontogenetic shifts in diet. Here I describe the diet of *T. s. infernalis* at a seasonal marsh in California.

I examined *T. s. infernalis* diet at Ledson Marsh, an 11-ha seasonal wetland, located in Annadel State Park, Sonoma County, California, USA (38.4086°N, 122.5995°W; datum: NAD83). The marsh is situated in hilly terrain surrounded by oak woodland and Douglas-fir forest. Winter rains typically fill the marsh to a maximum depth of ca. 150 cm that gradually recedes and the marsh is usually dry by early fall. The marsh is densely vegetated with wetland plants and is inhabited by an abundance of amphibians including: *Pseudacris regilla* (Northern Pacific Treefrog), *Taricha torosa* (California Newt), *T. granulosa* (Rough-skinned Newt), *Rana draytonii* (California Red-legged Frog), and *R. catesbeiana* (American Bullfrog). These species breed during the winter or spring and larvae typically metamorphose from mid-summer through early fall, before the marsh dries. Although abundant in

summer, *R. catesbeiana* tadpoles rarely metamorphose at the marsh due to late-season breeding and a protracted tadpole life stage.

I captured garter snakes at the marsh on 12, 13, 19, and 20 September 1998 using 12 drift fence and trap arrays located along the marsh shoreline, supplemented with hand captures. I hand palpated each snake captured until stomach contents were regurgitated and marked each snake by scale clipping. I grouped snakes into sub-adult and adult age groups based on review of a length frequency histogram that showed a clear bimodal size distribution.

Of the 62 *T. s. infernalis* captured during this study (no recaptures), 19 contained retrievable stomach contents and four snakes had multiple prey items (Table 1). I identified three prey species in the stomachs of snakes including: newly metamorphosed *P. regilla*, larval *Taricha* (species undetermined), and newly metamorphosed *R. draytonii*. No *R. catesbeiana* tadpoles were retrieved. *Rana draytonii* with a mean SVL of 32.1 mm (N = 14) was the largest prey consumed followed by larval *Taricha* with a mean SVL of 22.7 mm (N = 7). A single *P. regilla* was recovered with an SVL of 12 mm. The age (size) of *T. s. infernalis* corresponded to prey species taken (Table 1). Adult snake diet consisted of 84.2% *R. draytonii*, 10.5% larval *Taricha*, and 5.2% *P. regilla*. In contrast, the smaller sub-adult snakes consumed larval *Taricha* exclusively.

This diet study indicates that pre- and post-metamorphic amphibians are important seasonal prey for the Ledson Marsh *T. s. infernalis* population. The relatively high species richness of amphibians at Ledson Marsh apparently maintains a sizeable *T. s. infernalis* population, based on lack of recaptures during this study. *Thamnophis s. infernalis* consumed four of the five amphibian species that occurred at the marsh, the exception being the non-native *R. catesbeiana*. I suspect that *R. catesbeiana* were not taken because during the time of the study, they occurred as either small-sized tadpoles or large adults, both of which are likely outside the size preference for *T. s. infernalis*. Small *R. catesbeiana* tadpoles may be energetically too costly to forage for and adults are too large for snakes to consume. Finally, my results suggest that young *T. s. infernalis* may have a more specialized diet than adults, a pattern that has been noted for *T. sirtalis* in general (Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. Oklahoma Press, Norman. 332 pp.) and *T. s. tetrataenia* (San Francisco Gartersnake; Larsen et al. 1991. Trans. West. Sect. Wildl. Soc. 27:37–41).

Fitch (*op. cit.*) reported that *R. draytonii* is an important food item for *T. sirtalis*. In my study, *R. draytonii* also appeared to be an important prey item. Juvenile *R. draytonii* were the dominant and largest prey taken by adult snakes, and presumably contributed the largest proportion of consumed biomass. This frog has declined substantially during the past century and is listed as threatened under the Federal Endangered Species Act (Miller et al. 1996. Fed. Reg. 61:25,813–25,833). Although *T. s. infernalis* is not considered rare, *T. s. tetrataenia* has been state and federally listed as endangered since 1971 and 1967, respectively, and the South Coast garter snake (*T. s.* sp.) is a state species of concern (Jennings and Hayes 1994. Amphibian and Reptile Species of Special Concern in California. California Dept. Fish and Game, Rancho Cordova, California. 255 pp.). Recovering *R. draytonii* populations could have substantial benefits for populations of *T. sirtalis* and other species of *Thamnophis*.

TABLE 1. Diet of *Thamnophis sirtalis infernalis* at Ledson Marsh, Sonoma County, California, USA. Prey species included: newly metamorphosed *Pseudacris regilla*, larval *Taricha* spp., and newly metamorphosed *Rana draytonii*.

	Snakes		Stomach Contents		
Snake age class	Mean total length (cm)	N	*Pseudacris regilla*	*Taricha* spp.	*Rana draytonii*
Sub-adult	19.3	26	0	6	0
Adult	41.3	36	1	2	16
All	32.0	62	1	8	16

I thank J. Alvarez for reviewing a draft manuscript and M. Hastings for supporting this study. Field studies were conducted under permits from California Department of Fish and Game and California Department of Parks and Recreation.

Submitted by **DAVID G. COOK**, 3003 Magowan Drive, Santa Rosa, California 95405, USA; e-mail: dcook@scwa.ca.gov.

GEOGRAPHIC DISTRIBUTION

Instructions for contributors to Geographic Distribution appear in Volume 41, Number 1 (March 2010, 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 MACULATUM (Spotted Salamander). USA: INDIANA: GIBSON CO.: Patoka River National Wildlife Refuge and Management Area (38.3622ºN, 87.380ºW; NAD 83). 27 August 2009. Sarabeth Klueh and Angela Garcia. Verified by Chris Phillips. Illinois Natural History Survey (INHS 2009ae). New county record. (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science, vii–404 pp.) Juveniles were found under a log.

Submitted by **SARABETH KLUEH** (e-mail: sklueh@dnr.in.gov) and **ANGELA GARCIA**, Wildlife Diversity Section, Indiana Department of Natural Resources Division of Fish and Wildlife, 553 E. Miller Drive, Bloomington, Indiana 47401, USA.

AMPHIUMA MEANS (Two-toed Amphiuma). USA: GEORGIA: BULLOCH CO.: Statesboro. In ephemeral pond on Georgia Southern University campus adjacent to US Hwy 301 (32.42673°N, 81.788009°W; no datum available). 20 June 2009. Jocelyn Hyers, Angel Shepard, and Lance McBrayer. Verified by Ray Chandler. Georgia Southern University - Savannah Science Museum Herpetology Collection (SSM 2324)**.** New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). Three individuals were captured at this site on separate dates, using minnow traps. One specimen was vouchered, the others were photographed and released.

Submitted by **JOCELYN HYERS, ANGEL SHEPARD**, and **LANCE MCBRAYER,** Department of Biology, Georgia Southern University, Statesboro, Georgia 30460, USA.

AMBYSTOMA OPACUM (Marbled Salamander). USA: INDIANA: Gibson Co.: Patoka River National Wildlife Refuge and Management Area. (38.36869ºN, 87.32598ºW; NAD 83). 28 April 2009. Alisha Maves. Verified by Chris Phillips, Illinois Natural History Survey (INHS 2009af). New county record (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii–404 pp.). Single individual found under a wooden pallet among moist leaf litter.

Submitted by **ALISHA MAVES** and **LINDSEY LANDOWSKI,** US Fish and Wildlife Service, Patoka River National Wildlife Refuge, 510 1/2 West Morton Street, P.O. Box 217, Oakland City, Indiana 47660, USA (e-mail: Lindsey_Landowski@fws.gov).

AMPHIUMA TRIDACTYLUM (Three-toed Amphiuma). USA: ARKANSAS: Nevada Co.: 9.7 km E of Prescott off St. Hwy. 24 (33.790561ºN, 93.280106ºW; WGS 84). 06 September 1973. H. W. Robison. Verified by R. Tumlison. Henderson State University Herpetological Collection (HSU 1476). New county record. Specimen is an adult collected from a flooded roadside ditch. *Amphiuma tridactylum* has now been reported from 26 of 75 (35%) counties of the Coastal Plain of Arkansas (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.; Plummer et al. 2008. Herpetol. Rev. 39:103).

Submitted by **CHRIS T. McALLISTER**, RapidWrite, 102 Brown Street, Hot Springs National Park, Arkansas 71913, USA (e-mail: drctmcallister@aol.com); and **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@yahoo.com).

DESMOGNATHUS AENEUS (Seepage Salamander). USA: GEORGIA: Bartow Co.: Pine Log WMA, at Stamp Creek Rd. and Stamp Creek; seepage at head of first order branch N of bridge (34.25530°N, 84.68699°W; WGS 84). 12 March 2010. S. Graham and Z. Felix. AUM 38307–38310. Paulding Co.: Paulding Forest WMA, seepage along ravine and first order branch, ~ 50 m S of U.S. Hwy 278; headwaters of Raccoon Creek (33.93520°N, 84.96891°W; WGS 84). 12 March 2010. S. Graham and Z. Felix. AUM 38311–38313. All verified by Craig Guyer. New county records (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.).

Although range maps currently illustrate the distribution of seepage salamanders as continuous from the Blue Ridge Mountains of Georgia southwest through the Talladega Uplands to high elevation sites in Alabama (e.g., Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington. 587 pp.), few or no records actually support this (Jensen et al. 2008, *op. cit.*; Graham 2009. Herpetol. Rev. 40:232–233). Disjunct populations of this salamander apparently exist (Mount 1975. Amphibians and Reptiles of Alabama. Auburn Printing Co., Auburn, Alabama. 347 pp.; Graham 2009, *op. cit.*), and it was therefore possible that a distribution gap occurred in this area. These new records fill this substantial distribution gap (~ 70 km) between the nearest recorded populations to the NE in Cherokee County, Georgia, and to the SW in Haralson and Carroll Counties, Georgia, confirming that the distribution of this species is indeed continuous along the Talladega Uplands in Georgia as range maps suggest.

Sean Graham is supported in part by NIH grant R01-A149724 to T. Unnasch.

Submitted by **SEAN P. GRAHAM,** Auburn University Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA (e-mail: grahasp@auburn.edu); and **ZACH I. FELIX** Biology Department, Reinhardt College, Waleska, Georgia, USA.

EURYCEA CHAMBERLAINI (Chamberlain's Dwarf Salamander). USA: ALABAMA: Barbour Co.: Barbour County WMA; 50 m S County Rd. 49 at small tributary of Johnson Creek, ~ 1.5 km E of WMA boundary (32.00626°N, 85.40797°W; WGS 84). 26 March 2010. S. Graham and R. Birkhead. AUM 38343–38345. Henry Co.: Small branch 200 m S Hutto Pond and County Rd. 117 (31.66042°N, 85.31718°W; WGS 84). 13 May 2009. S. Graham. AUM 34913–34914. Russell Co.: Swamp S of County Rd. 163 (Huguley Rd.), ~ 4 km (by road) SE of State Rt. 51 intersection (32.40518°N, 85.33476°W; WGS 84). 26 March 2010. S. Graham and R. Birkhead. AUM 38342. All verified by Craig Guyer. New county records (Mount 1975. Amphibians and Reptiles of Alabama. Auburn Printing Co., Auburn, Alabama. 347 pp.; Graham et al. 2008. Herpetol. Rev. 39:476). These records fill a distributional gap (~ 30 km) for this species from Lee County, Alabama to the N, Bullock and Macon counties, Alabama, to the W (Graham et al. 2008, *op. cit.*), and Muscogee, Stewart, and Early counties, Georgia, to the E (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.; Graham et al. 2010. Southeast. Nat., *in press*).

S. Graham is supported in part by NIH grant R01-A149724 to T. Unnasch.

Submitted by **SEAN P. GRAHAM** Auburn University Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA (e-mail: grahasp@auburn.edu), and **ROGER D. BIRKHEAD** Alabama Science In Motion, Auburn University, Alabama, USA; (e-mail: birkhrd@auburn.edu).

GYRINOPHILUS PORPHYRITICUS (Spring Salamander). USA: ALABAMA. Randolph Co.: Small creek W of U.S. Hwy. 431, 0.32 km S of intersection with County Rd. 610. 07 March 2010. S. Graham. AUM AHAP-D 268. Digital photo. Verified by Craig Guyer. New county record (Mount 1975. Amphibians and Reptiles of Alabama. Auburn Printing Co., Auburn, Alabama. 347 pp.). Extends range ca. 40 km SE of nearest records in Cleburne County, Alabama.

Submitted by **SEAN P. GRAHAM** Auburn University Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA; e-mail: grahasp@auburn.edu.

HEMIDACTYLIUM SCUTATUM (Four-toed Salamander). USA: MASSACHUSETTS: Nantucket Co.: Nantucket, southeast shore of Sesachacha Pond near a small tributary stream (41.29231°N, 69.98880°W; WGS 84). 02 October 2009. Collected under a plywood cover board by Andrew A. McKenna-Foster. Color digital photo voucher verified by J. Martinez and J. Rosado. Museum of Comparative Zoology (MCZ A-139525). New county record (Cardoza and Mirik 2009. Massachusetts Division of Fisheries & Wildlife, State Reptiles and Amphibians List). This is the first record of this species on the island of Nantucket.

Submitted by **ANDREW A. MCKENNA-FOSTER**, Maria Mitchell Association, 4 Vestal St., Nantucket, Massachusetts 02554,

USA (e-mail: andrew.mckennafoster@gmail.com); and **SCOTT D. SMYERS**, Oxbow Associates, Inc., P.O. Box 971, Acton, Massachusetts 01720, USA (e-mail: smyers@oxbowassociates.com).

ANURA — FROGS

HYLA VERSICOLOR (Gray Treefrog). USA: PENNSYLVANIA: Clarion Co.: State Gamelands 63 wildlife pond ca. 0.15 km S from Buckhorn Rd. access (41.23532°N, 79.48662°W; WGS 84). 26 June 2009. Luke P. Bobnar and Kurt J. Regester. Verified by Charles Williams. Clarion University Vertebrate Collections and Museum (CUP A024). Adult male. New county record (Hulse et al. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York. xii + 419 pp.).

Submitted by **LUKE P. BOBNAR** (e-mail: s_lpbobnar@clarion.edu), and **KURT J. REGESTER**, Department of Biology, Clarion University, Clarion, Pennsylvania 16214, USA.

PSEUDACRIS BRACHYPHONA (Mountain Chorus Frog). USA: ALABAMA: Randolph Co.: Seepage E of U.S. Hwy. 431, 0.64 km S of Big Buck Rd. intersection (33.43538°N, 85.55646°W; WGS 84). 07 March 2010. S. Graham. AUM AHAP-D 269. Digital video file with audio. New county record (Mount 1975. Amphibians and Reptiles of Alabama. Auburn Printing Co., Auburn, Alabama. 347 pp.). Chorus of calling males recorded. GEORGIA: Haralson Co.: (Mountain View Rd. East, 50 m N of Tallapoosa River (33.87875°N, 85.16297°W; WGS 84). 12 March 2010. S. Graham. AUM AHAP-D 271. Video file with audio. Single male recorded calling. GEORGIA: Polk Co.: At intersection of Cobb Mountain Rd. and Mountain View Rd. (33.90718°N, 85.19728°W; WGS 84). 12 March 2010. S. Graham. AUM AHAP-D 270. Video file with audio. Single male recorded calling. New county records (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). All identifications verified by Craig Guyer.

Range maps illustrate the distribution of *Pseudacris brachyphona* as continuous from the Blue Ridge Mountains of Georgia west through the Talladega Uplands to high elevation sites in Alabama (Mount 1975, *op. cit.*; Jensen et al. 2008, *op. cit.*), however, records are lacking for portions of this presumably continuous range. These new records fill a distribution gap (~ 70 km) between the nearest recorded populations to the E in Paulding County, Georgia, and to the SW in Cleburne County, Alabama, confirming that populations occur along the Georgia section of the Talladega Uplands, and that the distribution of this species is indeed continuous here as range maps suggest.

Submitted by **SEAN P. GRAHAM,** Auburn University, Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA; e-mail: grahasp@auburn.edu.

PSEUDACRIS CRUCIFER (Spring Peeper). USA: GEORGIA: Haralson Co.: Coppermine Rd., 100 m E of intersection of Coppermine Rd. and Corinth-Five Points Rd. (33.83487°N, 85.12062°W; WGS 84). 12 March 2010. S. Graham. AUM AHAP-D 272. Video file with audio. Verified by Craig Guyer. New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). Chorus of multiple males recorded.

Submitted by **SEAN P. GRAHAM,** Auburn University, Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA; e-mail: grahasp@auburn.edu.

PSEUDACRIS CRUCIFER (Spring Peeper). USA: TENNESSEE: Hamilton Co.: Volunteer Army Ammunition Plant site (35.10437°N, 85.13053°W; WGS 84). 20 April 2009. Daniel S. Armstrong, Joseph F. Simpson, Thomas P. Wilson. Verified by C. Manis. UT Chattanooga Natural History Museum (TPW/UTCH-ERP 4657). First record for Hamilton County (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Misc. Publ. No. 12, The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee, 19 pp. Hard copy and Internet [http://www.apsu.edu/amatlas/]. Accessed 20 April 2009). Specimen collected using a drift fence/pitfall array surrounding an ephemeral wetland. Voucher collected under Tennessee Wildlife Resources Agency Permit 3082 and UTC AUP No. 0408TPW-04.

Submitted by **JOSEPH F. SIMPSON** (e-mail: joseph-simpson@utc.edu), **DANIEL S. ARMSTRONG** (e-mail: daniel-armstrong@utc.edu), and **THOMAS P. WILSON**, Department of Biological and Environmental Sciences, University of Tennessee at Chattanooga, 615 McCallie Avenue, Chattanooga, Tennessee 37403, USA (e-mail: thomas-wilson@utc.edu)

PSEUDACRIS FERIARUM (Upland Chorus Frog). USA: GEORGIA: Haralson Co.: Coppermine Rd., 100 m E of intersection of Coppermine Rd and Corinth-Five Points Rd. (33.83487°N, 85.12062°W; WGS 84). 12 March 2010. S. Graham. AUM AHAP-D 272. Video file with audio. Chorus of calling males recorded. Paulding Co.: Seepage at head of first order branch S of U.S. Hwy. 278 (33.93227°N, 84.97599°W; WGS 84). 12 March 2010. Z. Felix. AUM AHAP-D 267. Audio file. Chorus of calling males recorded. All verified by Craig Guyer. New county records (Jensen et al. 2008. Amphibians and Reptiles of Georgia, University of Georgia Press, Athens, Georgia. 575 pp.).

Submitted by **ZACH I. FELIX,** Biology Department, Reinhardt College, Waleska, Georgia 30183, USA (e-mail: zif@reinhardt.edu); and **SEAN P. GRAHAM,** Auburn University, Department of Biological Sciences, 331 Funchess Hall, Auburn, Alabama 36849, USA (e-mail: grahaspauburn.edu).

GYMNOPHIONA — CAECILIANS

GEOTRYPETES SERAPHINI (Gaboon Caecilian). REPUBLIC OF CONGO. Mayongongo Village (04.11ºS; 14.57ºE; no datum available; elev. 331 m.) 09 December 2008. USNM 576262. Verified by George Zug. First records from the southern Republic of Congo. Two individuals (one collected) captured by villager, Célestine Louboko, while digging at edge of river in degraded forest near manioc field. Specimens were preserved, including tissue sampling and testing for chytrid fungus by Ange-Ghislain Zassi-Boulou and Sylvestre Boudzoumou, Groupe D'Etude et de Recherche sur la Diversité Biologique, Brazzaville, Republic of Congo. Previously reported from Gabon, Democratic Republic of Congo, Ivory Coast, and Ghana (Dumeril 1859. Arch. Mus. Natl. Hist. Nat. Paris 10:222; Laurent 1974. Copeia 1974:787–788; Rödel and Branch 2002. Salamandra 38:245–268; Rödel et al.

2005. Salamandra 41:107–127). Presence in southern Republic of Congo assumed (e.g., www.amphibiaweb.org), but not previously documented.

Submitted by **ANGE-GHISLAIN ZASSI-BOULOU** and **SYLVESTRE BOUDZOUMOU**, GERDIB (Groupe D'Etude et de Recherche sur la Diversité Biologique), BP: 2400, Brazzaville, Republic of Congo; and **KATE JACKSON**, Whitman College, Walla Walla, Washington 99362, USA (e-mail: jacksok@whitman.edu).

***POTAMOTYPHLUS KAUPII*.** BRAZIL: MARANHÃO: Municipality of Estreito (06.58459ºS, 47.44936ºW; no datum available), Tocantins River, Estreito hydroelectric power plant (UHE Estreito). 16 September 2007. I. Martins. Herpetological collection Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP 141871). Verified by H. Zaher. Previous general references to Amazon and Orinoco drainage systems of Colombia, Venezuela, Ecuador, Peru, and Brazil, below 500 m (Caramaschi and Pombal 2000. Herpetol. Rev. 31:49; Frost 2010. Amphibian Species of the World: an Online Reference. Version 5.4 [8 April 2010]. Electronic database accessible at: http:research.amnh.org/vz/herpetology/amphibia/, American Museum of Natural History, New York; Taylor 1968. The Caecilians of the World. A Taxonomic Review. Univ. Kansas Press, Lawrence. xiv + 848 pp.; Wilkinson et. al. 2004. IUCN Red List of Threatened Species. Version 2009. A Taxonomic and Geographical Reference. Allen Press, Inc., Lawrence, Kansas. vi+732 pp.). First record for the state of Maranhão and upper Tocantins River and also the first record for Cerrado biome. this is southern limit of the distribution, located 800 km from the previous southern limit of distribution at Amapá (Caramaschi and Pombal 2000, *op. cit.)*.

Submitted by **CARLOS EDUARDO DOMINGOS CINTRA**[2], **HELDER LUCIO RODRIGUES SILVA**[1,2], **FERNANDA ANZILIERO GONÇALVES**[2], and **NELSON JORGE DA SILVA JR.**[1,2]. [1]Universidade Católica de Goiás, Centro de Estudos e Pesquisas Biológicas – CEPB, Av. Universitária, 1440, S. Universitário, CEP 74.605-010, Goiânia, Goiás, Brazil; [2] Systema Naturae Consultoria Ambiental Ltda., Rua 58, N. 217, Jardim Goiás, Goiânia, Goiás, Brazil, CEP 74.810-250.

CROCODILIA — CROCODILIANS

ALLIGATOR MISSISSIPIENSIS (American Alligator). USA: GEORGIA: Miller Co.: Mayhaw Wildlife Management Area, 0.26 mi NE junction Griggs Lucille Road and Cypres Creek (31.19848°N, 84.79229°W; WGS84). 03 March 2006. Collected by A. M. Durso and UGA herpetology class. Verified by Kenneth L. Krysko. FLMNH 157207. First county record documented by a voucher (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia. 575 pp.). The carcass of a subadult *A. mississipiensis* was found by the margin of a pond. This record lies ca. 18.7 km S of a 1997 record from Early County, Georgia (Moulis 1997. Status Survey of Barbour's Map Turtle [*Graptemys barbouri*] in Georgia. Unpubl. report to Georgia DNR. 38 pp. + appendices).

Submitted by **ANDREW M. DURSO**, Eastern Illinois University, Department of Biological Sciences, Charleston, Illinois 61920, USA; e-mail: amdurso@gmail.com.

TESTUDINES — TURTLES

APALONE MUTICA MUTICA (Midland Smooth Softshell). USA: IOWA: Butler Co.: S bank of West Fork Cedar River, ca. 1 km NE of Co Rd T-55 bridge, 9.2 km N of New Hartford (42.636867°N, 92.6379°W; WGS84). 278 m elev. 28 June 2004. Jeffrey W. Tamplin and Matt Keller. Verified by James W. Demastes. University of Northern Iowa Vertebrate Collection (UNI-JWT13). New county record. Extends the species' range into the West Fork Cedar River drainage in Iowa. *Apalone mutica* inhabits the Missouri, Mississippi, lower Cedar, Iowa, and Des Moines river drainages in Iowa but is thought to be absent from interior river systems in northern Iowa (Christiansen and Bailey 1997. The Lizards and Turtles of Iowa. Iowa Department of Natural Resources, Nongame Technical Series No. 3. Des Moines, Iowa. 20 pp.; Ernst and Lovich 2009. Turtles of the United States and Canada. 2nd edition. Johns Hopkins Univ. Press, Baltimore, Maryland. 828 pp.; http://www.herpnet.net/Iowa-Herpetology/). Adult *A. mutica* have been trapped and released along the West Fork Cedar River in Butler County, Iowa since 2004 and successful nesting has been observed since 2006. Habitat is riverine with a sand and gravel bottom, containing sand bars and sandy stream banks; banks are lined with patchy clearings of grasses and willow (*Salix* sp.) saplings, interspersed among deciduous woodlands.

Submitted by **JEFFREY W. TAMPLIN**, Department of Biology, University of Northern Iowa, 1227 W 27th Street, Cedar Falls, Iowa 50614, USA; e-mail: jeff.tamplin@uni.edu.

MORENIA PETERSI (Indian Eyed Turtle). INDIA: UTTARKHAND: Haridwar, Bhikampur, Laksar Road (29.44ºN, 78.02ºE; no datum available). Archana Bahuguna. 29 August 2009. ZSI NRC 02. Verified by Indraneil Das. First record from Uttarakhand State. From marshy area. Previously known from Assam, Bihar, West Bengal, and Uttar Pradesh in India, as well as Nepal and Bangladesh (Das 1995. Turtles and tortoises of India. Oxford University Press, Bombay. x + 176 pp.). Extends range west ca. 400 km from Dudhwa National Park, Uttar Pradesh, reported by Javed and Hanfee (1995. Hamadryad 20:21–26).

Submitted by **ARCHANA BAHUGUNA**, Northern Regional Centre, Zoological Survey of India, 218, Kaulagarh Road, Dehra Dun 248 195 Uttarakhand, India; e-mail: archana.bahuguna65@gmail.com.

TERRAPENE CAROLINA (Eastern Box Turtle). USA: INDIANA: Gibson Co.: Patoka River National Wildlife Refuge and Management Area (38.37535ºN, 87.35398ºW; NAD 83). 22 April 2009. Sarabeth Klueh, Angela Garcia, and Alisha Maves. Verified by Chris Phillips, Illinois Natural History Survey (INHS 2009ah). New county record. (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.)

Submitted by **SARABETH KLUEH** (e-mail: sklueh@dnr.in.gov) and **ANGELA GARCIA**, Wildlife Diversity Section, Indiana Department of Natural Resources Division of Fish and Wildlife, 553 E. Miller Drive, Bloomington, Indiana 47401, USA; **ALISHA MAVES** and **LINDSEY LANDOWSKI** (e-mail: Lindsey_Landowski@fws.gov), US Fish and Wildlife Service, Patoka River National Wildlife Refuge, 510 1/2 West Morton Street, P.O.

Box 217, Oakland City, Indiana 47660, USA.

TRACHEMYS VENUSTA (Mesoamerican Slider). USA: FLORIDA: Gilchrist Co.: Santa Fe River, 1.2 km downstream from Rum Island (29.834354°N, 82.690575°W; datum WGS84). 19 January 2010. Matthew H. Kail. Verified by Kurt Buhlmann and Michael Seidel. Florida Museum of Natural History (UF 157304). New state record. Adult male (straight carapace length 243 mm, plastron length 216 mm, mass 1690 g) captured by hand at 2130 h along the northern shoreline. High leech load (80–100 leeches) and presence of algae on carapace suggest that this is not a recently released captive. This non-native species may potentially harm the closely related native Yellow-bellied Slider (*Trachemys scripta scripta*) population through interbreeding and genetic introgression.

Submitted by **MATTHEW H. KAIL** (e-mail: snappergi@aol.com), and **DARCY T. GARRENTON**, Teaching Zoo, Santa Fe College, Gainesville, Florida 32606, USA (e-mail: dgarrent@kent.edu); **ERIC SUAREZ**, Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida 32611, USA (e-mail: eric.suarez725@yahoo.com); **GERALD R. JOHNSTON**, Department of Natural Sciences, Santa Fe College, Gainesville, Florida 32606, USA (e-mail: jerry.johnston@sfcollege.edu); and **JOSEPH C. MITCHELL**, Mitchell Ecological Research Services, Gainesville, Florida 32627, USA (e-mail: dr.joe.mitchell@gmail.com).

SQUAMATA — LIZARDS

ANOLIS (=NOROPS) SAGREI (Cuban Brown Anole). USA: TEXAS: Fort Bend Co.: Collected in author's backyard (29.702888°N, 95.790955°W; WGS84). 10 March 2010. A. Wood. Texas Cooperative Wildlife Collection (TCWC 94268). Verified by James R. Dixon. New county record (Dixon 2000. Amphibians and Reptiles of Texas. 2nd ed., Texas A&M Univ. Press, College Station, 421 pp.)

Submitted by **ADAM WOOD**, 24018 Seventh Heaven, Katy, Texas 77494, USA; e-mail: saleenadam@hotmail.com.

ANOTOSAURA VANZOLINIA. BRAZIL: RIO GRANDE DO NORTE: Municipality of Tenente Laurentino Cruz, Serra Nova (06.109°S, 36.719°W; datum WGS84, elev 704 m). 21 September 2009; 21 and 23 October 2009. L. Barros Ribeiro. Coleção Herpetológica do Departamento de Botânica, Ecologia e Zoologia, Universidade Federal do Rio Grande do Norte, Natal. Rio Grande do Norte (CHBEZ 2863, 2924, 2925). Verified by M. T. Rodrigues. First state record, extends the known geographical distribution of this species ca. 135 km N from the nearest record in the municipalities of São José dos Cordeiros/Sumé (Reserva Particular do Patrimônio Natural Fazenda Almas) (07.471°S, 36.881°W), state of Paraíba.

The gymnophthalmid lizard *Anotosaura vanzolinia* has been found in Rui Barbosa, Bahia State (Freitas and Silva 2007. Guia Ilustrado: a Herpetofauna das Caatingas e Áreas de Altitudes do Nordeste Brasileiro. Editora USEB, Pelotas, Brazil. 384 pp.); Agrestina (type locality) and district of Serra Negra, Bezerros municipality, state of Pernambuco (Rodrigues 1986. Pap. Avul. Zool. 36[20]: 237–250); Cabaceiras (Rodrigues 1986, *op. cit.*); São José da Mata (Delfim and Freire 2007. Oecol. Bras. 11[3]:365–382), São José dos Cordeiros and Sumé (Reserva Particular do Patrimônio Natural Fazenda Almas) in the state of Paraíba (Freire et al. 2009. *In* E. M. X. Freire [org.], Répteis Squamata das Caatingas do Seridó do Rio Grande do Norte e do Cariri da Paraíba: Síntese do Conhecimento Atual e Perspectivas, pp. 51–84. Editora da UFRN. Natal, RN, Brazil).

Submitted by **MELISSA GOGLIATH** (e-mail: melbiologa@gmail.com)[1,2], **LEONARDO B. RIBEIRO** (e-mail: ribeiro.lb@gmail.com)[1,2], and **ELIZA M. X. FREIRE** (e-mail: elizajuju@ufrnet.br)[1,2], [1]Laboratório de Herpetologia, Departamento de Botânica, Ecologia e Zoologia, Centro de Biociências, Universidade Federal do Rio Grande do Norte, Campus Universitário, 59072-970, Natal, RN, Brazil; [2]Programa de Pós-graduação em Psicobiologia/ Universidade Federal do Rio Grande do Norte, 59078-970, Natal, RN, Brazil.

ASPIDOSCELIS SEXLINEATA (Six-lined Racerunner). USA: ILLINOIS: Hancock Co.: One *Aspidoscelis sexlineata* was captured on the Mississippi River sand levee south of Warsaw, Illinois (40.34295ºN, 91.44906ºW; WGS 84). 09 August 2009. James T. Lamer and Terri L. Tobias. Illinois Natural History Survey (INHS) 21467. 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, 282 pp.). Four other individuals were observed in the area.

Submitted by **TERRI L. TOBIAS** and **JAMES T. LAMER,** Western Illinois University, Alice Kibbe Field Station, Warsaw, Illinois 62379, USA.

CHAMAELEO GRACILIS (Slender Chamaeleon). MALI: SIKASSO REGION: 8 km E of Yanfolila (11.11ºN, 08.04ºW; no datum available). 05 July 2008. Sébastien Trape. Institut de Recherche pour le Développement at Dakar (IRD TR-2953). Verified by Laurent Chirio. First record for Mali where only *Chamaleo senegalensis* and *C. africanus* were previously known (Joger and Lambert 1996. *In* Ulrich [ed.], Tropical Biodiversity and Systematics. Proceeding of the International Symposium on Biodiversity and Systematics in Tropical Ecosystems, Bonn, 1994, pp. 189–202. Zoologisches Forschunginstitut und Museum Alexander Koening, Bonn; TIGR Reptile Database 2009. http://www.reptile.database.org/. Accessed December 2009).

Submitted by **SEBASTIEN TRAPE**, Laboratoire ECOLAG, Université Montpellier II, 34095 Montpellier Cedex 5, France; e-mail: sebastien_trape@yahoo.fr.

DAREVSKIA BRAUNERI SZCZERBAKI (Rock Lizard). GEORGIA: ABKHAZIA: Gudauta District: Lzaa village, Pitsunda-Myussera Hills. ZISP 24397, 25816–25818. 17 April 2006. Three specimens found by Konstantin Milto and Mark Pestov. Several specimens were registered in 5–7 July, 7–9 August 2008, and 7–12 August 2009 by Mark Pestov and Olga Bezman-Moseyko. Verified by Ilya S. Darevsky. Lizards observed on clay-rock cliffs of Black Sea coast between Lzaa settlement (43.16813ºN, 40.4108ºE; no datum available) and mouth of Mysra River (43.15009ºN, 40.45921ºE). Known from a small territory on northeastern coast of Black Sea in Krasnodar Region, Russia, and a subspecies endemic to Crimea-Novorossisk subprovince of East Mediterranean Province in Caucasus, inhabiting narrow coastal zone from Anapa

town to Cape of Utrish. This new locality, 297 km to southeast from earlier localities, may be the southernmost border of the range, and is a first record for the country.

Submitted by **KONSTANTIN D. MILTO** (e-mail: coluber@zin.ru), **MARK V. PESTOV**, and **OLGA S. BEZMAN-MOSEYKO**, Zoological Institute, Department of Herpetology, St. Petersburg, Universitetskaya emb., 1, 199034, Russia.

MESALINA BREVIROSTRIS (Short-nosed Desert Racer). IRAN: SISTAN & BALUCHISTAN PROVINCE: Gando Protected Area: Garm Beet (61.30ºN, 25.47ºE; ca. 146 m elev.). Nastaran Heydari. 20 October 2008. Verified by Steven C. Anderson. Zoology Museum Golestan University, ZMGU 2429. First confirmed record for Sistan and Baluchistan Province. Associated with *Phoenixdactylifera*, *Prosopis cineraria,* and *Nannorhops ritchieana* in lowland sandy hills. 850 km E of nearest record (Qeshm Island and Mahor Birinji; Anderson 1999. The Lizards of Iran. Society for the Study of Amphibians and Reptiles, Ithaca, New York. 415 pp.; Haas and Werner 1969. Bull. Mus. Comp. Zool., Harvard Univ. 138[6]:327–405)**.**

Submitted by **NASTARAN HEYDARI**, Department of Biodiversity, Khuzestan University of Science and Research, Ahwaz, Iran (e-mail: heydari.pr@gmail.com); **HAJI GHOLI KAMI,** Department of Biology, Faculty of Sciences, Golestan University, Gorgan, Golestan Province, Iran (e-mail: hgkami2000@yahoo.com); and **SOHEILA SHAFIEI**, Department of Biology, Faculty of Science, Shahid Bahonar University of Kerman, Iran (e-mail: shafiei_soheila@yahoo.com).

PANASPIS NIMBAENSIS (Mount Nimba Lidless Skink). SENEGAL: ZIGUINCHOR REGION: Djibonker (12.32ºN, 16.21ºW; no datum available). 01 March 2009. Sébastien Trape. Institut de Recherche pour le Développement at Dakar (IRD TR-2954). Verified by Laurent Chirio. First record for Senegal (Cisse and Karns 1978. Bull. IFAN. 40A:144–211; TIGR Reptile Database 2009. http://www.reptile.database.org/. Accessed December 2009). Species previously reported from Guinea (Angel 1944. Bull. Mus. Nat. Hist. nat. Paris. 16:293–294), Ivory Coast (Barbault 1974. Bull. Soc. Zool. France. 99:345–361), and Gambia (Emms et al. 2007. Herpetol. Bull. 99:3–18).

Submitted by **SEBASTIEN TRAPE**, Laboratoire ECOLAG, Université Montpellier II, 34095 Montpellier Cedex 5, France; e-mail: sebastien_trape@yahoo.fr.

PLESTIODON FASCIATUS (Five-lined Skink). CANADA: ONTARIO: Lambton Co.: Village of Point Edward, ca. 60 m from shore of St. Clair River (42.992970ºN, 82.410727ºW; WGS 84). 20 May 2009. Daniel W. A. Noble and Jonathan D. Choquette. Verified by Ross D. MacCulloch. Royal Ontario Museum photographic vouchers (ROMdm 00251–00254). First municipality record and first observations in vicinity since 1932. Nearest record is historical from ca. 6 km S in the city of Sarnia, Ontario in 1932 (NMC 1740; Patch 1934. Copeia 1934:50–51). The Sarnia population (NHIC EO 16753) is considered extirpated by Ontario Ministry of Natural Resources Natural History Information Centre (NHIC). Records exist for only two other distant locations in Lambton County (both extant): Walpole Island (NHIC EO 1218) 45 km S and Pinery Provincial Park (NHIC EO 1212) 55 km NE. Three skinks (1 male, 1 female, 1 juvenile) were observed in a pile of logs, railway ties, and metal pipes in an isolated marina waste area. Two juveniles were observed 26 August and five juveniles on 11 September 2009 at same site. All were actively foraging or basking.

Submitted by **JONATHAN D. CHOQUETTE**, School of Environmental Design and Rural Development, University of Guelph, Guelph, Ontario N1G 2W1, Canada (e-mail: jchoquet@uoguelph.ca); **STEPHEN J. HECNAR**, Department of Biology, Lakehead University, Thunder Bay, Ontario P7B 5E1, Canada (e-mail: shecnar@lakeheadu.ca); **DANIEL W. A. NOBLE** (e-mail: nobled@uoguelph.ca), and **RONALD J. BROOKS**, Department of Integrative Biology, University of Guelph, Ontario N1G 2W1; (e-mail: rjbrooks@uoguelph.ca).

SQUAMATA — SNAKES

CROTALUS HORRIDUS (Timber Rattlesnake). USA: FLORIDA: Volusia Co.: Lake Woodruff National Wildlife Refuge (29.105°N, 81.36697°W; WGS84). 20 July 2009. Wesley Allie and Wyatt Brouillard. Florida Museum of Natural History (UF 155622). Verified by Kenneth Krysko. First state record. Extends distribution ca. 61.2 km SE of nearest locality, Silver River State Park (Ashton and Ashton 1988. Handbook of Reptiles and Amphibians of Florida. Part One: The Snakes. Revised edition. Windward Publ. Co., Miami, Florida. 176 pp.).

Submitted by **W. BOYD BLIHOVDE** (e-mail: boyd_blihovde@fws.gov) and **KELLY A. BRADY,** Lake Woodruff National Wildlife Refuge, 2045 Mud Lake Road, DeLeon Springs, Florida 32130, USA (e-mail: kbrady@stetson.edu).

EUNECTES MURINUS (Green Anaconda). BRAZIL: PIAUÍ: Municipality of Ilha Grande, Delta of Parnaíba River, locality of Saquim (2.775656°S, 41.804756°W; datum WGS84). 13 October 2008. E. B. de Andrade and P. da C. Silva. Coleção Herpetológica do Museu Paraense Emílio Goeldi, Belém, Brazil (MPEG 23.36). Verified by T. C. Ávila-Pires. Species distributed in Trinidad Island, Venezuela, Colombia, Peru, Ecuador, Guiana, French Guiana, Suriname, and Brazil (Amazon Basin, central, and northeastern Brazil (Cunha and Nascimento 1993. Bol. Mus. Para. Emílio Goeldi, sér. Zool. 9[1]:1–191; Freitas and Silva 2007. A Herpetofauna das Caatingas e Áreas de Altitudes do Nordeste Brasileiro. 384 pp.). First record for state of Piauí, extending range ca. 332 km NE from the municipality of Arari, state of Maranhão (Cunha and Nascimento 1993, *op. cit.*) and ca. 390 km W from the municipality of Aquiraz, state of Ceará (Mendonça et al. 2009. Herpetol. Rev. 40:238).

Submitted by **ROBERTA R. DA SILVA-LEITE,** Universidade Federal do Piauí, Campus Ministro Reis Velloso, Av. São Sebastião nº 2819, Parnaíba, Piauí, Brazil, CEP 64202-020 (e-mail: Roberta.ufpi@gmail.com); **IGOR JOVENTINO ROBERTO**, Aquasis - Associação de Pesquisa e Preservação de Ecossistemas Aquáticos, Programa Biodiversidade. Praia de Iparana s/n, SESC Iparana, Caucaia, Ceará, Brazil, CEP 61627-010; **DANIEL LOEBMANN,** Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Rio Claro, São Paulo, Brazil, Caixa Postal 199, CEP 13506-970; **THIAGO DA SILVA NASCIMENTO**, Universidade Federal do Piauí, Campus Ministro Reis Velloso, Av. São Sebastião nº 2819, Parnaíba, Piauí, Brazil, CEP 64202-020; **PEDRO DA COSTA**

SILVA, Associação de Guias e Condutores de Turismo de Ilha Grande, Centro, Ilha Grande, Piauí, Brazil, CEP 64224-970.

HETERODON PLATIRHINOS (Eastern Hog-nosed Snake). USA: ILLINOIS: Schulyler Co.: 2.3 km SW of Sugar Grove, 0.2 km N of jct. Co. Rd. 1700E (La Grange Lock Road.) and Co. Rd 270N (Quarry Road.) on Co. Rd. 1700E (40.0122°N, 90.5871°W; NAD 83). 10 May 2007. J. E. Petzing and K. L. Knuffman. Verified by C. A. Phillips. Illinois Natural History Survey (INHS) 20531. First county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. 300 pp.). DOR adult.

Submitted by **JOHN E. PETZING**, 1018 Prickett Avenue, Edwardsville, Illinois 62025, USA; e-mail: jepetzing@yahoo.com.

OPHEODRYS VERNALIS (Smooth Green Snake). USA: MINNESOTA: Houston Co.: County Hwy 26 ca. 4.8 km N of Reno (43.64493°N, 91.27580°W; WGS 84). 19 September 2009. Found DOR, photographic records were deposited in the James Ford Bell Museum (JFBM P316). Verified by Kenneth H. Kozak and Amy M Luxbacher. Oldfield and Moriarty (1994. Amphibians & Reptiles Native to Minnesota. Univ. Minnesota Press, Minneapolis. 237 pp.) list no museum record for this species in Houston County but do plot its occurrence with a symbol representing sightings or literature records. To the best of our knowledge this is the first vouchered specimen for Houston County.

Submitted by **ERICA P. HOAGLUND**, Minnesota Department of Natural Resources, Division of Ecological Resources, Nongame Wildlife, 1335 Oakdale Ave. Apt. 209, West Saint Paul, Minnesota 55118, USA (e-mail: Erica.Hoaglund@dnr.state.mn.us); and **CHRISTOPHER E. SMITH**, Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, 1980 Folwell Avenue, Saint Paul, Minnesota 55108, USA; (e-mail: smit4155@umn.edu).

SONORA SEMIANNULATA SEMIANNULATA (Variable Groundsnake). USA: NEVADA: Lander Co.: Shoshone Range, 34.8 air miles N of Austin (39.99452°N, 117.14979°W; WGS84), elev. 1680 m. 12 June 2009. J. Shedd. Verified by J. Vindum. California Academy of Sciences photo voucher (HPV 62). First documented account from Lander County aside from two unverified reports from the vicinity of Battle Mountain (L. Teske, pers. comm.). Only one other specimen (CAS-SUR 10032) of this species is formally documented from Lander County, at 22 mi E of Battle Mountain. This distance from Battle Mountain appears to actually be Eureka County by both road or air miles. Found under rock after heavy rains at 1100 h. The specimen was orange and black-saddled morph. Predominant vegetation consisted of *Artemisia tridentata*, *Atriplex confertifolia,* and *Chrysothamnus viscidiflorus*. Sheds from two other individuals also found in the vicinity under rocks.

Submitted by **JACKSON D. SHEDD**, 516 Civic Center Drive, Oceanside, California 92054, USA (e-mail: jackson.shedd@gmail.com); and **GUSTAVO GONZALEZ**, P.O. Box 873, McGill, Nevada 89318, USA.

STORERIA DEKAYI WRIGHTORUM (Midland Brownsnake). USA: ILLINOIS: Whiteside Co.: SE of Fulton, tributary of Cattail Creek at Union Pacific RR trestle/overpass just W of Chase Road (41.8448°N, 90.1405°W; NAD 83). 05 October 2007. J. E. Petzing. Verified by C. A. Phillips. Illinois Natural History Survey (INHS) 20865. First county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv. Manual 8, Champaign, Illinois. 300 pp.). Adult collected on east bank of tributary.

Submitted by **JOHN E. PETZING**, 1018 Prickett Avenue, Edwardsville, Illinois 62025, USA; e-mail: jepetzing@yahoo.com.

THAMNODYNASTES ALMAE (NCN). **BRAZIL:** PARAÍBA**:** Cabaceiras: Fazenda Bravo (7.483333ºS, 36.283333ºW; WGS84). 28 February 2003. S. Abrantes et al. Universidade Federal da Paraíba (UFPB 4263); BAHIA: Itiúba (10.700000ºS, 39.850000ºW; WGS84). 5–9 May 1973. Expedition ABC-MZUSP. Museu de Zoologia da Universidade de São Paulo (MZUSP 5433–34) and Paulo Afonso (9.400000ºS, 38.216667ºW; WGS84). 22 March and 10 April 1988. Anonymous collector. Museu de Zoologia da Universidade Federal da Bahia (MZUFBA 131–38); PERNAMBUCO: Petrolândia (9.133333ºS, 38.300000ºW; WGS84). 20 April 1988. Companhia Hidroelétrica do São Francisco. Instituto Butantan (IB 52119). ALAGOAS: Piranhas (9.616667ºS, 37.750000ºW; WGS84). 29 April 1994. Companhia Hidroelétrica de Xingó. Museu de Zoologia da Universidade Federal da Bahia (MZUFBA 847). All verified by F. L. Franco. The species was known from the type locality, Rodelas municipality, Bahia state (Franco and Ferreira 2002. Phyllomedusa 1:57–74) and a recent record in Milagres, Ceará state (Roberto et al. 2009. Herpetol. Rev. 40:238). First records for the states of Paraíba, Pernambuco, and Alagoas, all in Caatinga habitats, extending range ca. 289 km NE and the two new records from Bahia extend the range ca. 244 km S from type locality (Franco and Ferreira 2002, *op. cit.*). Funded by FAPESP (2009/50627-4).

Submitted by **THAÍS BARRETO GUEDES,** Laboratório de Ecologia e Evolução, Instituto Butantan, Av. Vital Brazil 1500, CEP 05503-900, São Paulo, SP, Brazil; e-mail: thaisguedes@butantan.gov.br.

THAMNOPHIS PROXIMUS PROXIMUS (Orange-striped Ribbonsnake). USA: IOWA: Bremer Co.: Sweet Marsh Wildlife Management Area, 1.6 km NW of Co Rd C-28 and Sable Avenue Intersection, 3.3 km NE of Tripoli (42.812997°N, 92.217967°W; WGS84). 303 m elev. 30 April 2004. Jeffrey W. Tamplin, Thomas F. Bierman, and Gretchen R. Spies. Verified by James W. Demastes. University of Northern Iowa Vertebrate Collection (UNI-JWT15). New county record extends the species' range into northeastern Iowa. *Thamnophis proximus* occurs across southern Iowa but was thought to be absent from north-central and northeastern Iowa (Christiansen and Bailey 1990. The Snakes of Iowa. Iowa Department of Natural Resources, Nongame Tech. Ser. No. 1. Des Moines, Iowa. 16 pp.; Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, D.C. 668 pp.; http://www.herpnet.net/Iowa-Herpetology/). Two adults were observed mating at ca. 1530 h. After mating was completed the male was collected as a voucher specimen. Habitat was a grassy clearing with forbs and small saplings, adjacent to marshes and cultivated fields.

Submitted by **JEFFREY W. TAMPLIN**, Department of Biol-

ogy, University of Northern Iowa, 1227 W 27th Street, Cedar Falls, Iowa 50614, USA; e-mail: jeff.tamplin@uni.edu.

VIRGINIA VALERIAE ELEGANS (Western Smooth Earthsnake). USA: ARKANSAS: Cleveland Co.: 3.2 km SE of Kingsland off St. Hwy. 97 (33.834775°N, 92.287903°W; WGS 84). 14 June 1986. D. Ragland. Verified by R. Tumlison. Henderson State University Herpetological Collection (HSU 1477). New county record. Partially fills a distributional hiatus among Bradley and Ouachita counties (McAllister and Robison 2009. Herpetol. Rev. 40:367; Robison and Daniel. 2006. Herpetol. Rev. 37:502; Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.).

Submitted by **CHRIS T. McALLISTER**, RapidWrite, 102 Brown Street, Hot Springs National Park, Arkansas 71913, USA (e-mail: drctmcallister@aol.com); and **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@yahoo.com).

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More Range Extensions for Papuan Reptiles and Amphibians

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The herpetofauna of the Papuan region—comprising New Guinea, the Solomon Islands, and associated satellite islands—is extremely rich but remains relatively poorly known. Hundreds of species likely remain to be discovered, scores are known but remain to be described, geographic ranges of known species are often poorly understood, and important parts of the region remain sparsely surveyed. Recent work has considerably expanded our knowledge of species' distributional ranges in this region (Günther 2003; Kraus and Allison 2004, 2006a; Kraus and Shea 2005), but much remains to be done. Much of this recent expansion in our understanding has resulted from expeditions to previously unstudied localities. However, additional relevant information already resides in museum collections but has remained unsurveyed. Herein I report a number of significant range extensions for amphibians and reptiles from New Guinea, the majority of these records coming from the holdings of the Australian Museum in Sydney and the Bishop Museum in Honolulu, but supplemented with additional records from the Museum of Comparative Zoology and United States National Museum. Coordinates for BPBM specimens use the AGD66 datum unless otherwise noted; those from other museums are taken from their catalogues, converted by me to decimal degrees, and presumably were taken from maps using the AGD66 datum.

Frogs

Albericus darlingtoni. PAPUA NEW GUINEA: Southern Highlands Prov.: E slope Mt. Itukua, Muller Range, 5.66954°S, 142.62334°E (WGS84 datum), 2177 m elev. 26–30 March 2009. F. Kraus, J. Anamiato. BPBM 33664–33668. Range extension of ca. 125 km WNW of nearest locality at Mendi (Menzies 1999).

Albericus gunnari. PAPUA NEW GUINEA: Central Prov.: Dorobisoro, 9.4592391ºS, 147.9371584ºE, 600 m elev. 7–8 October 2003. F. Kraus. BPBM 18347–51; halfway between Laronu and Mimai, 8.4501811ºS, 147.9772933ºE, 1000 m elev. 14 February 2004. F. Kraus. BPBM 19223–33. Range extension of ca. 40 km to NE of type locality (Menzies 1999).

Choerophryne burtoni. PAPUA NEW GUINEA: Southern Highlands Prov.: E slope Mt. Itukua, Muller Range, 5.67046°S, 142.63038°E (WGS84 datum), 2037 m elev. 25 March 2009. native collectors. BPBM 33671. Range extension of ca. 80 km to NW of type locality at Moran area of same province (Richards et al. 2007).

Cophixalus riparius. PAPUA NEW GUINEA: Madang Prov.: Fungoi, Kaironk Valley, Schrader Mts., 5.333333ºS, 144.41666667ºE. 14 December 1963–2 January 1964. H. G. Cogger. AMS R22667–22756. First record for province and for Schrader Mts.; range extension of ca. 80 km NW of nearest locality at Mt. Wilhelm (Zweifel 1962).

Cophixalus shellyi. PAPUA NEW GUINEA: Madang Prov.: Fungoi, Kaironk Valley, Schrader Mts., 5.333333ºS, 144.41666667ºE. 24 December 1963. H. G. Cogger. AMS R23086, 23123. First records for Schrader Mts. and range extension of ca. 60 km NW of nearest locality at Wahgi-Sepik Divide (Zweifel 1980).

Cophixalus variabilis. PAPUA NEW GUINEA: Central Prov.: Sogeri Plateau, Itikinumu Rubber Plantation. 14 November 1971. G. R. Zug. USNM 197456, 231508; Northern Prov.: 10 km NNW Popondetta. 27 December 1971. G. R. Zug. USNM 197457. First record is a range extension of ca. 20 km N of previously northernmost record along Musgrave River; second is a new provincial record and first report of species along northern versant of Owen Stanley Mts. (Kraus and Allison 2006b).

Hylarana daemeli. PAPUA NEW GUINEA: New Ireland Prov.: Napus, New Hanover Island. 29 August 1973. P. Comorford. AMS R41249; Taskul, New Hanover Island. 28 August 1973. P. Comorford. AMS R41250. First record for province (Menzies 2006).
Hylarana milneana. PAPUA NEW GUINEA: Morobe Prov.: Bulolo. No date. C. Gunther. AMS R12186, 12188, 12190–95; Northern Prov.: Inamaturu, Mt. Lamington, 8º56'S, 148º10'E. No date. C. T. McNamara. AMS R9874. First records for each province, and latter is range extension of 270 km to the N; previously known only from Milne Bay and Central provinces (Kraus and Allison 2007).

Hylophorbus richardsi. PAPUA NEW GUINEA: Southern Highlands Prov.: E slope Mt. Itukua, Muller Range, 5.66954°S, 142.62334°E (WGS84 datum), 2177 m elev. 20–27 March 2009. F. Kraus, J. Anamiato, and native collectors. BPBM 33756–62. Range extension of ca. 55 km to NW of type locality at Mt. Sisa (Günther 2001).

Lechriodus platyceps. PAPUA NEW GUINEA: West Sepik Prov.: summit Mt. Somoro, Torricelli Mts., 3.392ºS, 142.133ºE. 8 March 1990. T. Flannery. AMS R136293. Second record for country, first record for Torricelli Mts., and range extension of ca. 110 km E of

Bewani Mts. (Kraus and Allison 2006a).

Liophryne allisoni. PAPUA NEW GUINEA: Central Prov.: 2.3 km SSW Fane, 8.56933ºS, 147.07675ºE, 1800 m elev. 5 October 2003. F. Kraus. BPBM 18315. New provincial record and range extension of ca. 140 km to S of area around Wau (Zweifel 2000).

Litoria auae. PAPUA NEW GUINEA: Southern Highlands Prov.: Bobole, 6.20ºS, 142.76666667ºE. October 1985. S. Donnellan. AMS R132359–71; Namosado, 6.25ºS, 142.783333ºE. 1985. S. Donnellan. AMS R132380–81. In describing this species and *L. kumae*, Menzies and Tyler (2004) noted that five poorly preserved specimens from these localities (in SAM) appeared to be *L. kumae*. However, all AMS specimens listed above have white spots, have lighter ground color than seen in *L. kumae*, and are larger (male SVL = 29.3–35.3, N = 12; female SVL = 34.2–39.8, N = 3) than that species; they clearly fit the diagnosis of *L. auae*. They thus bring the range of *L. auae* to at least the edge of the range of *L. kumae* and serve to fill in the gap between eastern populations of *L. auae* and the Ok Ma isolate to the west (Menzies and Tyler 2004).

Litoria kumae. PAPUA NEW GUINEA: Southern Highlands Prov.: 1.2 km N Tangi, 5.64700ºS, 142.65259ºE (WGS84 datum), 1660 m elev. 5 April 2009. Native collectors. BPBM 33991–400. Range extension of ca. 35 km to NW of Tari for this restricted-range species (Menzies and Tyler 2004).

Litoria purpureolata. PAPUA NEW GUINEA: West Sepik Prov.: Imonda, 3.3333ºS, 141.166667ºE. 1 March 1990. P. German. AMS R135573; vicinity of Utai aerodrome, 3.389ºS, 141.585ºE, 210 m elev. 26 April 1986. A. Allison. BPBM 14463–65, 14467; base of Mt. Sumbau, 3.38333ºS, 142.5333ºE. 8 March 1990. P. German. AMS R135576. First records for country, and range extensions of ca. 280 km, 330 km, and 470 km E of type locality (Oliver et al. 2007).

Litoria pygmaea. PAPUA NEW GUINEA: Madang Prov.: Madang. 8 September 1964. Collector unrecorded. AMS R111666. First record for province and range extension of ca. 120 km from populations in the Central Highlands (Richards and Price, 2004) and 300 km from population at Wamangu, East Sepik Province (Dahl et al. 2009).

Nyctimystes fluviatilis. PAPUA NEW GUINEA: West Sepik Prov.: Parkop, Torricelli Mts., 3.42457°S, 142.51866°E, 416 m elev. 14 May 2005. F. Kraus. BPBM 23251–52; 3.2 km SSE Mt. Sapau summit, Torricelli Mts., 3.39329°S, 142.52826°E, 550 m elev. 18–25 May 2005. F. Kraus. BPBM 23253, 23256–59, 23263–65; Wilbeite Village, Torricelli Mts., 3.416667°S, 142.116667°E, 10 June 1988. T. Flannery. AMS 130396. Western Prov.: Kavorabip, 5.133333°S, 141.11666667°E. 22 August 1972. F. Parker. MCZ 110312–13. First records for country and range extensions of ca. 450 km to E and 330 km to SE, respectively, from the type locality along the Idenburg River (Zweifel 1958).

Nyctimystes zweifeli. PAPUA NEW GUINEA: Chimbu Prov.: Doido, 6.55°S, 144.83333°E. 14 April 1985. S. Donnellan. AMS R114802, 114804; Southern Highlands Prov.: Bobole, 6.20ºS, 142.76666667ºE. October 1985. S. Donnellan. AMS R132353–58. First records for each province and range extensions of 360 km ESE and 150 km SE of the type locality at Telefomin (Tyler 1967).

Hypsilurus hikidanus. PAPUA NEW GUINEA: Chimbu Prov.: Toromambuno, Mt. Wilhelm, 5.8442028ºS, 145.1018018ºE. 4 July 1955. J. L. Gressitt. BPBM 2693–96. First record for country and range extension of 850 km to the east from type locality at Wissel Lakes (Manthey and Denzer 2006).

Hypsilurus longii. SOLOMON ISLANDS: Isabel Island: Alu Alu village, 8.3ºS, 159.55ºE. 23 February 1991. H. Parnaby and I. Aujare. AMS R137241; Kaipitu River, near Alu Alu village, 8.3ºS, 159.55ºE. 24 February 1991. H. Parnaby and I. Aujare. AMS R137243; Makira Island. 20 November 1987. G. Mengden. AMS R127290; Makira Island: Sgsgna village. 16 November 1987. T. Flannery. AMS R130465. New island records that extend the range of this species to the southern end of the Solomon Islands. Previously reported only from Bougainville at the NW end of the chain (Manthey and Denzer 2006). McCoy (2006) inferred that the Isabel Island specimens, which he had not seen, belonged to this species based on their large size. I confirm that presumption.

Hypsilurus macrolepis. SOLOMON ISLANDS: Choiseul Island: Malangona, 7.049ºS, 156.778ºE. 14 March 1964. P. Temple. BPBM 2488. New island record and range extension to NW from Santa Isabel Island (Manthey and Denzer 2006).

Hypsilurus magnus. PAPUA NEW GUINEA: Central Prov.: Moitaka, Port Moresby. September 1985. S. Donnellan and K. Aplin. AMS R122448; Madang Prov.: Warius River, 5.9592435ºS, 145.86632ºE, 400 m elev. 31 August 1987. C. P. Kendrick. BPBM 21635. Morobe Prov.: Tekadu, 7.664855ºS, 146.5638586ºE, 400 m elev. 20 October 1996. A. Allison. BPBM 13171. Southern Highlands Prov.: Bobole, 6.20ºS, 142.76666667ºE. October 1985. S. Donnellan and K. Aplin. AMS R122427–29, 122441, 122476; Namosado, 6.25ºS, 142.783333ºE. 1985. S. Donnellan and K. Aplin. AMS R122433–40, 122442–46, 12249–51, 122461–70; Fogamaiyu, 6.51666ºS, 143.083333ºE. December 1985. S. Donnellan and K. Aplin. AMS R122471–75; confluence of Libano and Hegigio rivers, 6.3990666ºS, 142.9761333ºE, 250 m elev. 4–6 August 2003. A. Allison. BPBM 28231–35. Western Highlands Prov.: Manjim, Ganz River, 5.53333ºS, 144.483333ºE. 16 July 1954. Troughton and Campo. AMS R14751–57; Jimi River, 5.35ºS, 144.3333ºE. 21 July 1954. Troughton and Campo. AMS R14761–62; Baiyer River, 5.55ºS, 144.0ºE. 14 August 1969. Collector unrecorded. AMS R28690; West Sepik Prov.: Trefas Village, 5.9 km N, 7.3 km E of Utai, 3.333ºS, 141.651ºE, 320 m elev. 22 September–23 October 1996. A. Allison. BPBM 23159, 23165, 23172; Menawa River, 8.4 km N, 11.4 km E of Utai, 3.312ºS, 141.688ºE, 560 m elev. 24 September 1996. A. Allison. BPBM 23161–62. First records for country (Manthey and Denzer 2006), suggesting the species is widely distributed across most of New Guinea.

Hypsilurus schultzewestrumi. INDONESIA: Papua Prov.: Bokondini, 40 km. N. of Baliem Valley, 3.63ºS, 138.6ºE (datum unknown), 1400 m elev. 18 November 1961. L.W. Quate and S. Quate. BPBM 3296; PAPUA NEW GUINEA: Chimbu Prov.: Goglme, 5.93333ºS, 145.03333ºE. No date. J. Hope. AMS R29126–28; Eastern Highlands Prov.: Roka Estate Village on Goroka-Daulo Pass Road, 6.05S, 145.4E. No date. A. K. Lee. AMS R64740–71;

Koge, 6.10ºS, 145.01666ºE. 16 October 1965. F. Parker. AMS R68895; Irumbafoi, 6.23333ºS, 145.26666ºE. 13 July 1964. Collector unrecorded. AMS R86887; Enga Prov.: Yaramanda, West Baiyer Valley, 5.61666ºS, 143.916666ºE. 22–28 August 1955. R. N. H. Bulmer. AMS R14849–50; Madang Prov.: Fungoi, Kaironk Valley, Schrader Mts., 5.333333ºS, 144.41666667ºE. 14 December 1963–1 January 1964. H. G. Cogger. AMS R21190–91, 23039, 24328–30; West Sepik Prov.: Telefomin, 5.136775ºS, 141.633333ºE. 30 August 1963. P. Temple. BPBM 3858. First is new country record; remainder are new provincial records. Previously known with certainty only from type locality at Nondugl, Western Highlands Province, Papua New Guinea (Manthey and Denzer 2006).

Snakes

Toxicocalamus stanleyanus. MADANG PROVINCE: between Hinihon and Reinduk, 1000 m elev. 24 March 1974. G. B. Opit. BPBM 5711. First record for province; nearest record is Gulf Province ca. 300 km away on S side of Central Dividing Range (McDowell 1969; O'Shea 1996).

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Literature Cited

Günther, R. 2001. The Papuan frog genus *Hylophorbus* (Anura: Microhylidae) is not monospecific: description of six new species. Russian J. Herpetol. 8:81–104.

———. 2003. Notable distribution records of New Guinean frog species and genera beyond their known ranges (Amphibia: Anura). Faun. Abh. 24:209–216.

Dahl, C., V. Novotny, J. Moravec, and S. J. Richards. 2009. Beta diversity of frogs in the forests of New Guinea, Amazonia, and Europe: contrasting tropical and temperate communities. J. Biogeog. 36:896–904 [online supporting information].

Kraus, F., and A. Allison. 2004. New records of reptiles and amphibians from Milne Bay Province, Papua New Guinea. Herpetol. Rev. 35:413–418.

———, and ———. 2006a. Range extensions for reptiles and amphibians along the northern versant of Papua New Guinea. Herpetol. Rev. 37:364–368.

———, and ———. 2006b. Three new species of *Cophixalus* (Anura: Microhylidae) from southeastern New Guinea. Herpetologica 62:202–220.

———, and ———. 2007. Taxonomic notes on frogs of the genus *Rana* from Milne Bay Province, Papua New Guinea. Herpetol. Monogr. 21: 33–75.

———, and G. Shea. 2005. Additional reptile and amphibian range extensions for Milne Bay Province, Papua New Guinea. Herpetol. Rev. 36: 471–473.

Manthey, U., and W. Denzer. 2006. A revision of the Melanesian-Australian angle head lizards of the genus *Hypsilurus* (Sauria: Agamidae: Amphibolurinae), with description of four new species and one new subspecies. Hamadryad 30:1–40.

McCoy, M. 2006. Reptiles of the Solomon Islands. Pensoft, Sofia, Bulgaria.

McDowell, S. B. 1969. *Toxicocalamus*, a New Guinea genus of snakes of the family Elapidae. J. Zool., London 159:443–511.

Menzies, J. I. 1999. A study of *Albericus* (Anura: Microhylidae) of New Guinea. Austr. J. Zool. 47:327–360.

———. 2006. The frogs of New Guinea and the Solomon Islands. Pensoft, Sofia, Bulgaria.

———, and M. J. Tyler. 2004. *Litoria gracilenta* (Anura: Hylidae) and related species in New Guinea. Austr. J. Zool. 52:191–214.

Oliver, P., S. J. Richards, B. Tjaturadi, and D. Iskandar. 2007. A new large green species of *Litoria* (Anura: Hylidae) from western New Guinea. Zootaxa 1519:17–26.

O'Shea, M. 1996. A Guide to the Snakes of Papua New Guinea. Independent Publ., Port Moresby, Papua New Guinea.

Richards, S., C. Dahl, and J. Hiaso. 2007. Another new species of *Choerophryne* (Anura: Microhylidae) from Southern Highlands Province, Papua New Guinea. Trans. Roy. Soc. S. Aust. 131:135–141.

———, and D. Price. 2004. *Litoria pygmaea*. *In* IUCN 2008. 2008 IUCN Red List of Threatened Species. www.iucnredlist.org. Accessed 30 October 2009.

Tyler, M. J. 1967. A new species of frog of the hylid genus *Nyctimystes* from the highlands of New Guinea. Trans. Roy. Soc. S. Aust. 91:191–195.

Zweifel, R. G. 1958. Results of the Archbold Expeditions. No. 78. Frogs of the Papuan hylid genus *Nyctimystes*. Amer. Mus. Novitates 1896: 1–51.

———. 1962. Results of the Archbold Expeditions. No. 83. Frogs of the microhylid genus *Cophixalus* from the mountains of New Guinea. Amer. Mus. Novitates 2087:1–26.

———. 1980. Results of the Archbold Expeditions. No. 103. Frogs and lizards from the Huon Peninsula, Papua New Guinea. Bull. Amer. Mus. Nat. Hist. 165:390–434.

———. 2000. Partition of the Australopapuan microhylid frog genus *Sphenophryne* with descriptions of new species. Bull. Amer. Mus. Nat. Hist. 253:1–130.

BOOK REVIEWS

Herpetological Review, 2010, 41(2), 249–250.

Natural History of West Indian Amphibians and Reptiles, by Robert W. Henderson and Robert Powell. 2009. University Press of Florida (www.upf.com). Hardcover. xxiv + 495 pp. US $85.00. ISBN 978-0-8130-3394-5.

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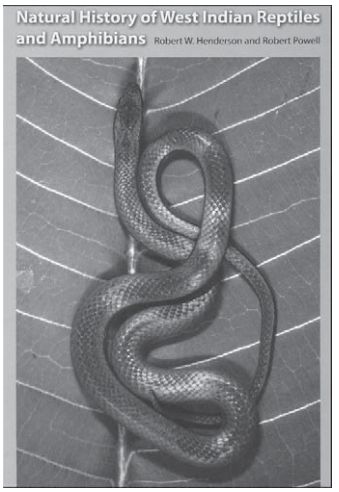

The West Indies are home to more than 6.3% of the world's reptile species, including more than 600 species found nowhere else on earth (Hedges 1996). This extraordinary diversity, combined with the presence of herpetology's best-known example of adaptive radiation (*Anolis* lizards) and the region's proximity to the United States have made the West Indies a Mecca of herpetological research for over a century. When it comes to comprehensive book length treatments of this herpetofauna, West Indian herpetologists have tended to prefer substance over style. For nearly two decades, the best example of this was Schwartz and Henderson's (1991) *Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History* (hereafter S&H), which makes up for a lack of illustrations with comprehensive species descriptions, dot maps, and natural history notes for every species of West Indian amphibian and reptile. S&H remains one of the most impressive compendia ever published on a regional herpetofauna and has served a foundation for herpetological research in the West Indies for nearly two decades.

Henderson and Powell's (2009) (hereafter H&P) new compendium on the natural history of West Indian amphibians and reptiles expands the foundation provided by S&H, and provides an impressive resource for the next generation of West Indian herpetological research. Although it shares S&H's emphasis on style over substance (there are few illustrations), it is much more than a mere rehash of S&H's classic work; instead, H&P focus primarily on updating and expanding the natural history information included in S&H. H&P also provide the first comprehensive assessment of the conservation status of reptiles and amphibians—a key contribution given the relatively small ranges of many of the region's endemic species. Along the way, H&P nearly triple the number of references contained in S&H, a testament to H&P's scholarship and the expanding body of literature pertaining to the natural history, ecology and conservation of West Indian herps (over 2600 references in H&P versus 883 in S&H).

Henderson and Powell lead off with an insightful review of the West Indian herpetofauna and efforts to study it, including a wide-ranging consideration of this fauna's future. The "Where We are Today" section includes an excellent summary of the history of West Indian herpetology. H&P also use informal meta-analyses to illuminate the uniqueness of the West Indian herpetological fauna and to highlight the taxonomic imbalance of previous work on West Indian herps; some taxa have enjoyed sustained natural history research while little is known of many other taxa beyond their existence. Following up on this observation, H&P's introduction closes with a discussion of the future of West Indian herpetology that serves as both a roadmap for future research and a call to arms for the herpetological community.

One of the most important features of H&P is the information it contains on the conservation status of West Indian reptiles and amphibians, including a comprehensive summary of the various threats facing this fauna. Although the West Indies are home to hundreds of narrowly distributed endemic species living in heavily disturbed environments, conservation efforts are focused almost exclusively on a few particularly charismatic species like rhinoceros iguanas, boas, and racers. One reason for this is that the tenuous status of many lesser-known West Indian reptiles and amphibians has been overlooked by the broader community of conservationists. H&P begin their efforts to overcome this oversight with an extensive review of the literature that considers the impact of threats like introduced species, habitat loss, accidental and intentional killing by humans, climate change, natural disasters, non-native parasites, pollution, loss of prey sources, human overpopulation, and commercial exploitation.

The remainder of the book is composed primarily of species accounts (arranged alphabetically and by Linnaean rank). The structure of the species accounts in H&P differs substantially from those found in S&H. Gone are range maps, physical descriptions of species, type specimen and locality data, and discussion of the systematic relationships among species. Missing from both books are images of species and characterization of calls for amphibians, although H&P point to other resources for these data. Information on natural history, meanwhile, is greatly expanded. Material new to this volume includes impressive species-by-species conservation summaries including IUCN, CITES, or other assessments as well as any relevant literature on specific threats to each species (e.g., habitat loss, active hunting/extermination by Amerindians or current residents, etc).

H&P contains accounts for 152 species not recorded in S&H (an increase of 26%), reflecting both increased interest in West Indian Herpetology as well as a shift in taxonomic methods over the last two decades. Unlike S&H, however, subspecies are only rarely discussed and phenotypic or ecological distinctions among subspecies are not addressed. The content of each species' Natural History section varies depending on the available references. Headings include: abundance, activity, behavior, biomass, competition, diet

and foraging, dispersal, growth, home range, movement, parasites, population size and density, predation, reproduction, sex ratio, size, tail autonomy, thermal biology, as well as ecomorphology information for anoles. H&P draw upon years of field experience, an exhaustive literature review, and an international network of West Indian herpetologists to compile each detailed and rigorously researched species account.

We have only a few minor complaints with H&P, including unqualified use of generalizations and anecdotal field observations, the absence of a small number of natural history references, and the potential that geographic variation in the natural history of species is overlooked by focusing exclusively on taxa recognized at the species level. The inclusion of anecdotes and antiquated natural history observations is a double-edged sword. Although we agree with H&P's comprehensive approach, we caution readers against over-interpreting information that is presented in accounts without bias or explanation. Anecdotal claims like the suggestion that *Anolis strahmi* is "[n]ot easily alarmed," for example, are often oversimplifications. The *Bothrops caribbaeus* account cites Tyler (1849) on envenomation: "If not bitten in a large blood vessel, little danger exists for a loss of life if a mixture of lime juice, rum, and salt is imbibed, followed by intoxication and sleep." Although amusing to the experienced herpetologist, this account could easily be misconstrued as factually accurate information by the uninitiated. Although this is an extreme example of the potential problems with anecdotal information, it might be useful to include some evaluation of poor or unreliable references.

We conducted basic literature searches for natural history information on 73 taxonomically dispersed accounts; this work confirmed the thoroughness of H&P's scholarship. In most cases H&P cited every reference to a species that we could find, in many cases supplementing the references we were able to find with somewhat more obscure references that could not be located with internet-based searches. The few neglected references we did find tend to originate from journals outside the purview of practicing herpetologists; for example, H&P missed a note on Burrowing Owl predation on *Typhops hectus* from the Journal of Raptor Research (Wiley 1998). In other cases, individual species accounts did not reference relevant material that is cited elsewhere in the volume. Species accounts for *A. porcatus* and *A. allisoni*, for example, should have included some mention of the character displacement that Schoener (1977) reported in central Cuba.

Although it may be asking too much, including some information on taxonomic relationships among species would have been a useful addition. With such information, it might be possible to extract some suggestive information about the natural history of recently described or relatively poorly known species by examining accounts of closely related taxa. For instance, the account for *A. marron* contains very little detail. This species was elevated to species status from populations previously placed in *Anolis brevirostris* (Arnold 1980). Although specific natural history studies since this elevation are lacking, the close evolutionary relationship of these species suggests some overall similarity between the two.

H&P's book is a monumental contribution to West Indian herpetology. Its comprehensive coverage and the level of detail afforded each species is virtually unparalleled among references for diverse herpetofaunas. H&P is a necessary companion to S&H for any herpetologist working in the West Indies. Henderson and Powell's new volume provides much more comprehensive natural history information for the West Indies than its predecessor, although S&H remains important because of its dot maps, type records, and morphological descriptions. We can now look forward to the forthcoming field guide (S. B. Hedges, *in prep*.), complete with range maps and color photographs for every West Indian species, which will complete an important trinity for West Indian herpetology.

Literature Cited

Arnold, D. L. 1980. Geographic variation in *Anolis brevirostris* (Sauria: Iguanidae) in Hispaniola. Breviora 461:1–31.

Hedges, S. B. 1996. The origins of West Indian amphibian and reptiles. *In* R. Powell and R.W. Henderson (eds.), Contributions to West Indian Herpetology: A Tribute to Albert Schwartz, pp. 95–127. Contributions to Herpetology, Volume 12. Society for the Study of Amphibians and Reptiles, Ithaca, New York.

Schwartz, A., and R. Henderson. 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. University Press of Florida. Gainesville. 457 pp.

Schoener, T. W. 1977. Competition and the niche. *In* C. Gans and D. W. Tinkle (eds.), Biology of the Reptilia, Volume 7. Ecology and Behaviour A, pp. 35–136. Academic Press, London.

Tyler, L. 1849. Notes on the serpents of St. Lucia. Proc. Zool. Soc. London 1849:100–104.

Wiley, J. W. 1998. Breeding-season food habits of burrowing owls (*Athene cunicularia)* in southwestern Dominican Republic. J. Raptor Res. 32:241–245.

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Timber Rattlesnakes in Vermont and New York—Biology, History, and the Fate of an Endangered Species, by Jon Furman. 2007. University Press of New England (www.upne.com). Softcover. xiii + 207 pp., 8 pp. pls. US $24.95. ISBN 978-1-58465-656-2

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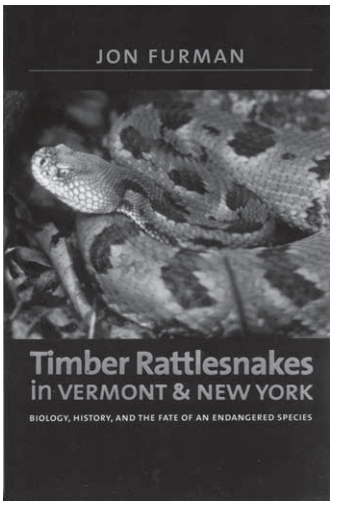

What better way to demonstrate obstacles and solutions to conserving and saving a sometimes misunderstood endangered species than to document the process in a readable fashion? Conservation can be particularly difficult with long-reviled and late-maturing species such as venomous snakes, which engender an innate response of fear and repulsion in many people. Herpetologists are thoroughly familiar with common negative attitudes among the general public toward snakes, especially venomous ones (but you'd never know it if you visit a reptile house at any zoo). Furman

approaches this dilemma in some detail, contrasting the knowledge, experiences, attitudes, and behavior of professional biologists and conservationists with those of outdoors laymen and snake hunters. This has resulted in a book of intimate detail including documentation of extensive field trips by the author guided by those doing field research specifically on conservation and population biology of Timber Rattlesnakes, plus in-depth interviews with 'the other side,'i.e., individuals and their family members who have historically harvested (killed) thousands of these animals for sport, bounty, or some valued feature of their bodies.

Timber Rattlesnakes were once found across much of the eastern United States east of the Mississippi River but are now exterminated or found more often in geographically restricted areas. Furman's book covers the current northern limit of the species' range in the east, focusing on a pocket encompassing three counties in New York and one adjacent county in Vermont where bounties on this species over a 75-year span led to elimination or decimation of most populations. Since the bounties were legally discontinued by state laws in the 1970s, many of these populations have recovered to some extent. The snake's recovery process has been followed and enhanced for the past 40 years by a handful of dedicated biologists and concerned citizens.

Furman's first chapter is the longest and most comprehensive, providing a broad introduction to Timber Rattlesnake anatomy, foraging, prey, predators, habitats, dens, movements (including swimming), body temperatures, basking areas, aggressive behavior, use in church rituals, mating, and longevity. For these features, he draws on an extensive recent literature and provides detailed sources (accumulated at the end of the text) which include quotes and comments from current researchers. Answered are questions about the complex structure of the jaws, fangs, and facial pits and their complex functioning in the lives of these animals; the significance of the rattle and its maximum number of segments; and the age at sexual maturity and frequency of litter production by the late-maturing females, some of which may reproduce only once every five or six years, depending upon food availability.

Chapter 2 is short and concerns mainly maximum body sizes, discussing the uncertainty about whether individuals have ever reached six feet in total length. Earlier workers may have included the rattle in their measurements and may also have stretched the snakes to try and achieve record lengths. Perhaps a six-footer is possible but current workers seldom find individuals as long as five feet.

Snakebite is the focus of the longer chapter 3 and includes statistics on 'dry' bites, constituents of the venom, symptoms, and treatment of bites based on consultation with noted experts. Furman includes case studies of individuals he has known personally, detailing the circumstances of their bites, the treatments and consequences including lasting damage, both psychological and physical. This is one of the most pertinent sections of the book for those who are concerned about avoiding or dealing with a bite from one of these snakes.

Rattlesnake fossils go back as far as the Miocene and those of Timber Rattlesnakes back nearly a million years. The species was once more abundant at the northern limits of its range but has been exterminated from eastern Canada, Rhode Island, Maine, and much of New York State (Chapter 4). Furman documents some of the most egregious killings, sometimes numbering in the thousands of snakes. Even our early presidents Jefferson and Madison, traveling together on an outing in May 1791, shot two rattlesnakes near "Fort George" within the area covered in Furman's book (Ketcham 1971). However, well over 100 dens still exist in southern New York and a few dozen in the other northeastern states. Conservation efforts, elimination of bounties, and state endangered species listings have mostly assured protection and rejuvenation of many of these populations. Chapter 5 addresses this transition during the 1980s and 1990s in New York and Vermont as the species was listed in 1983 as threatened in New York and in 1987 as endangered in Vermont.

Chapter 6 is a fascinating one, tracing the history of bounty hunting in New York and Vermont over the years and documenting the dollar amounts of the per-snake bounty, which worked its way up from 25 cents in 1896 to five dollars in each of New York's three timber rattlesnake counties by 1956. Bounties were discontinued in both states in 1971, with the last payment in 1973 in New York. Resolutions on the bounty systems by the County Board of Supervisors in the three New York counties are a valuable part of the historical record (heretofore undocumented) and are included in Furman's source notes. Higher bounties in New York encouraged some collectors to bring snakes or snake parts from other states, including Vermont, to get the larger payments. Since termination of the bounty system, snake numbers have recovered to perhaps 8–10,000 statewide in New York, and observers have noted greater numbers of the largest individuals in recent years.

Furman's last three chapters are each devoted to one of the famous (or infamous) rattlesnake bounty hunters and their families in Vermont and New York. Furman personally spent many hours interviewing these now elderly (or deceased) individuals to gain insight into why they started killing and/or collecting rattlesnakes and how many they may have killed over the years (thousands) for rather substantial annual profits in several cases. Much as we would like to completely deplore their behavior, some of these individuals performed at least a few redemptive services. These included enabling the sale of family land in Vermont which included a rattlesnake den for protection by The Nature Conservancy. One of the bounty hunters performed crude experiments on feeding and hibernation but hosted "snake roasts" for local social gatherings, while others boiled rattlesnake fat and used the resulting oil as a medicinal ointment for burns, joint pains, and such.

The book finishes up with a short chapter called 'Rays of Hope' which reemphasizes the elimination of bounties, the establishment of formal endangered status, and the willingness of many residents to refrain from killing 'nuisance' snakes and instead to cooperate with conservationists to relocate them unharmed to other places nearby. These workers also give frequent public talks about the nature of the snakes and the need for their conservation. Furman relates the experiences of conservationists and professional biologists in New York who continue to struggle with pressures from real estate developers and industrialists wanting to destroy critical habitat for Timber Rattlesnakes, and who often testify in court cases.

The book is enhanced by individual photos of biologists and former bounty hunters, plus color photos of timber rattlesnakes. There are also sobering color photos of a snakebite victim's hand. Excellent color maps by W. H. Martin of the species' former and current distributions are also presented. An extensive nine-page

cross-reference index concludes the work.

I have had the good fortune to have spent many hours in the field and at conferences with the author and many of the biologists and colleagues whose work forms the crux of this book. Over the years, I have been overwhelmed with their knowledge and dedication to the welfare of this most complex and sophisticated species of snake. Several have contributed their entire professional careers to this species and have expended their own funds to study the species or buy lands for its protection. My appreciation for the snakes themselves has also grown immensely after seeing their quiet and retiring nature in the field. Furman's book is well worth the read as it captures this species' natural history and many insights about nature, enabling conservation for the future through solid and intimate knowledge of Timber Rattlesnakes.

LITERATURE CITED

KETCHAM, R. 1971. James Madison: A Biography. The University Press of Virginia, Charlottesville. xiv + 753 pp.

Herpetological Review, 2010, 41(2), 252–254.

The Biology of the Coccidia (Apicomplexa) of Snakes of the World, by Donald W. Duszynski and Steve J. Upton. 2009. Published by the authors (available at: https://www.createspace.com/3388533). 422 + i–viii pp. Softcover. US $70.00. ISBN 97814486179.

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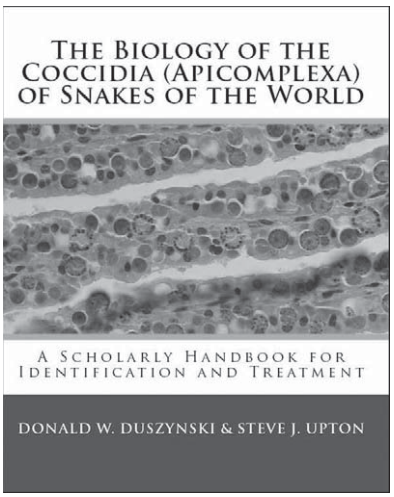

This is an excellent and much welcome summation of all of the coccidian parasites (Protista: Apicomplexa) of the suborder Ophidia (= Serpentes) by two well-known parasitologists who have had a life-long interest in and are the world's foremost authorities on the subject. The book has already received favorable reviews (see Agnew 2010; Graczyk 2010; Modrý 2010) as well as positive reviews provided within the text by six knowledgeable parasitologists with experience in the study of coccidia (see pp. iii–iv). I will not stray too far from those previous reviews except to say I will provide an equally fair assessment but with some balance.

The content includes 13 chapters, literature cited, glossary (and list of abbreviations), and index. One of its major strengths is the extensive literature cited section which spans some 27 pages (>6% of the book). If ever anyone needed to locate vague or hard to find citations on the coccidia of snakes, they need only check this compilation. The book is an easy read for herpetologists and parasitologists alike, and others (zoo biologists and veterinarians) will find it a valuable asset to their personal library.

The introductory chapter deals with some general aspects of snake and coccidian biology, as well as several terms (in bold face) relating to the subject and helpful to the layperson. It also provides figures of Nomarski interference-contrast photomicrographs of oocysts of three genera and six species of coccidia for comparative purposes. A minor error appears in the figure legend (Fig. 1.1 F); I believe the oocyst of *Isospora wilsoni* from *Tantilla gracilis* is from the symbiotype host snake collected from Arkansas, not Florida (see Upton et al. 1992, Figs. 5–6). Inclusion of Fig. 1.2 on phylogenetic relationships among the major taxa of snake families (cladogram) strongly suggests that a great deal of knowledge on snake coccidia remains to be discovered as only select members of seven of 17 (41%) snake families have been previously reported to harbor species of coccidia. In other words, about 235 species of snakes in 10 families have **never** had coccidian parasites reported from them, not to mention many others from the other seven families!

Chapter 2 provides more detailed information on the general systematics and life-cycles of coccidia. It is very well done and shows the reader that coccidia have varied, somewhat complex life-cycles, including direct or indirect ones that include both sexual and asexual reproduction. Development of coccidia occurs within various host cell types of the vertebrate intestinal tract or related structures and some (those with indirect life-cycles) even utilize an intermediate host. Several figures within this chapter enhance our understanding of these life-cycles and are a must read for those needing to know details of the four major types of life-cycle strategies employed by snake coccidia. There are some minor typos on line 2 of Fig. 2.4 (A) and font sizes are larger but the photomicrographs of the *Caryospora* spp. are superb.

Chapter 3 covers techniques, including collection, storage, and identification of coccidia. This is another very important chapter in the book. It helps teach the non-specialist (and herpetologists and veterinarians with little experience) to process hosts for coccidia as well learning detailed methods for the isolation of oocysts. However, be forewarned that some cost is involved in acquiring the materials necessary for such study and practice is recommended before wasting important specimens for which you have limited snake fecal material. One thing not said on page 24 is that some commercial microscopic coverslips do not adequately allow oocysts to adhere to their surface via the flotation method. So, if you have enough material, do some practice runs using the various types of coverslips. And, those fortunate enough to spend some time on a brief sabbatical in a laboratory with an expert will certainly be trained thoroughly enough to be on their own. This all takes a lot of practice and many herpetologists have soon learned that collecting the snake, getting its feces, placing an equal aliquot in vials of 2.5% (w/v) aqueous potassium dichromate, and then shipping it overnight to a trained specialist, may be the best way to go. But even that has some limitations and requires a previously understood collaboration. The chapter ends with a discussion of taxonomic terms that are found throughout the book and professional quality line drawings (Fig. 3.1A–D) showing oocyst morphological

structures that should be measured and documented for species identification and formal description.

The following eight chapters (Chapters 4–11) deal with the individual major snake taxa (families, genera, and species) harboring coccidia in a useful, easy to follow, standardized format. The arrangement of taxa is mostly according to the system given by Uetz (2007) via the JCVI/TIGR Reptile Database (http://www.reptile-database.org/); however, the reader should be warned that some snake taxonomy has been in a state of flux and has changed since the book was written and may be expected to change even further. And for some published binomials that have undergone recent nomenclatural changes, the authors attempt to report both the old and new names, but they do so inconsistently (i.e., *Python* vs. *Broghammerus*; *Elaphe* vs. *Pantherophis*). In addition, *Eimeria desotoensis* was described from *Virginia striatula* from Arkansas and Texas (i.e., city of DeSoto is type locality), not just Arkansas (see p. 86, but corrected on p. 116). And, the symbiotype host of *Eimeria rhombifera* is *Nerodia rhombifer*, not *Nerodia cyclopion* (see p. 109 and check type locality). Some of the taxonomic confusion is abated by thoroughly cross-referencing in the index, but some host taxonomic confusion and different common name usage still occurs. And most unfortunately, other errors (mostly typos) become exponential in these chapters (see criticism below).

I must admit that it is somewhat troubling that the authors overlooked many of the typos contained within the book (primarily in Chapters 4–11, pp. 31–302). Some of these errors appear to be typical word.doc problems (and possibly pdf errors), and with two authors writing separately, hidden codes may have leaked into the final document without them knowing. These errors (typos) include, but are not limited to: misspellings, lack of required italicization, letters left out, extra letters/words, different font sizes, transpositions, etc. Examples include misspellings: species inquirendae at least 12 times (pp. 34, 40, 41, 44, 144, 197, 200, 210, 265, 271, 288 [twice]), the specific or subspecific epithets *reticulatus* (misspelled *reticulates* on pp. 40 [twice], 44 [twice], 338 [twice], 345, 366 [three times], 368, 411), *obsoleta* (misspelled *obsolete* on pp. 146, 242, 260 [twice], 328, 341–342, 365), *lineata* (misspelled *lineate* on pp. 148, 156, 277, 365), *catenifer* (misspelled *cantenifer* on pp. 145, 277, 334, 339, 356), *vulpina* (misspelled *vulpine* on pp. 260, 337 and *vupina* on p. 335) authors Freed (misspelled Free on pp. 126, 199), Lainson (misspelled Lanison on pp. 136–137) and Ovezmoukhammedov (misspelled Ovezmoukhammedova on pp. 349 and 390 [three times]).

Other corrections needed are to include the hosts *Agkistrodon piscivorus* in Table 7.1 and *Masticophis flagellum* in Table 9.2. The misconception that no species within the family Leptotyphlopidae (blind snakes) have been examined for coccidia (p. 220) is incorrect as McAllister et al. (1995, p. 63) examined four specimens of *Leptotyphlops* (=*Rena*) *dulcis* from New Mexico (n = 1) and Texas (n = 3) and none were infected with coccidia. On a lighter side, the shakes on (p. 109) should be snakes, the Lind Snakes (p. 219) should be Blind Snakes, and the western coachwhip "terrapin" (pp. 261, 342) should, of course, be a snake.

The authors report that there are about 4000 known species of parasitic protists in six major taxonomic groups that infect a wide variety of vertebrates and invertebrates. Of these, only 156 coccidians of snakes are considered valid species and only 208 of 3180 (7%) extant snake species have been examined for and reliably reported to harbor coccidia. This is especially true about the 55+ unknown species of *Sarcocystis* previously known from snakes and reported simply as *Sarcocystis* species inquirendae. Part of this enigma lies in the fact that it is impossible to determine *Sarcocystis* species definitively without experimental transmission studies because the sporocysts found in the feces of the definitive host, are very similar in size and morphologies (Duszynski and Upton 2009; McAllister et al. 1995). In an attempt to abate this problem, the authors make several pleas (Chapters 9, 13) for cooperation between herpetologists and parasitologists to work as equal partners "*if we are ever to have an inkling of the true biodiversity of snake parasites…*" and "*to be more receptive to working together….*". As someone who has collaborated on snake coccidia with academic herpetologists, including those with state and federal agencies and employed by zoos (McAllister et al. 1993, 1995, 1996), I could not agree more.

The authors provide descriptions of four new species of coccidia (**ii and Chapters 5, 7, 9) to include one eimerian (p. 64), one caryosporan (p. 200), and two *Sarcocystis* spp. (pp. 225, 236). One description, however, contains a serious typo (Chapter 5, p. 64) of the new species of *Eimeria* from *Lampropeltis getula californiae*. The spelling of the specific epithet as first given is misspelled: *Eimeria lamporpeltisgetuli* should be *E. lampropeltisgetuli* but it must stand until corrected in a future justified emendation under Article 32.5 of the Code (Ride et al. 2000). Interestingly, on pages 85, 147, 154, and 414, that specific epithet is spelled correctly but incorrectly twice (pp. 331, 350).

The photomicrographs and line drawings are top-notch and improve the overall message of the book. They allow the reader to employ a quick and user friendly comparative approach when examining different morphologies among similar oocysts of the various coccidian taxa of snakes. However, the following five figures of sporulated oocysts appear to be photomicrographs, not line drawings, as suggested in their respective figure legends (Figs. 4.1C, 5.6, 5.35, 5.98, 7.1G). The book cover includes a nice black and white photomicrograph showing numerous endogenous developmental stages of an *Eimeria* sp.

Chapter 12 provides strategies for management and therapy of reptilian coccidiosis, including the more serious disease, cryptosporidiosis. This chapter should be of special interest to veterinarians and zoo personnel who treat and house sensitive species. It includes very detailed information about a proprietary website, Veterinary Information Network (VIN; http://www.vin.com), where veterinarians from all over the world discuss common issues, problems, drugs, and treatment regimens (see Table 12.1). Ultimately, this will allow veterinarians immediate access to what therapies have worked for others and to access appropriate references.

The book ends with Chapter 13 in which the authors ask the question "*so what does all of this mean*?" The authors provide two very important tables in this chapter (13.1–13.2), although they contain numerous typos (pp. 320 [five], 328, 331, 333 [two], 334–335, 337 [three], 338 [five], 339 [two], 340–341, 342 [three], 343. 345, 346, 349, 350 [two], 351 [two], 353 [two], 356). Most importantly, these tables allow the reader to quickly see an alphabetical list of all coccidian parasites recorded from all snake hosts and a host-parasite index (through 2008). This will be indispensable to those needing to cut-to-the-chase if they have a new host and/or distributional record, or even better, a new species of coccidian.

Two additional tables (13.3–13.5) may be directed toward the more serious snake coccidian researcher as they cover cross-transmission studies, pathologies, and endogenous developmental stages from snakes. Needless to say, there are several typos in these tables (i.e, original is misspelled orignal 12 times!) and other typos are found on pp. 362, 365 (three), 366 (three), 368, and 370 (two).

It is abundantly evident that these authors devoted much time and energy to preparing this work, reviewing hundreds of references as well as spending several years developing a readable text for specialists and non-specialists alike. Drs. Duszynski and Upton should be commended for taking on this task effectively and covering global aspects of the biology of the coccidia of snakes. On the other hand, there are too many typos and errors and hopefully those will be corrected if a second edition is done. The $70 cost for a paperback may be a little out of line and could dissuade some non-specialists from purchasing a copy but all parasitologists and those herpetologists, veterinarians, and zoo biologists interested in snake coccidia should own a copy, regardless of the cost.

In summary and with these typographical concerns aside, the authors have done a yeoman's job in having in one place and in a highly organized manner, all of the world's literature on snake coccidia through 2008. First and foremost, they have produced a text that all parasitologists, but particularly those interested in coccidian biology, could use as a quick identification guide on species that they might recover from snakes. They have also produced a compilation that professionals, amateurs, and zoo herpetologists might use should they be interested in knowing anything about coccidia that could be infecting their snake of interest, research subject, captive specimen, or even pet. Lastly, they have produced a book that could be useful to small-animal veterinarians who examine snakes brought in as patients to their practice. As a whole, it is the gold standard and is much enhanced by the figures and layout. Undoubtedly, this book will become indispensable and THE source for any person remotely interested in snake coccidia, and I emphatically recommend it.

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Literature Cited

Agnew, D. W. 2010. Vet Med Today: Book Reviews: The Biology of the Coccidia (Apicomplexa) of Snakes of the World: A Scholarly Handbook for Identification and Treatment. J. Am. Vet. Med. Assoc. 236:641.

Duszynski, D. W., and S. J. Upton. 2009. The Biology of the Coccidia (Apicomplexa) of Snakes of the World: A Scholarly Handbook for Identification and Treatment. CreateSpace Inc., DBA of On-Demand Publishing, LLC, an Amazon.com Company (available at: https://createspace.com/3388533). 422 pp.

Graczyk, T. K. 2010. Book review: The Biology of the Coccidia (Apicomplexa) of Snakes of the World. J. Parasitol. 96:29.

McAllister, C. T., S. J. Upton, D. G. Barker, and C. W. Painter. 1996. *Sarcocystis* sp. (Apicomplexa) from the New Mexico ridgenose rattlesnake, *Crotalus willardi obscurus*. J. Helminthol. Soc. Washington 63:128–130.

———, ———, C. M. Garrett, J. N. Stuart, and C. W. Painter. 1993. Hemogregarines and *Sarcocystis* sp. (Apicomplexa) in a western green rat snake, *Senticolis triaspis intermedia* (Serpentes: Colubridae), from New Mexico. J. Helminthol. Soc. Washington 60:284–286.

———, ———, S. E. Trauth, and J. R. Dixon. 1995. Coccidian parasites (Apicomplexa) from snakes in the southcentral and southwestern United States: new host and geographic records. J. Parasitol. 81:63–68.

Modrý, D. 2010. Book review. The Biology of the Coccidia (Apicomplexa) of Snakes of the World: A Scholarly Handbook for Identification and Treatment. Acta Protozool. 49:85.

Ride, W. D. L., H. G. Cogger, C. Dupuis, O. Kraus, A. Minelli, F. C. Thompson, and P. K. Tubbs. 2000. International Commission on Zoological Nomenclature. International Code of Zoological Nomenclature. Fourth Ed. International Trust for Zoological Nomenclature, The Natural History Museum, London, UK. (available online at: http://www.iczn.org/).

Uetz, P. 2007. The JCVI/TIGR Reptile Database: http://www.reptile-database.org.

Upton, S. J., C. T. McAllister, S. E. Trauth, and D. K. Bibb. 1992. Description of two new species of coccidian (Apicomplexa: Eimeriorina) from flat-headed snakes, *Tantilla gracilis* (Serpentes: Colubridae) and reclassification of misnomer species within the genera *Isospora* and *Sarcocystis* from Snakes. Trans. Am. Microsc. Soc. 111:50–60.

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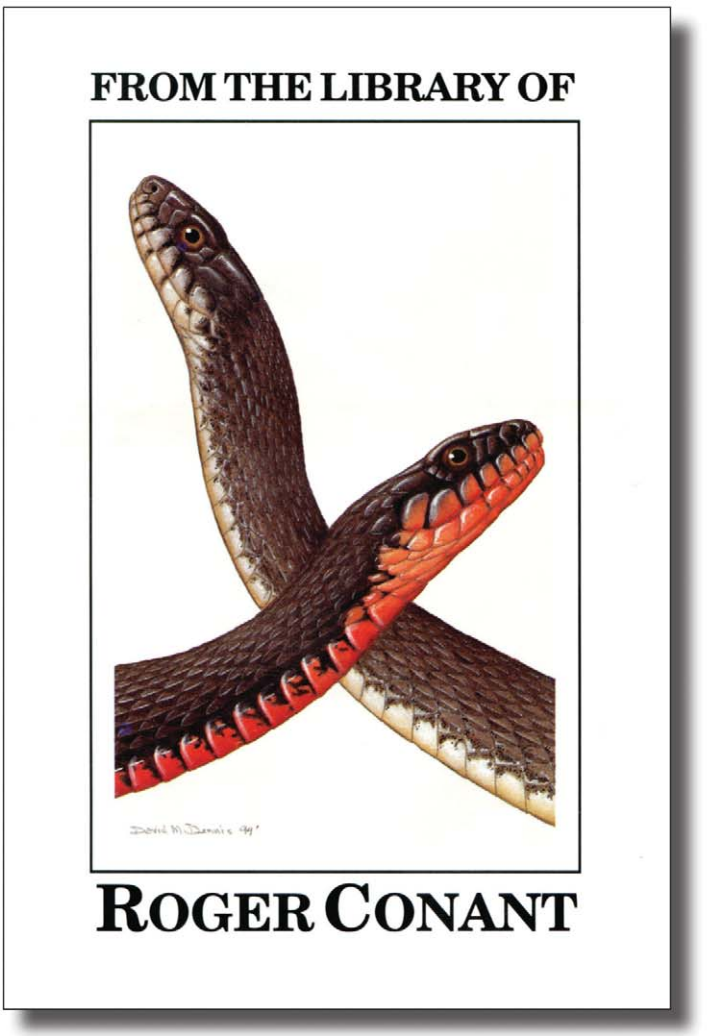

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