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SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES

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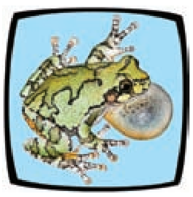


The Society for the Study of Amphibians and Reptiles, the largest international herpetological society, is a not-for-profit organization established to advance research, conservation, and education concerning amphibians and reptiles. Founded in 1958, SSAR is widely recognized today as having the most 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.

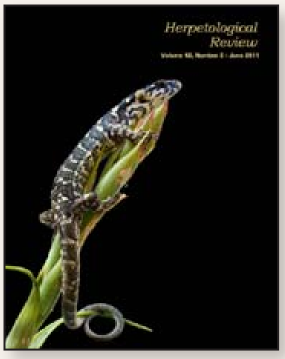
All members and institutions receive the Society's primary technical publication, the *Journal of Herpetology*, and its news-journal, *Herpetological Review*; both are published four times per year. Members also receive pre-publication discounts on other Society publications, which are advertised in *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
2011 — Minneapolis, Minnesota, 6–11 July (with ASIH, HL)
2012 — Vancouver, British Columbia, 8–14 August (with World Congress of Herpetology)
2013 — Albuquerque, New Mexico, dates to be determined

ABOUT OUR COVER: *ABRONIA FROSTI*



The arboreal alligator lizards of the genus *Abronia* comprise a group of 28 species, ranging from Tamaulipas and Guerrero, Mexico southward to southern Honduras. The group is characterized by high levels of endemism, with many species confined to cloud forest uplands and in some cases known only from their type localities. Small natural ranges combined with rampant deforestation and profoundly inadequate protection measures offer a bleak prognosis for the future—as grimly recounted by Campbell and Frost (1993. Bulletin of the American Museum of Natural History, No. 216, 121 pp.; available online: http://hdl.handle.net/2246/823).

Given the precarious status of many of these forested ecosystems, a number of species of *Abronia* are seriously imperiled. In a recent assessment of the conservation status of Guatemalan herpetofauna, all 10 species of *Abronia* occurring in that country were considered highly vulnerable (Acevedo et al. 2010. *In* L. D. Wilson, J. H. Townsend and J. J. Johnson [eds.], Conservation of Mesoamerican Amphibians and Reptiles, pp. 406–434. Eagle Mountain Publishing, Eagle Mountain, Utah). Two species—*A. campbelli* and *A. frosti*, both Guatemalan endemics—have been considered extinct based on near-complete destruction of habitat at their only known localities (Acevedo et al. 2010, *op. cit*; Campbell and Mendelson 1998. Mesoamericana 3:21–23).

Recently, however, a small population of *A. campbelli* was rediscovered near the type locality in Guatemala (Ariano-Sánchez and Torres-Almazán 2010. Herpetological Review 41:290–292), offering hope that this species can be saved. The remaining habitat had been reduced to about 400 epiphyte-laden oak trees, an essential habitat element for these lizards. On the heels of that exciting news comes another report in this issue of *HR* of the discovery of a single sub-adult *A. frosti* near the type locality, a species not seen since 1996 despite considerable search effort. Daniel Ariano-Sánchez and colleagues (see pages 196–198) detail this important find, describe what remains of the habitat, and offer critical steps to assure this species' survival.

Our cover image, depicting a sub-adult female *Abronia frosti*, was recorded by **Thomas Schrei**. He used a Canon 40D digital camera and Sigma 180mm f3.5 APO Macro DG lens, mounted on a Manfrotto tripod. The image was shot at f16, ISO 400, with ½ second exposure. Considering that this specimen is the only known living individual of its species, special care was taken to avoid stressing the animal. After many failed attempts in which the lizard persisted in moving, it was allowed to climb the inflorescence of a bromeliad where it finally came to rest. The image was shot in studio against a velvet black background using natural light, with some fill light reflected from white cardboard. Schrei is a student and conservationist living in Guatemala City, in his final year toward a degree in biology at the Universidade del Valle de Guatemala. He works for the local NGO Zootropic as the coordinator of the Natural Reserve for the Conservation of the Guatemalan Beaded Lizard (*Heloderma horridum charlesbogerti*) and associated captive breeding program.


PHOTO BY HUGO VILLAVICENCIO

SSAR BUSINESS

Annual Report (2011) Grants-in-Herpetology Committee

An award in the amount of $500 was made to each of the following individuals:

Conservation.—**Anne G. Stengle**, University of Massachusetts, "Genetic Connectivity Within a Metapopulation of Timber Rattlesnakes (*Crotalus horridus*)."

Education.—**Michelle Lester**, Central Washington University, "Fresh Science: Amphibians".

Field Research.— **Michael Habberfield**, State University of New York at Buffalo, "Investigating the influence of pool and landscape features on the spatial patterns of amphibian breeding in a vernal pool complex in central New York."

Laboratory Research.—**Beck A. Wehrle**, California State University-Northridge, "Why Do Lizards Lounge? The role of sociality in exchanging microbial communities among hatchling *Iguana iguana*."

Travel.—**Denita M. Weeks**, California State University-Northridge, "Fundamental Niche Modeling and Implications of Global Climate Change for the World's Southernmost Gecko."

International.—**Kerry L. Holcomb**, Central Washington University, "Body Temperature and Water Regulation Strategies of Mexican Beaded Lizards (*Heloderma horridum horridum)* in a Tropical Deciduous Forest near Chamela, Jalisco, Mexico"

2010 Grants-in-Herpetology Committee.—Chair: Joshua Kapfer. Reviewers: Rebecca Christoffel, Brian Halstead, Jerry Husak, Lucas Joppa, Richard King, Charles Knapp, Yu Man Lee, Chad Montgomery, Nicola Nelson, Michael Pauers, Robert Powell, Kevin Zippel.

SSAR congratulates the 2011 GIH recipients and thanks the committee members for their efforts.

Herpetology Courses and Graduate Programs: An Appeal

As an aid for students at all levels, SSAR is now compiling for its website a list of all herpetology courses and graduate programs, worldwide. This will be regularly updated. The list will cover all herpetology courses (or vertebrate biology courses having a sizable content on amphibians and reptiles) that are regularly taught at colleges, universities, biological stations, and other academic institutions anywhere in the world, with name of instructor and detailed course information. The availability of masters and/or doctoral degree-granting programs and names of relevant faculty and their contact information will be included.

Those who wish to have their courses and programs listed should send the following information (in this order, please):

1. Country (State or Province)
2. Institution: name and city
3. Department name
4. Course: number, title, frequency (annual or alternate years), undergraduate- and/or graduate-level course
5. Instructor: name and contact address (email if possible)
6. Graduate herpetology program: note if masters and/or doctoral level
7. Faculty involved in program: name and contact address (email if possible)
8. Special notes: limit to 30 words

Send this information to Prof. Kraig Adler at Cornell University (e-mail: kka4@cornell.edu; postal: Mudd Hall, Ithaca, New York 14853–2702, USA). As soon as the list is compiled, a notice will appear in *Herpetological Review* that will indicate how the list may be accessed and updated. Please help to make this list as complete and useful as possible.

MEETINGS

MEETINGS CALENDAR

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

6–11 July 2011—Joint Meeting of Ichthyologists and Herpetologists (ASIH / HL / SSAR), Minneapolis, Minnesota, USA. Information: http://www.dce.k-state.edu/conf/jointmeeting/

17–22 July 2011—IX Congresso Latinoamericano de Herpetologia, Curitiba, Brazil. Information: http://clah2011esp.blogspot.com/

20–23 July 2011—Biology of the Rattlesnakes Symposium, Tucson, Arizona, USA. Information: http://www.williamkhayes.com/rattlesnakes/

27–30 July 2011—34th International Herpetological Symposium, Fort Worth, Texas, USA. Information: http://www.kingsnake.com/ihs/

10–11 August 2011—Annual Meeting of Southwest Partner in Amphibian and Reptile Conservation (SW PARC), Tucson, Arizona, USA. Information: www.swparc.org/meetings.html

15–16 August 2011—Current Research in Sonoran Desert Herpetology V, Tucson, Arizona, USA. Information: www.swparc.org/meetings.html

14–17 August 2011—9th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles, Orlando, Florida, USA. Information: www.turtlesurvival.org.

17–18 August 2011—12th Annual Meeting of Northeast Partners in Amphibian and Reptile Conservation (NEPARC), Millersville, Maryland, USA. Information: http://www.pwrc.usgs.gov/neparc/

25–29 September 2011—Joint 16th SEH European Congress of Herpetology & 47th DGHT Deutscher Herpetologentag (annual meeting of the German Society for Herpetology and Herpetoculture, scientific part), Luxembourg. Information: http://www.symposium.lu/herpetology

30 September–2 October 2011—47th DGHT-Nachzuchttagung (annual meeting of the German Society for Herpetology and Herpetoculture, herpetocultural part), Trier, Germany.

8–14 August 2012—World Congress of Herpetology 7, Vancouver, British Columbia, Canada (together with SSAR, HL, ASIH). Information: http://www.worldcongressofherpetology.org/

2–7 September 2012—4th International Zoological Congress (IZC), Mount Carmel Campus, University of Haifa, Haifa, Israel. To receive the first and subsequent meeting announcements, contact the organizers at: izc2012@sci.haifa.ac.il.

NEWSNOTES

Roncadell Digital Library

Roncadell—a conservation organization based in Valencia, Spain—has established a digital library containing a number of important herpetological works long out of print, as well as a few modern titles. To view the catalogue and to download digital files, please visit their website at:

http://roncadell.jimdo.com/biblioteca-digital/llibres-antics/herpetologia-i-peixos/

Herpetological Reunion at Louisiana State University, Baton Rouge

Several former graduate students and friends of Dr. Douglas A. Rossman gathered with Doug and his spouse Sharon for a second reunion at the LSU campus from 2–6 April 2011. Present at the celebration were Doug's former students Janalee P. Caldwell, Donald E. Hahn, Jeff Boundy, Kenneth L. Williams, and Larry David Wilson. Guests included Laurie J. Vitt and Viola Williams. Robert A. Thomas from Loyola University joined "Rossman's Renegades" to recount tales from USL (now University of Louisiana at Lafayette). Former students unable to join the reunion, but remembered, were Frank T. Burbrink, Darrel R. Frost, Richard M. Blaney, Patricia K. Blaney, and Edmund D. Keiser. Also remembered were three colleagues now deceased: Ernest A. Liner, Gerald C. Schaefer, and Alexander Varkey.

Apart from enjoying the local world-class Cajun cuisine, the attendees reminisced with one another, admittedly with some embellishments. In addition, Christopher Austin provided a tour through the LSU Museum of Science herpetological range; thanks are due him for making arrangements for our visit. The highlight of the gathering was Doug's recounting of his move to Iowa and his activities in both herpetology and Norwegian mythology since his retirement. Long a passion of Doug's, his work in Norwegian mythology has resulted in the publication of five books since his retirement.

PHOTO BY PHOTO BY L. J. VITT

Doug Rossman and former grad students at recent LSU herp reunion. L–R: Ken Williams, Jan Caldwell, Doug, Don Hahn, Larry Wilson, and Jeff Boundy.

Jan and Laurie made a presentation on their work in Brazil and Don showed slides (yes, slides) of his early trips to Honduras, including to the Bay Islands with Larry and his then new wife Elizabeth. Later, at one of the dinners, Don was a hit with an impromptu comedy and magic show.

This reunion was the second get-together. The first took place in 1998 at LSU in connection with Doug's retirement from the institution. That gathering was a bit more formal and was emceed by Larry. Each of Doug's students rose to tell his or her story since graduation, again salted with appropriate embellishments. We all are looking forward to the next reunion in 2024.

Journal of Natural History Education and Experience

The *Journal of Natural History Education and Experience*, a publication of the Natural History Network, is an electronic, peer-reviewed, open-access journal. Its purpose is to foster a renaissance in natural history education and appreciation by providing a forum for disseminating information on views on the place of natural history in society and techniques, curricula, and pedagogy for natural history education at all levels: K–12, undergraduate, graduate, and general public.
Recent articles include:

- Rewilding Natural History (Peter Kahn and Patricia Hasbach)
- Revitalizing Natural History Education by Design (M. Kolan and W. Poleman)
- Natural History from the Ground Up: developing a college-level natural history program in the new millennium (D. Gilligan)
- A Bird in the Hand: A placed-based, hands-on curriculum in ornithology (S. Trombulak)
- Teaching Natural History and the Spirit of Place (F. Taylor and J. Tallmadge)

The Natural History Network (naturalhistorynetwork.org) is an affiliation of teachers, scientists, and nature writers who seek to promote the values of natural history through discussion and dissemination of ideas and techniques on its successful practice to educators, scientists, naturalists, artists, writers, the media, and the public at large.

The journal seeks papers that provide perspectives on natural history as a mode of engagement with the world as well as information that will promote the development of natural history curricula and are generally accessible to natural history educators. Content of the journal ranges from the applied to the philosophical, but entirely focused on the principles or practice of natural history education and experience.

Educators and practitioners who have perspectives or successful curricula that they would like to share are especially encouraged to submit articles for publication.

For more information, visit www.jnhe.org or write to Steve Trombulak, editor of the *Journal of Natural History Education and Experience*, at trombulak@middlebury.edu.

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; 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."

Intercontinental Dispersal in a Fossorial Reptile

Intercontinental dispersal has been a feature of the biogeographic history of many animals, either by passage across land bridges, or by long-distance oceanic rafting. The family Dibamidae consists of burrowing, essentially limbless lizards and has traditionally been split into two geographically disjunct clades: *Anelytropsis*, a monotypic genus with a restricted distribution in northeastern Mexico, and *Dibamus*, containing approximately 20 species occurring in southeast Asia. In this study, the authors collected molecular data (one mitochondrial and six nuclear genes) for nine dibamid species including *Anelytropsis* and used Bayesian methods to reconstruct a phylogeny and to estimate divergence times among the dibamid lizards. These analyses recover three deeply divergent but morphologically conserved clades: mainland and insular *Dibamus* clades and an *Anelytropsis* clade. Furthermore, all analyses find *Anelytropsis* to be the sister of one of the two *Dibamus* clades (to which clade analyses fail to distinguish with confidence). The dating analysis places the origin of these three lineages to between 90 and 49 million years ago. Therefore, if the intercontinental dispersal which must have occurred to lead to this disjunct distribution occurred by way of a land bridge, it most likely occurred across Beringia in the late Palaeocene or Eocene. Alternatively, oceanic-rafting across the Pacific remains a possible explanation. Additionally, the discovery of the deep genetic divide separating *Dibamus* is surprising, and given the tremendous similarity between species in both clades, constitutes a remarkable example of morphological conservatism.

Townsend, T. M., D. H. Leavitt and T. W. Reeder. 2011. Intercontinental dispersal by a microendemic burrowing reptile (Dibamidae). Proceedings of the Royal Society of London, Series B (*in press*). doi: 10.1098/rspb.2010.2598.

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Impact of Overwintering Conditions on *Bd* Infection and Mortality in Toads

As host/pathogen dynamics can be severely impacted by temperature variations, factors such as global warming are predicted to influence future patterns of disease. Despite this potential, few studies have experimentally tested the effects of changing temperature on host/pathogen interactions. In this study, the authors have experimentally tested the effect of overwintering temperature on susceptibility of common toads, *Bufo bufo*, to infection and mortality caused by the amphibian pathogen *Batrachochytrium dendrobatidis* (*Bd*). Two groups of newly metamorphosed toadlets were subjected to one of two overwintering treatments. The first saw toads held at 8°C for 36 days, 4°C for 11 days followed by 8°C for a further 36 days. The other group was held at 8°C for 16 days, 4°C for 51 days followed by 8°C for a further 16 days. Following overwintering (and a 16 day recovery period), animals from both treatments were either infected by a high dose of *Bd*, a low dose or a control treatment. Infection status was then determined. Toads from the warmer overwintering regime suffered a greater chance of infection, however once established, the proliferation of *Bd* was higher in toads from the colder overwintering treatment. There was no difference between treatments in survival, or in any consistent influence of disease on survival for that matter. Instead, condition, mass and mass lost over winter was the best predictor of toadlet survival, which led the authors to conclude that larval growth is a more important to survival of toadlets than overwintering conditions or *Bd* infection rate.

Garner, T. W. J., J. M. Rowcliffe, and M. C. Fisher. 2011. Climate change, chytridiomycosis or condition: an experimental test of amphibian survival. Global Change Biology 17: 667–675.

Correspondence to: **TRENTON GARNER**, Institute of Zoology, Zoological Society of London, Regent's Park, NW14RY, London, UK; e-mail: trent.garner@ioz.ac.uk

Evolution of a Cryptic Species Complex in Northern Australia

Cryptic speciation is the process whereby lineages separate and accumulate genetic differences without concurrent morphological divergence. This phenomenon provides an interesting opportunity to investigate morphological stasis and determine if phenotypic stability is a consequence of either adaptive or non-adaptive processes. In this study, the authors have examined a pair of sister species occurring in northern Australia: the agamid lizards *Diporiphora magna* and *D. bilineata*. A phylogenetic analysis based on one mitochondrial gene (ND2) and a nuclear gene (RAG1) revealed eight deeply divergent and geographically discrete clades. No consistent morphological differences were observed between the clades, confirming this system's status as a cryptic species complex. Morphological and ecological data was collected, analyzed in principal component analyses, and compared with phylogenetic data to determine whether evolution in these characters fit models of neutral drift (Brownian motion) or constrained or correlated evolution. These phylogenetic comparative methods favored a model of constrained evolution, suggesting adaptive processes are important in maintaining morphological similarity among clades. The authors suggest that the homogenous habitat structure, but highly variable environmental conditions has promoted morphological stability in these species. This study highlights the potential for adaptive processes to maintain morphological stasis and that dynamic environments may select for cryptic species.

Smith, K. L., L. J. Harmon, L. P. Shoo and J. Melville. 2011. Evidence of constrained phenotypic evolution in a cryptic species complex of agamid lizards. Evolution (*in press*). doi:10.1111/j.1558-5646.2010.01211.x.

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Behavioral Alleviation of the Costs of Reproduction in *Anolis* Lizards

The costs of reproduction for a female can be alleviated by modification of behaviors during reproductive periods. In this study, the authors examined these behavioral modifications in green anole lizards, *Anolis carolinensis*. The effect of reproductive load on three behaviors (locomotion, social displays and foraging) was examined. Observations were made of female lizards in the field and then focal individuals were captured and their reproductive load was determined (by measuring the total amount of reproductive tissue: eggs, follicles and oviducts). Locomotion and social display behavior both declined with reproductive load, however no effect of reproductive load on foraging behavior was detected. In the second part of the study, the authors conducted analyses to determine if these behaviors and reproductive loads were phylogenetically correlated across eight additional *Anolis* species. No associations were found between the evolution of reproductive load and any of the behaviors, and may represent varying life history strategies or selective ecological pressures across *Anolis* species instead.

Johnson, M. A., J. L. Caton, R. E. Cohen, J. R. Vandecar, and J. Wade. 2010. The burden of motherhood: the effect of reproductive load on female lizard locomotor, foraging and social behavior. Ethology 116: 1217–1225.

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Ageing and Fitness Correlates Determined in a Wild Population of Lizards

Ageing can have complex and interrelated impacts on a range of fitness traits, and therefore, it is essential that it is accounted for in studies investigating potentially age-related variation. Despite this, due to the complex nature of identifying age components of variation, especially in wild populations, they are rare. In this study, the authors have taken a comparative approach to investigation ageing in a wild population on the common lizard, *Lacerta* (*Zootoca*) *vivipara*, in southern France. Five fitness components were examined and three physiological traits (resting metabolic rate, corticosterone level, cell-mediated immunity). Age-related variation was discovered in multiple fitness aspects, including senescence in female reproduction, measured by litter success. Further, old females had a higher metabolic rate and T cell-mediated immune response compared to young females. Interestingly, only females that had a high investment in reproduction when young, displayed senescence later in life. This trade-off is expected theoretically but is rarely observed in the wild. Some of the effects of ageing were also related to differences in environment and individual characteristics. This study highlights the importance of taking an integrative approach to studies of ageing, as it is a complex and interrelated process, potentially involving a range of fitness traits.

Massot, M., J. Clobert, L. Montes-Poloni, C. Haussy, J. Cubo, and S. Meylan. 2011. An integrative study of ageing in a wild population of common lizards. Functional Ecology (*in press*). doi: 10.1111/ji.1365-2435.2011.01837.x.

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Impact of Environmental Conditions on Predator Responses in Tadpoles

Behavioral plasticity is a valuable capability, especially in unpredictable environments. However, an organism's ability to behaviorally respond to one environmental factor may be constrained by another, seemingly unrelated environmental factor. For frogs, a well-studied phenotypically plastic response relates to hatch timing. Embryos have been demonstrated to hatch in response to predators, certain abiotic conditions and changes in resource availability. In this study, the authors have examined the impact of environmental conditions on hatch timing in the neotropical treefrog, *Dendropsophus ebraccatus*. This frog lays eggs both above the water (attached to leaves) and directly in the water, exposing these eggs to different desiccation risks. The impact of desiccation on predator-induced hatching and escape success from two predators (terrestrial *Azteca* ants and aquatic tadpoles) was investigated. In response to both predators, eggs hatched prematurely (up to 67% earlier than unpredated clutches). however, when exposed to desiccating conditions, egg clutches subjected to attacks from the *Azteca* ants suffered lower predator escape success than those from hydrated clutches of either predator treatment. Indeed, desiccated eggs recently placed in the water showed no difference in early hatching success relative to eggs eggs having been submerged in water long term. The reduction in predator escape from desiccated clutches probably impacts recruitment in wild populations, and highlights the importance of other environmental factors in mediating phenotypically plastic responses.

Touchon, J. C., J. Urbina and K. M. Warkentin. 2011. Habitat-specific constraints on induced hatching in a treefrog with reproductive mode plasticity. Behavioral Ecology (*in press*) doi: 10.1093/beheco/arq192.

Correspondence to: **JUSTIN TOUCHON**, Department of Biology, Boston University, Boston Massachusetts 02215, USA; e-mail: jtouchon@bu.edu

Impact of Agricultural Land Use on Stream Dwelling Turtles

Anthropogenic modifications to riparian habitat can have serious consequences for stream dwelling organisms. In this study, the authors examined whether the diversity and abundance of freshwater turtles differed between agricultural riparian zones, and those that had been undisturbed or restored. This study was conducted in the Lower Flint River Basin (LFRB) in south-west Georgia, USA, which possess a high diversity of freshwater turtles. In total, nine species were encountered, from two streams within the LFRB. Diversity (species evenness) was positively correlated with the amount of undisturbed landcover in the riparian habitat. However, associations between riparian habitat and abundance differed between species. For some species, abundance increased in less-forested, more disturbed sections of stream, but for the state-protected and endemic *Graptemys barbouri* (Emydidae), abundance was lowest in disturbed riparian zones. The impacts of agriculture on species diversity could relate to the availability of prey species in these stream sections which are sensitive to runoff. This study indicates physical alterations such as increased sedimentation or a reduction in nesting sites may reduce the number of species that can be supported in a stretch of stream.

Sterrett, S. C., L. L. Smith, S. W. Golladay, S. H. Schweitzer and J. C. Maerz. 2011. The conservation implications of riparian land use on river turtles. Animal Conservation 13:38–46.

Correspondence to: **SEAN STERRETT**, 180 East Green Street, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia 30602, USA; e-mail: sterretts@warnell.uga.edu

Artificial Water Points Assist Cane Toads in Invading Arid Zones

In many cases, biological invasions occur from "invasion hubs," satellite populations that once established, facilitate expansion. By concentrating management effort on these invasion hubs, the spread of invasive species may be contained. While there is good theoretical support for this management strategy, it has rarely been practically demonstrated. Artificial water points (AWP) have been installed by humans throughout arid landscapes, increasing the availability of standing water. The increase in AWP has potentially opened up many otherwise inhospitable landscapes to colonization by invasive species. In this study, the authors have examined the importance of AWP in the invasion of northern Australia by the Cane Toad, *Bufo marinus*. They experimentally excluded toads from some AWP with fencing and by hand-counting the toads trapped within the fences and comparing toad abundance in areas with and without access to AWP, they demonstrated that AWP do provide dry season refuges for the toads as well as provide a resource subsidy. The authors suggest that AWP operate as invasion hubs for cane toads in arid Australia. The authors also modelled the impact of excluding toads from AWP throughout arid Australia, and predicted that this would reduce the area across which toads could colonize by 38%. This study highlights the importance of anthropogenic landscape modification in the spread of invasive species and illustrates the potential for controlling the spread of these species through cordoning off invasion hubs.

Florance, D., J. K. Webb, T. Dempster, M. R. Kearney, A. Worthing, and M. Letnic. 2011. Excluding access to invasion hubs can contain the spread of an invasive vertebrate. Proceedings of the Royal Society of London, Series B (*in press*). doi:10.1098/rspb.2011.0032.

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Logging Activity Does Not Impact Behavior of Timber Rattlesnakes

Forest management activities have the potential to profoundly alter the landscape, and as a consequence, may have serious impacts on the animals that live in these landscapes. For this study, the authors have examined the impact of commercial logging on the behavior of Timber Rattlesnakes (Viperidae: *Crotalus horridus*) in Pennsylvania, USA. Over a four-year period, behavior was examined using radiotelemetry, mark-recapture and visual surveys in areas both prior to and following logging. Direct observations of mortality during logging was low (observed mortalities represented less than 2% of the population per year), as were rates estimated from the mark-recapture data (less than 7%). Following logging, snakes maintained their previous ranges, and actually increased the divesity of utilized habitats to include sites in logged areas. Indeed, contrary to the concern that gravid females might suffer disproportionate mortality, the authors posit that their preference for areas with favorable thermoregulatory opportunities kept them out of the logging areas until operations were completed.. The authors propose that the most significant cause of mortality was direct killing by loggers, and suggest that to reduce the impacts of logging on rattlesnakes, workers in this region should be prohibited from killing encountered snakes.

Reinert, H. K., W. F. Munroe, C. E. Brennan, M. N. Rach, S. Pelesky, and L. M. Bushar. 2011. Response of timber rattlesnakes to commercial logging operations. Journal of Wildlife Management 75:19–29.

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African Geckos, Coalescent-based Species Delimitation Methods, and the ICZN

As methods for acquiring diverse DNA sequence data continue to accumulate, methods for analyzing these data are also improving. For a while now, researchers have had the ability to evaluate hypotheses of speciation using data from across the genome, rather than relying on single molecular markers or detectable morphological differentiation. More recently, advanced methods for extracting the underlying "species tree" from a suite of potentially discordant "gene trees" have opened the door for more rigorous tests of speciation. The authors of a recent study[1] investigated species limits in a clade of West African geckos (Gekkonidae: *Hemidactylus fasciatus* complex) using one of these new methods: Bayesian species delimitation (BSD). This method exploits the genealogical information inherent in DNA sequence data to evaluate hypotheses of species limits under expectations derived from coalescent theory. Using sequence data from five nuclear DNA genes from samples collected across the distribution of *H. fasciatus*, the authors conducted a genotype clustering analysis to identify genetic populations and constructed a species tree for these populations using the sequence data. Subsequently, they conducted an analysis which utilized coalescent theory to simulate gene trees based on the sequence data; these simulated trees were used to differentiate between ancestral polymorphisms and post-divergence gene flow (the latter being viewed as evidence against speciation). The structuring analysis identified four genetic groupings and the BSD analysis found strong support for all four groups being genetically independent and therefore distinct species. The same analysis conducted with the hypothesis of each population being a separate species found the same results with the exception of an insular locality representing a fifth species. The authors describe these four lineages as species, citing clustering with the respective holotype in their BSD model as the species diagnoses.

Several researchers subsequently published a commentary[2], taking exception to the use of model-based clustering analyses to describe new species and indicating that these analyses should be accompanied by explicit, character-based diagnoses (which could include molecular characters). While conceding that the focus on characters may be artificial, they argue that species descriptions lacking diagnostic characters are in strict violation of the International Code of Zoological Nomenclature (ICZN) and could lead to taxonomic inflation (a precipitous rise in "superficial" species descriptions that could ultimately undermine conservation efforts). Finally, they contend species delimitation should incorporate data from multiple, independent categories and species descriptions based solely on clustering in an analysis performed under a particular model should be avoided.

The authors of the original article responded in an invited reply[3] by addressing the claim of taxonomic inflation and the validity of solely using BSD to identify species. They argue that BSD simultaneously incorporates multiple, independent lines of evidence and is therefore less prone to taxonomic inflation than methods relying on a single character, such as a single-locus gene tree (as under the Phylogenetic Species Concept). Furthermore, they maintain that coalescence of independent genes across the genome is a more intrinsic feature of speciation than either the acquisition of unique morphological characters or single-gene reciprocal monophyly, making BSD a superior tool in the effort to rigorously identify species. Finally, they indicate that more detailed and ICZN-compliant descriptions of the species identified in their study are forthcoming.

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ZOO VIEW

Herpetological Review, 2011, 42(2), 136.

The Snake Handles

The Reptile House at The National Zoological Park in Washington DC is a splendid example of "Associationist" zoo design: exotic style used to enhance the spectacle of zoo going. The ten panels on the original entrance doors alternately display a lumbering *Stegosaurus* and battling yin-yang *Protoceratops* (Fig. 1, left). The panels are of gesso (a preparation of plaster of Paris, glue, and sometimes horsehair). Each of the four doors to the Reptile House held a bronze door pull which consisted of a ring formed by two intertwined serpents. It is generally assumed that John Joseph Earley was the artist connected with the design and execution of these handles, although where they would have been cast is not known.

In spirit, if not actual design, they are reminiscent of the staff of Mercury. These serpents are entwined, rather than opposing as on the caduceus. In Chinese mythology, the world was surrounded by two entwined snakes, symbolizing the power and wisdom of the creator.

In its original configuration, the art went beyond merely visual and into the tactile—one had to pull on the snake handle to open the doors. Therefore, most visitors would have had to place their hand on a reptile before entering the building. In 1980 the Reptile House was renovated and the entrance doors were refurbished and placed inside the building to the entrance of what was called HerpLab (now known as Resource Room). The original handles were replaced in 2005 with replicas cast through the lost wax process at a local foundry (Fig. 1, right).

A photograph of the original entrance door and herpetological history of the Zoo may be seen in Murphy and Xanten (2007). (Herpetol. Rev. 38:262–373).

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Editor's note.—Béla Demeter was a research biologist in the Department of Herpetology at National Zoological Park for many years until retirement. He now is a volunteer interpreter at the National Gallery of Art in Washington.

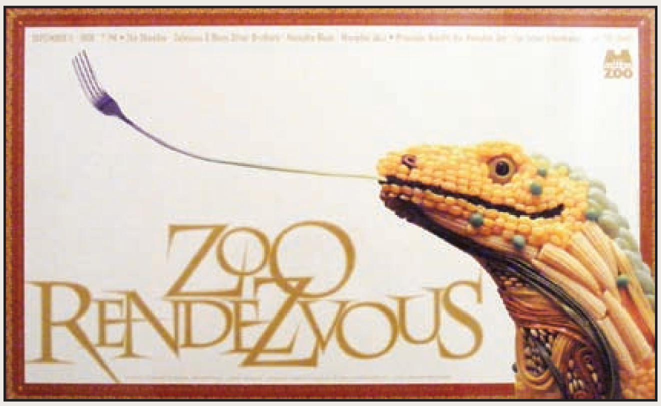
Fig. 1. (**left**) Battling *Protoceratops* on entrance door of Reptile Building at Smithsonian National Zoological Park in Washington DC. Photograph by Mehgan Murphy, Smithsonian National Zoological Park. (**right**) Replica of entwined snake handles on entrance door of Reptile Building at Smithsonian National Zoological Park in Washington DC. Photograph by Mehgan Murphy, Smithsonian National Zoological Park.

Snake Crushes Bus

The Copenhagen Zoo in Denmark has designed one of the most intriguing advertising campaigns: a Boa Constrictor constricting a city bus. Notice how cleverly they altered the apparent roof of the bus. The advertising agency was Bates Y & R in Copenhagen, Creative Director was Ib Borup, and Art Director was Peder Schack. Thanks to Britta Benzer Ankersen, Michael Jorgensen, and Gerard Visser for providing this image.

Jolly Green Giant

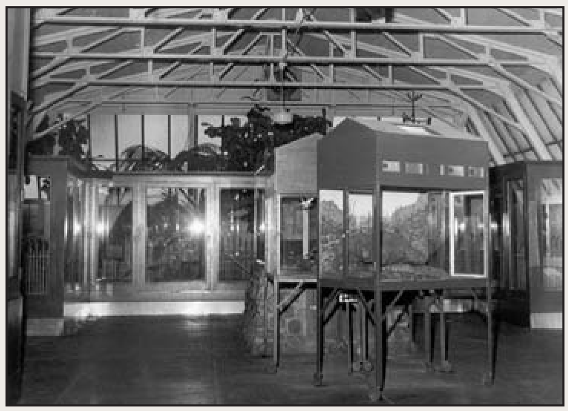
Curator of Herpetology Steve Reichling and Graphic Designer Tonya Kuhl, both of the Memphis Zoo in Tennessee, sent this poster of a vegetative Komodo Dragon for an event held at the Zoo in 1998. The format was developed by the company Good Advertising.



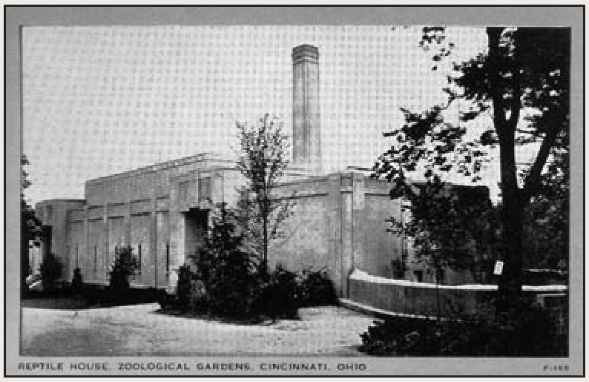
Reptile Buildings During the Great Depression in the 1930s

"But should snakes get any money at all? They are not the fuzzy, feel-good animals that one might have imagined would have received taxpayer money at a time when many Americans were going hungry." This was a question asked by Mrs. Charles J. Dolan in her editorial to a St. Louis newspaper: "What are the St. Louisans thinking of to let the gentlemen of the Zoo Board go ahead without protest with their amazing proposal to squander $100,000 of the taxpayers' money on a climax of absurdities —and worse—a chamber of horrors that nobody wants—a snake house."

—Jesse C. Donahue and Erik K. Trump, 2010



(**top**) Entrance to reptile building at Smithsonian Institution's National Zoological Park, opened in 1931 and still in operation. Credit: photograph by Jessie Cohen, Smithsonian National Zoological Park. (**center**) Postcard of St. Louis Zoological Park's reptile house in 1944, still in operation, which is one of the most beautiful facilities ever built for reptiles and amphibians. Credit: provided by Brint Spencer. (**bottom**) Exhibits in old reptile display at Philadelphia Zoo during the 1930s. Credit: undated photograph by Franklin Williamson, courtesy of Zoological Society of Philadelphia, provided by Brint Spencer.



Postcard of original Reptile House, now bird house, at Cincinnati Zoological and Botanical Gardens. Credit: provided by Brint Spencer.

In their book *American Zoos During the Depression. A New Deal for Animals* (2010, McFarland & Co., Jefferson, North Carolina; ISBN: 978-0-7864-4963-7), authors Donahue and Trump follow the amazing growth of zoo construction in the United States supported by federal programs. In Chapter 4, "Why snakes? The spectacle and science of snakes," they document the design and development of many reptile buildings that occurred during the 1930s. Some of the most spectacular zoo buildings were built or improved at that time: National (Washington, DC), Toledo, St. Louis, Brookfield, Cincinnati, San Antonio, San Diego, Buffalo, and Philadelphia. As a testament to their durability and beauty, some still are operational today.

It may surprise the reader, but the production of antivenin in North America during this period was supported in large part by zoo herpetologists, who provided venom to the manufacturers, raised public awareness about snakebite treatment, and distributed antivenin.

JAMES B. MURPHY, *Section Editor*

RESPONSES TO JOE MENDELSON'S ESSAY

In the last issue of *HR*, Joe Mendelson from Zoo Atlanta authored a thought-provoking essay on what it means to be an amphibian biologist today. His piece elicited many responses and has generated much discussion. In this issue, we are pleased to offer four companion essays from Kraig Adler, Harry Greene, Michael Lannoo, and Larry David Wilson. The focal species of Mendelson's essay, *Ecnomiohyla rabborum* (Rabb's Fringe-limbed Treefrog, now reduced to two living individuals, both male), is shown here with George B. Rabb. The frog was named in honor of herpetologists and conservationists George and Mary Rabb.

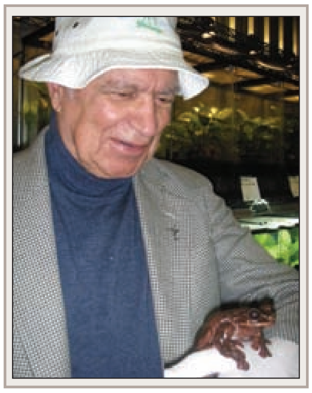


PHOTO BY LARA T. LONG

Herpetological Review, 2011, 42(2), 138–139.

No White Flags!

Joe Mendelson's essay provides heart-breaking affirmation of the state of the planet: even with the best efforts humanity can muster, we will lose a lot of existing biological diversity before this crisis bottoms out. Other commentators have stated that Polar Bears and Tigers are already toast, too far gone to save in the wild—can you imagine conceiving of that possibility when we were kids, that the largest mammalian carnivores on Earth would come so close to extinction in our lifetimes? Equally disturbing are a variety of looming threats—as just unstudied one example, what if

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PHOTO BY CYNTHIA PRADO

Harry Greene examining a Bolson Tortoise (*Gopherus flavomarginatus*), among a group of about two dozen that have been restored to their late Pleistocene range in New Mexico.

some critical factor changed just enough that dinoflagellates and diatoms, which provide much of our oxygen, crashed as suddenly and mysteriously as the Golden Toad? And in the face of this overall situation, conservationists and environmentalists are too frequently acting as if business as usual is sufficient, or at least all that we can hope to accomplish.

Can we find reasons for hope? Well, the undergraduates I teach are bright, talented, hard working, and idealistic—maybe they can pull off what we've thus far failed to accomplish, and I surely hope so. What else? Thanks to the Pleistocene rewilding initiative and Ted Turner's Endangered Species Foundation, Bolson Tortoises have a toehold back in New Mexico (Donlan et al. 2006; Truett and Phillips 2009) and thus TWO latitudinally disparate populations with which to face climate change. We have folks like Joe Mendelson attempting other bold, risky endeavors in the face of withering criticism from some of his peers. And there's the cowboy I met a few years back in a bar near the Pecos River, who when asked if he'd shot a big Indigo Snake, replied, "Hell no, why would we do that? Our boss won't even let us kill those ol Diamondbacks anymore, except right around the foreman's house, cause he's got kids and all."

Perhaps there's still room for optimism, and our rallying cry should be "no white flags!"

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Herpetological Review, 2011, 42(2), 139–142.

Amphibian Extinction Crisis: The Key Threat of Habitat Loss and a Potential Major Role for Amateurs

I love amphibians. I once said that to one of my molecular biology colleagues at Cornell, who looked at me like I was totally crazy. The readers of *Herpetological Review* will know what I meant. Like many of them, I became fascinated with frogs and salamanders when I was a boy. Much later, amphibians became my primary study animals for behavioral research as well as some systematics and faunal work. Long ago I came to have a deep respect for the ways in which they make their livings and for their dazzling diversity and aesthetic beauty. Thus, Joe Mendelson's article in the March issue came as a real jolt—although not an altogether unexpected one, unfortunately. The world that he, Mike Lannoo, Karen Lips, Kevin Zippel, and my other young colleagues live in is far different from the one that those of my generation have enjoyed. While the chytrid fungus is the current plague, an even more insidious one is the loss of habitat—one pond here, a forest patch there, or a stretch of stream or riverbank. And this scourge is happening in the USA and in Europe as much as it is in the tropics. Joe's depressing observations have caused me to reflect on my own experiences with amphibians, the impacts that we have had on them, and their future prospects for survival.

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PHOTO BY DOLORES ADLER

Kraig Adler on a field trip in Ithaca, New York, with plastic box of salamanders, April 2011.

As high school students in Ohio in the 1950s, David Dennis, who became a natural history artist and photographer, was my constant field companion. We first explored Ohio for herps, then West Virginia, and finally worked our way south to Kentucky, Virginia, and North Carolina by the time we were in college in the early 1960s. Thus, we came to know many of the localities immortalized by E. R. Dunn, the first plethodontid expert: Grandfather Mountain, White Top, and Clingman's Dome; the French Broad River; and Yonahlossee Road (not the current road by that name). Dave and I have also enjoyed the Nantahala Mountains, Tusquitee Bald, Burke's Garden, and Bat Cave, among many other places. It was just east of Boone, North Carolina, late one night about 1960, that we saw our first Yonahlossee Salamander (*Plethodon yonahlossee*) (Fig. 1). I can still vividly remember Dave, Steve Tilley, another regular field companion, and me yipping and yelling at seeing that most handsome of salamanders. (Of course, we didn't yet have it in our hands, and that can be a real challenge.) In those days, we could stop at outcrops along the road or in ravines below bridges and find salamanders in large numbers almost anywhere we looked, especially if it was after nightfall.

PHOTO BY DAVID DENNIS

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

Fig. 1. *Plethodon yonahlossee* (Yonahlossee Salamander) during courtship in the field.

In August 1976, Dave and I led a three-car caravan after the SSAR meeting in Oxford, Ohio, for three days of salamandering in the Southern Appalachians. We saw and photographed 26 species (and those were the days before Dick Highton and Steve Tilley described a plethora of new plethodons and desmogs from that region). Tim Halliday, the British herpetologist and future amphibian conservationist who was visiting the USA for the first time, was part of our group. (He has only three species of salamanders in his country, all of them newts.) Late one night at Old Yonahlosee Road, along the foot of Grandfather Mountain near Linville, North Carolina, we observed literally hundreds of salamanders. Conditions were perfect: it was breeding season, warm, and a very light rain was falling. We saw eight species of *Desmognathus*, *Eurycea*, *Gyrinophilus*, and *Plethodon* in our headlamp beams. All were crawling about and many of them even high into the vegetation to feed. Several were courting including the Yonahlossees. Tim got a bit giddy. It was truly a Homeric scene!

Over the years, I have taken small groups of Cornell students to the Southern Appalachians for salamanders. To see a Cave (*Eurycea lucifuga*), a Red (*Pseudotriton ruber*), or a Green (*Aneides aeneus*) salamander for the first time is unforgettable. They make an impression on a student. By the 1980s, however, my favorite haunts were being converted to gated retirement communities, parking lots, and golf courses, even near Linville and the Yonahlossee Road itself. For me, one of the most telling experiences was at a meadow stream a few km south of Boone along Route 105 towards Linville, just behind the Lebanon Baptist Church. That was always the best place to reliably find the Long-Tailed Salamander (*Eurycea longicauda*; Fig. 2). They were very active in the tall grass along the edge of Willow Brook, making them tough to collect without damaging that magnificent tail. These animals were abundant there for decades until the early 1990s when, after only a two-year hiatus between our visits, we returned to find the area had been completely developed for upscale housing. I thought we must have taken a wrong turn, so went back to a landmark (the church) and tried again, only to find that the stream as I knew it was gone, and so too were those beautiful salamanders.

Dave Dennis and I once witnessed a local extinction. In 1961, we visited the type locality of the tiny Seepage Salamander (*Desmognathus aeneus*) together with Jesse C. Nicholls, Jr. In 1946, he had collected the types for Sherman C. Bishop, a specialist on salamanders who later wrote the standard handbook on the topic. When we arrived at the wooded, sphagnum-covered site, along a small tributary of Peachtree Creek about 5 km east of Murphy, North Carolina, bulldozers were clearing the area. When the operators took their lunch break, the three of us rushed in to search for salamanders. We eventually collected about 50 of them (Fig. 3). (These topotypes are now at the Carnegie Museum in Pittsburgh.) After lunch ended, the bulldozers started up again and cleared the rest of the site of all of its trees. The type locality is now in cultivation and unsuitable habitat for salamanders. It was depressing to watch the total destruction of an ideal habitat for this patchily distributed and uncommon species.

Overzealous scientific collecting is sometimes to blame for severe habitat destruction. In 1964, I visited the Sierra Madre del Sur of southern Mexico and along a stream at 1070 m on the southwestern slopes of Cerro Teotepec in Guerrero I found an odd hylid frog that I could not identify (Fig. 4). A few weeks later, our party of three encountered a much larger one composed of an American professor and his students. In my enthusiasm, I showed the professor my frogs, which he did not recognize either, and I stupidly noted where they were found. As luck would have it, our party revisited the Teotepec site a couple of weeks later and found it ravaged. Most of the emergent vegetation was uprooted and nearly all of the arboreal bromeliads had been dropped to the ground and dismembered. I half suspected what had happened and this was confirmed when, a month later in Oaxaca, we encountered the professor and his party again. Groups of students had been assigned to each side of the stream to tear up the water plants. Other students were sent up into the trees to throw down the bromeliads for their colleagues to tear apart on the ground. In fact, despite all the devastation, they got no adults

PHOTOS BY DAVID DENNIS

Fig. 2. (**left**) *Eurycea longicauda* (Long-tailed Salamander). Fig. 3. (**center**) *Desmognathus aeneus* (Seepage Salamander). Fig. 4. (**right**) *Hyla* (now *Exerodonta*) *pinorum* (Mexican Pine Woods Treefrog), Guerrero, Mexico. This species may now be extinct.

at all! (I had taken five males on my first visit by patiently locating them by their calls at night, without disturbing any vegetation.) I learned my lesson and, when I described three new hylids from this trip I purposely did not reveal precise directions to the type localities, although these data are in my field notebook. I don't know precisely what effect the damage at the Teotepec site had on the amphibians, but certainly that stream site was less habitable for frogs for a long time to come. Unwittingly, I had contributed to this desecration and I have never forgotten my role in it.

My attitude towards amphibian conservation and the protection of habitats in which they live has changed as a result of these and other experiences I've had. I am happy to see the emergence of hobbyist groups, like Tree Walkers International (TWI), that promote healthy wild populations of amphibians. Among other beneficial projects, TWI provides information for volunteers to create amphibian habitats in their own backyards. And my attitude toward more radical approaches may be surprising. For example, I harbor a waning hope that the Golden Toad (*Incilius periglenes*) of Costa Rica may still survive, not in the wild perhaps, but as a breeding colony kept by some amateur terrarist who has not divulged its existence. Because this species is rigidly protected under IUCN listing, any owner of live specimens in the USA could be prosecuted under the Lacey Act. The owner would be loath to reveal that he or she possesses these toads, but the real losers are the toad, Costa Rica, and all of us. If such a captive colony exists, we need to find a way to absolve the owner in order to recover this exquisite animal, one of the most sexually dimorphic frogs in the world. If the owner would have to pay a fine, I would happily contribute to the fund.

Let me go one step further. I believe we need to reevaluate the role of serious amateurs who, with patience and skill, have learned how to breed so many species of amphibians. Some are actually the world experts on particular species. We should ask them to help us conserve endangered species. Amphibian Ark (AArk), an NGO sponsored by the world's zoos and aquariums, is heavily involved in captive-breeding efforts, but AArk does not have the capacity to preserve all of the endangered species. At best, the resources of such organizations might be sufficient to save 10% of the endangered species. Who will help with the rest? If we continue to take a purist approach and say that such breeding can only be handled by accredited zoos, universities, and other public institutions, then surely many—probably most—species of disappearing amphibians are doomed. But if zoos were to provide breeding stock to amateurs (who would have to be properly certified), then amateurs must be willing to reciprocate in helping to restock zoos and provide stock for reintroductions in the wild. The permitting authorities would have to be receptive, but currently the United States Fish & Wildlife Service is not. In Australia, on the other hand, the first place the government turns is to the hobbyist community, Kevin Zippel informs me. I realize that the issues involved are not simple and all parties need to rise above their parochial interests. We must find a way to certify qualified amateur terrarists and ask for their help in this noble effort.

A novel effort involving amateurs has been underway since 2009 to breed the endangered Oregon Spotted Frog (*Rana pretiosa*) (see http://seattletimes.nwsource.com/html/localnews/2009421766_inmatefrogs06m.html). With guidance from Marc Hayes, a researcher with the state's wildlife department who is well known to herpetologists, two inmates at the minimum-security Cedar Creek Corrections Center in Washington State have been hatching frogs from eggs each April. They hold the tadpoles and froglets in plastic pools where they are fed every two hours and the water is refreshed regularly. Perhaps because of the inmates' intensive care for their animals, the mortality they observe is lower than that reported at several zoos where this species is also being bred. More than 1000 young frogs are then released each fall at sites where this species was once abundant. Why couldn't this low-cost method for headstarting endangered amphibians be copied elsewhere? I am told that a similar plan is being considered in New York State to headstart Hellbenders (*Cryptobranchus alleganiensis*). This idea could also be expanded to exotic species. Because of high security in a prison facility, some of the Fish & Wildlife Service's concerns would be alleviated.

I do not wish to become an "extinction biologist," Tim Halliday's morbid term, or what Joe Mendelson calls a "forensic taxonomist." If we are to avoid this fate, we must think in new ways and find new solutions to old problems. And we must do it very quickly. Will a partnership with the amateur community make a difference in the long run? I don't know. Is it worth the gamble? Certainly. Are there better ideas? Let's hear them.

Herpetological Review, 2011, 42(2), 142–145.

No Retreat, Baby, No Surrender

Having written or edited more words on amphibian declines and malformations than most, it would be easy for me to look big picture and give up. We see the über rich convert, directly or indirectly, our favorite ecosystems into gated communities of manicured McMansions, copping an attitude of "this land was made for me not you." And we see that globalization has its unintended consequences, spreading disease and invasive species like a Biblical plague. Pesticides, now everywhere, are either deforming or de-sexing, and we can only wonder if chemicals are doing that to frogs, what are they doing to us, or more importantly, our kids?

There is an old John Prine song that puts a perspective on all this and our potential reaction to it. The chorus goes:

> "You can gaze out the window, get mad and get madder,
> Throw your hands in the air, say what does it matter.
> But it don't do no good to get angry, so help me I know.
> For a heart stained in anger grows weak and grows bitter.
> You become your own prisoner, as you watch yourself sit there,
> Wrapped up in a trap of your very own chain of sorrow."
>
> —*John Prine, "Bruised Orange (Chain of Sorrow),"*
> *Atlantic Records (1978)*

As amphibian biologists bearing witness to the sixth mass extinction (Wake and Vredenburg, 2008), we have to be careful not to lock ourselves down into some form of pre-clinical post-traumatic stress disorder. The world, whether it realizes it or not, needs us. My guess is that most of our angst does not come while doing fieldwork, but rather after we return. In the field (unless our study site has been ravaged), and right after we come back, we are dirty and itchy and maybe a little sore and bloodied, but happy and optimistic. We have seen our animals and they have shown something of themselves not seen before. Then we sit in our cramped little offices with our big flickering computer screens and we start to think. That's when the darkness creeps in (to paraphrase Greg Brown, 'People think small things when they stay too long in little rooms' ["One Night," Red House Records, 1982]), and that sets Prine's chain of sorrow reverberating between our amygdalas.

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PHOTO BY LISA SCHMITT

MJL at Boundary Waters northwest of Ely, Minnesota August, 2009.

There are ways to cope (humans are nothing if not adaptable). The technique used by U.S. G.I.s during WWII in Europe (although certainly combatants everywhere for all time have used it) went like this. Observing that soldiers obsessed with their own death often froze during combat, producing the thing they most feared, savvy G.I.s played a mind trick: they told themselves, "Screw it, I'm already dead, I just don't know where or when, and when it happens I probably won't even know it." And they became themselves again and they fought, and many of them lived to see VE Day. Understanding this, at some level biologists can find happiness knowing they are recording something that no one in the entire history of the universe may ever see again. Then, perhaps, a good thing happens: because they were themselves and because of their energy and efforts, the thing is preserved; because they persisted, that thing continues to live.

A second way to cope is even more desperate and epitomized by the New York City firefighters at the World Trade Center on 9/11 who went into the North Tower and up the stairs after the South Tower had already collapsed. As with the G.I.s, they must have thought, "I'm already dead." But unlike the G.I.s, they probably also thought that today, maybe this very hour, was the time they were going to die. They went up anyway, and to hear stories, they were calm. Again, working with animals and ecosystems the experience is similar (although the extinction experience is happening to them, not to us; not yet). It is possible to know death is imminent and face it, head on. It is even possible to be calm while doing it. As Edward Abbey (1990) quipped, "When the situation is hopeless, there's nothing to worry about."

Fig. 1. Drift fence around Crawfish Frog (*Lithobates areolatus*) breeding wetland in southwestern Indiana. Twenty-five years ago, this area was an open pit coal mine, since filled and recontoured, then purchased by the state as a Fish and Wildlife Area. The property was re-planted to native vegetation and is being managed as prairie, including using prescribed burns, shown here, to control for herbaceous and woody invasive species. Crawfish Frog populations can be robust under these conditions.

The trick in all this is to not lament the loss, whether it be us or the things we love, but to get on with it, and to find energy; and rather than mourn what is no longer, try to celebrate those things that are or were. Easier said than done, and for people in certain sub-professions of our field this can be more than difficult. My friends who work in zoos and aquariums, especially those who run captive breeding programs, are particularly vulnerable. Much like neurosurgeons, their jobs are high stress—they fail to succeed and there are forever consequences. To the extent that I can (without having a job with these sorts of ramifications), I empathize. I understand their loss of hope, which can sometimes descend deeper, into a place that is much darker and from where it is more difficult to rise. These are people who, if they drink, drink faster and more than your average herpetologist, which is saying something.

What our friends need to understand is that the problem does not lie with them; it lies within the situation they find themselves in. If roles were reversed it would be us on the floor next to that barstool. We are asking them to be on the front lines of the sixth mass extinction, and we're not giving them the financial or emotional support they need. They are frazzled and fraying. It is easy for them to think they're alone, and following a loss, it's easy for them to despair. But their fight is our fight, and they need our help.

I have never been privileged to work on amphibians in any place that was anywhere near pristine (I cut my herpetological teeth in Iowa—surely one of the most ravaged landscapes on earth). The ecosystems of my youth were wonders of existence. Not in the sense of wonder applied to many natural places; instead, in the sense of "I wonder how any wetland can possibly persist here?" These places never elicited any human emotion faintly resembling hope. I was working inside the Ed Abbey quote of desperate situations with nothing to worry about. But things have changed in the Midwest, some for the better, and I write this now to encourage colleagues who are losing, or who have lost, hope. I write this to celebrate the things that still are, and for things that remain possible. Specifically, I offer three examples of ecosystems involving Midwestern amphibians that have turned around, or where animals have found a way around, when there was no sane right to expect they would. And as I conclude, I suggest a mechanism to celebrate the forms of life for which this world is no longer "meant for one as beautiful as you" (Don McLean, "Vincent," Madacy Records, 1971).

Case Study 1: Mine-spoil prairies.— From the perspective of habitat loss, surface coal mining is about as nasty a business as you will find. One of our study sites is situated on the eastern margin of the Illinois Coal Basin. Here, coal seams lie about 30 m below the surface, shallow enough to be mined using surface drag-line techniques and the world's largest shovels. Companies currently mining this coal include Peabody, Foundation, Alliance, Armstrong, and Patriot. Surface coal mines are gigantic open pits with no recognizable ecology (except, perhaps to a microbiologist). Surface coal mining has taken place in our region for nearly a century, largely unregulated. Then, in 1977, the U.S. Federal Surface Mining Control and Reclamation Act became law. This legislation required that companies re-contour the landscape, replace topsoil, and re-vegetate. Our study site, 729 ha, was mined from 1976–1982, then reclaimed (Lannoo et al. 2009). It was re-vegetated by Peabody to non-native herbaceous vegetation (using the least expensive seed sources possible, for example, tall fescue, bush clover, and smooth brome). Then, in 1988, this land was purchased by the Indiana Department of Natural Resources, and land managers (two in particular, Ron Ronk and Randy Millar) have been eliminating non-native herbaceous plantings, replacing them with native grassland species, and instituting burning regimes for prairie maintenance. Using these processes they have created what we term mine spoil prairies. Reclaimed mine spoil prairies are not restorations *per se*, as these areas were not extensive grasslands at the time of European settlement. Instead, their history was primarily deciduous forest with scattered prairies, cleared for agriculture, and then dug for coal before being reclaimed.

During the first two field seasons of a large study designed to understand the biology of Crawfish Frogs (*Lithobates areolatus*), my graduate students Nate Engbrecht, Jennifer Heemeyer, Vanessa Kinney, and I captured or encountered an astonishing total of 33 amphibian and reptile species on this reclaimed coal spoil prairie, including two State Endangered species (Crawfish Frogs and Kirtland's Snake [*Clonophis kirtlandii*]) and three species of Special Concern (Blanchard's Cricket Frogs [*Acris blanchardi*], Eastern Box Turtles [*Terrapene carolina*], and Rough Greensnakes [*Opheodrys aestivus*]. We found 12 new county records (Lannoo et al. 2009; Kinney et al. 2010). Given the environmentally destructive reputation of surface coal mining, and the negative impacts that coal mining has had on amphibians, it is startling to

Fig. 2. (**left**) Male Crawfish Frog (*Lithobates areolatus*) captured in a drift fence/pitfall trap array after leaving its breeding wetland. Fig. 3. (**right**) Neotenic Eastern Tiger Salamander (*Ambystoma tigrinum*) viewed along the bottom a freshwater reservoir at Badger Army Ammunition Plant, near Baraboo, Wisconsin, USA.

know that such a richness of amphibian and reptile species could exist on a mine spoil prairie. The diversity of amphibians at our study site today exceeds that of Kankakee Sands, a restored native prairie 150 km north, despite the fact that 25 years ago our field site was an open pit mine, supporting no ecosystem that any vertebrate, or vertebrate ecologist, would recognize. Regional reptiles and amphibians were abundant enough, and occupying landscapes connected enough, that 33 species found their way to this new ecosystem without anybody's help, or in fact, anybody noticing.

Case Study 2: Cannibal Morph Eastern Tiger Salamander Wetlands.—In 1981, working in the region of northwestern Iowa called Okoboji, I discovered cannibal morph larvae in Eastern Tiger Salamanders (*Ambystoma tigrinum*). At the time this observation was publication worthy (Lannoo and Bachmann 1984) but no big deal, because Eastern Tiger Salamanders and western Barred Tiger Salamanders (*A. mavortium*) were considered the same species (*A. tigrinum*), and cannibal morph larvae were well known from Barred Tiger Salamander populations. But today, Eastern and Barred Tiger Salamanders are considered separate species, and these Eastern Tiger populations host the only known animals that express the full cannibal morphology (large, wide heads and hypertrophied teeth). As such, I've always thought they deserve federal protection under the Endangered Species Act as a Distinct Population Segment.

At the time of this discovery, the effects of early twentieth century swamp busting efforts were no different in Okoboji than anyplace else in the Midwest, and the habitats available to Tiger Salamanders had been reduced to four wetlands and associated uplands in Gull Point State Park, the Nature Conservancy's Frieda Haffner Kettlehole, and a smattering of public or private semi-permanent wetlands that may or may not have held water, depending on the phase of the hydrologic cycle.

Then, beginning in the late 1980s and early 1990s, the U.S. Fish and Wildlife Service, through its Waterfowl Production Area (WPA) program (http://www.fws.gov/refuges/whm/wpa.html), and with help from the Iowa Department of Natural Resources, Ducks Unlimited, Pheasants Forever, and other groups , began purchasing land in the Okoboji region—their goal was 30,000 acres. They broke tile lines to create wetlands and planted emergent rushes and sedges to facilitate restoration, and they seeded uplands to native prairie using local genotypes. This program continues, and if the acreage goal has not been met, they are close. Today, classes out of the Iowa Lakeside Laboratory can explore three massive, created grassland/wetland complexes (Spring Run, Welch Lake, and Excelsior Fen) in addition to the 160-acre native Cayler Prairie and its 200-acre annex.

The Okoboji region once supported a Northern Leopard Frog (*Lithobates pipiens*) frog leg industry that saw something like 20 million Leopard Frogs a year captured and shipped along railroads to restaurants as far east as Philadelphia (Lannoo 1996). This level of commercialization was, surprisingly, sustainable. What caused the Leopard Frog decline was swamp busting in the 1920s and 1930s, which eliminated ~98% of breeding wetlands. Today, due to the restoration efforts detailed above, there are likely more Leopard Frog populations on the Okoboji landscape than there have been since the early 1930s. There are also more Tiger Salamander populations, and I have found cannibal morphs in these new populations. While I still feel these animals should have federal protection, I am newly confident that barring some disease that affects salamanders the way *Bd* has affected frogs, that Eastern Tiger Salamander populations exhibiting cannibal morphs are secure, for the time being.

Case Study 3: A Neotenic Population of Tiger Salamanders at Badger Army Ammunition Plant.—In 1942, the U.S. Army purchased 30 km^2 acres of farmland immediately south of Baraboo, Wisconsin, near the region of Aldo Leopold's famous Shack, to create Badger Army Ammunition Plant, built to manufacture smokeless gunpowder. The Army erected scores of buildings and required a water source for, among other things, fire fighting (as you can imagine given the nature of the enterprise). Two large reservoirs (4 million and 6 million gallons—envision large swimming pools) were dug at elevation into the south side of one of the Baraboo Hills, lined with concrete, and filled with fresh water. The smaller reservoir is chlorinated, and nothing much lives there. But at some point, breeding adult Eastern Tiger Salamanders began entering the larger reservoir. Following breeding, adults could not exit the reservoir to return to their upland habitats, because a 15-cm vertical lip extends from the water surface to the walkway. These adults likely died, as did any offspring that metamorphosed. But permanently aquatic animals could survive, and did, and this reservoir now supports a neotenic population of Tiger Salamanders. Mike Mossman of the Wisconsin DNR, Gary Casper of Great Lakes Ecological Services LLC, and the University of Wisconsin-Milwaukee Field Station, Steve Kimble at Purdue, several members of the Wisconsin DNR and U.S. Army, and I have been investigating the biology of this population, and the implications of the biology of this population. For example, what are the consequences in terms of gene flow and speciation to having a neotenic population of Tiger Salamanders embedded in a landscape matrix hosting metamorphosing populations of Tiger Salamanders? An interesting question addressing the response of an ancient genome to a recent anthropogenic change. Could anyone have imagined this amphibian response—a form of herpetological flipping the bird—to what most would consider a major environmental insult to the majestic Baraboo Hills?

In the first example, I note that one unintended consequence of restoring coal spoils to prairie is the proliferation of native amphibian and reptile species. In the second, I suggest that native amphibian populations respond well to intentional wetland restorations, and that rare phenotypes can be preserved. In the third, Tiger Salamanders, which surely must be among the most adaptable of all organisms, have turned the presence of a fresh water reservoir if not entirely to their advantage, not entirely to their disadvantage, and may have created a population spinning off onto its own evolutionary trajectory. All represent Midwestern examples of amphibian survival from an overly exploited landscape that give us hope.

I realize that for those amphibian biologists on the front lines, this will not be enough. Victories for populations of common, widespread species may not provide salve when dealing with extinctions of some of the neatest little animals anybody has ever seen. Why wouldn't we expect burnout and despair, and the sorts of behaviors in bars typically reserved for returning soldiers and off-shift firefighters? Again, these are people that need to know they're not alone, and that they have our support. I propose *Herpetological Review* erect a new section called "From the Ark," that both gives us a sense of the animals being captive reared and their status, and their stories—front line accounts from the fight to stop the sixth mass extinction. Such a section would allow for both sharing of stories—stories we need to know as they are happening—and perhaps some much-needed venting. These stories could publicize our cause to a much larger audience.

I close with another lyric from the folk tradition; this one from a guy everybody knows:

> "Yes, we made a promise we swore we'd always remember.
> No retreat, baby, no surrender."
> Blood brothers in the stormy night with a vow to defend.
> No retreat, baby, no surrender."
>
> (Bruce Springsteen, "No Surrender"
> Columbia Records, 1984)

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Imperatives and Opportunities: Reformation of Herpetology in the Age of Amphibian Decline

Joe Townsend and I closed the final chapter of *Conservation of Mesoamerican Amphibians and Reptiles* (CMAR), published last year, with the following quotation from the chapter entitled "Exploration of a Little-Known Planet" in E. O. Wilson's masterful 2006 book *The Creation: An Appeal to Save Life on Earth*:

> "Despite the slow pace of exploration, biologists in the past two or three decades have found that Earth's biodiversity is disappearing at an accelerating rate, from habitat destruction, including habitat destruction now underway from climate warming, plus the spread of invasive species, pollution, and overharvesting. If these human-caused forces are left unabated, we could lose as many as half the species of plants and animals on Earth by the end of the century."

Taking E. O. Wilson's message to heart, Joe and I (Wilson and Townsend 2010:777) concluded that "Unless we act now, we [eventually might discover] that rationality provided us much better hindsight than foresight …"

Herpetologists have been slow to respond to imperatives facing the animals on which we work. As Joe Mendelson (2011) pointed out in his introspective essay, it was not until 1989 that "hallway conversations" at the First World Congress of Herpetology pointed to the possibility that amphibians might be in decline on a global scale. Two years later, David Wake formalized this concern with a paper in *Science* (1991). Since that time, however, global amphibian decline has become a hot topic, with attention given to this subject in a broad array of formats. Today, we have the Global Amphibian Assessment and its offshoots, including the GAA website, the AmphibiaWeb site, the seminal book by James Collins and Martha Crump (2009), and the conservation section in the *Journal of Herpetology*, to name a smattering of efforts to address this hugely important problem.

Much of the focus on global amphibian decline has been on the role of the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*; Longcore et al. 1999) in bringing about declines and extinctions among amphibian species, as evidenced in part by the Amphibian Diseases section in *Herpetological Review*. Bd is a major concern that must be controlled.

PHOTO BY I. LUQUE-MONTES

LDW in Parque Nacional Cerro Azul Meámbar, Honduras, May 2008, with a *Mastigodryas dorsalis*, a Vulnerable species.

Unfortunately, the study of the ecology of this fungus with the hope of bringing it under control is not enough.

In light of the acknowledged impact of *Bd*, it is all the more significant an outcome of the Global Amphibian Assessment to declare that "Habitat loss and degradation are by far the greatest threats to amphibians at present, affecting nearly 4,000 species. The number of species impacted by habitat loss and degradation is almost four times greater than the next most common threat, pollution" (Stuart et al. 2010:13). This conclusion is consistent with those typically reached in environmental science and conservation biology textbooks. Evidently, the principal malfeasor for global amphibian decline is not *Batrachochytrium dendrobatidis*, but rather *Homo sapiens*. Humanity is the crux, both in the sense of "the basic, central, or critical point or feature" and "a puzzling or apparently insoluble problem" (American Heritage Dictionary, 3rd edition). At this point, the story becomes a constellation of problems so complicated that space here does not allow for a full elaboration of the causal labyrinth. My intention is not to rehash this story, because it appears as a series of recommendations in the closing CMAR chapter (Wilson and Townsend 2010:774), among other places in that volume. Nonetheless, we indicated that "Any serious, long-term approach to issues relating to conservation biology must be predicated on the understanding that biodiversity decline ultimately is created by uncontrolled human reproduction as measured against a fixed planetary resource base, which has produced an unsustainable existence for our species … ."

Apparently, we have entered an era in which our effort to control the planetary resource base is boomeranging on us. A few hours spent with any good environmental science text will justify this statement. We have entered into the Age of Environmental Superproblems (Bright 2000). As noted by Wilson and McCranie (2004: 13), this term is used to "describe environmental synergisms resulting from the interaction of two or more environmental problems, so that their combined effect is greater than the sum of their individual

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PHOTO BY J. TOWNSEND

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

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Fig. 1. (**left**) Adult female *Plectrohyla chrysopleura*, La Liberación, Refugio de Vida Silvestre Texíguat, Honduras, a Critically Endangered species. Fig. 2. (**right**) Adult *Duellmanohyla salvavida*, La Liberación, Refugio de Vida Sivestre Texíguat, Honduras, a Critically Endangered species.

effects. These problems represent an environmental worst-case scenario—the point when environmental problems become so serious that they produce unanticipated results, and a successful resolution threatens to slip forever from the grasp of humanity." In a sense, then, humanity has focused on the small picture to the point that the big picture has become even bigger—perhaps too big.

What humanity requires on a global basis is easy to state, but will be the most difficult cultural revolution ever undertaken by our species. The future human agenda must transform the emerging Age of Environmental Superproblems into the Age of Sustainability (Meadows et al. 2004). Sustainability often is defined as "The ability to meet humanity's current needs without compromising the ability of future generations to meet their needs" (Raven and Berg 2004:G-15). These authors also point out that "sustainability implies that the environment can function indefinitely without going into decline from the stresses imposed by human society on natural systems such as fertile soil, water, and air." The intent of this essay is not to detail how environmental sustainability can be accomplished; it is sufficient to say that it will involve creating a sustainable environmental footprint for humanity. Rather, its intent is to explore the role that the science of herpetology could and should play in the over-arching effort to achieve global sustainability.

Below are my suggestions for herpetologists to respond to the phenomenon of amphibian decline, and to transform the science into a force for achieving global environmental sustainability.

Transforming Pessimism to Realism.—I chose herpetology as my life work in that pivotal interval between undergraduate and graduate school. I credit Hobart M. Smith with helping me make that decision; his example as a herpetological speed demon and his counsel as a caring mentor pulled me away from ichthyology and pushed me into my eventual career. Hobart Smith's interest in the American tropics, especially Mexico, also became my interest. Years later, I visited Latin America, at the invitation of the late Ernest A. Liner, who then became another influential mentor. I briefly referred to that life-changing trip in my contribution to the remarkable seven-page obituary of Ernie that appeared in this journal. The following year, I accompanied John R. Meyer on a three-month sojourn to Honduras, an experience that 44 years ago set the hook for my career. During this time, there have been highs (the discovery of new species and the continuing series of publications about what we found) and lows (the specter of advancing habitat degradation and loss, the unexplained disappearance of once-plentiful streamside frogs, and the widespread calamitous damage done by Hurricane Mitch). Like Joe Mendelson, I also experienced the apparent loss of species my coauthors and I described, indeed one of the toughest blows a taxonomist can bear. In the face of the lows detracting from the highs, it would be easy to give up and move on to other pursuits. In this connection, I received the latest, heroically redesigned issue of this journal in which Jim Murphy, in the Zoo View section he edits, included a short piece entitled "Hopelessness" that remarked about "a continuing culture of despair" among conservation biologists, especially younger ones, who are bemoaning the absence of a message of hope in what they are hearing at conferences. Upon reading Jim's commentary, I was reminded of something Joe Townsend and I wrote in the concluding CMAR chapter (p. 777): "The extinction cycle described by conservation biologists … will assume tornadic dimensions, sweeping life's diversity into an ever-widening and ever more rapid spiral, leading to a crescendo the likes of which has not occurred on our planet since the close of the Cretaceous, which marked the most recent mass extinction episode." Had we ended the chapter on this point, we could have been accused of contributing to "the culture of despair." However, we went on to say (p. 777) that "Given our conclusions, three major approaches seem possible. Some people, the pessimists among us, will look at what we have written and decide that the conservation agenda will never be accomplished, no matter what is done. Other people, the optimists around us, will think that everything will turn out just fine, whether conservationists do anything. Neither of these approaches can be expected to move the conservation agenda forward. The beliefs of both the pessimists and the optimists rob them of any opportunity to participate meaningfully in the process of designing workable solutions to the problems we face. Thus, it is left to the realists to assess any given situation or problem and design solutions that deal with things as they actually are, instead of how we wish them to be. This realistic approach marks the contributions to this volume."

Unfortunately, we need to hear the bad news to wake us out of our complacency, but if that is all we hear we are not stimulated to make things better. Giving up is easy, which is what the pessimists *and* optimists do. The work begins when the realists recognize where events seem to be heading, decide these trends are undesirable, and commit to the demanding, perhaps life-long task to make things better. So, the picture for conservation biologists is bleak, but if we give up, the outcome is determined. Instead, if we devote our time toward making the world a better place than when we arrived (in my case, when the world was embroiled in WWII), then the outcome becomes shaped by our efforts.

Reconceptualizing Herpetology.—Back in the early 1960s, when I was saddling up for graduate school, I thought the going would be rough but that trail's end would be rosy. I thought I would be doing what I enjoyed and get paid for it, too. The person I am today might think that young guy from the Great Corn Desert of central Illinois was a tad naïve, but it turned out that I had the opportunity to work with "my critters" while making a reasonably comfortable living. In retrospect, my study program was designed for a world that was fast disappearing. Had my instructors known then what I know now, that program might have been much different. My comments are meant primarily for the field herpetologist, but in my mind herpetology begins and ends in the field. Furthermore, the "field" turned out to be Mesoamerica, principally Honduras. Pretty much by accident, I became interested in a socioeconomically underdeveloped area with a rapidly-growing human population competing for habitat with the members of an imposing, diverse herpetofauna characterized by high endemism. This description of the Honduran herpetofauna would not have applied to the Honduras I entered in 1967, because in the interim the known herpetofaunal diversity in the country has just about doubled and the percentage of endemicity has become the highest in Central America (Wilson and Johnson 2010).

If I could design a modern program for graduate study, it would have to be grounded in the principles of environmental science and conservation biology. No matter where one's research interests might lead, they will be pursued against a backdrop of humanity's impact on the natural world. In his thought-provoking piece, Joe Mendelson (2011:22) opined that "There no longer exists a natural upland ecosystem in Mesoamerica." Although, in context, the statement is startling, it, unfortunately, is not surprising to anyone who has spent time working in this region. I first went to Honduras in 1967, and it took me two weeks before I found my first snake; unlike Joe Mendelson, I cannot claim that my lack of early success was due to the unexplained disappearance of my target animals. We did not describe our first new species in the country, *Leptodactylus silvanimbus*, until 13 years later (McCranie et al. 1980). We found the first specimen of that species *under a log in a pasture* cut out of cloud forest! For us, this came to be the rule rather than the exception. So, if one is interested in working in a natural ecosystem (i.e., one undisturbed by humans), one is in for a long hunt because in the age of global environmental problems (e.g., global climate change), there are only various approximations to natural ecosystems anywhere on Earth. That such is a given is evident by the lack of a warning in herpetological publications, similar to those on cigarette packages, that "This study was conducted in a disturbed ecosystem."

The next most important area to explore would have been the language, political science, and cultural history of my chosen region of study: Latin America. I would have reached that region better prepared to understand the people.

A lot more is involved with this story, but suffice it to say that real success is gained by never giving up, having the most destination-specific educational training, and coming to understand that people everywhere have similar goals and aspirations. For herpetology to have a meaningful role in human affairs, students will have to learn about the realities posed by life in the 21st century. They will need to understand the imperatives all humans face, and how these imperatives will shape the opportunities that will exist for herpetologists.

Imperatives and Opportunities for Fieldwork.—The imperatives are evident to those who wish to learn the "big picture;" the opportunities are what we wish to make of them. What follows are some of the ideas I gained over the last four and one-half decades on conserving the creatures we study.

Permits to work in foreign countries have become *de rigueur*, which is the imperative; the opportunity is to understand the operation of the permitting agency, to earn the confidence of its personnel, and to use whatever resources one has to contribute to the success of this agency. At a minimum, this last effort should include the submission of a detailed report on the findings, in the language of the host country (our 2010 Honduras project report, incidentally, was publicized recently in a long article in *La Tribuna*, one of Honduras' major newspapers). In addition, contributions can be made to agency efforts to publicize their work through posters and and other methods.

Permits provide a means of introduction to local people, including protected areas personnel (including those of involved NGOs) and community leaders; up-front explanations of the goals of the projected work help gain access to areas of interest, provide assistance and training opportunities on site, and, ultimately allow reporting the results of the work to those same stakeholders, including educators, schoolchildren, and print and TV journalists, with the help of the local people who were on the trip (e.g., *guardarecursos*). Therein lies both the imperative and opportunity.

In planning for fieldwork, look farther afield than in the past, because opportunities lie in such previously unsurveyed areas. For example, much has been made of the species richness of the Quebrada de Oro area of northern Honduras and its subsequent decline (McCranie and Casteñeda 2007; McCranie and Wilson 2002; Wilson and McCranie 1998). A number of endemic amphibians were thought to have disappeared from this area, and some have been presumed to be extinct. Recent work, however, in another area of the long Cordillera Nombre de Dios has allowed for reassessment of the conservation status of some of these heretofore-thought-to-be-absent amphibians (Townsend et al. 2011; Townsend et al., *in press*), including *Plectrohyla chrysopleura* and *Duellmanohyla salvavida* (Figs. 1 and 2). A similar example involving *Plectrohyla hazelae* was reported in the previous issue of this journal (Heimes and Aguilar 2011). These examples, along with that of *Incilius holdridgei* (Abarca et al. 2010), give us good reason to expect that others will also reappear.

The necessity to return to the capital of the country in question to obtain export permits and the like is yet another imperative that provides other opportunities. Such a requirement can allow for meeting with local biologists at colleges and universities for strategy discussions, content presentations, and development and maintenance of other longer-term associations, such as cooperative appointments (see my address above) and meeting organization. Promising local young biologists also turn up at such times, providing the chance to help further their education in one's own country. This accounting of the opportunities offered while "in country" just scratches the surface of what is limited only by imagination and commitment.

Since herpetologists are the ones who discovered that "their animals" are in decline, their research priorities can be reconfigured to include studies that determine the conservation status of the target organisms and highlight the herpetofauna of existing and proposed protected areas, as we are doing in Honduras (e.g., Townsend and Wilson 2008; Townsend et al., *in press*). Increasing the accessibility of this information can be accomplished by presenting scientific results either in a bilingual format (Townsend and Wilson 2008) or in the language of the residents of the area in question (e.g., Wilson et al., *in press*), or better yet, through dissemination of results to the general public through local media outlets and public presentations.

A Final Imperative and Opportunity.—That human beings are responsible for almost all environmental problems, including those of interest to conservation biologists, is a virtual given (Wilson and Townsend 2010). However, the scramble to determine the role of *Bd* in the global amphibian crisis almost has quarantined the attention of herpetologists searching for answers to the causes of this crisis. In my opinion, another of the basic rules of environmental science has been lost in the shuffle…sort of. This is the simple rule that in nature everything is connected to everything else. This statement also applies to the human world and its relationships with the natural world; humans are, after all, a product of the same processes that created the natural world. For herpetologists, the implication should be obvious. Although not yet officially tabulated to the extent done for amphibians, the reptiles, our *other* group (of course, including turtles and crocodilians, but excluding the feathered ones) is also in decline. While awaiting the Global Reptile Assessment, the contributors to CMAR conducted their own assessment of the conservation status of Mesoamerican reptiles (in addition to the amphibians), with the results summarized by Wilson and Townsend (2010), who concluded, using their Conservation Status Scores, that of 1139 species of reptiles scored, 966 (84.8%) fell into their very high category of conservation significance. With respect to the individual orders, only crocodilians, of which there are three species in Mesoamerica, had less than 80% of the constituent species in the very high category, based largely on their comparatively broad distributions. A higher percentage (93.0) of amphibians fell into the very high category, especially because of the scores for salamanders, but this indicates that amphibians are only slightly worse off than reptiles. Thus, it appears that another imperative faces herpetologists, especially those working in Mesoamerica, presenting another array of opportunities. So, how long will we have to await a Global Reptile Assessment? More to the point, how long will the reptiles have to wait to be given their fair measure of attention?

Acknowledgments.—I appreciate Jim Murphy asking me to write this essay. I am indebted to Louis W. Porras and Josiah H. Townsend for their extremely helpful counsel as this essay took shape. I also wish to thank Ileana R. Luque Montes for the use of the photo of me and J. H. Townsend for the use of the photos of the frogs that accompany this work.

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INSTITUTIONAL PROFILE

Herpetological Review, 2011, 42(2), 150–159.

Herpetology at a Biogeographical Junction: Research and Teaching at the Hebrew University of Jerusalem (Israel)

The herpetofauna and herpetology are particularly attractive in the southern Levant, the southwestern tip of the "fertile crescent." This area, historically known as Palestine and now shared by Israel and Jordan, serves as meeting arena for faunal elements from Africa, Asia, and Europe (Bodenheimer 1935; Por 1975) and the local herpetofauna is heterogeneous and rich in accordance (Disi 1996, 2002, 2011; Haas 1952a; Werner 1988). Herpetology is attractive here not merely because the species are ample and the open questions endless. Rather, mesic Mediterranean, semi-arid Irano-Turanian, arid Arabian and Saharan, and Afro-tropical ecosystems, and their assorted interactions, are all accessible at short range, by good roads, from universities. Moreover, a country-wide network of some twenty field schools and research stations provides bases for local research. The oldest university is the Hebrew University of Jerusalem, established in 1925. Its zoological collections were started earlier, as told below. It has a history of ramified herpetological research, especially collection-based but also in the field.

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History of the collection.—The Hebrew University's collection of amphibians and reptiles was started by Israel Aharoni before the university was even conceived. Aharoni, born in Lithuania in 1882, was studying Zoology and Semitic

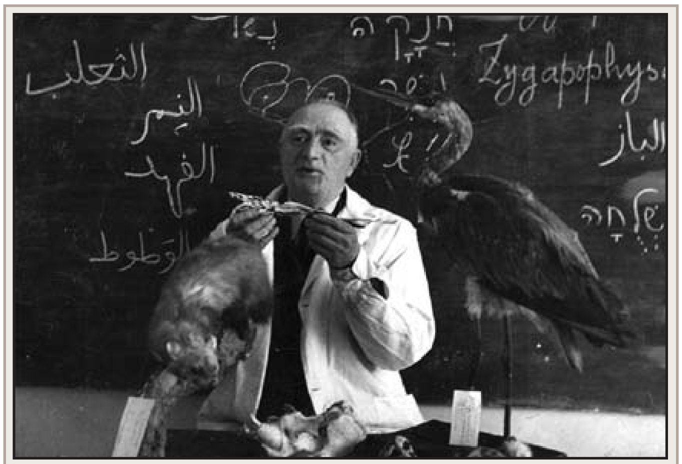

Fig. 1. Israel Aharoni teaching about Palestine's vertebrates, 1941. The blackboard carries names and terms in Arabic, Hebrew, and Latin.

PHOTO BY NAHUM TIM GIDAL, COURTESY OF THE HEBREW UNIVERSITY OF JERUSALEM languages in Prague until in 1901 he immigrated to the Palestinian province of Syria within the Turkish Empire. Residing at Rehovot and Jerusalem and teaching school, he continued to privately learn zoology and started to investigate the local fauna. Gradually he amassed collections of various groups from Palestine and adjacent areas, often assisted by Arab hunters, and became a knowledgeable and renowned animal expert, specimen supplier to institutions abroad, and Hebraist (Leshem 2000).

Soon after the opening of the Hebrew University of Jerusalem on Mt. Scopus in 1925 (under the British Mandate of Palestine), its head of Zoology, F. S. Bodenheimer (1897–1959), recruited Aharoni to teach vertebrate zoology. He came with his collections (those not earlier deposited in Palestinian clerical establishments or European museums and universities), including a significant reptile collection (Bodenheimer 1959). Specimen data tags, however, though commonly present, were often too generalized (e.g., "Syrian desert") or referred to Aharoni's location when receiving them from collectors (e.g., "Rehovot" for desert lizards). Cataloging the collection was later undertaken by his daughter Bat-Sheva Aharoni. The university, presumably regarding animal-lore as inferior, allotted to this treasure a humid cellar (Jacob Wahrman, pers. comm.). Gradually the collection grew through the additional activity of faculty (especially G. Haas) and students (especially H. Mendelssohn and H. Steinitz).

Aharoni was an enthusiastic teacher (Fig. 1). His textbook on the country's reptiles (Aharoni 1929) was pioneering in coining Hebrew species names, besides including interesting biological observations and eclectic anatomical details. It also bore witness to the collection having contained some representation of Europe's herpetofauna. Aharoni's book includes some European species, notably *Lacerta agilis,* ostensibly as part of the local fauna; this has been explained as probably resulting from his having had a jar with European material on his desk when writing. Aharoni succumbed to a heart attack in 1946.

The war of independence (1948–1949), while establishing the state of Israel, left the Mt. Scopus campus, Israel's university, as an Israeli enclave locked within Jordanian-occupied territory. Libraries and collections were held hostage on the campus; Jordan forbade their evacuation. Until June 1967 the Israeli garrison was replaced every fortnight through a UN-supervised convoy of armored cars traversing the Jordanian territory. Each convoy carried also supplies for a fortnight.

A few Hebrew University representatives were permitted to participate in order to inspect and care for the cultural treasures on the mountain, susceptible to shooting from the outside and vandalism on the inside. This was an adventurous mission for the staff. The Jordanians would inspect the returning cars and people's bags for items smuggled out but refrained from bodily search. So in all weather the staff wore coats, ascended slim and descended obese, with books tucked in belts, large preserved snakes strapped across breasts, and small specimens filling pockets and specially contrived carton receptacles strapped to shins under long pants.

PHOTO BY Y. L. WERNER

FIG. 2. Georg Haas (left) explaining his fossil snakes to visiting former student, president-of-Israel Ephraim Katzir, 1977.

By this and other means the Department of Zoology's reptile collection was gradually growing in its temporary home, tall wood cabinets along one wall of the spacious office of Dr. Georg Haas (Fig. 2), in the Italian Nunnery St Antonio College in Jerusalem's Talbiye quarter. Since 1950 this was the department's location, because the university, banned from its campus, was scattered throughout Jerusalem (see History of teaching). Haas (1905–1981; Werner 1982a, b), leading the development of this and some other collections, endeavored to include instructive exotic specimens. He cultivated international relations, arranged exchanges, and extracted donations. The amphibian collection was rather the project of Dr Heinz Steinitz (1909–1971; Boschwitz 1971; Kuehne 1972; Por 1973), otherwise ichthyologist, histologist, and experimental morphologist.

Meanwhile the young generation, led by Jacob Wahrman (1924–2005; Richler 2006), was conducting collecting trips all over the country, with emphasis on the poorly explored southern desert, the Negev. During the 1950–60s the Department of Zoology had two jeeps (one shared with the Department of Parasitology, Medical School). These served in trips planned to survey the country with a view to mapping species distributions. Many trips were systematically multi-purpose, with emphasis on trapping rodents (Zahavi and Wahrman 1957) but some were primarily herpetological. These survey efforts contributed much to the animal distribution maps in the Atlas of Israel (Wahrman 1970).

In 1965 the Department of Zoology and the Collections were moved from the Italian Nunnery to a group of buildings adjoining the Russian Compound (downtown) that had been evacuated by the Medical School, which moved to its

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Fig. 3. *Discoglossus nigriventer* Mendelssohn and Steinitz, 1943, the only two specimens comprising this species. The smaller one (HUJR-236), dorsal view, is the type. The larger one (HUJR-544), caught 1955, shows the typical ventral coloration, somewhat faded. Scale, number tags are 22 mm long.

PHOTO BY NURIT WERNER

Fig. 4. The tank containing *Varanus griseus* (mostly roadkills) has been rolled out from under the shelves, opened, and two specimens exposed. The human scale is Yehudah Werner, 2010.

salem's western outskirts. Here the collections had their own separate masonry building and herpetology occupied two spacious rooms.

The collection today.—In 1985 the Department of Zoology moved to the HUJ sciences campus at Giv'at Ram, and its population-oriented staff and the collections moved into the Berman and Lubin buildings, evacuated by the Department of Psychology that had moved to the resurrected Mt. Scopus campus. The herpetological collection remains in the Lubin Building, occupying a hall housing the wet material and an adjoining work space housing also literature and dry specimens.

The collection comprises over 22,000 catalogued specimens of amphibians and reptiles, derived in principle from three sources. 1) Most specimens are from the "survey area," Israel with the Golan plateau, and Sinai. This is the most extensive regional record of Levant taxa. It is the world's only collection with the full Israeli herpetofauna, having the only two existing specimens of the extinct *Discoglossus nigriventer* (Fig. 3). It also includes one of the last local crocodiles. 2) Comparative material from surrounding countries. 3) Instructive material representing systematically or geographically important groups (e.g., *Sphenodon*). Recently the type material in the collection, 17 species and 23 subspecies, has been reported by Ben-Eliahu and Golani (2010a).

The bulk of the collection (85%) is in 75% ethanol (amphibians and geckos, 70%) denatured with 5% methanol, after fixation with formalin. In recent years fixation is preceded by taking tissue samples for DNA work. Because the collection is much used for research, specimens are individually tagged with their main data, and assembled in glass jars carrying the list of numbers. The jars are on open metal shelves. Large (75 liter) plastic "tanks" contain straight-fixed snakes and bulky specimens such as turtles. It is a local innovation that these tanks rest on individual wheeled bases and are on the floor under the jar shelves, from where they are easily rolled out (Fig. 4.).

The rest comprises stuffed or dry specimens, skeletons, and skins. A unique (largely uncatalogued) resource is a large collection of microscope slides, mainly of karyology, ontogeny, cranial morphology, and tail regeneration of amphibians and reptiles, from the work of several researchers. Since 1994 tissue samples from fresh specimens have been preserved separately for future DNA analysis (several hundred samples). Several hundred shed skins, feces, eggshells, and donated specimens await cataloguing.

In recent decades the sources of new material have been changing (Ben-Eliahu and Golani 2010b). The planned collecting trips have receded and ceased for both economics and conservation. Course field trips have stopped in 1999 upon the teacher's retirement. Currently an estimated annual average of 250 specimens come as vouchers from specific research projects or, mostly as roadkills, from the Israel Herpetological Information Centre (of the Society for the Protection of Nature in Israel), individual rangers of the Israel Nature and Parks Authority, students, and others, including herpetoculturists abroad.

Cataloging.—Before the computerization era, cataloging was retrieval-friendly through three devices. 1) The single set of serial numbers serving the whole collection is subdivided into sections for groups: 1–800, Amphibia; 801–1000, Chelonia; 1001–3000 Sauria; 3001–5000, Ophidia and 5001–7000

Table 1. Expeditions and projects that significantly contributed specimens.

Dates	Expedition or project	Collectors	References	N
1928; 1936	Iraq, Egypt (research trips)	F. S. Bodenheimer, O. Theodor & G. G. Wittenberg	Haas 1952b	~65
1935–1965	Vouchers: cephalic anatomy	G. Haas	Haas 1935; 1936; 1937; 1947; 1952c; 1959; 1964	Many
1936, 1945	Transjordan (two collecting trips)	G. Haas et al.	Haas 1943; Werner 1971; 2004a	22
1949–1951	Display collection	M. P. Pener		~65
1956–1957	Sinai (collecting trips)	Y. L. Werner, J. Wahrman, J. H. Hoofien et al.	Werner 1973	~60
1956–2006	Vouchers: lizard life history & eco-morphology	Y. L. Werner	Frankenberg & Werner 1992a; Werner 1968; Werner & Lampl 1992; Werner & Seifan 2006; Werner et al. 1993	Many
1959	Eastern Africa (research trip)	E. Nevo		~40
1960–1968	Vouchers: evolution of frogs	E. Nevo	Nevo 1968	~50
1962–1964	Vouchers: physiology of Australian lizards	M. R. Warburg	Warburg 1965; 1966	~140
1965	Cyprus & Lebanon (collecting trip)	H. Zinner	Zinner 1967	~155
1966	Greece, Turkey, Syria, Lebanon, north Jordan (collecting trip)	H. Zinner	Zinner 1967; Werner 1991	~390
1967–68; 1993–94	Vouchers: hearing in lizards	Y. L. Werner	Gehr & Werner 2005; Werner 1972,1976; Werner & Igic 2002; Werner & Wever 1972; Werner et al. 2001a,b, 2005, 2008; Wever & Werner 1970; Withers et al. 2000	~300
1967–1981	Sinai (methodical survey)	Y. L. Werner, A. Haim, et al.	Werner 1982c; 1988	~930
1969	Turkey (research trip)	Y. L. Werner	Almog et al. 2005	~20
1970–1971	Australia (vouchers: hearing and voices in lizards)	Y. L. Werner	Johnstone & Werner 2001; Weber & Werner 1977; Frankenberg & Werner 1984, 1992b	~290
1971	Namibia (research trip)	Y. L. Werner	Werner 1978	33
1972–1995	Warburg teaching collection	M. R. Warburg		138
1992	Golan plateau student survey trip	Y. L. Werner et al.	Sivan & Werner 1992	~200
2007–2011 (ongoing)	Ongoing research project on roadkills	G. Vine (INPA ranger)		~215

again Sauria, and so on. Each group is catalogued in a separate volume, so searching for a snake does not require leafing through all the frogs and lizards. 2) A card file of locality names, each card carrying the geographical coordinates, and a brief record of specimens from that locality. 3) A cross index by species on large durable cards. Entering specimens into both card indexes was discontinued when computerization started. The species index had been initiated by Jacob Wahrman, to whom the collection owes much of its professional 'law and order' spirit.

PHOTO BY Y. L. WERNER

Fig. 5. "Prehistorical" faunistics lesson by H. Mendelssohn, at the students' request given in the fresh air, 1955. The barracks were an extension to the biology premises in the Italian nunnery, necessitated by the immigration-driven rise in student numbers.

PHOTO BY Y. L. PHOTO BY JACOB WAHRMAN

Fig. 6. "Historical" field trip of the faunistics course to the Negev (11 March 1963). Jacob H. Hoofien, invited to reinforce the staff as reptile expert, speaks to the students using an improvised board suspended on a jeep.

Computerizing the HUJ collections has been a chronic effort for some decades, involving trial-and-error with programmers and programs. Now, however, the herpetological catalog approaches completion and functionality in Microsoft's Excel.

Staff.—During 1953–1973 a student 'research assistant' (parallel to the teaching assistants), 18 hours/week, helped in the collection. In 1972 the Department of Zoology established the 'Zoological Museum' (a term later outlawed). The department's chairperson, Hefziba Eyal-Giladi, appointed Adam Ben-Tuvia (1919–1999; Golani 1999) as museum Director, and Yehudah Werner as Curator of Amphibians and Reptiles. From 1973, the university budget started to deteriorate. Since then, technical assistance in the herpetological collection diminished to an on-and-off basis, with expectable consequences. In 1999, upon the mandatory retirement of Curator Werner, a part-time collection manager was appointed—Naomi Sivan, MSc, formerly Werner's academic technical assistant and research associate. But she was soon replaced (on budget grounds) by Boaz Shacham, then BSc. Recently the collection's research capacity has been reinforced by the appointment of a Research Associate, Hervé Seligmann.

Research.—The collection has been serving research by staff, research students, student course-projects, visitors, and investigators abroad (through lending). The local research goes far beyond the classical issues of systematics (e.g., Werner et al. 1999) and distribution (e.g., Werner 1987). Subjects have ranged from developmental morphology (e.g., Eyal-Giladi 1964) through polymorphism (e.g., Shacham 2004), functional morphology of tails (e.g., Werner 1961, 1968), eyes (e.g., Werner and Seifan 2006), and ears (e.g., Werner et al. 2008) to longevity (e.g., Werner et al. 1993) and reproductive biology (e.g., Frankenberg and Werner 1992a). In addition, the collection houses the voucher specimens of projects from cephalic anatomy (e.g., Haas 1973) to auditory physiology (e.g., Werner 1972).

Current research includes the northwards penetration, along the Jordan Valley, of lizards and snakes from the Negev Desert (Shacham et al. 2009); identification and distribution of some *Acanthodactylus* lizards (Werner); sexual dimorphism in snakes with emphasis on eye size (Werner, Babocsay [Budapest], Faiman [Parasitology], Razzetti [Pavia], and Seligmann); sexual size dimorphism in Israeli snakes (Werner and Ventura); size variation in Israeli tortoises and the identity of *Testudo floweri* (Meiri, Itescu, H. Shacham, and Werner); sizes of parietal eyes in lizards (Labra [Oslo] and Seligmann; Labra et al. 2010); left-handed *Sphenodon*s grow more slowly (Seligmann, *in press*); error coordination between codon-anticodon mismatch and tRNA misacylation decreases developmental instability in lizards (Seligmann); and off-frame stops increase developmental stability (Seligmann).

Field research, in addition to leading or aiding routine conservation-oriented surveys, focused in recent years on the foraging mode of geckos. Several projects explored the synergism of the many factors modulating the foraging activity pattern (e.g., Werner et al. 2006; Seligmann et al. 2007).

Teaching.—Teaching herpetology at HUJ has comprised an undergraduate course, a graduate course, field trips, and student projects at all levels. All these have interacted with the collection, although for the courses a designated teaching collection also exists.

History of teaching.—With the redeployment of the HUJ after the 1948 War of Independence, its teaching was resumed in rented quarters scattered throughout Jerusalem. Biology was studied directly towards the MSc and comprised one major and two minors, such as Botany with Zoology and Biochemistry or Zoology with Botany and Parasitology. Since Israel Aharoni had passed away in 1946, "Faunistics" was taught throughout the 1950s by Heinrich Mendelssohn, fortnightly visiting from the Biological-Pedagogical Institute of Tel Aviv (Fig. 5).


PHOTO BY Y. L. WERNER

FIG. 7. The two historical specimens of *Testudo kleinmanni* that were found separately on 11 March 1963, photographed in the lab (left, ventral aspect).

After some provisional locations, by 1950 the Departments of Botany and Zoology had settled in a wing of the Italian Nunnery St. Antonio College in Jerusalem's Talbiye quarter, where Georg Haas (Werner 1982a, b) and others endeavored to assemble new collections. By 1963 when Mendelssohn, tired of travelling to Jerusalem, resigned, the collections could already provide specimens for demonstration. A year-long lecture course was developed, obligatory for all 120 Biology sophomores: one semester vertebrates (headed by G. Haas), one semester invertebrates, including entomology. Haas opened the herpetology chapter saying Israel harbored 40 species of lizards, 33 snakes, and four non-marine turtles (a recent count had 44 lizards and 44 snakes; Werner and Sion 2008).

The course included field trips. One of the first of these yielded the re-discovery of the Egyptian Tortoise, *Testudo kleinmanni*, in Israel. Its occurrence had been reported in the older literature ("Testuco leithi," Lortet 1883; Tristram 1884) but in the intervening decades even targeted quests had failed to find it. It took the combination of numerous searchers and correct season and weather to find it in the northern Negev sands ("14 km S of Beer Sheva") on 11 March 1963 (Figs. 6, 7). Later the Israeli population was defined a separate species, *Testudo werneri* (Perälä 2001), but this has since been contested (Široký and Fritz 2007).

The BSc course.—In 1967 the Life Sciences Institute was founded, comprising the departments of Biochemistry, Botany, Genetics, and Zoology. Thereupon BSc studies were established, and the mandatory faunistics course was subdivided into four elective one-term fauna courses accompanied by a mandatory common course on shared principles (it soon became a biogeography course), all in the third year. Among the four courses, "Introduction to the Knowledge of Amphibians and Reptiles" was somewhat unique in its integration of different zoological disciplines, from chromosomes to thermoregulation, leaning on teacher's research experience (Werner 2004b, 2005). Fig. 8 shows the course's view of the

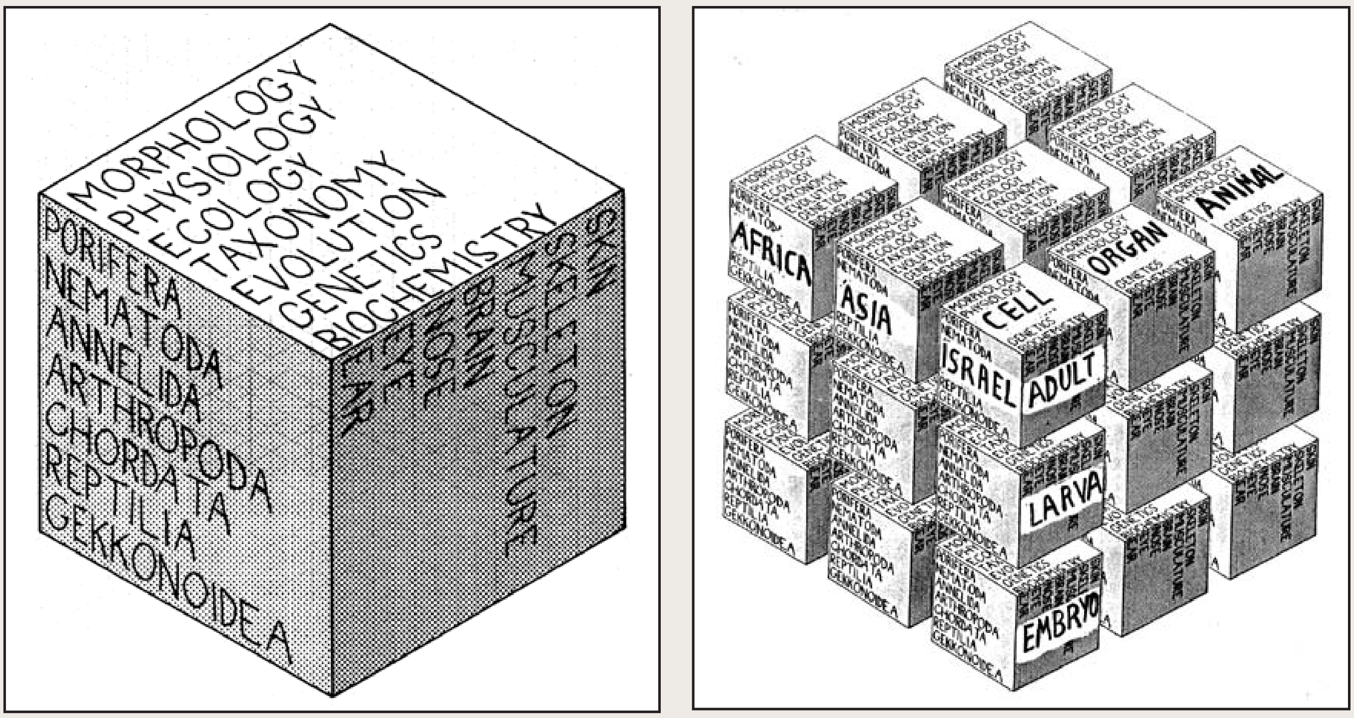

FIG. 8. Scheme of the composition of zoology. A) Primary cube showing three main dimensions: discipline, organ system, systematics. Journals exist for all subdivisions, and most internal intersection cubes exist (e.g., physiology of eye of reptiles). B) Additional dimensions require piling copies of the primary cube: geography, organization level, ontogenetic time. The last can be replaced with paleontological time. In each dimension, only a few units are shown as examples. Herpetology is conceived as intersecting and including all six other dimensions.

PHOTO BY Y. L. WERNER

Fig. 9. Herpetology course 1980 field trip. Using a school's art classroom (at Ma'ale Efrayim) to identify the collected live reptiles, each protected in an inflated plastic bag.

PHOTO BY A. BOUSKILA

Fig. 10. Dror Hawlena (sitting) explains pitfall-trap operation to students of Ben Gurion University of the Negev, Western Negev desert, Israel, 1999.

multi-dimensionality of zoology and hence of herpetology. A typical five-hour session presented both some Israeli taxa and some natural history topic(s), preferably matched, such as systematics of lizards, and tail regeneration. Course activity comprised teacher's lectures, students' proseminars, individual lab work, and museum-style 'demonstrations.' Field trips included meeting the species, comparing the habitats, and experiencing field methods. In later years, transportation expenses constrained the course to 17 students. Usually it was full, occasionally including a student from another university, a schoolteacher on study leave, or a zoo staff member.

The MSc course.—Among the fauna courses, only in herpetology was a viable MSc course developed, "Herpetology for Advanced Students," starting in 1975–1976. Following initial experimentation with contents, it comprised a planned symposium-like journal club, and individual research projects planned for potential later merging. Some of these student projects (mostly partly collection-based) were published (notably Perry et al. 1990). This course was normally given every other year to 5–7 students, in alternation with moderately reptile-biased 'Projects in Comparative and Functional Morphology'.

The field trips.—The field trips of the two herpetology courses were sometimes held together (Fig. 9). The BSc students emphasized acquainting themselves with species, habitats and methods but the MSc students mostly collected data for their projects. Initially we depended on the collection to know and plan in advance what the students could encounter everywhere; later (with budgets dwindling) the course field trips became research expeditions planned to fill data (and specimen) voids, so that students shared the experience of discovery. In the 1990s students increasingly opposed the collecting of specimens. We discussed the difference, even clash, between conservation and avoidance of cruelty to animals, and the conservation role of collections through the clarification of biodiversity.

Other student projects.—Many BSc student research projects within the frames of other courses (mainly but not only Prof. J. Heller's systematics course), were carried out in the herpetology collection. Typically these were performed by a team of two or three students, each reporting on her or his share (e.g., comparing meristic, respectively mensural, characters in two lizard samples) towards later merging. Several of these were published (respectably), including descriptions of new taxa. One of the first projects made the Biological Reviews, Cambridge (Wolf and Werner 1994).

Theses.—In the course of time, many morphological, developmental, and especially comparative-anatomical MSc or PhD theses on amphibians or reptiles, and some on their behavior, have interacted with the collection to varying extent. These included for example the MSc theses of Zakbach (1939), Eyal-Giladi (1949, 1964), Nevo (1957), Stettiner-Kallner (1958), Ginzburg (1965), Frankenberg (1972), Shy (1978), Bouskila (1984), Shani (1990), Por Efrati (1991), Bogin (1999), and Shacham (2004), and the PhD theses of A. Moscona (1950), H. Moscona (1950), Feldman (1952), Boschwitz (1958), Werner (1961), Kochva (1962), Nevo (1964), and Frankenberg (1978). The PhD of Seligmann (2003), 99% collection based, has significantly impacted the field (e.g., Lachman et al. 2006). One foreign student obtained his PhD here (Babocsay 2006). Additionally, the collection has occasionally served in the MSc theses of students from other Israeli universities.

Outreach.—Questions from the public and especially herpetology students, often by e-mail from neighboring countries, are regularly answered. Groups of visitors to the collection are introduced to reptile biology and its research. During 1982–1998, and again in recent years, the staff has been playing a leading role in organizing national herpetological symposia ("study days") for the general public, including rangers, inspectors, teachers, students, amateurs, and others.

Prospects.—With the (mandatory) retirement of Werner in 1999 the teaching activity (not the research) has largely abated. However, currently one PhD student and one MSc student work respectively on behavioral ecology and reproductive ecology of geckos. The collection is now poised to receive a new curator. Thanks to the appointment of Dror Hawlena (Fig. 10), presumably the educational activity will soon be revived and rejuvenated.

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*Marks titles translated from Hebrew by YLW.

Editor's note: Dr. Werner joined the university in 1950 as student and in 1953 as employee, and since 1999 has serves as Professor Emeritus.

Note added in proof: The following relevant paper appeared too late for inclusion in the text:

Shay, O. 2011. Zoological museums and collections in Jerusalem during the late Ottoman period. J. Museum Studies 5(1):1–19.

ARTICLES

Herpetological Review, 2011, 42(2), 160–165.

Ecological Consequences of Continual Volcanic Activity on the Lizard, *Anolis lividus*, from Montserrat

Understanding the effects of environmental disasters on ecosystems and mechanisms of ecological recovery is a central pursuit in biology. Acute episodes, such as tsunamis or volcanic eruptions, can decimate entire ecosystems, but research has shown that recovery from single devastating events can prove to be rapid. For example, following the destructive eruption of the Krakatau islands in Indonesia in 1883, which left its land and associated waters completely sterilized, both the terrestrial and marine life rebounded quickly (Barber et al. 2002; Dammerman 1929; Thornton 1996). Furthermore, under certain conditions ecosystems can prove to be resilient to environmental devastation. For example, corals growing on hard substrate, such as rock, were largely unaffected by the tidal waves of the tsunami in Aceh, Indonesia in 2005, whereas corals growing on rubble and sand, and their associated communities, were devastated (Baird et al. 2005).

Many contemporary environmental disasters occur continually, and require that ecosystems respond to recurrent assault. Beginning in 1995 the island of Montserrat in the West Indies has suffered acute and persistent volcanic activity from the Soufrière Hills Volcano (Robertson et al. 2000). The most devastating volcanic events are pyroclastic flows, or high-speed currents of rocks and gas resulting from dome collapse, and periodic ash clouds composed of volcanic gases and particulate matter (Montserrat Volcano Observatory Team 1997; Fig. 1). There are also periodic landslides termed lahars that deposit meters of pyroclastic material into the river valleys, and acid rain that affects the areas closest to the volcano. These events occur regularly and are undoubtedly traumatic to the Montserratian ecosystem, particularly in communities in the southern half of the island, where volcanic impact is more severe and continual. Knowledge of how persistent volcanic activity affects the island's endemic flora and fauna can inform efficient conservation efforts, but little is currently known.

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FIG. 1. View of Plymouth, the defunct capital, where *Anolis lividus* was once quite abundant, as seen from the sea following the January 2010 dome collapse.

Research has shown that the long-term effects of the volcano on local wildlife can be severe. For example, despite intense sampling, many endemic coleopteran species have not been captured since volcanic activity began (Marske et al. 2007). Furthermore, the rare endemic oriole, *Icterus oberi*, is in imminent threat of extinction (Lovette et al. 1999). More than half of the oriole's habitat has been destroyed due to eruptions from the Soufrière Hills (Hilton et al. 2003), while periodic ash episodes further deplete populations and nesting sites (Dalsgaard et. al. 2007). The endemic galliwasp, *Diploglossus montiserrati*, was commonly found before the eruption of 1995, but only a handful of individuals have been captured since, despite extensive sampling by the Department of Agriculture (G. A. L. Gray, pers. comm.). And while efforts are focused on the northern half of Montserrat, even less is known about populations in close proximity to the volcano, especially in the permanent exclusion zone of the island, where human traffic is prohibited.

Beginning in 2009 we have been monitoring populations of the endemic anole, *Anolis lividus* (Fig. 2), both in the safe zone (northern Montserrat) and in the permanent exclusion zone (southern Montserrat). In comparison to many other reptiles and amphibians on the island, much is known about the biology of *A. lividus*, such as its natural history (Lazell 1972; Schwartz and Henderson 1991; Underwood 1959; Williams 1962), malarial parasites (Staats and Schall 1996), and evolutionary relationships (Losos and Thorpe 2004; Schneider et al. 2001; Thorpe and Malhotra 1996). Despite more general knowledge of the species, there has been no assessment of how populations have been affected by volcanic activity until now. We present the first field observations of lizard habitat conditions from six sites within the permanent exclusion zone in southwestern Montserrat. The extent of environmental damage due to ash, gas venting, and acid rain varies in the exclusion zone, but some areas appear qualitatively similar to sites in northern Montserrat, which are comparatively less affected by volcanic activity. Despite the availability of apparently suitable habitat, we captured only a single adult male lizard in the permanent exclusion zone, suggesting that volcanic activity in this area may have a dramatic impact on lizard abundance.

Additionally, we compared body size among populations of *A. lividus* across the island, and compared current average body size to those of ethanol-preserved specimens in the Museum of Comparative Zoology collections at Harvard University, which were collected before the major volcanic eruption. We find that average body size (snout–vent length) is lower in recently-sampled populations, which may indicate that persistent volcanic episodes periodically deplete populations, making it rare for males to attain larger body sizes. Interestingly, however, the sole male found in the exclusion zone was also the largest collected to date, suggesting that large body size may facilitate colonization or persistence in this highly disturbed area. Because lizard abundance in the exclusion zone is extremely low, it is possible that volcanic activity may cause local extinction and may also delay or hamper recolonization.

Materials and Methods.—Because of the periodic fluctuations in volcanic activity, Montserrat is subdivided into zones that vary according to risk, which the Montserrat Volcano Observatory (MVO) monitors and updates according to current conditions (Fig. 3). While most of the north is permanently open, areas south of Salem in the west and Jack Boy Hill in the east are restricted, especially when volcanic activity increases. Even when the volcano is relatively calm, these areas are more affected by acid rain, ash, and pyroclastic activity than the northern half of the island. Travel into the permanent exclusion zone is prohibited, but the MVO granted our team special permission to enter the northwestern fringe of the exclusion zone for one day (29 June 2009) to survey *Anolis*

Fig. 2. Adult male *Anolis lividus* captured in Jack Boy Hill, in northeastern Montserrat.

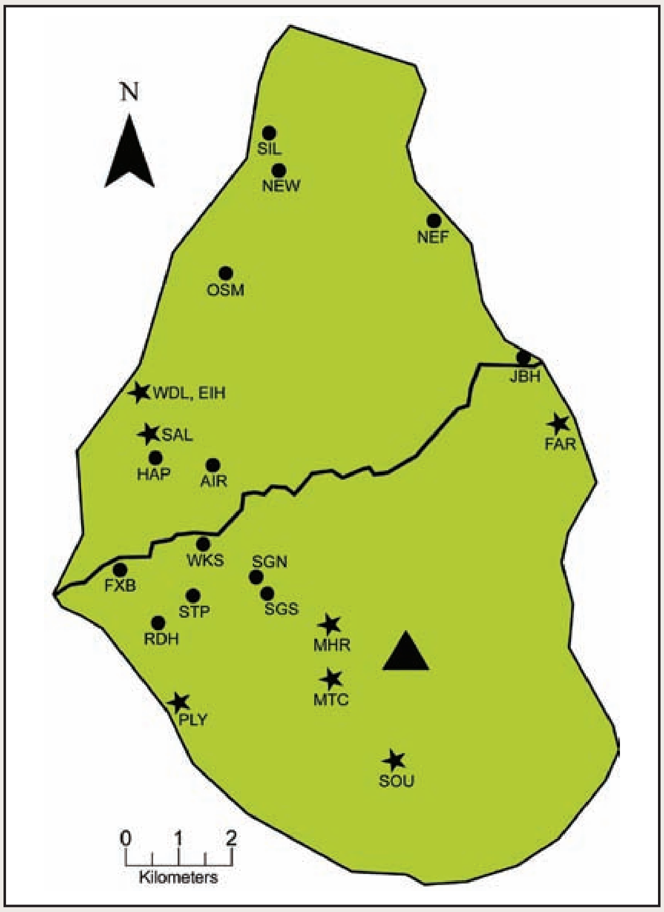

Fig. 3. Map of Montserrat showing our sampling strategy. Black dots denote localities sampled in 2009 and 2010 and stars denote localities sampled before the eruption (museum specimens). The black line shows the permanent exclusion zone boundary, and the triangle shows the location of the Soufrière Hills volcano.

Table 1. Data for body size and habitat conditions collected from wild-caught and museum specimens. Sites visited in the exclusion zone are denoted with an asterisk (*).

Locality	Abbreviation	Coordinates (lat, long)	Individuals	Min SVL (mm)	Max SVL (mm)	Ash Impact	Sulfur Odor	Acid Rain Impact
Summer Sampling (June 2009)								
Air Studios	AIR	16.74, -62.22	13	43.3	60.4	Low	Absent	Absent
Jack Boy Hill	JBH	16.76, -62.16	5	41.8	60.7	Low	Absent	Absent
Northeast Field	NEF	16.78, -62.18	13	47.2	64.5	Low	Absent	Absent
Sturge's Park*	STP	16.72, -62.22	0	-	-	High	Present	Absent
Richmond Hill*	RDH	16.71, -62.22	0	-	-	High	Present	Absent
Weeke's*	WKS	16.73, -62.22	1	-	67.9	Low	Absent	Absent
Fox's Bay*	FXB	16.72, -62.23	0	-	-	Low	Present	Absent
St. George's Hill - N*	SGN	16.72, -62.21	0	-	-	High	Present	Present
St. George's Hill - S*	SGS	16.72, -62.21	0	-	-	High	Present	Present
Winter Sampling (January 2009, 2010)								
Silver Hills - Rendezvous Bay	SIL	16.81, -62.20	11	44.7	63.9	Low	Absent	Absent
New Town	NEW	16.80, -62.20	13	48.6	63.5	Low	Absent	Absent
Old Sugar Mill	OSM	16.78, -62.21	7	41.3	58.2	Low	Absent	Absent
Happy Hill	HAP	16.74, -62.22	10	44.7	64.5	Low	Absent	Absent
Summer Sampling Museum Specimens								
Emerald Isle Hotel	EIH	-	5	56.3	68.4	-	-	-
Farmer's Estate	FAR	-	7	48.2	70.8	-	-	-
Monkey Hill River	MHR	-	2	55.5	62.0	-	-	-
Mount Chance	MTC	-	2	50.8	58.9	-	-	-
Plymouth	PLY	-	14	50.0	64.7	-	-	-
Salem	SAL	-	2	48.9	50.0	-	-	-
South Souffriere	SOU	-	1	-	55.4	-	-	-
Woodlands	WDL	-	7	51.5	62.8	-	-	-
Unknown	UNK	-	1	-	64.8	-	-	-

lividus, providing a first glimpse into lizard habitat conditions in this area.

In the exclusion zone we visited six sites of varying degrees of volcanic impact and seven sites outside of the zone (Table 1, Fig. 3). Because our time was limited in the exclusion zone, we qualitatively assessed each site we visited for relative ash, sulfur, and acid rain impact as compared to sites we visited in the safe zone. Ash impact referred to abundance of standing ash. We considered a site to have low ash impact if only a light coat of ash was present, no more than a few centimeters deep, and high impact when large quantities of standing ash were present, often at least half a meter high. Two observers confirmed the odor of sulfur and the presence of trees denuded of leaves with blanched trunks and branches were considered strong evidence of acid rain damage.

We captured adult male lizards with a standard noose and using digital calipers we measured body length (snout–vent length; SVL), which is the distance from the tip of the snout to the cloaca. We captured and measured individuals from populations outside of the exclusion zone in the winters of 2009 and 2010 (N = 43) and in the summer of 2009 (N = 30). We kept summer and winter individuals separate for statistical analyses because population body size can vary by season in lizards.

We also measured SVL for 41 ethanol-preserved specimens of adult male *A. lividus* from the Museum of Comparative Zoology at Harvard University, all of which were captured before the 1995 eruption (Table 1). While there was no minimum body size for inclusion in our analyses, we only considered samples captured in summer because of low sample size for museum specimens captured in winter. Because exact coordinates are unavailable for these animals we provide approximate localities based upon the available information of capture site. We performed all analyses on log-transformed data using SPSS ver. 16.0 statistical software (SPSS Inc., Chicago, Illinois; http://www.spss.com). We conducted

FIG. 4. Image of several trees and a satellite dish damaged by acid rain in St. George's Hill (SGS), in the exclusion zone. The damaged trees are defoliated with blanched trunks and branches.

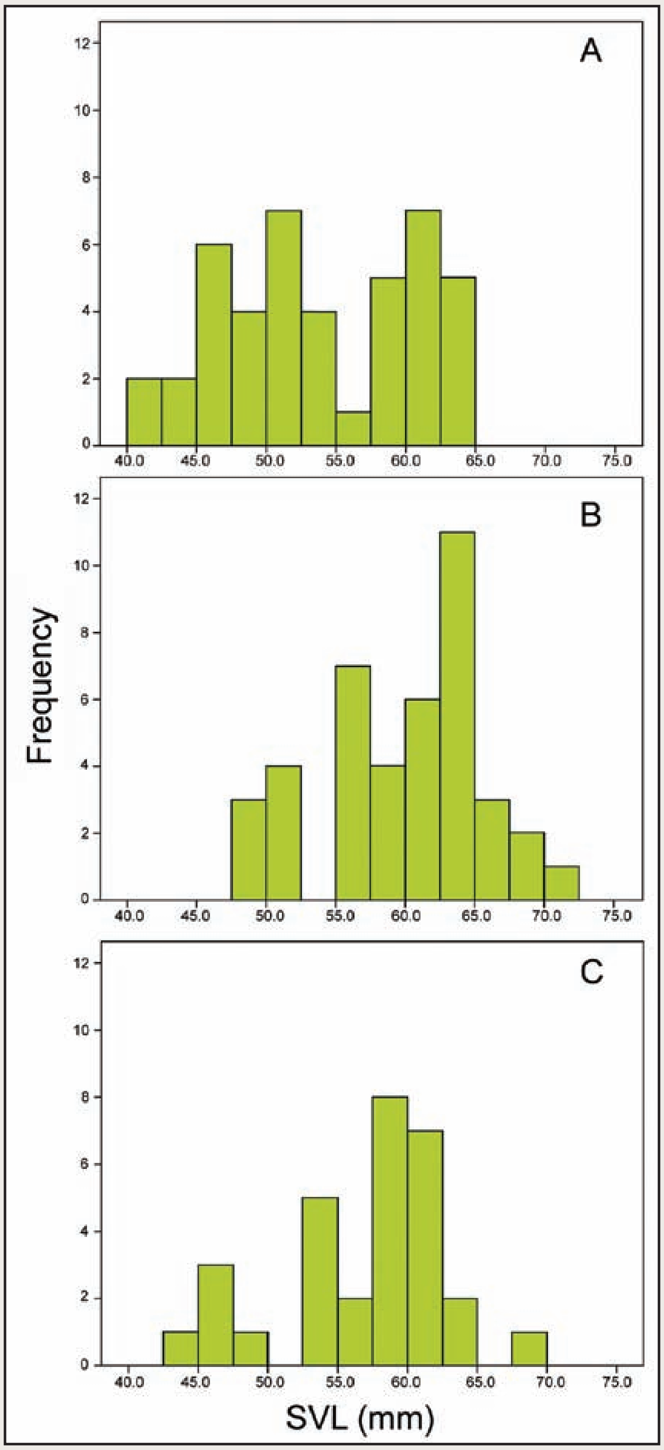

FIG. 5. Histograms depicting distributions of body length (SVL) for (a) lizards captured in winter 2009/2010, (b) museum specimens captured in summer before the eruption of 1995 (c) lizards captured in summer 2009.

a one-way ANOVA on mean body length to determine if SVL of ethanol-preserved specimens differed from that of the animals we captured in summer and in winter. We performed post-hoc tests (Tukey) to identify populations that differed from each other.

Results.—While sites in the north are qualitatively quite similar to each other, there are pronounced environmental differences between the sites visited in the exclusion zone (Table 1). Ash impact in Fox's Bay and Weeke's was low and comparable to sites outside of the exclusion zone (Air Studios, Northeast Field, Jack Boy Hill), but the remaining sites had considerably more ash present. Acid rain damage was noticeable only in St. George's Hill, although it may affect other sites to a lesser extent (Fig. 4). We noticed a distinct sulfurous odor in the air in all exclusion zone sites except Weeke's, and it was not appreciable anywhere outside of the exclusion zone. While the sites within the exclusion zone differed from each other environmentally, they were similar in that lizard abundance was very low. While lizards were abundant in the sites sampled outside of the exclusion zone, we observed only two animals (a mating pair) in a day of surveying, both of which were perching on the same tree in Weeke's.

We divided our data into three groups: winter 2009/2010, summer 2009, and summer-collected museum specimens. Histograms (Fig. 5) show the distributions of body size for the summer 2009 (N = 30, mean = 56.9 mm, SD = 5.7), winter 2009/2010 (N = 43, mean = 53.9 mm, SD = 6.8), and museum collection lizards (N = 41, mean = 59.9 mm, SD = 5.8). The male we caught in the exclusion zone (SVL = 67.9 mm) is also the largest lizard we have sampled to date across all seasons. However, several lizards from the museum collections were larger than this male, and the largest lizard sampled on Montserrat is 70.8 mm in body length. An analysis of variance (ANOVA) revealed that mean SVL differed significantly between groups sampled ($F = 9.785$, df=2, $p < 0.001$), and a post-hoc test (Tukey) showed that only the winter samples and the museum specimens were significantly different from each other ($p < 0.001$).

Discussion.—Our field observations revealed that habitats within the exclusion zone differed qualitatively in their degree of volcanic impact. Most importantly, the sites closest to the boundary of the exclusion zone, Fox's Bay and Weeke's, appeared very similar to our sampling sites outside the zone, except that a sulfurous odor was appreciable in Fox's Bay. Despite being qualitatively more similar to the northern portion of Montserrat, all sites within the exclusion were alike in that *Anolis lividus* was uniformly scarce. We sampled as close to Plymouth as we could safely get (Richmond Hill), where *A. lividus* was considered ubiquitous before the eruption and now appears absent or nearly so (Lazell 1972). The only two lizards that we found in the exclusion zone were a mating pair in Weeke's, the site that is physically closest to the exclusion boundary and also qualitatively most similar to the north. Furthermore, this male was the largest lizard by more than 3 mm that we have sampled to date (although it is also 3 mm smaller than the largest museum specimen).

Mean body size in winter-caught lizards was significantly smaller than the summer-caught museum population, which is not unexpected because body size increases from winter into the breeding season. However, if seasonal effects alone could account for the difference in body size between museum and winter-caught specimens, then the winter specimens should also be significantly smaller than our summer-caught specimens, but this is not the case. Although not significant, there is a trend towards larger average body size in the museum specimens than in the summer 2009 samples. This may reflect a collection bias towards larger animals in the museum collections, but cannot explain why we have not caught larger animals. The largest museum specimen (SVL = 70.8 mm) is much larger than the biggest (SVL = 67.9 mm) and second largest (SVL = 64.5 mm) specimen, collected at Weeke's and Happy Hill, respectively. Our collection technique is completely agnostic; we capture any adult males we see and given that larger males should be more conspicuous it appears that larger males are potentially less abundant..

Population size in anoles can be quite large, especially in the West Indies, and is fairly constant between years (Andrews 1979; Losos 2009; Schoener 1985, but see Schoener and Schoener 1978). The scarcity of anoles in the exclusion zone, an area where *A. lividus* once abounded, suggests that populations within the exclusion zone potentially go locally extinct more often, and that more persistent environmental assaults in that area may retard recolonization efforts as compared to sites further north. Although recolonization by canopy insect populations is quite rapid (Marske et al. 2007), it would likely take more time for lizards, which have a longer generation time and take longer to disperse than flying insects. Furthermore, dispersal from the north into more suitable parts of the exclusion zone may be hampered by the Belham River valley, a wide mudflat straddling the exclusion boundary, as this barren riverbed is periodically covered in ash and pyroclastic material. However, long-term ecological surveys are needed to tease apart the patterns affecting local abundance and extinction. As we sample populations at a single point in time we lack detailed data regarding the ecological fluctuations a given region has undergone due to volcanic activity that can affect local extinction and recolonization.

If periodic episodes deplete populations closer to the exclusion zone more often, then it would be rare for males to live long enough to grow very large in that area, but the largest male we sampled in our trip came from Weeke's, in the exclusion zone. It is possible that larger animals are more resilient to periodic environmental fluctuations, such as crashes in insect populations. Larger lizards are socially dominant over smaller males, and have better territories, which may be more important in areas that are periodically food-limited by crashes in insect populations (Rand 1967; Stamps and Krishnan 1994; Stuart-Smith et al. 2007; Trivers 1976). Again, more sampling in the permanent exclusion zone is needed to determine if the male we caught was rare, or if there is greater size spread in populations close to the volcano. Further investigation of *Anolis lividus* both within and outside the permanent exclusion zone will provide insights into the ecological processes influencing response to continual volcanic activity.

Material Examined.—All samples are from the Herpetology collections at the Museum of Comparative Zoology (MCZ) at Harvard University. Specimen numbers and corresponding localities are provided. MCZ 18318 (Plymouth), MCZ 38379 (Plymouth), MCZ 57785 (Plymouth), MCZ 57786 (Plymouth), MCZ 57787 (Plymouth), MCZ 65333 (Plymouth), MCZ 65335 (Plymouth), MCZ 82022 (Plymouth), MCZ 82023 (Plymouth), MCZ 82024 (Plymouth), MCZ 82025 (Plymouth), MCZ 82026 (Plymouth), MCZ 82027 (Plymouth), MCZ 82028 (Plymouth), MCZ 82032 (Woodlands), MCZ 82033 (Woodlands), MCZ 82034 (Woodlands), MCZ 82035 (Woodlands), MCZ 82036 (Woodlands), MCZ 82037 (Woodlands), MCZ 82038 (Woodlands), MCZ 82044 (Farm Estate), MCZ 82045 (Farm Estate), MCZ 82046 (Farm Estate), MCZ 82047 (Farm Estate), MCZ 82048 (Farm Estate), MCZ 82049 (Farm Estate), MCZ 82050 (Farm Estate). Collected by Julian Boos in 1970: MCZ 125465 (Salem), MCZ 125466 (Salem), MCZ 125468 (Monkey Hill River), MCZ 125469 (Monkey Hill River), MCZ 125470 (Emerald Isle Hotel), MCZ 125472 (Emerald Isle Hotel), MCZ 125473 (Emerald Isle Hotel), MCZ 125474 (Emerald Isle Hotel), MCZ 125475 (Emerald Isle Hotel), MCZ 65331 (South Soufrière), MCZ 82042 (Mount Chance), MCZ 82043 (Mount Chance), MCZ 55837 (Unknown).

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Slevin's Bunchgrass Lizard (*Sceloporus slevini*) Population Barely Extant on the Sonoita Plain, Arizona

Species can be rare because they are truly rare, highly spatially clumped, or elusive due to species characteristics, and when all three determinants are operating there is a compounded effect on rarity (McDonald 2004; Rabinowitz 1981). For species that are truly rare it is important to obtain reliable information on population trends and to determine whether downward trends are simply natural population fluctuations or trajectories likely to result in extinctions (Barrows 2006). Ultimately, however, the critical need is to determine the reasons for rarity so that appropriate conservation measures can be implemented (Barrows 2006; Roberts et al. 2009). Slevin's Bunchgrass Lizard, *Sceloporus slevini* (formerly *S. scalaris slevini*, see Smith et al. 1996) meets all three of the above determinants of rarity within its limited range in the United States. This small and secretive species is a bunch grass specialist that is rarely observed far from its bunch grass refugia (Fig. 1). Although widely distributed at high elevations along both axes of the Sierra Madre Occidental of Mexico from northern Durango to northern Chihuahua, in the United States it occurs in a limited series of disjunct populations, largely within the Madrean Archipelago of southeastern Arizona where populations are mainly confined to isolated montane meadows above 2100 m (Smith et al. 1997). In addition, several disjunct lower elevation populations (~1300–1600 m) have been recorded in the plains grasslands of Arizona and New Mexico (Bock et al. 1990; Dixon and Medica 1965; Lowe 1964; Smith et al. 1998; Stebbins 2003).

Anthropogenic and non-anthropogenic events have been implicated in the reports of past and recent population declines of *S. slevini* at sites where they were once abundant. Ballinger and Congdon (1996) searched the study areas they worked in the Chiricahua Mountains in the 1970's when densities ranged from 100–200 lizards per hectare (Ballinger and Congdon 1981), but found only four juveniles, attributing the decline to overgrazing by cattle. In 1998 *S. slevini* was reported "decimated" at the National Audubon Society Appleton-Whittell Research Ranch (ARR), a relatively low elevation site (~1478 m) on the Sonoita Plain of Arizona (Smith et al. 1998). Despite intensive searching during June–September of 1997, a group of researchers failed to find any *S. slevini* (Smith et al. 1998). Nine years previously, relatively high numbers of lizards had been recorded at the same sites (Smith et al. 1998). For example, from 12–20 August 1989, 53 adults were recorded from ARR and adjacent areas of the Sonoita Plain (Bock et al. 1990). One of us (TM) also worked at ARR during the mid-1990's when lizards were abundant (Mathies and Andrews 1995) and similarly noted their subsequent disappearance. The decline and potential extirpation of this population was attributed to a prolonged drought (Smith et a1. 1998).

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The population of *S. slevini* at ARR is considered important, in part, because it is one of the few large populations known in plains grassland (Bock et. al. 1990). There are also differences in life history attributes between the ARR population and montane populations, including the phenology of reproduction, two vs. one clutch of eggs a season (Mathies and Andrews 1995), and a larger body size (Mathies and Andrews 1995; C. d'Orgeix, unpubl. data). Genetic differences are implied by the absence of unicolor individuals in the ARR population (Smith et al. 1990; T. Mathies, unpubl. data). Unicolor individuals occur in various proportions in the montane populations in northern Chihuahua, Mexico (22%; Anderson 1972) and the United States (20%; Van Devender and Lowe 1977). Unicolor individuals also occur in populations in close proximity to the ARR population in the Huachuca Mountains at Ramsey Canyon (Smith 1946), and on Carr Peak (C. d'Orgeix and T. Mathies, unpubl. data), indicating a lack of genetic exchange between ARR and montane populations. Because of the possible differentiation of this population from other nearby populations, our objectives were to determine whether the species is still extant at ARR, and if so, to establish survey plots and methodology for future monitoring efforts.

Materials and Methods.—Our study area is on the 3160-ha ARR on the Sonoita Plain, Santa Cruz County, Arizona, a plains grassland-oak savanna, which unlike the surrounding region, has not been grazed by livestock for over 42 years. Stratified sampling was used to select 10 sites in areas that appeared to be good habitat for *S. slevini*, having primary coverage of bunch grasses interspersed with low woody shrubs and patches of bare soil. One 100 x 100 m plot was established on each site by selecting a random position as plot corner and then mapping out the other three corners in Universal Transverse Mercator coordinates (Datum: NAD27 CONUS) using handheld global positioning system (GPS) units (Models: GPSmap 60CS and Rhino530, Garmin International Inc., Olathe, KS, USA). Three of the 10 sites were located within the area where Bock et al. (1990) initially found *S. slevini* to be abundant (C. Bock, pers. comm.), and where Smith et al. (1998) later found them apparently absent. Plots were surveyed 10 June to 29 July, 2007 [10 years after Smith et al. (1998)] and again 24 July to 4 August, 2009. Each plot was surveyed three times each year on three different days. A GPS unit was used to navigate a series of parallel non-overlapping "transects" across the width of each plot. Each transect was surveyed by two to three persons walking side by side approximately two meters apart. Plots were surveyed between 0730 h and 1800 h when conditions were sunny, or if overcast, when air temperatures were high enough for lizard activity (see Mathies and Andrews 1995). We walked 8 to 11 transects per plot per day at about 2.5 kph with each person walking a total of about 1080 m distance per plot. Lizards were located visually while walking transects and captured by hand. To identify individuals we recorded their sex and measured each lizard's snout–vent length (SVL) to the nearest 1 mm, body mass to nearest .01 g and removed 2–4 mm of tissue from the tip of the tail. GPS location was recorded and the lizard was released at its point of capture. Individuals were subsequently identified based on the missing tail tip, location, sex, SVL, and mass. Coordinates of plot corners and individual *S. slevini* were mapped using ArcView (Version 3.2, ESRI, Redlands, CA, USA) Geographical Information System (Fig. 2).

Results and Discussion.—We confirmed that *S. slevini* was present at ARR on both years of the study. However, despite intensive searching, few were encountered in 2007 (N = 5, 2 males and 3 females) and in 2009 (N = 3, 2 females and 1 male). Thus, densities appear to be quite low (1–2.5 lizards per 100 m^2, for occupied plots). Lizards were detected on four of our ten plots. The only plot on which lizards were detected in both study years was Plot 2, which was within the area censused by Smith et al. (1998). Four of the five lizards detected in 2007 were on Plot 5, but we detected no lizards there in 2009. Within years, only one of the eight lizards found was recorded on a subsequent census. These data contrast with 2006 and 2007 censuses of a high elevation population in the Huachuca Mountains where the same individuals were seen on subsequent days at the same locations (D. Bridgers, C. d'Orgeix, and T. Mathies, pers. obs.).

In 1989 when lizard densities were high, Bock et al. (1990) encountered approximately 9 lizards per man-hour. However, in 1997 Smith et al. (1998) walked a total of 7 km in June and again in August reporting a total absence of *S. slevini.* We found that detection of a single *S. slevini* on our plots in 2007 and 2009 required coverage of about 6.4 km and 10.7 km of transect at about 2.5 and 4.3 man-hours, respectively.

Smith et al. (1998) suggested that *S. slevini* is adapted to the more mesic high elevations and that the two consecutive years of severe drought (1995–1996) preceding the observed decrease was the cause of the ARR population decline. Precipitation data from ARR support both contentions; prior to the observed abundance in 1989, the study area experienced two consecutive years of much higher than average precipitation (1983, 1984) followed by another four consecutive years of above average precipitation (Fig. 3A). Except 2000,

Fig. 1. Male *Sceloporus slevini* in the bunchgrasses *Bouteloua gracilis* and *B. curtipendula* at the National Audubon Society Appleton-Whittell Research Ranch, Santa Cruz County, Arizona.

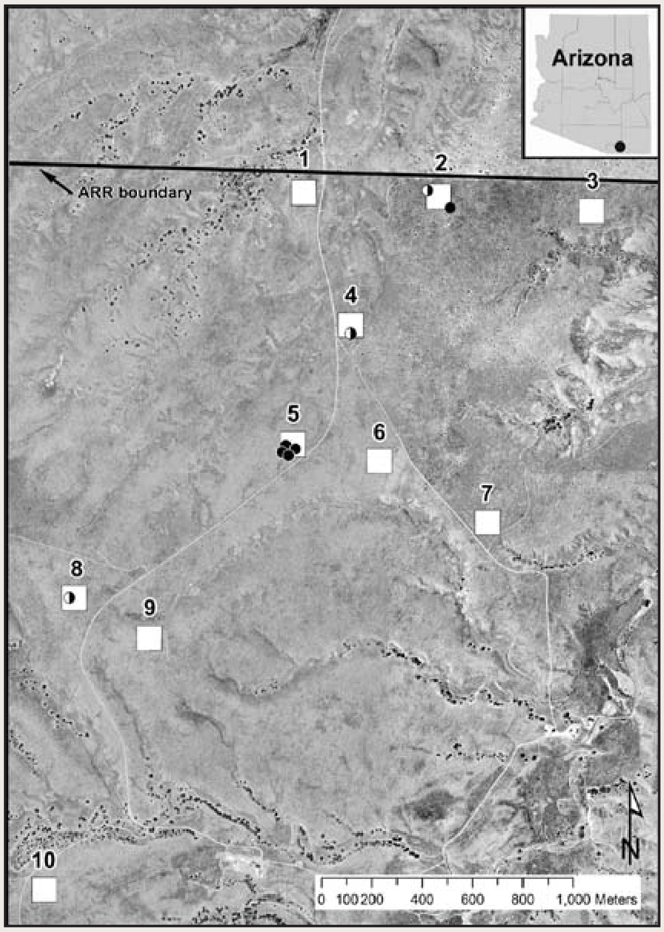

Fig. 2. Distribution of the ten 100 x 100 m survey plots for bunch grass lizards, *Sceloporus slevini,* on the National Audubon Society Appleton-Whittell Research Ranch (ARR), Santa Cruz County, Arizona. The filled circle in the inset indicates the general location of the study area. Numbers above plots are plot numbers. Filled (2007) and half-filled (2009) circles are the locations of the eight *S. slevini* detected in this study.

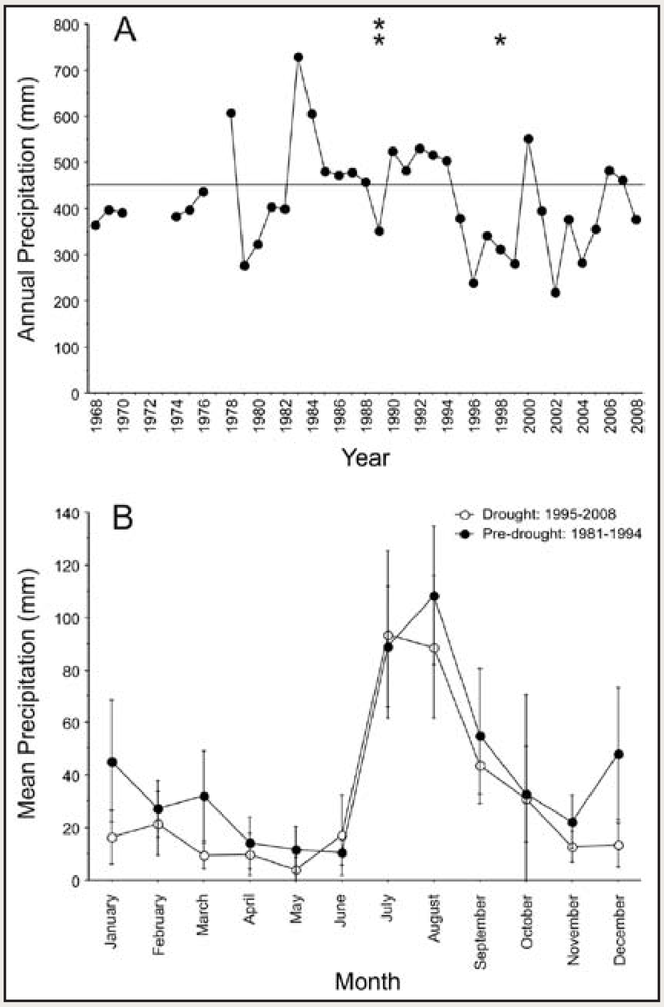

FIG. 3. A) Annual precipitation at the National Audubon Society Appleton-Whittell Research Ranch, Santa Cruz County, Arizona. Data for years 1971–1973 and 1977 were not available. The horizontal line represents the mean precipitation for 23 years of available data from 1968–1994 prior to onset of drought in 1995. Double asterisks indicate year when high densities of *Sceloporus slevini* were observed (1989: Bock et al. 1990); single asterisk indicates year when no lizards were observed (1998: Smith et al. 1998). B) Mean (± 95% confidence interval) precipitation by month. Filled circles are for 14-year period prior to onset of drought (1981–1994); unfilled circles are for 14-year period from when recent drought began (1995) to present (2008).

2006, and 2007, below average precipitation totals have continued to present (Fig. 3A).

Certain life history attributes of *S. slevini* enable rapid population increase under favorable environmental conditions. Unlike females in nearby montane populations, females in the ARR population can produce two clutches a season (Mathies and Andrews 1995; see also Ortega and Barbault 1986). Moreover, *S. slevini* is an early maturing species; because hatchlings are periodically active on sunny winter days and exhibit winter growth, sexual maturity is attained by the first spring (Ballinger and Congdon 1980; Newlin 1976). However, other attributes would result in rapid population decline if this species is sensitive to drought. Adults are short-lived with an estimated yearly mortality of 62-76% in a montane population (Ballinger and Congdon 1981). Thus any population sustaining two consecutive years of no recruitment could be reduced to low levels or extirpated.

Precipitation data for the months when nesting and egg incubation occur do not support the idea that drought directly affected egg laying and hatching success. Again, when comparing the 14-year period of pre-drought years and the subsequent 14-year period of drought years, mean monthly precipitation for the three months when egg laying and hatching occur (July–September: Mathies and Andrews 1995) did not differ (two-factor ANOVA; $F_{1,75} = 1.16$, $P = 0.28$), nor was the interaction significant (Fig. 3B; $F_{2,75} = 0.99$, $P = 0.38$). The drought has instead been primarily manifest in the months outside the July–September nesting-hatching season (two-factor ANOVA; $F_{1,224} = 12.19$, $P = 0.0006$). Because *S. slevini* is an early maturing species with rapid population turnover, population persistence requires that hatchlings of both sexes grow substantially during these months in order to reach sexual maturity by first spring. Maturing females, in addition to obtaining resources necessary for growth, must also acquire food for the fat body growth required for egg production. Food abundance and growth rates of all size classes of *S. slevini* were shown to be lower in a drought year than a non-drought year (Ballinger and Congdon 1980) and the phenology of fat body development in females indicates that reserves accumulated in the fall are used for egg production in the spring (Newlin 1976). Regardless, a proximate mechanism for a drought-induced population crash remains unclear.

Climate change (warming) has recently been implicated in local extinctions at 12% of 200 sites surveyed since 1975 for 48 *Sceloporus* species in Mexico, and lizard extinctions are projected to increase globally (Sinervo et al. 2010). The population crash of *S. slevini* at ARR may therefore be symptomatic of this larger trend. However, another low-elevation Sonoita Plain population, approximately 30 km SW of ARR, appears to have relatively high numbers of lizards (C. d'Orgeix and T. Mathies, pers. obs.), and high elevation populations in the Huachuca and Chiricahua Mtns. appear to be robust (C. d'Orgeix and T. Mathies, pers. obs.). These data contrast with the expectation that either other nearby low elevation populations should show similar declines in population numbers, or that lower elevation populations should be less adversely affected by global warming than higher elevation populations (Sinervo et al. 2010). Furthermore, the contrasts in population numbers between ARR and other nearby populations indicate that environmental complexity (Barrows and Allen 2007) masks the proximate causes for the decline at ARR.

Our primary finding that the population at ARR remains extant, albeit at extremely low numbers, presents a unique opportunity to compare this population's dynamics with those of other populations of *S. slevini* at both low and high elevations to test hypotheses of drought influenced population declines (Barrows 2006), differences in environmental complexity between populations (Barrows and Allen 2007) and climate change extinctions (Sinervo et al. 2010).

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Using Scrape Fishing to Document Terrapins in Hibernacula in Chesapeake Bay

Chesapeake Bay's Diamondback Terrapin (*Malaclemys terrapin terrapin*) population has made considerable recovery from the commercial exploitation that led to its near extirpation in the late 19th and early 20th centuries (Carr 1952; McCauley 1945). Nevertheless, it continues to face increasing threats from human population growth, degradation of the Bay, exposure to man-made hazards (Butler et al. 2006; Roosenburg 1991; Siegel and Gibbons 1995), and, during the period of this study (2003–2005), continued commercial harvest in the Maryland portion of the Bay. The state of Maryland maintained an active terrapin fishery that was closed only during the terrapin nesting season (May–July), had no daily or seasonal catch limit, and exclusively targeted breeding-age females, i.e., terrapins with plastron length ≥15.2 cm. Although the fishery was perceived as small, with little market demand, the long season and 'no limit' regulation left the fishery vulnerable to overharvest. Concern over this vulnerability led us to examine the method of traditional winter harvest and characteristics of terrapins occupying hibernacula. Although generations of Chesapeake Bay watermen have pursued winter harvest of terrapins, fishing methods, locations of hibernacula, and the terrapins occupying them have not previously been documented.

Here we utilize watermen fishing skills and harvest methods to locate, sample, and describe terrapins occupying estuarine bay hibernacula. Because the region has long been a center for the commercial harvest of Blue Crabs (*Callinectes sapidus*), we also examine terrapin captures for potential effects of selective by-catch mortality of small terrapins associated with decades of commercial crab pot use in the region (Roosenburg et al. 1997; Warner 1977; Wood 1997).

MATERIALS AND METHODS

We sought collaboration with a former terrapin harvester to learn fishing methods and to access hibernacula in the Tangier Sound region of Chesapeake Bay (Fig. 1). Tangier Sound is bordered by extensive brackish tidal marshes and historically has harbored large terrapin populations (McCauley 1945). Sampled hibernacula were chosen to be geographically separated and to represent a selection of sites of former terrapin harvest. Four sites were chosen near large marsh islands ca. 8–12 km offshore (Smith Island, South Marsh Island, and Bloodsworth Island) and two additional sites were located near the mainland (Janes Island and Nanticoke River; Fig. 1). Two sites located within tributaries (Nanticoke River and Janes Island) and a third located within interior South Marsh Island were within zones where commercial crab potting is prohibited by state regulation. The remaining three sites (Smith Island–N, Smith Island–S, and Bloodsworth Island) were within areas of heavy potting activity. We also selected St. Jerome Creek, a site of former harvest on the western shore of Chesapeake Bay that differed in being located in a navigable tidal creek having forested shoreline in lieu of extensive bordering salt marsh.

To capture terrapins watermen adapted a dredge, or scrape, used to capture molting blue crabs from shallow, near-shore waters using locally built, shallow-draft vessels (also called scrapes; Warner 1977). Being hand-made, terrapin scrapes vary in size, but most are based on a 1.5 m wide blue-crab design. In 2003, we used a blue crab scrape that was modified by attaching a larger mesh catch bag and welding 12 short 7.6 cm teeth every 13 cm along the scraping bar. The larger mesh bag (8 cm) helped minimize fouling and the teeth dug terrapins from bottom sediment. In 2004 and 2005, we used a slightly larger scrape framed from heavier 2 cm diameter steel stock. Its entrance measured 1.7 m × 0.4 m and its overall length was 2.4 m (Fig. 2a). The noteworthy difference of this scrape was the addition of numerous (30), longer (15 cm), and more closely spaced (6 cm) teeth on the scrape bar.

The scrapes were towed in a circular pattern behind a 12 m work boat and retrieved by hydraulic winch. The length of the tow rope was critical to proper operation as it adjusted the drag or "bite" of the scrape in bottom sediment. Capture success was measured by the number of terrapins captured/tow. Although there was no fixed time limit for each tow, several hundred tows averaged about 7 min in length, or a rate of 8.6 tows/h. While some commercial scrapes were equipped with side baffles to help guide terrapins into the catch bag, neither of our scrapes had baffles.

Captured terrapins were given a visible mark by drilling a 5 mm diameter hole in the 10th right marginal scute through which we attached a serially numbered monel fish tag (tag no.1005–3: National Band and Tag Co., P.O. Box 72430, Newport, Kentucky 41072). Passive integrated transponders, or PIT tags (model TX1400L: Biomark, Inc., 7615 West Riverside Drive, Boise, Idaho 83714), were used as permanent marks. Size dimorphism and tail characteristics (tail length and anus position in relation to edge of carapace) were the primary

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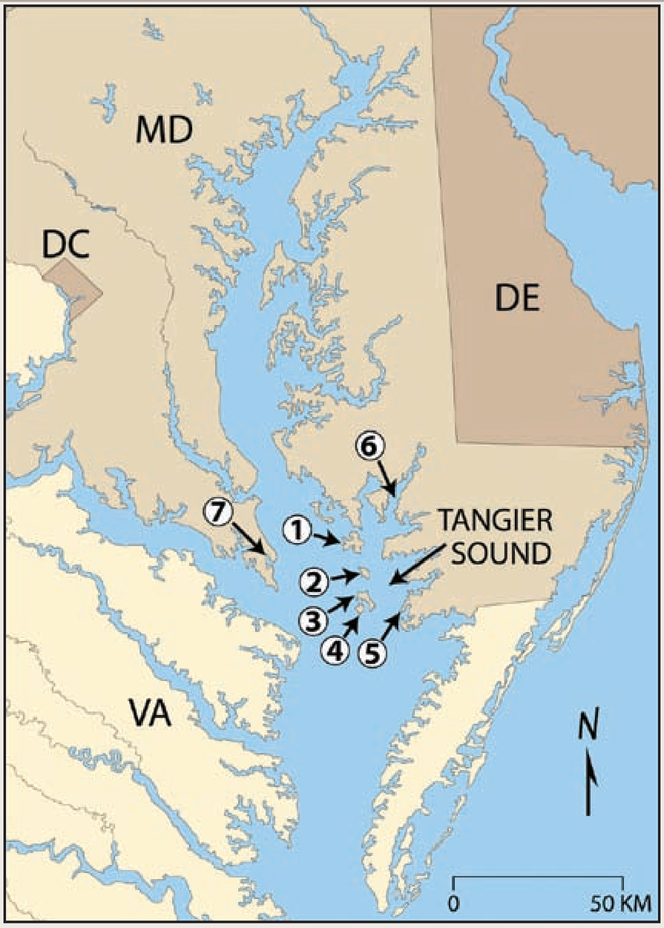

Fig. 1. Chesapeake Bay and vicinity showing Tangier Sound and the location of sites of winter sampling of Diamondback Terrapins, 2003–2005: 1) Bloodsworth Island, 2) South Marsh Island, 3) Smith Island–North, 4) Smith Island–South, 5) Janes Island, 6) Nanticoke River, and 7) St. Jerome Creek.

criteria used to sex terrapins (Carr 1952). Because only terrapins about 10 years of age (YOA) or younger could be aged by annular growth rings (as read from plastral pectoral scutes), we separated captures into two basic age classes: those ≤10 and those >10 YOA. Body mass was measured with a digital electronic balance to the nearest g and midline plastron length (PL) was measured with calipers to the nearest mm.

To dispel concerns about possible detrimental physiological effects associated from removal of terrapins from hibernacula, we conducted a field study to determine if short-term acute effects did occur. This question has management relevance because we observed commercial terrapin harvesters leaving captures on boat decks for up to several hours before sorting their catch and returning culls to the bay. In our experiment, one set of 12 newly captured terrapins (6 of each sex) were maintained in bay water (5°C) while simultaneously exposing a second set of 12 terrapins in a heated boat cabin at ca. 24°C, a temperature well above the range of ambient air temperatures (10–15°C) experienced on a boat deck on a mild winter day. Both sets of terrapins were held for a

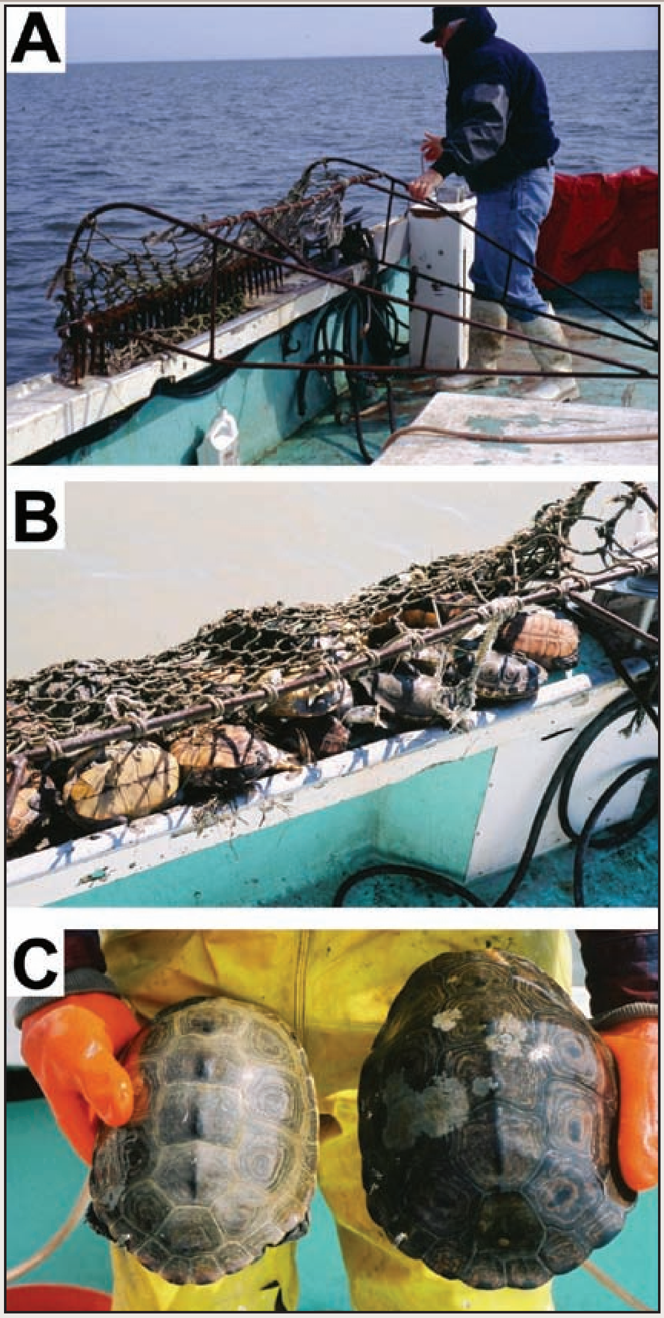

Fig. 2. A) A scrape, or dredge, used to harvest Diamondback Terrapins in winter in Chesapeake Bay. Design is based on a scrape used to harvest blue crabs but with heavier construction, addition of teeth on the scrape bar, and a larger mesh catch bag (see text for details). B) A retrieved scrape resting on the boat gunwale showing a good catch of terrapins. The scrape did not injure terrapins and as many as 24 were captured in a single tow. C) Two females caught 18 March 2005 from St. Jerome Creek demonstrate size and age in the diamondback terrapin. The female on the left (body mass of 1922 g, PL of 202 mm) was known to be 20 years of age by previous marking on the nearby Patuxent River (W. Roosenburg, pers. comm.). The female on the right is of unknown age and was the largest terrapin caught during our study (3022 g, PL of 228 mm). This specimen approximates the maximum size for the species within the Chesapeake Bay and likely within the species' range.

Table 1. Numbers and sex ratios of Diamondback Terrapins captured from six hibernacula in Tangier Sound and the St. Jerome Creek Site on the western shore of Chesapeake Bay, winters 2003–2005. Sites are listed by rank in cumulative sex ratio given as proportion female (*pf*).

Site	No. captures	Sex ratio (*pf*)
St. Jerome Creek	33	0.970 A[a]
Smith Island–S	74	0.784 B
Janes Island	222	0.734 B
Smith Island–N	377	0.719 B
South Marsh Island	141	0.709 B
Bloodsworth Island	160	0.588 C
Nanticoke River	168	0.345 D
Totals	1175[b]	0.660

[a] Values sharing the same letter are not different: individual 2-tailed z-tests of proportions (α = 0.05).
[b] Totals exclude between-year recaptures (N = 22).

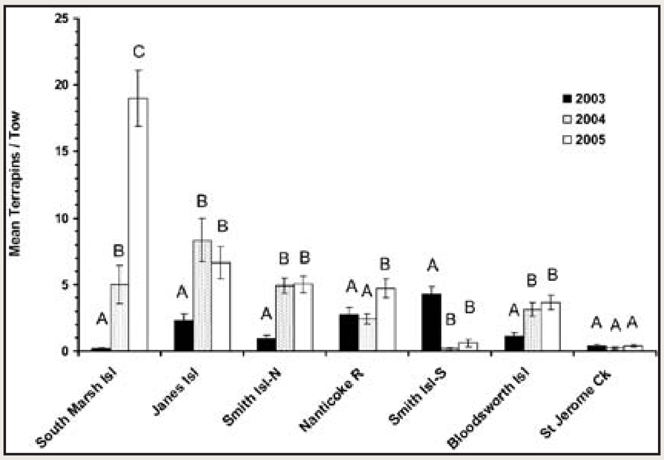

Fig. 3. A composite histogram of year- and site-specific terrapin capture rates (mean ± SE captures/tow) using a modified crab scrape in 2003 and a slightly larger scrape in winters 2004–2005. Capture rate had marked year and site effects (P < 0.001, individual tests using Krukal-Wallis one-way ANOVA on ranks). Means within sites sharing the same letter do not differ: Dunn's multiple comparison test (α = 0.05).

period of 2 h. Following the holding period, all terrapins were returned to the location of capture and placed in a 1.8 m × 2.4 m × 1.8 m wire holding cage made of 2.5 cm mesh galvanized chicken wire. The cage sat on the bottom and extended above tide level. After 3 weeks, the cage was retrieved and survival and outward condition of the terrapins assessed.

We used SigmaStat 3.1 (Systat Software, Inc, Point Richmond, California 94804) to evaluate assumptions of normality and homogeneous variance and to conduct analyses of variance. When necessary, we either transformed data to meet normality and equal variance or applied the nonparametric Kruskal-Wallis ANOVA test on ranks. Contrasts were tested using Tukey's test (parametric) or Dunn's method (non-parametric). Sex ratios and proportion of females <10 YOA were tested by 2-tailed *z*-tests of binomial proportions (Sokal and Rohlf 1995). We generated a simple Lincoln-Petersen estimate based on site-specific between-year recaptures to estimate hibernaculum population size (Seber 1973). This estimate is made under the assumption of population closure and equal catchability. We tested for two potential effects of selective by-catch mortality of smaller terrapins in crab pots as noted by Dorcas et al. (2007) and Wolak et al. (2010): larger size of both sexes based on PL and reduced presence of younger female terrapins. Data were combined across years within pot and no pot sample sites.

RESULTS

Hibernacula.—Hibernacula were located in semi-protected estuarine bays in near-shore shoal waters adjacent to extensive salt marsh. Sites had bottoms of moderately soft mud and were deep enough (1.5–3.5 m) to offer little risk of dewatering even under unusually low storm tides. Most bottoms were relatively clean of shell and organic debris; all were exposed to good tidal circulation but limited wave energy because of reduced wind fetch. Because terrapins were often buried in soft mud, continued scraping at such sites often increased capture success. On firm bottoms terrapins were only partially buried or not at all. Terrapins were not injured by capture and only rarely were they marked by the metal teeth or frame of the scrape (Fig. 2b).

Capture success.—During February and early March, 2003–2005, we captured 1175 terrapins from seven hibernacula (Table 1). Capture rate had a marked site and year effect (P < 0.001: individual tests, Kruskal-Wallis one-way ANOVA on ranks; Fig. 3). Capture rate for sites in Tangier Sound averaged 4.18 ± 1.02 SE captures/tow (N = 18), or about 36 terrapins/h. Capture rate generally increased in 2004 and 2005 with the use of the heavier scrape with longer, more closely spaced teeth (Fig. 3). The exceptions were the Smith Island–S site where harvest activity was suspected to have depleted the population in 2004 and 2005, and the St. Jerome site where capture success was low in all years (mean = 3.1 terrapins/h). St. Jerome Creek was the deepest site sampled at 3.5 m and during three winters produced the fewest (32 females and one male), but on average the largest terrapins. The largest, a 3022 g female with PL of 238 mm, was considerably larger than a known-age 20-year-old terrapin captured at the same site (Fig. 2c) and marked previously on the Patuxent River (W. Roosenburg, Ohio University, pers. comm.). Mass of 26 females averaged 2151 ± 56 g and PL ranged from 191 to 228 mm (mean 205 ± 1.6 mm). At our South Marsh site, heavy growth of eelgrass (*Zostera marina*) precluded capture of terrapins in 2003. However, in the absence of vegetation in 2004, capture success increased sharply, and in 2005, the site was our most productive hibernaculum, averaging19 terrapins/tow, or 160 terrapins/h (Fig. 3).

Sex ratio.—Sex ratio across all sites and years favored females: 0.66 proportion female (*pf*), or 1.94 females/male (N = 1175; Table 1). Cumulative yearly sex ratio declined from 0.730

pf in 2003 to 0.654 in 2004 and 0.641 *pf* in 2005 (P < 0.05: individual 2003 vs 2004, and 2003 vs 2005 *z*-tests of proportions). Discounting possible year effects, the decline in sex ratio was likely a result of use of the larger scrape with more numerous and closely spaced teeth that increased capture efficiency of males. Not only were generally more males captured, but the minimum size was lowered in some cases by as much as 15 mm. For sites within Tangier Sound, year- and site-specific sex ratio varied from a low of 0.32 *pf* to a high of 0.91 *pf*. The Nanticoke River, a site of known frequent terrapin harvest, was the only site where male captures outnumbered females (Table 1).

Estimate of female recruitment.—Using growth annuli to age terrapins, we found females ≤10 YOA to comprise 19.2% (145) of 764 captures. Site- and year-specific percentages varied from 0 to 39%. We estimated annual recruitment by assuming 100% annual survival in the 6-to-9 YOA classes and averaging the percent of these year classes to total annual female captures. Terrapins <6 YOA were not included because only 9 were captured (8 five-year-olds and 1 four-year-old); and 10-year-olds were excluded because advanced shell wear obscured growth annuli limiting the number that could be identified (N = 8). The 128 terrapins in the 6-to-9 year-old age classes represented 10.4%, 18.3% and 21.6 % of female captures during the respective three winters and yielded estimates of annual recruitment of 2.6%, 4.6%, and 5.4% (mean = 4.2 ± 0.83).

To eliminate potential error associated with reading growth annuli, we additionally estimated recruitment based solely on size metrics. We used mean size statistics from 44 known 9-year-old females, i.e., mean mass (1043 g), PL (165 mm), and mass-to-plastron ratio (6.340 g/mm), to separate females ≤9 YOA from all older females. The resulting mean estimates of percent annual recruitment were about 50% higher than those based on growth annuli: 6.0 ± 0.29% based on PL, 6.5 ± 0.35% based on mass, and 6.7 ± 0.16% based on mass-to-PL ratio. Although we recorded 19.2% of females ≤10 YOA, only 29 3-to-8-year-old males (7.9% of male captures) were so captured ($\chi^2 = 22.8$, P < 0.001, 1 df). We concluded that too few males in the younger age classes were captured to provide a meaningful estimate of recruitment.

Growth rate.—Females in the 5-to-10-year-old age classes exhibited marked growth as mean mass increased by a factor of 3 (from 397 to 1184 g) and mean PL increased 50% (from 115.9 to 174.0 mm; Fig. 4). Based on the Maryland harvest regulation of a minimum PL of 152 mm, most female terrapins would reach harvestable size at between 7 and 8 YOA. Too few males were captured to adequately interpret growth in the 5-to-9-year-old age classes.

Recaptures.—We recaptured 102 terrapins (8.7% of captures) by various means up to four years after initial capture, but only 22 terrapins, 21 females (2.6% of female captures), and a single male (0.25% of male captures) were recaptured during winter sampling. All 22 recaptures were recorded at the site of original capture. Recaptures were sufficient to estimate hibernaculum population size only at the Smith Island–N site, where sampling was increased as part of an ongoing population study. Based on 13 female recaptures in 2005,

TABLE 2. Mean mass of male and female terrapins captured at six sites within Tangier Sound and St. Jerome Creek on the western shore of Chesapeake Bay, winters 2003–2005. Includes only unique adult captures (excludes between-year recaptures) of females >10 years of age and males >9 years of age. For the six Tangier Sound sites there was no rank correlation between site-specific mean mass of males and females (r = 0.54, P > 0.05, 4 df).

	Mean mass (g) ± SE			
Site	N	Female	N	Male
St. Jerome Creek	26	2150.6 ± 56.4 A[a]	—	—[b]
Smith Island–S	49	1589.2 ± 34.1 B	16	455.2 ± 5.03 A[c]
Smith Island–N	236	1386.7 ± 17.3 C	104	407.3 ± 5.03 C
Bloodsworth Island	81	1324.8 ± 34.5 CD	63	436.5 ± 7.91 AB
South Marsh Island	72	1285.8 ± 34.0 CD	32	390.9 ± 13.03 CD
Janes Island	111	1248.1 ± 23.2 D	53	358.3 ± 7.14 D
Nanticoke River	46	1181.7 ± 30.9 D	101	412.3 ± 5.39 BC
Combined	621	1393.5 ± 22.6	369	407.3 ± 3.19

[a] One-way ANOVA found marked site effect for female mass ($F_{6,614} = 52.2$, P < 0.001). Means within columns sharing the same letter do not differ: Tukey's test ($\alpha = 0.05$).
[b] Insufficient sample size.
[c] One-way ANOVA on ln transformed data found a marked site effect for male mass ($F_{5,363} = 16.0$, P < 0.001). Means within columns sharing the same letter do not differ: Tukey's test ($\alpha = 0.05$).

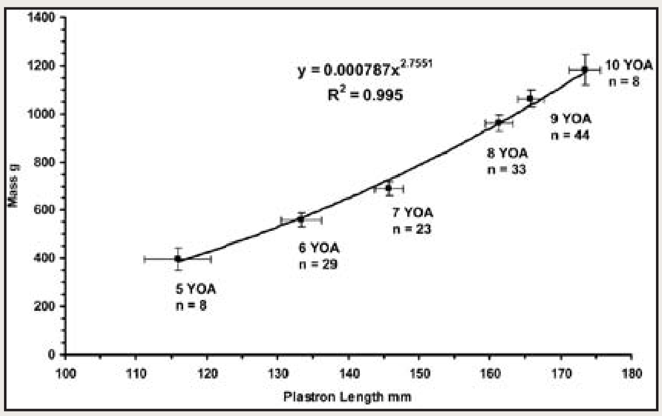

FIG. 4. Growth curve for 5- to 10-year-old female terrapins captured during winter sampling in the Tangier Sound region of Chesapeake Bay. Age was determined by counting growth annuli on plastral pectoral scutes. Points are means; brackets are ± SE. Small sample size in 5-year-olds resulted from general absence of these and younger (smaller) terrapins in estuarine bays in winter. Small sample size of 10-year-old terrapins resulted from shell wear that obscured growth annuli and limited the number that could be identified.

TABLE 3. Mean plastron length (PL) for male and female terrapins and the proportion of young females (*pf*) ≤10 years of age (YOA) captured at six sites within Tangier Sound, winter 2003–2005. Ranking in relation to zones with and without crab potting is shown. PL means include only unique captures (excludes between-year recaptures) of females >10 YOA and males >9 YOA.

Crab potting zone	Site	Mean plastron length (mm) ± SE Male (N)	Rank	Female (N)	Rank	*pf* ≤10 YOA	Rank
Pots	Smith Island–S	120.9 ± 1.16 A[a] (16)	1	186.8 ± 1.33 A[b] (49)	1	0.157 AB[c]	4
Pots	Bloodsworth Island	118.3 ± 0.73 A (63)	2	176.3 ± 1.49 BC (81)	3	0.133 B	6
Pots	Smith Island–N	116.2 ± 0.59 AB (104)	3	179.2 ± 0.72 B (236)	2	0.135 B	5
No pots	Nanticoke River	115.2 ± 0.57 B (101)	4	167.8 ± 1.40 D (46)	6	0.300 A	2
No pots	South Marsh Island	113.7 ± 1.24 BC (32)	5	174.5 ± 1.43 C (72)	4	0.309 A	1
No pots	Janes Island	111.5 ± 0.84 C (53)	6	173.9 ± 0.98 C (111)	5	0.186 AB	3
Combined		115.6 ± 0.33 (369)		178.2 ± 0.53 (595)		0.192 (764)	

[a] Kruskal-Wallis one-way ANOVA test on ranks found a marked site effect for plastron length (H = 48.0, P < 0.001, 5 df). Means within columns sharing the same letter do not differ: Dunn's test (α = 0.05).

[b] One-way ANOVA found marked site effects for plastron length ($F_{5,588}$ = 18.3, P < 0.001). Means within columns sharing the same letter do not differ: Tukey's test (α = 0.05).

[c] Values sharing the same letter are not different: individual 2-tailed z-tests of proportions (α = 0.05).

a mark-recapture estimate of 1210 females populated the site in winter 2004 (normal 95% C.I.: 684–1737; Seber 1973). Males were excluded from the estimate because no males were recaptured. However, based on the 2004 sample sex ratio of 0.744 *pf*, the estimate increases to 1613 when males are included. Based on capture rates, populations at two other hibernacula, Janes Island in 2004 and 2005 and South Marsh Island in 2005 (Fig. 3), likely exceeded this estimate.

Size characteristics.—Off-shore sample sites near Bloodsworth, Smith, and South Marsh Islands, had slightly heavier females than the near-shore sites of Janes Island and the Nanticoke River (Table 2). The largest females were at the St. Jerome site and the smallest at the Nanticoke River, a site of frequent harvest. Similarly, the mean mass of adult males (all >9 YOA) was highest for off-shore Smith Island–S/Bloodsworth Island sites and lowest for near-shore Janes Island (Table 2). As essentially all males are immune to commercial harvest by virtue of their small size, Nanticoke River males ranked comparatively higher in site-specific mean mass (third) versus the females captured there that ranked sixth (last). For the six Tangier Sound sample sites, site-specific mean mass of males and females was not correlated (Spearman rank *r* = 0.54, P > 0.05, 4 df). Consistent with the known dimorphism in the species, the mean mass of female terrapins (1276 g, N = 767) was about three times greater than that for males (401 g, N = 399). Only 4.6% of females (35 of 767) fell below a PL measurement of the largest male (138 mm).

Effects of crab pot bycatch.—We tested for the effect of selective crab pot mortality on female size and found female PL to be greater in pot versus no-pot zones (one-way ANOVA: $F_{1,593}$ = 47.7, P < 0.001; mean PL, pot zone = 179.6 ± 0.61, N = 366; mean PL, no-pot zone = 172.9 ± 0.73, N = 229). Because the male PL distribution was found to be non-normal, we applied the Kruskal-Wallis ANOVA test on ranks and found a larger median value in pot versus no-pot zones (H = 25.6, P < 0.001, 1 df; pot zone median PL = 117, N = 183; no-pot zone median PL = 114, N = 186). Site-specific tests showed a marked pattern of larger PL means at sites with crab potting that produced a consistent alignment of ranks to pot and no-pot zones (Table 3). We also found females to have a higher proportion of young ≤10 YOA in no-pot versus pot zones (one-way ANOVA: $F_{1,13}$ = 5.2, P < 0.04; mean proportion no-pot zone = 0.26 ± 0.13, N = 8; mean proportion pot zone = 0.11 ± 0.11, N = 7). Individual site-specific tests produced a similar pattern of a higher proportion of females at sites in no-pot zones with a consistent alignment of ranks to pot and no-pot sites (Table 3).

Testing for acute effects.—On initial placement of the 24 terrapins in the holding cage, three individuals were active enough to swim to the top of the water column. This indicated that their metabolism had increased enough to become active swimmers, but none were observed to breathe air at the surface. The swimming activity ceased shortly after placement suggesting that any increase in body temperature and metabolism was quickly reversed by return to cold water. All other terrapins were less active and simply sank to the bottom of the cage. Following the three-week holding period in February 2005, all terrapins were alive and observed to behave normally, i.e., were sluggish but active; there was no sign of morbidity.

DISCUSSION

Our discovery that upwards of a thousand or more terrapins can be concentrated at heavily populated hibernacula underscores the vulnerability of the species to winter scrape harvest. Our capture of 160 terrapins/h at South Marsh Island demonstrates how, in certain instances, hundreds of terrapins can be removed from a local area in a matter of hours, a majority of which would be harvest-size females. Because terrapin population traits include low recruitment, delayed maturity, long life, and limited dispersal (Gibbons et al. 2001; Harden et al. 2007; Tucker et al. 2001), high survival of long-lived adults is critical to sustaining populations (Mitro 2003). It follows that harvest removal of a large portion of breeding-age females would be devastating to local populations. Terrapins, like other long-lived turtles, have no compensatory means to replace such losses (Brooks et al. 1991; Congdon et al. 1993; Heppell 1998) and recovery would be predicted to be especially protracted.

As estuarine bay hibernacula have never been studied previously, no comparative data exist on numbers, size, and sex ratios. Moreover, we have no knowledge of how our capture characteristics have been altered by the confounding influence of two principal anthropogenic effects: 1) the direct loss of females to commercial harvest and 2) selective mortality of small terrapins as bycatch in crab pots (Roosenburg et al. 1997; Roosenburg 2004). Because our data show that heavy terrapin harvest would quickly devastate the adult female portion of the population, the prevalence of a female biased sex ratio in Tangier Sound is strong evidence of minimal harvest activity in the region in the recent past. Terrapin mortality in recreational (not commercial) crab pots primarily affects smaller terrapins (males and young females) that occupy habitats near shore where they are at risk to recreational crab pots (Roosenburg et al. 1997; Roosenburg 2004). Terrapin exposure and subsequent mortality in commercial crab pots in Tangier Sound therefore seems mediated by virtual restriction of commercial pots to offshore use. Indeed, Roosenburg (2004) suggested that Maryland's deep-water restriction on commercial crab potting likely has averted the decimating losses to Bay terrapin populations such as have been reported in Florida (Seigel 1993), South Carolina (Dorcas et al. 2007; Gibbons et al. 2001; Hoyle and Gibbons 2000; Tucker et al. 2001), and more recently, Georgia (Grosse et al. 2009). Nonetheless, decades of crab pot exposure seem apparent as our results indicate an effect of increased size of both sexes and reduced number of young females. These results are consistent with demographic effects attributed to selective crab pot mortality in tidal creeks of the Kiawah River, South Carolina (Dorcas et al. 2007), and at the Goodwin Islands at the mouth of the York River, Virginia (Wolak et al. 2010). Although other interpretations are possible, a non-normal PL distribution for males, in contrast to a normal distribution for females, lends support to an active mortality process affecting males. Additionally, and most significantly, we found the proportion of young females in the no-pot zone to be 2.4 times that in the pot zone. It follows that this apparent loss of females to crab pots, and the projected loss in recruitment it represents, would have the greatest long-term effect on terrapin productivity in Tangier Sound.

Our winter sampled sex ratios and the sex- and age-related vulnerability of terrapins to crab pots also may be driven by a fundamental distribution process related to size, i.e., larger terrapins dominating open-water estuarine bays and smaller terrapins seeking protected areas in tidal creeks and interior salt marsh. Roosenburg et al. (1999) provide evidence of larger adult females moving farther and spending more time offshore while smaller males and juveniles remain in near-shore shallow water. Findings from our summer captures at Smith Island support this notion as our interior salt marsh bait-trap captures yielded smaller terrapins of more even sex ratio (0.58 *p*f) and open-water Bay-shore fyke net captures produced primarily large females (0.87 *p*f; P. Henry, USGS, pers. comm.). That terrapins overwinter in interior tidal creeks and creek banks also has been documented (Yearicks et al. 1981). Our samples show that few females <6 YOA (with mean PL of 134 mm and mean mass of 560 g) and few males <6 YOA (mean PL of 105 mm and mean mass of 300 g) occupy estuarine bays in winter.

The comparatively pristine nature of Tangier Sound, in contrast to highly developed areas of the Bay, likely provides resilience to terrapin populations, as evidenced by our estimated female recruitment rate of 4–7%. This recruitment level seems favorable and sets a bench mark for future winter sampling, but its relation to population status is unclear without knowledge of other vital population statistics, especially an estimate of population growth rate (Mitro 2003). Further demographic study is needed to better establish the status of Tangier Sound terrapin populations.

Although terrapins were generally abundant in Tangier Sound, the paucity of numbers in St. Jerome Creek, a former harvest site, is enigmatic. The loss of terrapins at this formerly productive site may be related to harvest or perhaps a broader population decline documented during long-term study of terrapins on the nearby Patuxent River (W. Roosenburg, Ohio University, pers. comm.).

CONCLUSIONS

The nature of adult female terrapins to aggregate in hibernacula often in high densities and in easily accessible estuarine bays has made them exceptionally vulnerable to commercial winter harvest. Such harvest, if unregulated, can be devastating to local terrapin populations. Although no exact history can be reconstructed, winter scrape fishing may have played a part in the near extirpation of the species in Chesapeake Bay in the early 20th century (Carr 1952; Ernst and Lovich 2009; McCauley 1945). In 2007, a well-organized conservation movement successfully lobbied the Maryland legislature to permanently close the terrapin fishery. Commercial harvest of diamondback terrapins is now prohibited throughout Chesapeake Bay.

Now that the commercial terrapin fishery is closed, adopting scrape fishing as a winter sampling method could be of particular value in assessing the past effects of harvest and recovery of terrapin populations. Scrape fishing of hibernacula offers unique access to a large portion of the adult female segment of the population, including females approaching breeding age. Moreover, scrape sampling offers a novel means to advance scientific study of terrapins in winter, an aspect of the biology of the species that has been little addressed. In this light, we recommend further work be conducted to better understand physiological effects of removal from hibernacula and effects on long-term survival. We believe winter scrape sampling could be an important element of terrapin population and scientific study in Chesapeake Bay and perhaps elsewhere throughout the north temperate range of the species.

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A Large-Scale Snake Mortality Event

Road mortality has been shown to constitute a considerable threat for a variety of herpetofaunal species. A number of possible explanations for movement onto or across roads resulting in mortality have been proposed, including seasonal movements between habitats (Bernardino and Dalrymple 1992; Smith and Dodd 2003), seasonal dry-down of suitable habitats (Aresco 2005; Bernardino and Dalrymple 1992; Enge and Wood 2002), desire to access resources on the other side (Andrews and Gibbons 2005), movement to new areas for breeding (Lebboroni and Corti 2006), and movement and foraging following rainfall events (Ashton and Ashton 1988; Carr 1963; Cook 1983; Gibbons and Dorcas 2004; Tennant 1997).

In addition to the hazards of entering or attempting to cross roads, it appears that aspects of snake natural history may put them at a greater risk of road mortality than other herpetofaunal species. Snakes are known to use warm road surfaces for thermoregulation (Bernardino and Dalrymple 1992; Enge and Wood 2002; Rosen and Lowe 1994). Andrews and Gibbons (2005) report that snake roadkill may be magnified by immobilization behavior with some snake species stopping on the road during crossing. Some authors have suggested that snakes are commonly intentionally targeted by drivers (Ashley et al. 2007; Rudolph et al. 1999; Shepard et al. 2008).

In March of 2006, we observed a snake roadkill event along a newly opened road leading into the Southwest Florida International Airport located in Fort Myers, Lee Co., Florida, USA (26.5123°N, 81.7726°W). The airport developed a new terminal, which included the opening of this new road to the public in September 2005. The initial report of a snake roadkill event came from observations taken on 12 March 2006, suggesting that the majority of dead-on-road (DOR) snakes were killed during the preceding week (5–11 March). The observations were made along 1.5 km of the new airport access road; no snake carcasses were found before or after this section of the road. We documented this large-scale snake roadkill event, which appears to have been greater in magnitude and density than any other snake mortality event reported in the literature for this small of an area for this short of a time period (Beck 1938; Hellman 1956; Smith and Dodd 2003), with the exceptions of mass snake roadkill events associated with a hurricane (Carr 1963) and a snake migration event (Tennant 1997).

Methods.—The airport expansion included construction of a new four-lane roadway and creation of a canal (Figs. 1A and 1B). The roadway consisted of both an east and westbound terminal road with a grassy median separating them. The speed limit was 45 mph. Bike paths were located exterior to the roadway and had a width of 1.6 m as compared to a single road lane width of 3.6 m. Grassy shoulders were located exterior to the bike paths. The southern shoulder extended 10–12 m to a low (0.5 m) berm which separated the shoulder from a 20–25 m wide stormwater treatment swale. A second berm (1.5 m high and 15 m wide), located south of the swale, ran parallel to the canal which was approximately 15 m in width.

From 19–22 March, 2006, 1.5 km of the eastbound terminal road (Fig. 1B) heading towards the Southwest Florida International Airport was walked and snake species were recorded. The road was divided into 10 m segments. The location of each roadkilled snake along the eastbound side was recorded as follows: in the left hand lane of the road near the median, in the right-hand lane of the road near the bike path, on the bike path, or on the grassy shoulder. The area of grass along the road edge that could be reliably observed

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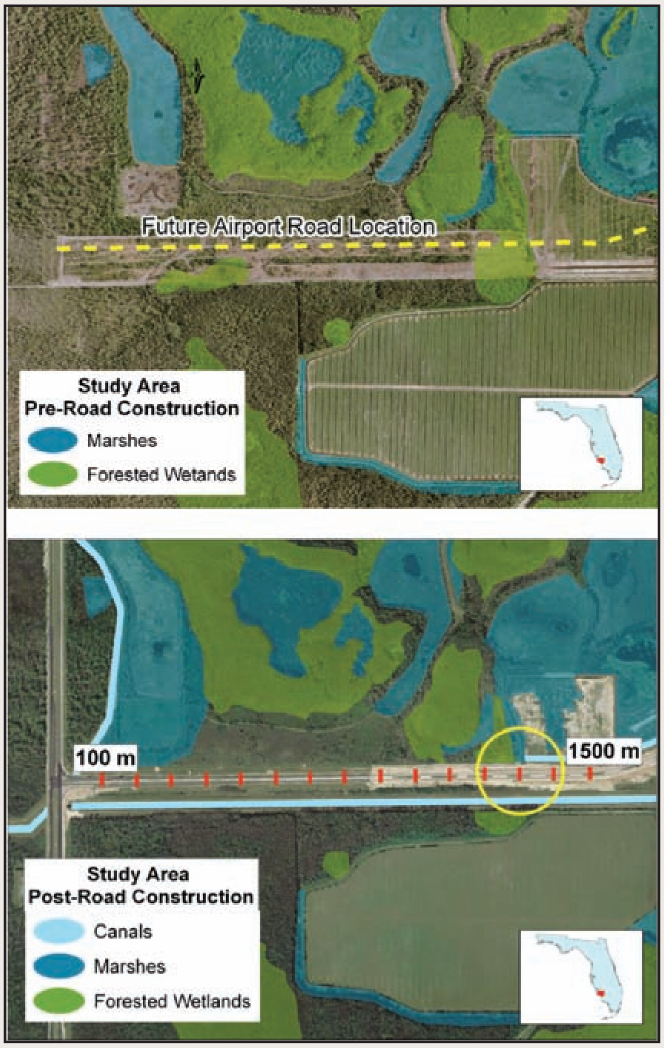

FIG. 1. A) Aerial photograph taken April 2002. B) Aerial photograph taken January–February 2005. Locations of the 100 m points along the road are indicated. The circled area represents road segments 12–14, where the highest proportion of DOR snakes occurred.

was approximately equal to the width of a single lane. Each 10 m road segment was visited only once during the four day sample. After each sampling event, the west-bound side of the road was carefully searched for carcasses, but no DOR snakes were located. If possible, DOR snakes were identified to species. No effort was made to sex the snakes, but immature individuals were distinguished. All snakes were categorized as "old" (dried or with considerable decomposition) or "new" (with moist, flexible body tissues, and assumed to have been killed within the previous 24 h). If any of the "old" snakes could not be identified due to extensive decomposition, they were recorded as an unidentified species.

We summarized the data for the entire sample and combined the data into 100 m road segments in an effort to identify a corridor for future protection. We tested for significant differences in position along the 1.5 km of the road length and for differences on the areas of the road (right lane, left lane, bike path, shoulder) using the single classification Goodness of Fit Test, with expected frequencies defined by relative areas (Sokal and Rohlf 1981) using SPSS Version 16.0 for Windows ($\alpha = 0.05$).

Results.—A total of 395 DOR snakes were recorded during the surveys. Of the species identified, *Nerodia fasciata pictiventris* was observed the most often (N = 140), almost double the amount of the next closest species, *Thamnophis sauritus sackenii* (N = 75). Other species identified include *Thamnophis sirtalis sirtalis* (N = 29), *Agkistrodon piscivorus conanti* (N = 15), *Storeria victa* (N = 4), *Pantherophis guttatus* (N = 1), and *Regina alleni* (N = 1). A large number (N = 130) of unidentified individuals were also recorded. Eight immature snakes were recorded, representing 2% of the DOR carcasses. Two live snakes were observed attempting to enter the road during our surveys, one of which was removed from the roadway, while the other was struck by a vehicle and killed. In addition, sixteen carcasses (4%) were scored as 'new,' thereby indicating that the event was a prolonged period of snake movement and mortality during the second and third weeks of March 2006. Six DOR frogs and two DOR turtles were also recorded.

The most DOR snakes were observed in road segments 12–14 (1200–1400 m) (Fig. 2). These segments exhibited significantly higher numbers of roadkilled snakes than other segments (G = 177.4, $P < 0.001$). Of the snake species observed, only five individuals were found in the left-hand lane. There were 116 individuals discovered in the right lane, and 77 in the bike path. The most individuals (N = 197) were found in the grassy shoulder. This distribution is significantly different than random (G = 237.5, $P < 0.001$). All three of the species with sample sizes large enough to allow for individual tests (i.e., *Nerodia fasciata pictiventris, Thamnophis sauritus sackenii,* and *Thamnophis s. sirtalis*), as well as the unidentified snake carcasses, showed significantly greater distributions toward the right-hand side of the road ($P < 0.001$ in all four tests).

To explore a possible weather-related explanation for the snake movement, we examined the pattern of rainfall and temperature at the Southwest Florida International Airport during the month of March in recent years. Almost all of the measurable rainfall recorded in March 2006 was from a single rainfall event on March 23, which was after the roadkill event. During the second and third weeks of March 2006 (5–18 March), the mean minimum temperature at the airport was 16.1°C and the mean maximum temperature was 28.3°C. During this same period, nine days had temperatures above the mean daily maximum as compared to the two previous and two post years.

Discussion.—Several studies have found that reptile carcasses are more often located closer to the edge of the road than the center of the road. In 1950, an unusually large number (N = 478) of juvenile mudsnakes (*Farancia a. abacura*) were discovered along U.S. Highway 441 in Paynes Prairie, Alachua County, Florida, almost half of which were DOR (N =

223) (Hellman 1956). Of these, only 10–20 snakes were found in the western half of the road and its adjacent shoulder; the remainder were located in the eastern half of the road and its shoulder. Approximately 12 individuals were found on the eastern slope of the embankment. A study conducted in 1998–1999 on this same highway discovered that carcasses were distributed unevenly on the paved surface, with most being located in the outside lanes (Smith and Dodd 2003). In Lake Jackson, Leon Co., Florida, 95% of turtles were killed as they first entered U.S. Highway 27 adjacent to the shoulder, and the remaining 5% were killed in the first two traffic lanes (Aresco 2005). A similar pattern was discovered in a road impact study conducted on a major road in Tuscany (Scoccianti 2006), with most of the reptile remains found very close to the edges of the road, and less frequently in the middle of the road.

Based on results from the aforementioned studies, it can be assumed that most reptiles are killed as they first enter a highway. This indicates that a majority of the snakes in our own study entered the highway from the south, and were hit as they first entered the east-bound lane of traffic. We assume the snake carcasses found on the bike path and in the grass were actually struck on the road, and the snakes attempted to move to safety after being injured. As seen on the aerial photograph (Fig. 1B), the wetland system located south of the newly opened road ends around road segment 13 (1300 m). It appears that the snakes may have followed the natural landscape to the east, which in effect funneled snakes onto the roadway when the wetland ended. This could explain why a majority of DOR snakes were found between road segments 12 and 14. Beyond road segment 15, the roadway curves north and the area between the shoulder and the canal berm rapidly expands to over 100 m in width.

Although we speculate that the snakes were attempting to cross the road to reach wetlands on the other side, the results may also suggest that snakes might have been moving onto the road to thermoregulate. The road surface in this study is comprised of asphalt. Shine et al. (2004) documented that during the day, mean substrate temperatures are similar on asphalt road surfaces as to those on surrounding surfaces (i.e., grass, dirt, and gravel). However, after sunset, the asphalt surface of the road is substantially warmer (4–9°C) than other surfaces. Since asphalt holds more heat than other surfaces, it is likely that the asphalt road surface leading into the airport warmed during the daytime and held the heat after sunset, thus attracting snakes to the roadway to thermoregulate. Because March 2006 was dry and had several warmer than mean daytime temperatures, with some cool nights, it is possible that most snakes were killed on the road after sunset as they attempted to warm themselves on the roadway.

It is possible that some snakes were not included in the survey count due to the presence of scavenging animals (e.g. crows [*Corvus* sp.], Raccoons [*Procyon lotor*], etc.) and/or fast deterioration due to the climatic conditions of southwestern Florida. Other studies have found that the number of DOR

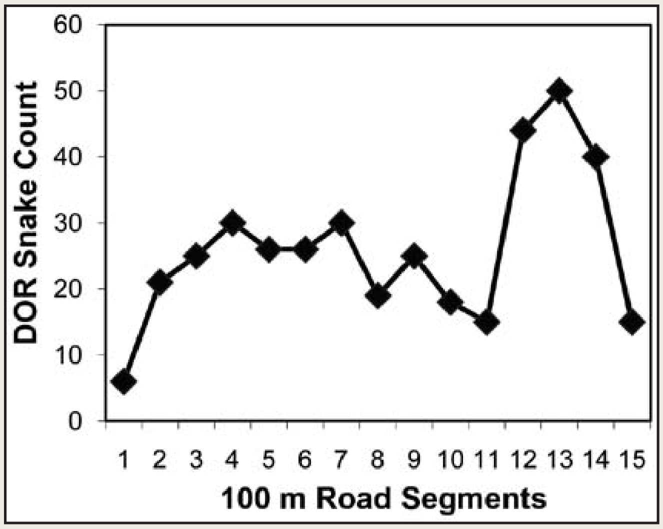

Fig. 2. Count of DOR snakes along road. Data were combined for 100 m segments of the road, from west to east. Counts include only confirmed snake carcasses.

individuals recorded is actually an underestimate of the true number killed (Bernardino and Dalrymple 1992; Enge and Wood 2002; Hels and Buchwald 2001; Smith and Dodd 2003). Even with possible underestimation of the magnitude of this event, the snakes counted in this survey constitute the most numerous mortality event for this spatial scale (1.5 km) reported in recent literature, and presumably comprised a significant portion of the snake community in the associated wetlands.

There are several potential ways to avoid mortality events such as this in the future. Aresco (2005) found that a drift fence system connected to existing drainage culverts significantly reduced road mortality of turtles. The fence physically prevented access to the roadway and directed the turtles through culverts beneath the road. Similarly, Scoccianti (2006) described a drift fence installed along both sides of a road in combination with a viaduct constructed by raising the road. Bernardino and Dalrymple (1992) discussed several options available to decrease the rate of road mortality, including the construction of wildlife underpasses, temporary closing of roads on main migratory nights, and installation of reduced speed zones. Smith and Dodd (2003) described the construction of a barrier wall and underpass system. Because not all of these strategies may be an option due to cost or impracticability, mitigation efforts should be restricted to those areas identified as important travel corridors or as connections between areas of significant habitats (Jackson 1999).

Future research should include quantifying roadkill dynamics following road construction or landscape modification where snake populations may be displaced and concentrated. These conditions appear to create the opportunity for large-scale roadkill events, and may require mitigation efforts. Because this snake mortality event only occurred along the portion of the road that was adjacent to the newly created canal, future studies should focus on similar types of road development. The construction of the roadway and the canal impacted forested wetland habitats; most of these impacts occurred between road segments 12 and 13 (Fig. 1B), which is also where a majority of the snake mortality took place. Further studies should be conducted to determine if this was a unique event, or if this is a common occurrence for this type of road development. If a trend is discerned, planning for future transportation infrastructure could more effectively focus on minimizing and mitigating impacts to these critical areas (Jackson 1999). The success of any mitigation efforts should also be carefully monitored.

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TECHNIQUES

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Using a Portable Reader for Non-invasive Detection of PIT-tagged Skinks Under Coverboards

A variety of methods exist for uniquely marking animals for mark-recapture studies. Due to its directness and accuracy, the mark-recapture method is an effective technique used to assess demographic parameters and life history and behavioral data such as density, survivorship, growth rate, and individual patterns of space use and social behavior (Fox and Shipman 2003; Hokit and Branch 2003; Tinkle et al. 1993). For lizards such as North American skinks, which are often secretive, delicate, cryptically colored, and difficult to capture, demographic studies can be problematic and produce incomplete and unsatisfactory results due to lack of recaptures (Cavalieri 2010; Somma 1985). Coverboards are the most reliable way to repeatedly observe such skinks (Cavalieri 2010; Sutton et al. 1999), but the success of actual capture using this method depends more on prowess than other techniques such as passive trapping. Thus, the family Scincidae, with the exception of a few species (Cooper 1999; Cooper and Vitt 1989, 1993; Fitch 1954), has remained an under-studied taxon in North America. Due to the difficulty of attaining recaptures and the risk of stress or injury to the lizard during hand capture, we strove to develop an alternative methodology to augment relocations of marked individuals.

Passive integrated transponders (PIT tags) are often used as a backup or alternative to toe-clipping, scale-marking, or other traditional marking techniques (Ferner 2007; Gibbons and Andrews 2004). The use of subcutaneously-implanted PIT tags in mark-recapture studies offers the unique advantage of a system of internal, permanent identifiers that are completely unambiguous if read correctly from the scanner (Gibbons and Andrews 2004; Hill et al. 2005).

The purpose of our study was to evaluate the performance of a modified PIT-tag system by determining: 1) the greatest distance at which a PIT tag can be read, both on the surface and under coverboards, 2) the effect of antenna orientation, and 3) the effects of experience level and fatigue of field workers on detection of field-employed PIT-tags.

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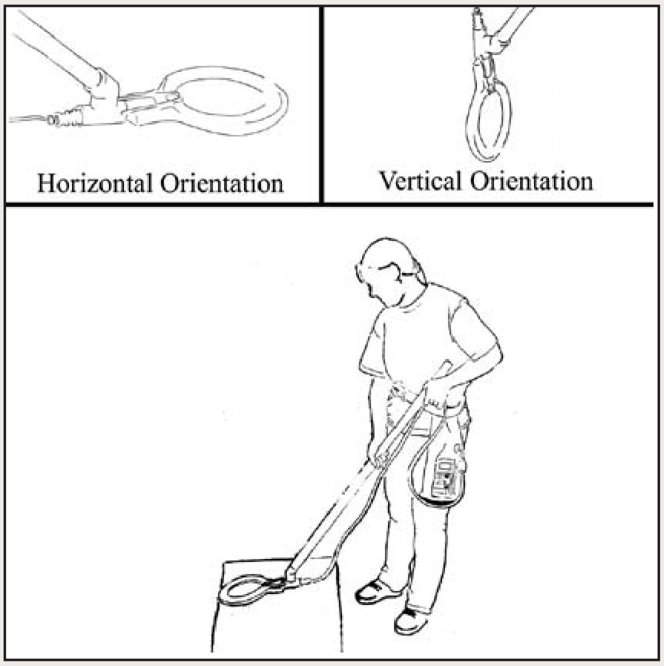

Fig. 1 Horizontal and vertical orientation of the antenna hoop and illustration of how to scan a coverboard with PIT-tag reader.

Materials and Methods.—Our study site, located in mixed-grass prairie in Payne County, Oklahoma, USA, was a 1-ha grid with 100 1.22-m × 0.61-m × 1.91-cm coverboards placed at the centers of the 10-m × 10-m cells. The soil was a well-drained silty clay loam with native prairie and old field grasses and approximately 4 cm of thatch.

We modified a Destron Fearing Portable Transceiver System (model 2001F-ISO, Biomark, Inc.) by mounting the racket antenna on a PVC pipe (Fig. 1). To prevent interference with the antenna, we used all non-metal construction. We glued a T-joint to a 45º elbow joint and attached this section to a 1.22-m PVC pipe (2.54 cm diameter) that served as a handle. We drilled two holes perpendicular to the elbow joint and passed the racket antenna through the opening in the T-joint so that the hoop portion was facing away from the opening of the 45º elbow joint. We threaded a plastic zip tie through each hole and the internal opening of the racket antenna and secured it to prevent the antenna from sliding forward out of the handle. We suspended the transceiver upside down from a belt in a harness to allow the person wearing it to easily read the display. We used 8.5-mm × 2.12-mm, 134.2-kHz ISO, 0.067-g glass-encapsulated, implantable passive integrated transponders from Biomark, Inc.

We first determined the maximum horizontal range at which a PIT tag could be read when placed on the ground and holding the antenna 4 cm above the substrate using two different orientations of the antenna hoop (Fig. 1): horizontal orientation (i.e., the opening of the hoop parallel to the ground) and vertical orientation (i.e., the opening of the hoop perpendicular to the ground). We determined reading distance by setting the transceiver to continuous scan and holding the antenna stationary while moving a PIT tag along a wooden measuring stick lying on the ground until the serial number registered. The point on the measuring stick at which the number was first read was the maximum horizontal reading distance at 4-cm height. We performed two sets of trials, one with the PIT tag in a plastic microcentrifuge tube and one with the PIT tag subcutaneously implanted into a Great Plains Skink (*Plestiodon obsoletus*) held in a mesh bag. We conducted 20 repetitions of each set at the study site, using a freshly charged transceiver for every repetition.

Because the horizontal antenna orientation gave the greatest horizontal reading distance in the trials above (see Results), we then determined the maximum vertical distance at which a PIT tag could be read through a coverboard with the antenna in the horizontal orientation. As before, we separately scanned a PIT tag in a microcentrifuge tube and a PIT tag implanted in a skink. We placed a tag under a coverboard (1.22 m × 0.61 m × 1.91 cm) and then held the antenna by the handle 1.37 meters above the coverboard, moving it in the horizontal orientation slowly down the wooden measuring stick until the tag registered. The vertical distance from the point at which the tag first registered from the lower edge of the antenna hoop to the surface of the coverboard was the maximum vertical reading distance. As before, we conducted 20 repetitions of each set, using a freshly charged transceiver.

In order to assess the accuracy of the PIT-tag reader system, we placed each of 20 PIT tags in microcentrifuge tubes under 20 randomly selected coverboards in a set of 100 in the field and recorded the serial number for each tag. We assembled two groups of volunteers: experienced (N = 7), those who had used the PIT-tag reader two days a week from May to August 2008 in this fashion, and novice (N = 10), those who had no prior experience with PIT-tag readers. We gave each isolated volunteer the antenna mounted on the handle with the transceiver in the holster, a clipboard, a pencil, a datasheet to record the serial numbers and location of detected PIT tags, and a demonstration of how to scan a coverboard and read the serial numbers. Each volunteer stood and passed the antenna in a serpentine pattern over each coverboard as closely as possible without touching it while holding the antenna in the horizontal orientation, record the serial number if a tag was detected, and then proceed to the following coverboard until all 100 coverboards were scanned in order. Each volunteer scanned coverboards while alone at the study site with no other volunteers observing, and was given unlimited time to scan coverboards.

We tested the following null hypotheses: 1) all tags have an equal chance of being found, 2) the success of finding tags is independent of experience level, and 3) the likelihood of finding tags does not vary with increased search time per coverboard. We used a Chi squared goodness-of-fit test to determine if all tags had an equal chance of being found, and a Chi-squared heterogeneity test to compare level of experience with success at finding tags. We used a linear regression of number of tags found vs. average duration of search per coverboard to determine if the likelihood of finding tags varied with increased search time per coverboard.

Results.—The maximum horizontal distance beyond the outside of the antenna hoop at which a PIT tag was read with the antenna held 4 cm above the ground in the horizontal orientation for a PIT tag in a microcentrifuge tube and for a PIT tag implanted in a skink was mean = 4.13 cm ± 1 SD of 0.55 and mean = 3.88 ± 0.70, respectively. In the vertical orientation, the maximum horizontal distance for a PIT tag in a microcentrifuge tube and for a PIT tag implanted in a skink was mean = 2.08 cm ± 0.60 and mean = 2.08 ± 0.81, respectively. The maximum vertical distance at which a PIT tag was read in the horizontal orientation through a coverboard for a PIT tag in the microcentrifuge tube and for a PIT tag implanted in a skink was mean = 13.10 cm ± 2.00 and mean = 12.24 ± 2.77, respectively.

The horizontal antenna hoop orientation allowed a greater range for detecting PIT tags than the vertical orientation, and a PIT tag enclosed in a microcentrifuge tube had approximately the same maximum read distance as a PIT tag implanted in a skink. Therefore, during the next portion of the experiment, we treated centrifuge tubes as skink surrogates and had volunteers use the horizontal antenna orientation to find PIT tags randomly placed under coverboards. The mean proportion of tags found was 71.8% and all tags had the same chance of being found ($\chi^2 = 4.85$, $df = 19$, P = 0.999). Experience level affected ability to find tags ($\chi^2 = 5.37$, $df = 1$, P = 0.020), with experienced readers finding 65% and novice readers finding 76.5% of tags. The likelihood of finding tags did not vary with increased average search time per coverboard ($r^2 = 0.058$, $F_{1,15} = 0.930$, P = 0.350).

Discussion.—All tags had the same chance of being found. This indicates that there was no bias for tags under different coverboards, suggesting that this is a good methodology for augmenting relocations of secretive, partially fossorial animals that are difficult to recapture.

Experience affected ability to find tags, but in an unexpected way. Novice readers found more tags than experienced readers. This is possibly because novice readers followed directions more thoroughly than experienced readers who had more confidence in their abilities and a *laissez-faire* attitude toward the process. Blomquist et al. (2008) made a similar comparison between an observer informed of the location of the tags and an uninformed observer, with PIT tags placed underground. The informed observer found more tags in one pass than the uninformed observer did with 3 passes though the study area. This is not directly comparable to our study because experience with the technique differs from actual knowledge of the location of the tags; however, our volunteers did know that PIT tags were only under coverboards, which helped focus their searching. We suggest that fieldworkers can find tags more easily when given a focal object, e.g., a coverboard, than when searching broadly in the field. The likelihood of finding tags did not vary with increased search time. This indicates that this technique works well without the need for slow, intensive searching.

Traditionally, PIT-tagging relied on physically recapturing an individual in order to scan the tag. Recently, there has been an increase in the number of studies using automatic remote interrogation systems that do not rely on subsequent recaptures. Harper and Batzli (1996) used fixed hoop antennae and transceivers over vole runways in enclosures to remotely assess movement of individuals; over a period of four months, they were able to detect 1645 uses of runways (or remote PIT-tag recaptures) having marked only 893 animals. Boarman et al. (1998) marked 172 tortoises within 3 km of their automated interrogation system; only 5 tortoises were scanned for a total of 77 recaptures by PIT-tag identification. Gruber (2004) marked 29 animals and had 178 remote PIT-tag recaptures using antennae coiled around the bases of trees to determine the movement of PIT-tagged geckos. These systems are advantageous because they collect data continuously with reduced man-hours once the initial set-up of equipment has been completed. The drawbacks of automatic remote interrogation systems include the need for a power supply and preventing theft of unattended equipment. Our system is a hybrid of traditional and automatic remote interrogation systems, with higher labor needs (as compared to completely automated systems) balanced by the ability to cover more ground and check more refugia.

Although there have been other studies using PIT-tag readers mounted on poles (Blomquist et al. 2008; Sasaki et al. 2009), none has used this method as a means of identifying animals under coverboards. Because we used a commercially available antenna, our system is easier to implement than others (Blomquist et al. 2008; Gruber 2004; Zydlewski et al. 2006), and may represent a useful tool for mark-recapture studies of small reptiles that commonly use cover objects.

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A New Rapid Assessment Technique for Amphibians: Introduction of the Species List Technique from San José de Payamino, Ecuador

The urgent need for baseline amphibian data in light of global population declines (Stuart et al. 2004) has led to a call for accurate and robust rapid assessment techniques for amphibian assemblages. This is especially pertinent in areas such as wet tropical rainforest where there is a scarcity of data (Duellman 2005; Gardner et al. 2007) and where robust and comparable data are particularly required to underpin difficult management decisions. The lack of amphibian data from wet lowland forest habitats is often a result of the logistical problems of conducting research in such areas (Doan 2003; O'Dea et al. 2004; Poulsen et al. 1997) where dense understory vegetation, inaccessible terrain, extreme rainfall and humidity, and seasonality (Doan 2003) hinder research. High species diversity and clustered distributions further complicate surveying (O'Dea et al. 2004; Poulsen et al. 1997). Amphibian survey methods used in temperate climates are not applicable to the rainforest environment in many instances (Doan 2003). This, coupled with the fact that rainforest inventorying is often abbreviated due to both the urgency of conservation concerns in the tropics (O'Dea et al. 2004; Heyer et al. 1994; Poulsen et al. 1997; Poulsen and Krabbe 1998) and by cost (Doan 2003; O'Dea et al. 2004; Pellet and Schmidt 2005), points to the need for amphibian rapid assessment techniques specifically designed for work in the difficult tropical rainforest environment (Doan 2003; Poulsen et al. 1997).

The aim of this paper is to introduce the Species List Technique (SLT) (MacKinnon and Phillipps 1993) as a rapid assessment technique for inventorying amphibian assemblages in tropical rainforest environments. We discuss the suitability of this technique to assess species richness and species accumulation. Results are compared over short (21 day) and longer (48 day) time periods to allow assessment of effectiveness in a rapid assessment context. Impact of the methods on the habitat and fauna, plus time and financial costs are also considered qualitatively. A set of standardization suggestions are made to ensure comparability between studies.

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The Species List Technique (MacKinnon and Phillipps 1993) was designed for rapid assessment of avifauna especially in tropical rainforest environments (O'Dea et al. 2004; Poulsen et al. 1997). This straightforward technique is standardised to provide an index of effort for opportunistic encounters, meaning no data are excluded from analysis (O'Dea et al. 2004). Cumulative species richness is related to the number of observations, rather than space or time, allowing for moderate differences in field technique and observer experience (Herzog et al. 2002). This standardization makes the SLT much more valuable for species assemblage comparisons between studies and sites than species inventories alone (Herzog et al. 2002). The time efficiency of the method, through constant data collection while in the field, lends itself for use in a rapid assessment setting.

All species seen or heard are recorded in species lists of predetermined length. The number of species recorded per list is chosen to reflect species richness. Lists of 8 to 20 species have previously been used for bird surveys (Bibby et al. 1998; Herzog et al. 2002). Different geographic areas can only be compared when species lists of the same length have been used. Therefore, it is important that standard amphibian list length should reflect species richness of all tropical areas where the SLT may be used. We assessed the use of lists of 3, 5 and 10 species for our amphibian survey in order to provide a balance between robust sample size for formation of species accumulation curves and comparability between sites of varying richness. The lower the number of species in a list, the more the shape of the accumulation curve (and therefore the species richness prediction) varies depending on sample size (Herzog et al. 2002). However, a high number of species per list will reduce the number of lists compiled and thus the accuracy of the accumulation curve. We found that the number of lists formed using 10 species lists was low (25 lists) and in less diverse tropical regions insufficient data may be collected to create an accumulation curve. Both 3 and 5 species lists gave a large enough sample size to create species accumulation curves. Therefore, based on Herzog et al.'s (2002) conclusion that longer species lists give more robust accumulation curves, we chose to use 5 species lists.

Species List Technique list formation begins when the first individual is observed. Each subsequent species (not individual) is added to the list until 5 species have been observed. Once a list is complete, a new list is started. Species can be repeated between, but not within, lists (Fig. 1). List formation continues throughout the length of the data collection period. Any species that cannot be immediately identified are assigned placeholder names until the species can be identified so that their order in the list is not affected. This data collection method has the key advantage that multiple observers can form their data into a single set of lists by recording the date and time each individual was observed to allow sequential addition of species to form lists during analysis, making time in the field as productive as possible.

Date	Species recorded	List #		
17/11/2007	*Nyctimantis rugiceps*	31	1	*Nyctimantis rugiceps*
17/11/2007	*Pristimantis lanthanites*		2	*Pristimantis lanthanites*
17/11/2007	*Bufo margaritifer*		3	*Bufo margaritifer*
17/11/2007	*Bufo margaritifer*		4	*Pristimantis ockendeni*
17/11/2007	*Bufo margaritifer*		5	*Pristimantis altamazonicus*
17/11/2007	*Pristimantis ockendeni*			
17/11/2007	*Pristimantis ockendeni*			
17/11/2007	*Pristimantis ockendeni*			
17/11/2007	*Pristimantis ockendeni*			
17/11/2007	*Pristimantis altamazonicus*			
17/11/2007	*Bufo margaritifer*	32	1	*Bufo margaritifer*
17/11/2007	*Osteocephalus yasuni*		2	*Osteocephalus yasuni*
17/11/2007	*Pristimantis luscombei*		3	*Pristimantis luscombei*
17/11/2007	*Pristimantis lanthanites*		4	*Pristimantis lanthanites*
17/11/2007	*Pristimantis ockendeni*		5	*Pristimantis ockendeni*
17/11/2007	*Pristimantis ockendeni*	33	1	*Pristimantis ockendeni*
17/11/2007	*Pristimantis ockendeni*		2	*Bufo dapsilis*
17/11/2007	*Pristimantis ockendeni*		3	*Osteocephalus yasuni*
18/11/2007	*Bufo dapsilis*		4	*Ameerega picta*
18/11/2007	*Pristimantis ockendeni*		5	*Hypsiboas cinerascens*
18/11/2007	*Pristimantis ockendeni*			
18/11/2007	*Osteocephalus yasuni*			
18/11/2007	*Ameerega picta*			
18/11/2007	*Ameeerga picta*			
19/11/2007	*Hypsiboas cinerascens*			

Fig. 1. An example of data collected in San José de Payamino and subsequent creation of Species Lists. Arrows highlight how individual observations are amalgamated into lists based on the order in which they are observed. Note that species are recorded only once per list regardless of number of individuals observed.

Data collection took place between June 2007 and May 2008 in the 27,000-hectare lowland tropical rainforest territory of the Kichwa community San José de Payamino, Orellana Province, Ecuador. Three sites within this territory (Sacha huasi, Bigay, and Paushiyacu) were each visited three times in one year and data were collected over the period of a week at each site (three weeks per site in total). However, due to logistical constraints, data collection could not take place during every day spent at the sites. Therefore, the number of days spent in data collection varied between 4 and 7 days during the week spent at each site. The methods were assessed separately over a short term (1 week at each site, totalling 21 days of data collection) and longer term (3 weeks at each site, totalling 48 days of data collection) period.

Species were recorded during night visual surveys utilizing pre-existing transects, opportunistic daytime observations and identification of calls. Each of three sites contained five parallel cut transects, each 100 m in length, with 20 m separation between transects. Visual sweeps were conducted along each transect, 2 m either side and up to 2.5 m in height, including low intensity disturbance of leaf litter, rolling small logs and turning over leaves. Detectability differences among species due to visibility, size or volume of calling were partially addressed by this methodical searching during night transects as reflected by the fact that one caecilian species (*Oscaecilia bassleri*) and two salamander species (*Bolitoglossa altamazonica* and *B. peruviana*) were observed. However, biases due to detectability are of concern with, although not unique to, this method (Bibby et al. 1998) and care must be taken to limit this bias. Transects are not a pre-requisite for SLT data collection and it is possible to include targeted areas while in the field, for example high density sites such as breeding pools in order to catalogue as many species as possible. Targeting like this is important for species where there are detectability issues and is not possible in more rigid sampling methods (Herzog et al. 2002). Opportunistic daytime observations included any amphibians observed around camp and on forest walks that were not part of targeted searches. Once a week, the first five calls heard at dusk were identified by comparison with reference recordings (Read 2000). Species accumulation curves were constructed by plotting the cumulative number of species observed as a function of list number (Gotelli and Colwell 2001). Species accumulation curves can be used as an indication of whether sufficient sampling effort has been undertaken to catalogue the total species richness of the area (Bibby et al. 1998). Species accumulation curves can also be extrapolated to show whether expected total species richness varies between areas (O'Dea et al. 2004). Chao 2 (Chao 1987) was used as an estimator of species richness as it has been shown to be effective in areas where many species are rare (O'Dea et al. 2004).

During the short term collection period, 35 species were recorded using SLT, with this number increasing to 55 in the longer time period. The accumulation curves were used to quantify whether the study area had been comprehensively surveyed (Fig. 2). The species accumulation curves did not reach an asymptote over either the short or longer time period. Thus, the number of new species being recorded had not declined, indicating that the species inventory for this study site had not yet reached completion. This is a reflection of the high amphibian species richness of San José de Payamino and the amount of effort needed to inventory such diverse areas. The Chao 2 estimator value of 41±10.74 for short term SLT is an underestimation of the total species richness and with a large standard deviation has limited accuracy. However, the longer term SLT Chao 2 value of 80.08 ± 0.24 is plausible given known species numbers in nearby lowland rainforest areas of Ecuador (84 amphibian species recorded in Jatun Sacha: Vigle 2008) and has a small standard deviation. Regression lines, extrapolated from the accumulation curves to give a prediction of total number of species in the area, gave predicted species numbers of 60.19 with the SLT long term trial and 60.45 with the SLT short term trial. These values, however, do not match with the Chao 2 estimate of species richness, which is much higher. This could be due to the large number of rare species, for which only one or two individuals were observed. Chao 2 has been shown to be a robust estimator in these circumstances (O'Dea et al. 2004). The prediction made by extrapolating the accumulation curves will be inaccurate due to the curves not having reached an asymptote (Gotelli and Colwell 2001). The SLT method has demonstrated that this area is not yet adequately inventoried and that amphibian surveying needs to continue in San José de Payamino. The complete number of species present is undoubtedly higher than the 55 thus far observed and the richness of this area needs to be accurately estimated before it can be compared with other sites. The high conservation value of this area has been shown by the amphibian species observed thus far. Further study must be undertaken for its full importance to be realized.

In light of amphibian sensitivity to habitat disruption (Gardner et al. 2007), it is important to consider the impact to the environment of any biological surveys. The Species List Technique requires no cutting of transects, and species searches can be carried out in any manner. Frequent disturbance to a site through having to repeat data collection at specified transects is avoided. If call surveys are included in list construction, site disturbance can be further decreased. Logistically, SLT needs little in the way of equipment, other than a notebook, ID guide and pencil, and therefore the expense associated with this methodology is negligible. Efficient data collection leads to rapid recording of species present, permitting more comprehensive, comparable inventories to be created during the time available. Personnel with a moderately varied range of experience can carry out data collection without creating bias (O'Dea et al. 2004) as richness is standardized in terms of number of observations rather than time. Therefore, sufficient time can be taken to ensure accurate identifications. This has obvious benefits to expeditions, where every member can take part in data collection, increasing the likelihood that an area will be comprehensively surveyed in the time available.

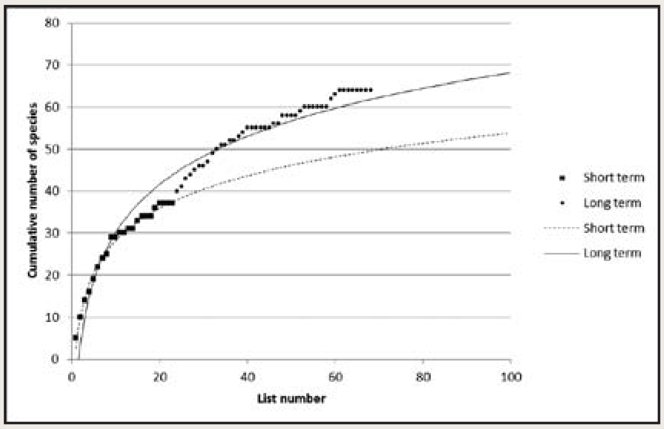

Fig. 2. Logarithmic species accumulation curves by list shown in terms of short or longer data collection periods. For longer-term data each curve represents the average value of 30 randomizations of sampling order and 10 randomizations for short term data. Logarithmic regression lines forecasted forward by 32 periods.

Standardization of SLT between users and sites will maximize comparability, a key benefit of the technique. Therefore, we recommend that five species lists are used for all studies. Researchers should ensure systematic as well as opportunistic searches to allow for differences in detectability between species. Species observations should also include day and night active species, as well as all habitat types within the area being surveyed to ensure comprehensive coverage. In seasonal areas, timings of surveys must also reflect activity periods of different species. Call surveys should only be carried out for areas where applicable reference recordings are available and the observer is confident in accurate identification. Areas should not be compared until they have been comprehensively surveyed, as assessed by reaching an asymptote in their species accumulation curve.

No single method will ever satisfy all scientific preferences and logistical constraints that befall field investigations (Doan 2003; O'Dea et al. 2004). Therefore, a compromise must be reached to take into account expense, environmental limitations, time constraints and the findings that can be taken from an investigation. When time is severely limited due to expense and the necessity for baseline biodiversity data in areas of conservation concern, then rapid assessment of a site is the best compromise (Heyer et al. 1994). The aim of this study was to assess whether SLT, previously only used to survey avifauna (O'Dea et al. 2004; Poulsen et al. 1997; Poulsen and Krabbe 1998), could be applied to amphibian assemblages. The Species List Technique facilitates rapid species inventorying alongside richness estimation, allowing standardized comparisons between areas where time for surveying is constrained. We therefore recommend the Species List Technique for the rapid assessment of amphibian assemblages in rainforest environments.

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A Taping Method for External Transmitter Attachment on Aquatic Snakes

Radio telemetry is extremely useful for studying habitat use and movements of free ranging snakes. Surgically implanting radio transmitters into the body cavity of snakes is standard practice in most studies (e.g., Reinert and Cundall 1982; Weatherhead and Blouin-Demers 2004), but this implanting method has its drawbacks. Surgery itself is risky for individual snakes because of the potential for infection or incomplete healing of the incision site. Also, transmitters that are small enough to be carried by small or slender snakes have a relatively short battery life and need to be removed or replaced often, thus requiring frequent surgeries. In rare or endangered snake species, the risk of using invasive implantation surgery may not be merited. External attachment methods are relatively non-invasive and allow removal and replacement of radio transmitters on smaller snakes. The Giant Gartersnake (*Thamnophis gigas*) is a semi-aquatic snake endemic to wetlands of the Central Valley of California, USA, and is federally and state listed as threatened (U.S. Fish and Wildlife Service 1999). Telemetry studies of the habitat use and movements of this species typically used surgically implanted radio transmitters, but this method is limited to larger snakes, primarily females, because of size requirements for surgery (> 250 g). To

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Fig. 1. Radio transmitter attached to a *Thamnophis gigas* by the off-tail method using surgical tape.

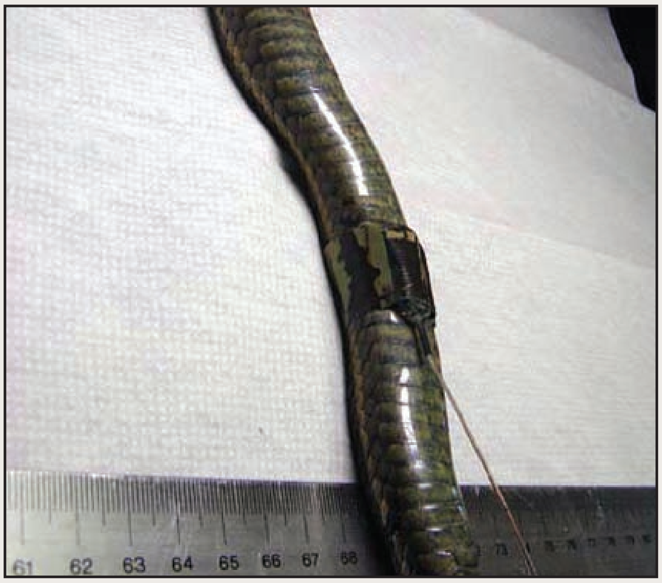

Fig. 2. Radio transmitter attached to a Thamnophis gigas by the body method using camouflage duct tape.

overcome difficulties and biases associated with radio telemetry of *T. gigas*, we developed and evaluated several alternative techniques to attach external radio transmitters using tape.

Materials and Methods.—We captured individual *T. gigas* by hand or in modified minnow traps (Casazza et al. 2000) at two sites in Colusa County (Colusa National Wildlife Refuge, 2003 and 2004, and Colusa Basin Drainage Canal, 2006). We measured, weighed, and marked each individual with a passive integrated transponder (PIT) tag in the field. In most cases, we attached transmitters to snakes while in the field and released them immediately after processing. However, if snakes appeared close to ecdysis, we held them in the laboratory until they shed. We taped transmitters to these snakes after shedding and released them at their capture locations as soon as possible.

We used 1.3 g radio transmitters (model R1620, Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA), measuring 8 × 19 × 4 mm with a 10 cm whip antenna. The flat, oblong shape of this transmitter has a low profile when attached to snakes (Fig. 1). Nominal battery life was 34 days, but many units exceeded this duration.

Initially, we used the method of Rathbun et al. (1993), which incorporated several strips of 3M™ Blenderm® clear plastic surgical tape. We also tried a type of cloth-backed gaff tape manufactured by Shurtape® that had been successfully used to mount transmitters onto penguins (C. Ribic, pers comm.). In 2004, we began using camouflage Duck® brand duct tape.

In addition to the various tape products we tried, we also modified the position of the transmitter on the snakes over the course of the study. Initially, we taped the antenna to the ventral surface of the snake and left the transmitter trailing off the end of the tail ("off-tail" method; Fig. 1), following Rathbun et al. (1993). In 2004, we changed the attachment site so that the transmitter was positioned on the ventral surface of the snake, about three-quarters of the distance from the snout to the vent, and the short antenna was directed caudally ("body" method; Fig. 2). We encircled the snake's body and the transmitter using one piece of tape (about 3 × 9 cm), which overlapped slightly on the dorsum of the snake. We secured the tape to the snake's ventral scutes anterior to the transmitter to prevent the transmitter's leading edge from snagging on obstacles in the environment. The reasoning for this ventral placement is that the radio transmitter would push into the body cavity by the weight of the snake thereby minimizing changes in the cross section of the snake as it moves through the environment. In removing transmitters from snakes, we carefully cut the tape with surgical scissors and cleaned any remaining adhesive on the skin with isopropyl alcohol.

We located snakes with transmitters 5–10 times per week from May through September, and 1–5 times per week thereafter until transmitters dropped off, were removed, or failed. Each time we located a snake, we attempted to confirm that the transmitter was still attached. We conservatively calculated retention time as the period from the snake's release to the last time the transmitter was known to be on the snake, either through visual contact or subsequent movement. Distances that individuals carried transmitters before dropping them were calculated as the sum of all movements from the release site to the final location. To determine if one attachment method or type of tape remained on snakes longer, we compared distances and durations by the type of tape and attachment technique. We used Kruskal-Wallis one-way analysis of variance to make these comparisons (JMP IN 5.1.2, SAS Institute, Inc., Cary, North Carolina, USA).

We attached radio transmitters to 62 *T. gigas* (39 females and 23 males) a total of 75 times in the course of three field seasons. Telemetered individuals averaged 76 cm (range: 60–98 cm) in snout-vent length and 271 g (range: 93–600 g) in mass.

For off-tail gaff tape attachment, snakes ranged from 69–72 cm and 138–600 g. For body gaff tape attachment, snakes ranged from 72–90 cm and 110–480 g. For body duct tape attachment, snakes ranged from 60–98 cm and 93–515 g.

Results.—Nine individuals dropped their transmitters prior to the first relocation. The remaining 66 transmitter attachments remained on the snakes for a mean of 14.3 days (range: 0.16–88 days), and were carried a mean distance of 391 m (range: 20–1700 m). All functioning transmitters were eventually recovered.

Table 1. Summary statistics for different locations and materials for externally attaching radio transmitters to snakes. N = number of attachments.

				Duration (days)		Distance (m)	
Method	Tape	Year	N	Mean	Range	Mean	Range
off-tail	surgical	2003	5	–	–	–	–
off-tail	gaff	2003, 2004	42	11.1	1.0–31.9	371	24–1700
body	gaff	2003, 2004	6	5.9	0.2–17.8	345	20–1505
body	duct	2004, 2006	22	22.9	0.2–88.0	440	35–1432

Our first attachments using the off-tail method with surgical tape (N = 5) failed almost immediately because of lack of adhesion of this tape, and we obtained no usable data from these individuals. Individuals with transmitters attached using the off-tail method with gaff Shurtape® tape (N = 42) traveled a mean distance of 371 m and retained their transmitters for a mean of 11.1 days (Table 1): however, radios in the off-tail position became entrapped in the environment in 13 individuals. Using gaff tape and the body method (N = 6), we were able to track snakes for a mean of 5.9 days (Table 1). We discontinued use of gaff tape after we discovered that its adhesive qualities were diminished after storage during the winter. With duct tape on the body (N = 22), individuals traveled a mean of 440 m and kept their transmitters for a mean of 23 days (Table 1).

We found no statistical differences ($p > 0.10$) in distance travelled ($\chi^2 = 0.907$, $p = 0.341$, df = 1) or duration of transmitter retention between transmitter attachment site ($\chi^2 = 0.254$, $p = 0.614$, df = 1) or tape type ($\chi^2 = 2.003$, $p = 0.157$, df = 1). We found no evidence of entrapment problems with radios attached by the body method. We found no discernable relationship between snake size and duration of radio attachment ($r = 0.13$, $p > 0.15$).

We recaptured 21 snakes that had external transmitters 95 times after their first attachment. Our overall recapture rate at both study sites from 2003 through 2006 was 2.0 captures per snake. We noted five snakes with scarring resulting from the off-tail attachment technique and four snakes with scarring from attaching the transmitter to the body. Several snakes could have carried transmitters longer and farther than we were able to measure. We were unable to recover nine transmitters before the batteries discharged or otherwise malfunctioned. On four occasions we removed attached, functional transmitters from snakes at the end of the field season. The longest duration for snakes retaining taped radio transmitters was in the late summer to early winter of 2006: three snakes were marked with the body taping method using Duck® tape from late summer into early fall. These radios remained on one snake for 42 days, and 87 and 88 days for the other two snakes.

Discussion.—Other investigators have used various techniques to attach transmitters to various snake species with mixed success. Ciofi and Chelazzi (1991) passed rubber tubing beneath the 22nd and 27th subcaudal scales of *Coluber viridiflavus*, providing an anchor through which they attached transmitters with nylon thread, which facilitated replacement of batteries without removing transmitters. Gent and Spellerberg (1993) studied movement rates for short periods (mean = 4.7 days) in *Coronella austrica* by mounting small transmitters on the dorsal side of the tail with surgical tape. Of 50 attachments, five were dropped on the first day and seven became snagged on vegetation and were removed by the researchers. Rathbun et al. (1993) taped transmitters onto the tail of nine *Thamnophis hammondii* using several strips of surgical tape. *Thamnophis hammondii*, another semi-aquatic gartersnake, retained their transmitters for a mean of 24.2 days. Cobb et al. (2005) and Figueroa (2006) glued small transmitters onto neonate *Crotalus horridus* and *C. oreganus helleri*, respectively, using cyanoacrylate glue, as did Jellen and Kowalski (2007) for neonate *Sistrurus catenatus*, with transmitters lasting 13–56 days. Although we did not evaluate a gluing method, it may not work well on the thin, smooth-scaled skin of *T. gigas* compared to the thick, rough scales of rattlesnakes.

More recently, Tozetti and Martins (2007) and Madrid-Sotelo and Garcia-Aguayo (2008) used duct style tape to externally attach radio transmitters to *Crotalus durissus* and *Oxybelis aeneus*, respectively, with an average monitoring time of 69.2 and 48.3 days, respectively. These attachments were dorsal compared to our ventral method. Madrid-Sotelo and Garcia-Aguayo (2008) also used cyanoacrylate glue in addition to the tape to affix the radio transmitters. Our monitoring time and that of Tozetti and Martins (2007) shows that duct tape alone can provide sufficient adhesion of radio transmitters to snakes. Again, our work shows that tape sufficiently adheres to these smooth-scaled snakes as well as the rough-scaled snakes in the study by Tozetti and Martins (2007). Also our work shows that ventral attachment of radio transmitters can work successfully in wetland habitats.

By attaching transmitters externally, we were able to obtain movement data on those *T. gigas* that were smaller than implantation procedures permit. We were also able to increase our sample size for snakes of all sizes. In addition, we were able to attach transmitters in the field immediately following snake captures, thereby reducing the interruption caused by captivity, anesthesia and surgery. An externally attached transmitter that fails prematurely will be lost by ecdysis, whereas implanted transmitters will remain in the body of the snake with unknown long-term consequences. During the active season, *T. gigas* shed their skin every 4–6 weeks, which invariably resulted in the loss of the transmitter. We found that *T. gigas* are often out of their burrows just prior to shedding, which permitted us to replace transmitters and continue tracking individuals.

We found the off-tail transmitter attachment technique was potentially more hazardous to the snakes than the body attachment. Four off-tail transmitters we recovered were snagged in vegetation, and the attached tape had distal pieces of tail that were pulled off by snakes. The shed radios we recovered that were attached with the body method showed no evidence of harming the snakes, but tape adhesive occasionally caused some superficial scarring. The small amount of tape used to affix transmitters with the body technique confers an additional advantage over the multiple pieces required to secure the antenna in the off-tail technique. When compared to the invasiveness of surgical implantation (Rudolph et al. 1998), the complications from taped transmitters are relatively minor. Taping did not cause any apparent mortality of the individuals in our study. The location of the radio attachment should be sufficiently posterior to allow for passage of gut contents at that location; we found no evidence of blockage of food items. We also did not detect any interference with shedding by taped radio transmitters.

We attribute our success of taping transmitters to *T. gigas* to several factors. The wetland habitat used by *T. gigas* has very little lignified vegetation and rocky outcroppings, and thus may be particularly forgiving to ventrally-mounted transmitters. Additionally, radio telemetry was conducted with concurrent, intensive snake trapping so we were able to recapture many animals, replace transmitters, and continue collecting data on the same individuals. A number of animals lost transmitters quickly and our dataset includes a long period of trial and error. In addition, our conservative calculations of distance and duration were designed to illustrate minimum expectations using our attachment method. Thus, our results may not reflect the full potential of this technique.

Taping radio transmitters to snakes is a simple, non-invasive and cost-effective way to collect movement data on individuals. This technique circumvents some of the limitations imposed by surgical implantation of transmitters, such as precluding studies of small snakes, poor recovery in cool weather (Rudolph et al 1998), and erratic behavior following periods of captivity while snakes recuperate from surgery. After surgically implanting transmitters in *T. gigas*, it is necessary to maintain them in captivity for up to two weeks to facilitate healing of the incision (Smith et al. 1988). Following this prolonged period of captivity, snakes often made unusually large movements immediately after release. Taping a transmitter to a newly captured snake and releasing it immediately rarely resulted in this response.

The period of time that a taped transmitter remains on a snake is not conducive to examine seasonal patterns in movement or annual home ranges. However, external transmitter attachment may facilitate research goals requiring one to monitor snake behavior over a within-season period (e.g., to measure rates of movement, Gent and Spellerberg 1993), or to monitor neonatal dispersal (Cobb et al. 2005; Figueroa 2006), reproductive behavior, habitat use, dispersal from hibernacula, and responses to landscape edges or features such as roads. The use of tape to attach radios in the fall facilitated location of winter hibernacula. Additionally, basking behavior associated with ecdysis facilitated transmitter replacement and continued long-term monitoring of individuals in spring and summer. Thus, our taping technique for the external attachment of radio transmitters to snakes, in addition to the variations tried by Tozetti and Martins (2007) and Madrid-Sotelo and Garcia-Aguayo (2008), demonstrates the potential for diverse applications of this technique in snake ecology and conservation. We recommend the use and further evaluation of the duct tape "body" method for use in future studies of snake movements.

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Shell Hardness Measurement in Juvenile Desert Tortoises, *Gopherus agassizii*

Thick, hard shells of adult tortoises and many turtles confer protection from predators and have apparently evolved among chelonians largely in response to predation pressures (Wilbur and Morin 1988). When threatened, turtles and tortoises pull in their heads and limbs, tuck in their tails, and present an armored surface and relatively round, smooth shape to their attackers—a defense that is usually successful in deterring injury or death from most predators (but see Emmons 1989; Medica and Greger 2009). However, hatchlings and young juveniles of many species have very soft, un-ossified shells and may suffer high mortality from predation (Ashton and Ashton 2008; Gilbert et al. 2008; Van Devender 2002). The rate at which shells harden (ossify) apparently has not been studied, but such information is important, especially in conservation efforts. For example, field studies of the threatened Desert Tortoise (*Gopherus agassizii*) have revealed very high predation pressures on young, mainly from ravens (Boarman 2003; K. A. Nagy, L. S. Hillard, S. Dickson, and D. J. Morafka, unpubl. data).

Chelonian species recovery programs involving head-starting procedures, which protect nests, hatchlings, and juveniles from predation until the young animals have grown through the highly-vulnerable stages, will involve decisions about when to release the juveniles into the wild. Such decisions should benefit from information regarding rates of development of shell hardness and shell size. Paired with data on predation and survivorship, knowledge of shell hardness would allow researchers to more fully understand how shell hardness influences predation risk and survivorship and identify particularly vulnerable periods in the life of juvenile chelonians. This information would allow for the development of better-informed conservation and management decisions. Also, knowledge of rates of shell hardening and shell growth can contribute to basic understanding of shell ontogeny among chelonians, as well as help answer ecological questions about effects of variability in average annual temperatures and rainfall, invasive species, and competition for food by other species on shell growth rate and ossification.

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Finally, comparisons of juvenile shell hardness development between populations or species may elucidate patterns of life-history evolution in response to differential predation patterns. Accordingly, we developed a reliable method for measuring shell "hardness" (compressibility) using machinist's calipers and applied it in a preliminary study of juvenile desert tortoises living and growing under essentially natural conditions in fenced enclosures in the open desert to predict the age and size at full shell hardening.

MATERIALS AND METHODS

Instrumentation.—Shell compressibility was measured using a 4-inch (maximum gap size), tension-calibrated, digital micrometer (Aerospace® brand; Fig. 1). The micrometer had a measurement range (spindle "throw") of only one inch, but we used 1-, 2-, and 3-inch inserts to allow measurement of shells ranging from zero to 102 mm (4 in) in height. The inserts were actually the calibration standards that came with the set of four micrometers (having jaw sizes of 1-, 2-, 3-, and 4-inches). Preliminary tests indicated that each of the four micrometers had rather different factory-set release tensions. Accordingly, we used only the largest micrometer, so as to minimize instrument error across various sizes of tortoises, adapting it to accommodate tortoises smaller than 75–100 mm by using the inserts. We fitted each of the three calibration standards with its own machined plastic collar

FIG. 1. Micrometer (4-inch), fitted with the 3-inch insert and machined white plastic collar to hold the insert in place, and shown attached to the wooden stand that was used for support in the field. This configuration allowed measurement of shell heights of up to 25 mm (one inch). Shell heights between 25–100 mm (1–4 in) could be measured by using either of the two shorter inserts (for 25–50 mm or 50–75 mm shells) or no insert (75–100 mm shells).

with set-screw so it could be attached and secured flush with the lower cylindrical measuring face of the micrometer. The micrometer was attached to a wooden stand to enable hands-free use (Fig. 1). The small knurled knob ("thimble") on the end of the handle advanced the spindle via a tensioned ratchet. When the spindle applied a factory-set force to the object being measured, the ratchet slipped, producing clicks, and the spindle no longer advanced.

The force exerted by the spindle at the pressure point where the ratchet slipped continuously averaged 636 g (SD = 37, CV = 5.8%, N = 7). The surface area of each measurement face was 28.3 mm^2, thus the force being exerted by both micrometer faces combined on the shell of tortoises when measuring CSH was 11.2 g/mm^2. No tortoises or shells showed any damage from our measurements. We purposely did not make measurements on hatchling tortoises due to their very thin and rubbery shells.

Measurement technique.—To measure shell heights, we held a tortoise level in its normal horizontal posture, then positioned the tortoise in the micrometer at its maximum shell height point, with its plastron just touching the lower caliper spindle face, or insert face, as appropriate for the size of the tortoise. We then determined the uncompressed shell height (USH) by slowly lowering the upper spindle by turning either the large knurled cylinder or the small knurled knob until the upper measuring face just touched the carapace, while being careful not to press the tortoise's plastron down on the lower measuring face and not to allow the tortoise to rest on the lower measuring face so its body weight deformed its plastron. We confirmed this "loose fit" in the caliper by very slightly sliding the tortoise back and forth, to assure that both caliper measuring faces were barely touching the tortoise's shell. The micrometer reading was recorded as USH, then the compressed shell height (CSH) was determined by continuing to rotate the small knob until the ratchet slipped continuously and at least six ratchet clicks in a row occurred. We recorded the micrometer reading at that point as the compressed shell height (CSH) value. It was important to make the CSH measurement gently but quickly, for two reasons. Small tortoises, which had the most compressible shells, sometimes began moving their legs after a short period of being compressed, adding uncertainty to the CSH measurements. Second, the shells of smaller tortoises were sufficiently elastic that if a tortoise was allowed to remain in the calipers at the compressed height position for another 10 or so seconds, it was then possible to compress them further before the six-click tension was again reached.

Hardness calculation.—Shell Hardness Index (SHI) was calculated with the equation:

$$SHI = 100 (CSH/USH)$$

where CSH is compressed shell height and USH is uncompressed shell height. Both heights in this study were measured to ± 0.001 inches.

SHI Reproducibility.—We evaluated the "machine" repeatability of the USH, CSH, and SHI determinations by making repeated measurements of USH and CSH on a flexible "tortoise mimic," which was a rubber pipette bulb. To evaluate "animal" repeatability, we made duplicate measurements of SHI on four yearling tortoises. We only made two measurements per animal because their soft shells were slow to recover their original shape following a SHI determination. We allowed 30 min between duplicate measurements to allow for shell recovery. The force exerted by the spindle at the pressure point where the ratchet slipped continuously was measured by inserting a small portable balance into the micrometer in place of a tortoise.

Field measurements.—We made initial applications of this method on two populations of Desert Tortoises (*Gopherus agassizii*) living in the field. Juvenile tortoises were studied at the Fort Irwin head-start facility (described in Morafka

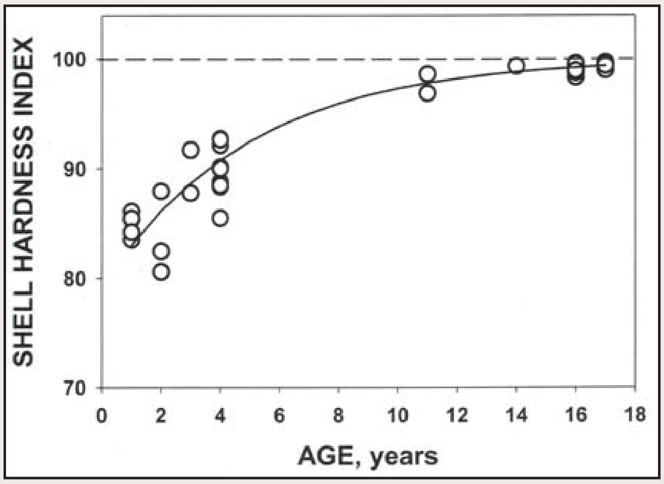

Fig. 2. Relationship between shell hardness and the age of juvenile tortoises living under natural conditions in the Mojave Desert. The solid line is an asymptotic curve fitted to the data, and the dashed line indicates a fully rigid shell, as in adult tortoises.

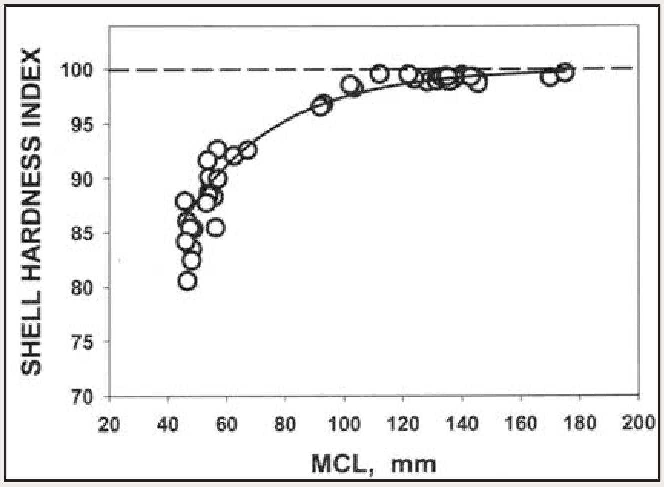

Fig. 3. Relationship between shell hardness and shell size (midline carapace length) of juvenile tortoises. The solid line is an asymptotic curve fitted to the data, and the dashed line indicates a fully rigid shell, as in adult tortoises.

et al. 1997 and Nagy et al. 1997), near the southern boundary of the US Army's National Training Center (35.1333°N, 116.4833°W) and at the Edwards Air Force Base head-start facility (34.7833°N, 117.7833°W) during 2007. The 28 tortoises studied at Fort Irwin were hatched inside predator-resistant, natural habitat enclosures between 1991 and 2003 and lived there under essentially natural conditions until their release into nearby open habitat in 2005 and 2006. They have been radio-tracked regularly since release. During recaptures in 2007 we measured SHI and midline (straight-line) carapace lengths (MCL in mm, measured from the notch just above the head to the notch above the tail to the nearest 0.1 mm with either digital or dial stainless steel 6-inch calipers). The 13 juveniles at Edwards AFB were also hatched inside fenced enclosures in natural habitat and their enclosures received only natural rainfall. They ranged in age from 1 to 4 years old when studied and we measured their MCLs and SHIs also during 2007.

Statistics.—We analyzed the relationships between SHI and tortoise age or MCL graphically, using SigmaPlot® (9.0) software. For regression analyses, we converted SHI values to shell compressibility values by subtracting SHI values from 100 so that "shell compressibility index" asymptotically approached zero as either age or MCL increased. The semi-logarithmic plots of these data yielded linear relationships, which we subjected to least-squares linear regression analyses with SigmaStat® (3.1) software. We used $\alpha = 0.05$ in tests for significant differences of the slopes and intercepts from zero.

RESULTS

Measurement reproducibility.—"Machine" repeatability measurements indicated that for USH the coefficient of variation (CV = 100 [SD/mean]) for 6 measurements was 0.15 %. For CSH, the CV was 1.32 % and for the SHI the CV was 1.35 %. "Animal" repeatability measurements indicated that the differences between duplicate SHI estimates were <4 % of the average measured SHI values of the four juveniles.

Field application results.—The shells of the 41 juvenile Desert Tortoises we measured had SHI values ranging from 80 to 100 (where SHI = 100 represents an incompressible shell). Among 39 juveniles for whom we had reliable age estimates, shells became harder in an apparently asymptotic manner as age increased (Fig. 2). There was more variation in shell hardness within younger cohorts than in older cohorts. The relationship between SHI and shell length, for 41 animals in this case, was also apparently asymptotic (Fig. 3). The relatively high variation in SHI among the smaller juveniles was again evident.

Predicting age and size at full shell hardening.—The relationship between SHI and age was significant ($F_{1,37} = 635.78$, $P < 0.001$, $R^2 = 0.945$) and gave an equation of ln(100-SHI) = 3.036-(0.203*AGE). Similarly, the relationship between SHI and size was significant ($F_{1,39} = 406.14$, $P < 0.001$, $R^2 = 0.912$) and gave an equation of ln(100-SHI) = 4.036-(0.031*MCL). If solved for an assumed SHI value of 98% of full shell hardness, predicted age is 11.5 years and predicted shell length is 109 mm. If the equations are solved with an assumed SHI value of 99%, predicted age is 15 years and predicted length is 130 mm MCL.

DISCUSSION

Shell hardness of young Desert Tortoises can be successfully and harmlessly evaluated using measurements of shell dimensions made with a micrometer equipped with a tension-developing ratchet-release thimble. A 4-inch micrometer along with 1-, 2-, and 3-inch spacer inserts allows a single micrometer to be used on tortoises ranging in shell height from yearlings <25 mm high up to 100 mm high. The advantage of using a single micrometer is that its unique ratchet release force should be the same for all animals measured, thus reducing error. The micrometer we used came from a set of four that ranged in size from 1 to 4 inches. Tests on the other three micrometers indicated that each had its own unique ratchet release force and all were precise but the mean forces developed differed by as much as 33% between micrometers. Thus, using a single micrometer can reduce measurement error substantially. Measurements of compressed shell height (CSH) were an order of magnitude more variable than those for uncompressed SH (CVs of 0.15 % and 1.32 %, respectively, for the rubber bulb "tortoise mimic") because of the added variability of the ratchet's slipping point and variation in the exact position and orientation of the compressed rubber bulb in the micrometer jaws. Nevertheless, the reproducibility (precision) of the shell hardness index (SHI) measurements was good (<2% CV for the rubber bulb and about 4% CV for living year-old tortoises). By using an "Index" rather than actual dimensions for shell hardness, results for tortoises of different sizes and ages can be compared directly.

Shells of neonate Desert Tortoises were quite soft during the months following hatching, with shells being compressible by more than 40% under moderate pressure. Because of the apparent discomfort some neonates showed and because of the possible injury to their very soft and thin shells, we did not make formal SHI determinations on neonates. Instead, we waited until the following spring, when neonates were about 7 months old, to begin measurements. At this age, SHI values were quite variable but averaged about 85% of full hardness. Over the next several years of life, shells hardened in an asymptotic fashion, and the log-transformed regressions of shell hardness with both age and shell size were linear. The high R^2 values for these relationships suggest that age and shell length account for most of the variation in log shell hardness in juvenile desert tortoises. Their shells became essentially incompressible (within 2% of complete shell inflexibility under a moderate force of 11.2 g/mm^2) by the age of about 11 years and a size of about 110 mm MCL.

These results can be useful in current tortoise conservation efforts. The Mojave Desert populations of *Gopherus agassizii* suffered severe declines in the 1970s and 1980s and were listed as Threatened in 1990 under the Endangered Species Act. The Recovery Plan (U.S. Fish and Wildlife Service 1994) included increased predation, particularly on hatchlings and juveniles, as a reason for listing. Natural mortality of the young of several species in the genus *Gopherus* is known to be quite high (Germano 1994; Morafka 1994; Tom 1994; Wilson et al. 1994; but see Bjurlin and Bissonette 2004). Hatchlings and young juveniles are small and have soft shells that make them much more vulnerable to predation than the hard-shelled and relatively large adults (Bjurlin and Bissonette 2004). The soft shells of juveniles may also be involved in their more rapid loss of body water and increased susceptibility to dehydration during droughts as compared to adults (Nagy et al. 1997). Several head-start projects are now underway in the Mojave Desert to protect tortoise nests, eggs, and juveniles from predators until they can be released with an expectation of high survivorship. We recommend that such tortoises be maintained under protection of the head-start pens until they reach a shell hardness of at least 98%. Tortoises in our sample, which were receiving natural rainfall and eating natural vegetation, reached this hardness by about 11 years of age or about 110 mm midline carapace length.

Shell hardness likely confers resistance to predation. Knowledge of the rates of development of shell hardness, paired with information regarding local predator populations and predation rates on juveniles with differing shell size or hardness, would allow managers of head-start programs to make informed decisions regarding the timing of the release of captive-raised juveniles based upon shell size and hardness. For example, understanding the relationship of juvenile desert tortoise shell size and hardness to predation risk by common ravens would allow managers to make decisions that maximize survivorship rates of released juveniles in areas with high raven densities. Additionally, knowledge of the effects of experimentally varying the growing conditions within head-start pens may provide information (1) to evolutionary biologists examining environmental influences on life-history evolution, (2) to population ecologists developing life tables for population modeling and conservation plan development, and (3) to managers maximizing the productivity of a head-start program using rearing techniques that enhance shell growth or hardness. For example, knowledge of differences in shell growth and hardness for juveniles raised in areas or in pens having differing proximate climates, watering/precipitation regimes, annual or seasonal food abundance or quality, or competition from other herbivorous species or pen mates (crowding effects) would reveal the importance of these ecological influences on juvenile tortoise ontogeny and life-history evolution.

The ability to determine degree of shell hardness or compressibility may be useful in studies of the ontogeny of shell growth and ossification in a variety of tortoise and turtle species. From an evolutionary perspective, comparisons of the development and growth of juvenile tortoise shells and their effects on reducing predation risk or enhancing survivorship among different populations or between species can be instructive in determining the effect of predation on life-history evolution. For example, researchers could examine whether juvenile tortoises in environments with lower predation risk allocate more energy toward shell growth at the expense of shell hardness, thereby growing and maturing faster than juveniles in populations or species located in areas of higher predation risk.

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CONSERVATION

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Rediscovery of *Abronia frosti* (Sauria: Anguidae) from a Cloud Forest in Cuchumatanes Highlands in Northwestern Guatemala: Habitat Characterization and Conservation Status

Species of *Abronia* are known to occur from southern Tamaulipas and Guerrero, Mexico, to southern Honduras. Guatemala has been a center of diversification of this group, with 10 species, eight of which are endemic (Ariano-Sánchez and Melendez 2009; Campbell and Frost 1993). A number of species of *Abronia* are critically endangered in the wild and two species (*A. campbelli* and *A. frosti*) were thought to have become extinct shortly after their discovery (Acevedo 2006; Acevedo et al. 2010; Brodie and Savage 1993; Campbell and Brodie 1999; Campbell and Mendelson 1998; Campbell et al. 1998). These two species had not been recorded in Guatemala since the late 1990s. Recently, however, a remnant population of *A. campbelli* was discovered in the country (Ariano-Sánchez and Torres-Almazán 2010). Acevedo et al. (2010) reported that three trips to the type locality between 1997 and 1999 failed to find any individuals of *A. frosti*. These authors also reported that the entire habitat in the area had been burned and that the species was presumed extinct. The rediscovery of *A. frosti* in this report was a result of a project focused on research and conservation of the Guatemalan species of *Abronia*. This project began in June 2009 and is operated by the Guatemalan NGO Zootropic.

Materials and methods.—Beginning in October 2009, a number of trips were made to the type locality of *A. frosti* (Campbell et al. 1998), in the northwestern part of Sierra de los Cuchumatanes, Guatemala, to search for the species. Standardized interviews with local villagers were conducted to determine the presence of *A. frosti* within the area. Interviews included showing local inhabitants photographs of *A. frosti* taken from Campbell et al. (1998), as well as images of the locally common species *Mesaspis moreletti* and *Sceloporus taeniocnemis* that are reasonably similar in appearance to *Abronia*. In addition, visual searches for the species were made in suitable habitat (including climbing oak trees) in the region.

Results.—Answers to standardized interview questions during the early trips to the area determined that local villagers were able to distinguish *A. frosti* from the other species of lizards in the area. In addition, villagers reported still seeing this species locally when they cut down old oak trees for firewood and within fresh masses of moss recently fallen from high tree branches after storms. Standardized interviews also revealed that the local inhabitants used to kill the lizards, until recently, because of a belief that seeing these animals is a bad omen; the very recent reduction in the killing of lizards by the local villagers is likely due to a very effective education program initiated in the area by our group.

The cloud forest inhabited by *A. frosti* is composed mainly of two species of oak: *Quercus boruscana* and *Q. acatenangensis* (Fig. 1). The trees of this forest are heavily covered by thick masses of moss and epiphytes and have an average height of 45.5 ± 4.26 m and an average diameter at breast height of 178.15 ± 19.83 cm. During our survey visits we found that the cloud forests in the region had been severely degraded due mainly to harvesting of the original oak forests for firewood (Fig. 2).

A sub-adult specimen of *A. frosti* with a SVL of 70 mm was found in October 2010 resting on a recently cut oak tree within a cloud forest remnant near the type locality in the highlands of Sierra de los Cuchumatanes, Huehuetenango, Guatemala (Fig. 3). The specimen was captured for the initiation of a captive breeding survival assurance colony, as part of the short-term conservation program for this species.

Discussion.—*Abronia frosti* has not been documented in the wild since its original discovery, 12 years ago, despite specific efforts to do so by different groups of herpetologists

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(Acevedo et al. 2010). One of the main factors for the success reported in this paper was the participation and support of local villagers within the area. This cooperation by local inhabitants was due to an awareness campaign conducted by Zootropic. Educational workshops with villagers were conducted in the Cuchumatanes region in order to increase the public awareness about the importance of the conservation of the cloud forest this species inhabits. Cloud forest in the area is severely fragmented, consisting mainly of small patches of intact habitat surrounded by a matrix of deforested land and plantations of native pine trees. In contradiction to Acevedo et al. (2010), the survey in this report finds that despite the degradation and fragmentation of the habitat, there remain some oak forest remnants within the area that should be considered for protection.

The height and diameter of the trees where *A. frosti* is found (Campbell et al. 1998; this report) suggest that this species is probably restricted to mature cloud forest habitat. The main factor leading to the decline of cloud forests in this region is logging for the production of firewood for both local use and commercial sale in the regional population center of San Mateo Ixtatán. Main conservation actions for the species should focus on preserving the last cloud forest remnants within the area and also the initiation of a captive breeding survival assurance colony of the species.

The rediscovery of *A. frosti* reported here and the recent rediscovery of breeding populations of *A. campbelli* in small forest remnants (Ariano-Sánchez and Torres-Almazán 2010) provide hope that these species may be somewhat resilient to the effects of forest fragmentation and habitat destruction. The discovery of a sub-adult *A. frosti* may mean that a breeding population of animals persists in the area lending further evidence to the persistence of this species in the midst of habitat degradation. Although the resilience of *A. frosti* to extinction is encouraging, there are a number of critical steps that need to be taken to ensure the long-term survival of this species in the region: 1) increase the connectivity within remaining, intact forest patches; 2) preserve the remaining cloud forest remnants; 3) reduce or eliminate the taking of individuals (killing and collection for illegal trade) by local villagers; and 4) promote the restoration of critical oak forest habitat.

The implementation of the above-proposed conservation measures may be difficult to accomplish due in great part to the complicated system of land use in the region. The majority of the forest range of *A. frosti* is managed as communal property. The residents of this region are not in agreement on the best use of this forest, including any reforestation program. In order to preserve the last remaining stands of mature oak forest in the area it will be critical to develop a program, along with the San Mateo Ixtatán municipality, to decrease logging for firewood in the area. One consideration in this area would be to increase the efficiency of ovens and kitchens of local villagers. Another strategy would be the promotion of establishment of plantations of fast growing tree species, suitable for firewood, in deforested areas near towns

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

FIG. 1. Patch of cloud forest habitat still remaining at the site where *Abronia frosti* was rediscovered.

FIG. 2. Habitat destruction caused by logging of oaks for firewood in the area where *Abronia frosti* was rediscovered.

FIG. 3. Specimen of *Abronia frosti* found within moss in a fallen oak tree in Catelac-Yolcutac Mountains in northwestern Cuchumatanes, Huehuetenango, Guatemala.

as an alternative to oak forest harvest. Another option is to promote the conservation of the last forest remnants through the formal participation of these communal properties within the Guatemalan system of protected areas. This strategy would require a strong political effort by the leaders of the communities that own the land. For these political leaders to promote these conservation actions will require the implementation of an effective and sustained program for the conservation of the last cloud forest remnants in northwestern Sierra de los Cuchumatanes.

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Note added in proof: In May 2011 another specimen of *Abronia frosti* (SVL 79.62 mm) was found by a local villager near the type locality. This individual is probably a female and was captured for the captive breeding program at Zootropic.

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Prime Time for Turtle Conservation

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In the race to extinction among all large groups of well-known animals, turtles hold the lead with 47.6% of 320 currently recognized turtle species identified as “Threatened” with extinction (Turtle Taxonomy Working Group [TTWG] 2010). Hoffmann et al. (2010) calculated threat levels a bit differently, by excluding data deficient or unevaluated species from the calculation; this method yields a higher percent of Threatened turtles, 54%. This exceeds global threat estimates for amphibians (41%), mammals (25%), bony fishes (15%), and birds (13%), and is similar only to primates, with 48% Threatened (Hoffmann et al. 2010). Furthermore, if our view is expanded to include ‘modern’ turtles and tortoises, those species that have occurred in the last 400 years, then 50% are threatened or already extinct (TTWG 2010). This percentage increases to 57% if data deficient and unevaluated species are eliminated from the calculation. By any of these approaches, turtles are in dire straits.

Partners in Amphibian and Reptile Conservation (PARC) is working with turtle and tortoise conservation groups to raise awareness for turtles by designating the year 2011 as the ‘Year of the Turtle.’ Their hopes are to: 1) communicate the need for conservation, research and education to the public, nature enthusiasts, biologists, and managers; 2) showcase ongoing work and species concerns; 3) acquire critical new information for selected species; 4) look for opportunities to leverage across diverse efforts to enhance effectiveness of actions; and 5) work to develop new procedures and policies that will benefit chelonians. Their website (www.yearoftheturtle.org) features monthly newsletters, calendar pages, partner links, and selected project information. Modeled, in part, after the highly successful 2008 – Year of the Frog that was organized by the Association of Zoos and Aquariums, the 2011–Year of the Turtle is a mechanism to network among those doing turtle and tortoise work, and those private citizens, groups or specialists that are interested in their plight.

Although Year of the Turtle is gaining worldwide momentum, it has a particular focus on chelonians in North America, where PARC has a growing constituency. Also, among world nations, the United States is a turtle and tortoise biodiversity hotspot. There is heightened concern to preserve the unique natural heritage of turtles in this geographic area. Currently, 57 of the 320 (18%) species of turtles known worldwide occur in the United States, with Mexico being the second-most turtle-rich nation, having 46 species (TTWG 2010). Furthermore, these two North American nations rank highest in turtle species diversity if the counts exclude sea turtles, with USA having 51 species (81 species and subspecies) and Mexico having 40 species (58 species and subspecies) (TTWG 2010). Twelve species of freshwater turtles and tortoises occur in Canada. Retaining the North American turtle natural heritage is a specific conservation concern. Here, we offer a primer on the status of world turtles, with some specific information and conservation and research recommendations for the North American fauna.

TURTLE STATUS AND THREATS

The conservation status of world turtles and tortoises is currently under reassessment. The International Union for the Conservation of Nature (IUCN) Red List is the official list of the conservation status of turtles and tortoises. An update to the list will be released this year, 2011, with scores of new species evaluations to be added. The current Red List, version 2010.4, includes 207 species (Table 1). Draft Red List designations for re-evaluated and newly evaluated turtles were released in December 2010, showing a raise in species in Threatened categories, from 129 to 152 (shaded rows, Table 1). The Convention on Trade in Endangered Species (CITES) species lists address international trade guidance. International law is enforced by countries that are party to this treaty; nearly all countries are signatories. CITES classifies species into three Appendices that are grades of protection. These Appendices are due for revision in 2012, and draft revisions to turtle and tortoise listings are being made now. Currently, there are 21 species of freshwater turtles and tortoises, as well as all sea turtles, on Appendix I, the most endangered group. CITES prohibits international trade for these species, except when the purpose of import/export is not commercial (e.g., scientific research). There are 23 species, seven genera, and one family (tortoises: Testudinidae)

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Fig. 1. Eastern Box Turtle (*Terrapene carolina*).

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Fig. 2. Spotted Turtle (*Clemmys guttata*).

PHOTO BY JEFFREY G. HALL

Fig. 3. Bog Turtle (*Glyptemys muhlenbergii*).

on Appendix II, the list that identifies species that may become threatened unless trade is closely controlled. There are 18 species and one genus (*Graptemys*) on Appendix III, the list that identifies species of concern by a Party (country) that already regulates trade in the species and needs cooperation of other countries to prevent unsustainable exploitation. Permits or certificates are needed for international trade of these species. One USA species is on Appendix III.

North American turtle conservation concerns can be further assessed by their national status ranks. In the USA, 9 of 57 (16%) freshwater turtle and tortoise species are listed under the Endangered Species Act (ESA, Table 2). In Canada, 6 of 12 species have conservation status by the Committee on Status of Endangered Wildlife in Canada (COSEWIC, Table 3). These lists do not overlap. It should be noted that the COSEWIC species appear on species of concern lists for certain US States.

The two top threats to turtles worldwide and in the US and Canada are habitat loss and fragmentation, and overexploitation for food, traditional medicines, and pets. Exacerbating these threats is the basic life history of most turtles and the small total ranges of many species. Their low fecundity and the several years it takes for young turtles to achieve maturity result in populations that are not resilient to sudden losses (Congdon et al. 1993). Small ranges mean that there are fewer total individuals and that there are fewer options for conservation action. All Canadian turtles are at the northern extent of their range, attributing to concern status for half of them.

Some examples of US turtles in peril and the reasons for concern are given below. Many more could be given. Each case is an example of the general issues, but the details are always different and they do matter.

The Plymouth Red-bellied Turtle (once recognized as the subspecies *Pseudemys rubriventris bangsi* and now understood as a highly isolated population) is confined to approximately 17 ponds entirely within Plymouth County, Massachusetts, more than 400 km from the mid-Atlantic populations of the same species. Similarly, the Alabama Red-bellied Turtle (*Pseudemys alabamensis*) occurs only in parts of Mobile Bay drainage in Baldwin and Mobile counties in Alabama, and Harrison and Jackson counties in Mississippi. Other species have specific habitat requirements so that the total amount of real estate available to them is small. The threatened Bog Turtle (*Glyptemys muhlenbergii*) requires very specific, nearly pristine, bogs to thrive so that although it ranges from upstate New York to Georgia, there is too little habitat left. The Flattened Musk Turtle (*Sternotherus depressus*) occurs only within the Black Warrior River system of Alabama, but cannot now live in much of that river because of water pollution and increased human activities.

A group of special interest is the map turtles of the Gulf South. Here, eight species are restricted to one or a small number of associated drainages in the southern USA that lead to the Gulf of Mexico. For example, the Pascagoula Map Turtle (*Graptemys gibbonsi*) is restricted to the Pascagoula River drainage in Mississippi and the newly described Pearl River Map Turtle (*Graptemys pearlensis*) is confined to the Pearl River drainage only in Mississippi and bordering Louisiana. Because each of these species is only found in riverine habitat the total amount of area occupied is necessarily quite small. Scientists are currently preparing a new Red List assessment of these species and it is likely that many of them will be found to be vulnerable or endangered.

Two of three species of US tortoises, the Gopher Tortoise (*Gopherus polyphemus*) and the Desert Tortoise (*Gopherus agassizii*), are threatened by the enormous expansion of urbanization within their ranges. In Florida, the primary home of the Gopher Tortoise, development has been displacing tortoises at an alarming rate as that state has had one of the highest human population growth rates in the country. Similarly, much of the western portion of the Mojave Desert in California has seen most of the available land put to human use in the last two decades. For example, in Victorville, California, the human population grew from 64,000 in 2000 to approximately 112,000 in 2010. Unfortunately, Desert Tortoises have also been severely affected by disease outbreaks even in relatively remote areas (USFWS 2006).

Other turtles that have in the past been both widespread and common are now suffering from habitat fragmentation and the effects of roads. This creates a pattern of many small populations that cannot interact with each other. As road density increases, many scientists believe that a tipping point will be reached where many of the small populations will go extinct. The concern has been raised for the Common Box Turtle (*Terrapene carolina*), a mostly terrestrial species (Dodd and Franz 1993). So, even species that were formerly regarded as common may be prone to widespread decline.

Exploitation of turtles for Asian commercial markets has skyrocketed and is now a major conservation concern worldwide, including in North America (Turtle Conservation Coalition 2011). Turtles have played an important role in Chinese civilization at least since the Bronze-Age Shang Dynasty over 3,000 years ago. At that time, hundreds of thousands of turtles were used in divination rituals in which tortoise and turtle shells were heated and the cracks obtained were interpreted for guidance. These oracle bones fill archaeological sites. Turtles also have always been recognized for their longevity and the Chinese have sought to acquire that virtue from them. Today, turtles are consumed in China for long life and for traditional medicine. The problem, known as the Asian Turtle Crisis (van Dijk et al. 2000), arises from the combination of this long tradition with a population of over 1 billion people who are becoming wealthier. The demand for turtles in China is now almost impossible to overestimate. But the result is clear: turtles are being sent from all over the world to China for consumption at a scale unimaginable only a few years ago (Compton 2000; Chen et al 2009). Southeast Asian countries such as Vietnam now have their entire turtle fauna (over 30 species) critically endangered due to this trade (Hendrie 2000). The economic incentives for local peoples to

Table 1. International Union for the Conservation of Nature (IUCN) Red List current turtle designations (version 2010.4), re-evaluations to update the current list (updated numbers), provisional designations of previously unevaluated species, and sum of these columns to represent draft new list (TTWG 2010). Shaded rows are considered "Threatened" categories. * Indicates a category being phased out. — Indicates number not available or not relevant.

	No. Species		
IUCN Red List Category	Current List	Re-evaluations	Provisional List
Extinct	6	+1 (7)	1
Extinct in the Wild	1	–1 (0)	1
Critically Endangered	30	+7 (37)	6
Endangered	40	+2 (42)	4
Vulnerable	59	–9 (50)	13
Lower Risk	41	–11 (30)	9
Conservation Dependent*	1	–1 (0)	—
Least Concern	18	+3 (21)	63
Data Deficient	11	+2 (13)	16
Not Evaluated	—	—	8
Total No. Species	207	121	

Table 2. United States Endangered Species Act (ESA) turtle listings. Available at: www.fws.gov/endangered/species/us-species.html.

Common Name	Scientific Name	Status
Flattened Musk Turtle	*Sternotherus depressus*	Threatened
Sonoyta Mud Turtle	*Kinosternon sonoriense longifemorale*	Candidate
Desert Tortoise	*Gopherus agassizii*	Threatened
Gopher Tortoise	*Gopherus polyphemus*	Threatened
Plymouth Red-bellied Turtle	*Pseudemys rubriventris bangsi*	Endangered
Alabama Red-bellied Turtle	*Pseudemys alabamensis*	Endangered
Bog Turtle	*Glyptemys muhlenbergii*	Threatened
Ringed Map Turtle	*Graptemys oculifera*	Threatened
Yellow-blotched Map Turtle	*Graptemys flavimaculata*	Threatened

Table 3. Committee on Status of Endangered Wildlife in Canada (COSEWIC) turtle listing. Available at: www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

Common Name	Scientific Name	Status
Eastern Musk Turtle	*Sternotherus odoratus*	Threatened
Blanding's Turtle (Nova Scotia population)	*Emydoidea blandingii*	Endangered
Spotted Turtle	*Clemmys guttata*	Endangered
Wood Turtle	*Glyptemys insculpta*	Threatened
Spiny Soft-shell	*Apalone spinifera*	Threatened
Western Painted Turtle (Pacific Coast population)	*Chrysemys picta bellii*	Endangered

participate in this global trade are staggering. Any turtle is worth serious money to a Vietnamese peasant, but some species, such as the Three-striped Box Turtle (*Cuora trifasciata*), sell for several thousand dollars apiece (Blanck et al. 2006). They are literally worth their weight in gold.

Commercial markets for turtles include the pet trade. Around the world people keep pet turtles and tortoises. In the last few decades they have become much more popular and, most importantly, the number of species found in the pet trade has increased dramatically (Shepherd and Nijman 2007; Shepherd and Nijman 2008). While most pet owners have relatively common species and do not pose a major conservation threat, some collectors become fanatic about getting rare or unusual species. Today, almost every species of turtle can be found for sale, legally or not, on the internet. Fanatic collectors can buy the world's rarest turtles if they have enough money, and many do. Prices for adult Ploughshare Tortoises (*Astrochelys yniphora*) from Madagascar can range to well over US $10,000 (Smith 2011). This market has driven many species to near extinction (Turtle Conservation Coalition 2011). Especially frustrating to turtle biologists is that when a new, rare species is described in the scientific literature, this publication immediately creates a market for the new turtle (Stuart et al. 2006). For example, the Roti Island Snake-necked Turtle (*Chelodina mccordi*) was described from a single small island in Indonesia and within a very few years most of the population had disappeared into the international trade.

Several US states have tightened their regulations over the commercial exploitation of any turtle species (P. Nanjappa, pers. comm.), in part because of increased evidence for the growing demand for turtles in Asia and worldwide. Turtles are still captured for the pet trade but it is hard to know how much of a conservation concern this harvest is. Formerly, both Common Box Turtles (*Terrapene carolina*) and Ornate Box Turtles (*Terrapene ornata*) were sent to Europe in large, unsustainable numbers. But this trade has been much reduced after the genus was put on CITES Appendix II. The individual state laws governing collection of turtles in general are a patchwork with most states allowing collection for personal use and others not. State herpetofaunal regulations have been compiled recently to aid in management of these animals (P. Nanjappa, unpubl. data). Unfortunately, much of the trade in rare species is illegal and therefore very hard to track, and few states have the capacity to establish effective monitoring programs.

An emerging threat for turtles is hybridization and genetic swamping. A major discovery in the biology of turtles became apparent recently when it was determined that almost any species of Old World freshwater turtle (Family Geoemydidae) could hybridize with any other species even if they were in different genera. More startling is that these hybrid offspring are fertile and capable of reproduction. Turtle farms in China have now produced turtles descended from three different genera between their parents and grandparents (T. Blanck, pers. comm.). These turtles are like orchids - endless new varieties can be produced. Hybrids have no legal protection under international law so a hybrid of two of the rarest turtles in the world is legal anywhere. These hybrid turtles show that habitat alteration that permits species that do not normally encounter each other to mix could cause a distinctive form to be lost through genetic swamping. Similarly, although this has not happened yet as far as we are aware, releasing hybrid turtles could cause the loss of native species. This threat is new and there is no other group of animals that faces a similar problem. We really have no idea how dangerous it could be. In the US, the chief concern is the introduction of the Red-eared Slider (*Trachemys scripta elegans*) into habitats of its close relatives, such as the Big Bend Slider (*Trachemys gaigeae*) which occurs in the Rio Grande drainage of Texas and New Mexico. This hybridization has the potential to wipe out the Big Bend Slider as a distinct species (T. J. Papenfuss, pers. comm.).

CALL TO ACTION: CONSERVATION AND RESEARCH RECOMMENDATIONS

Hoffmann et al. (2010) demonstrated that conservation actions can improve species status. We have the opportunity to change the fate of turtles around the world by taking steps implementing conservation actions, and doing so quickly. Let us use the Year of the Turtle as our Call to Action – we can work together to benefit turtles worldwide. The Partners page at the Year of the Turtle website (www.yearoftheturtle.org) lists some organizations that work on turtle and tortoise conservation, and many more groups and individuals are working to benefit these animals. Join one or start a new one. A source to learn more about the challenges and opportunities is Craig Stanford's *The Last Tortoise* (Stanford 2010). The most endangered species are reviewed by the Turtle Conservation Coalition (2011).

An important lesson that has emerged from consideration of the difficulties of turtle conservation is that all possible conservation tools must be considered and that each species and country have their own opportunities and challenges. This lesson leads to an overall ecumenical approach in which the effective use of any one conservation tool does not preclude the use of another tool. Sometimes there are conflicts between strategies, such as when trade regulations are written so tightly that they exclude (often unintentionally) the development of assurance colonies that may be needed for some species. It is important to global turtle conservation that these conflicts be minimized.

We can divide the strategies into 3 basic approaches: 1) rare species management; 2) keeping common species common; and 3) crisis management. Furthermore, we have learned much about the threats to turtles and how to combat them. These lessons result in additional key guidelines for both conservation and research directions; the common thread among these guidelines is the need for monitoring both to understand the status of species and to determine if conservation actions are working. The following are 7 conservation action examples from North America, combining these basic approaches and guidelines.

Manage rare species.—Rare species management is the traditional focus of conservation. The primary tool is, of course, native habitat protection and preservation. In the best of circumstances this may be all that is needed. In other cases the habitat may have to be restored and repopulated by animals raised elsewhere, often in captivity. Conservation efforts for the Bog Turtle (*Glyptemys muhlenbergii*) have involved protecting good habitat, restoring degraded habitat, and releasing captive-bred animals that have been raised to a size to offer them a better chance of survival ("headstarting"). Taken together these efforts have resulted in real success in strengthening this species' hold on survival. To aid communication among headstarting efforts, for which trial-and-error management is common, PARC is compiling projects for all herpetofauna (www.parcplace.org). Long-term monitoring of populations is a critical element in the management of both rare and common species.

Manage common species.—More conservationists are focusing efforts on managing common species to keep them common. There are three reasons for this approach. The first is that, as the case of the Passenger Pigeon (*Ectopistes migratorius*) reminds us, being common, even abundant, is no guarantee that a species will never go extinct. Second, we now realize that it is much less expensive to save a species while it is common rather than to wait for it to become rare before acting. The sooner action is taken, the greater the options available are, and when there are more options, one can be more effective. Third, if no one pays attention to a species because it is common, problems and declines may go unnoticed because of a faulty assumption. The Common Box Turtle (*Terrapene carolina*) is generally perceived to live up to its name. But many turtle researchers have emphasized that being complacent about this species is a serious mistake. One of the most important aspects of managing common species is addressing mortality and population fragmentation caused by roads. Fencing roads has proved useful for the Desert Tortoise (*Gopherus agassizii*) and may work for other species. Road patrols during Diamondback Terrapin (*Malaclemys terrapin*) nesting season are a labor intensive, but mainly successful method for reducing road mortality for that species. The search for creative solutions to this problem continues.

Manage crises.—Environmental crises can affect turtles. The Gulf oil spill of 2010 imperiled sea turtles and those species became icons of the disaster. In fact, the Diamondback Terrapin (*Malaclemys terrapin*) was perhaps even more at risk. There are three subspecies of terrapin living only in the estuaries along the Gulf of Mexico and their narrow ribbon of habitat was affected by oil washing on shore. Although only some populations were affected, terrapin biologists organized and were prepared to move animals out of harm's way if that became necessary. For sea turtles, over 25,000 eggs were moved during the Gulf oil spill, and this proved to be an effective conservation measure (Pittman 2010).

Almost unique to turtles is the crisis management problem presented by large-scale confiscations of illegal animals. Sometimes these confiscations can include thousands of turtles of over a dozen species. Emergency programs by turtle conservationists and veterinarians have been set up to sort, treat and relocate these animals that are often in very poor health.

Regulate commercial turtle harvest.—A recent compilation of herpetofaunal regulations for US states (P. Nanjappa, pers. comm.) shows that little capacity currently exists for coordination or monitoring of harvests of wild or captive herpetofaunal species. There is great variation among state fish and wildlife agencies with some having generally prohibited all commercial exploitation of wild turtles and others offering fewer restrictions. In 2009 and 2010, representatives of many of the US state fish and wildlife agencies met to begin to address regulatory issues and needs. This process will continue in 2011. Sea turtles benefit from federal regulation and funding, due to their rarity and international migratory nature; similar federal protections are afforded to tortoises, and could be considered for freshwater turtles. The US Fish and Wildlife Service is actively engaged in these turtle issues as well, and is a key player, with state fish and wildlife agencies, in the revision of CITES Appendices. Realistically, we may not be able to prevent or ask for bans on all harvest. However, we can encourage and support closely-monitored and well-regulated harvest; with such measures, some commercial turtle harvest could be acceptable.

Turtle farming operations have not been closely monitored or studied. In particular, how much do farms rely on native wild turtles for brood stock? In addition to understanding 'take' in wild populations, a greater understanding of the contribution of US turtle farms to US and world commercial markets is needed. This need is growing as production grows.

Create and institutionalize local interest groups for localized species.—Highly localized species need highly localized support groups; that is, groups of people that champion their local turtle. Such groups, formal and informal, exist for some species. Even in 1952, Archie Carr could write of the Plymouth Red-bellied Turtle population that "If it were not for the interest shown by local inhabitants of Plymouth County in the conservation of this interesting population of turtles it would soon be wiped out." The turtle conservation community needs to facilitate the creation of such groups. For example, this community could help folks living near some of the Gulf South *Graptemys* to develop a sense of pride and appreciation for their neighborhood endemics.

Implement range-wide population, habitat, and risk analyses for widespread species.—GAP Analysis is a conservation evaluation process where the ranges and populations of species are overlaid on protected areas such as National Parks to determine how well protected they are over their entire range. For example, we need a range-wide GAP analysis of the Common Box Turtle (*Terrapene carolina*) to estimate how many populations are currently protected and an assessment of the real risk that this species faces. Data from all states and Canada would be needed for this type of synthesis. The PARC-initiated USA Turtle Mapping Project (www.yearoftheturtle.org) is a necessary preamble for such a large-scale species assessment.

Additionally, a meta-population analysis for widespread species is needed to look for 'tipping points.' Many species of terrestrial turtles and tortoises live in populations that are more or less loosely connected by individuals who move between the local populations. This pattern is called a meta-population, and understanding how meta-populations work, and how they can fail, is an important aspect of the conservation of these species. Connectivity focal areas could be identified in such an analysis. As increasing road traffic prevents any movement from one population to another, isolated populations may have a greater chance of going extinct. We must determine at what point fragmentation of a meta-population causes a species to go extinct, and where the critical connection points exist. Many researchers believe there is a tipping point as meta-populations become increasingly isolated where they can fail and go extinct. We must determine how and when this may be true of turtles, and geographically where the important areas are to maintain connectivity.

Develop methods to assess and ensure high genetic diversity for greater evolutionary potential to respond to global change.—Genetic diversity is the basis of evolutionary adaptation to changing environments. Many turtle environments are predicted to shift under climate change scenarios. The details of these changes as they apply to particular species are generally unknown. With this uncertainty about environmental change, it becomes important to ensure that turtle and tortoise populations are genetically diverse so that they can respond to whatever change does actually occur. This is a strategy of hedging one's bets on the future. Increased efforts are warranted to evaluate turtle genetic diversity and the trade-off between how well-adapted turtles are versus how resilient turtles are to changes based on their genetics (i.e., their "adaptedness" versus their "adaptability"). This knowledge is especially important for reintroduction programs where animals may be reared in captivity and then released into the wild.

CONCLUSION

Our turtle heritage is diminishing at a rate outpacing that of other main animal groups. The 2011–Year of the Turtle partnership and campaign is an opportunity to raise awareness for turtles, celebrate our turtle heritage, herald conservation and research successes, and identify gaps in our understanding that can be the focus of future work. We outline seven conservation and research implications of the current turtle crisis, and associated conservation opportunities and actions. If we, the turtle conservation community can accomplish efforts in these selected areas, we can greatly help to sustain species and bolster the recovery of declining turtle species.

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AMPHIBIAN DISEASES

Herpetological Review, 2011, 42(2), 205–208.

Chytrid in a Canopy Amphibian: Picado's Bromeliad Treefrog, *Isthmohyla picadoi* (Hylidae), Persists at a Site Affected by *Batrachochytrium dendrobatidis*

The pathogenic fungus *Batrachochytrium dendrobatidis* (*Bd*) has been implicated as the cause of many global amphibian declines (Berger et al. 1998; Bosch et al. 2001; Briggs et al. 2005; Longcore et al. 1999; Ron and Merino 2000; Skerratt et al. 2007). Central American amphibians have experienced substantial declines (Stuart et al. 2004, 2008) and *Bd* has been identified as the cause in a number of these (Crawford et al. 2010; Lips et al. 2006). A more thorough understanding of the natural history and ecology of *Bd* is still needed, and knowledge of the geographic distribution of this fungal pathogen is important for biological conservation (Adams et al. 2007; Young et al. 2001). Likewise, modes of *Bd* dispersal are poorly understood; amphibians and water sources are implicated as the primary vectors, but birds and soil are potentially important vectors as well (Johnson and Speare 2005). *Bd* has also been implicated in historic die-offs in the highlands of western Panama (Lips 1999; pers. obs) and has been detected in environmental water gathered from both lotic and lentic sources (arboreal phytotelmata) in the region (Cossel and Lindquist 2009).

Picado's Bromeliad Treefrog, *Isthmohyla picadoi* (Dunn 1937), is an arboreal, bromeliad-dwelling species found in primary, secondary, and transitional humid montane forests of Costa Rica and Panama (Duellman 2001; Faivovich et al. 2005; Savage 2002; Solis et al. 2008). Stuckert et al. (2009) found that *I. picadoi* inhabits phytotelmata with source water temperatures that fall within the reproductive thermal range of *Bd* in laboratory settings as found by Piotrowski et al. (2004). The population of *I. picadoi* from the highlands of western Panama studied by Stuckert et al. (2009) persists despite catastrophic declines and extinctions of other amphibian species in the region due to *Bd* (Lips 1999). Although no data on the population exists prior to the arrival of *Bd*, the population currently appears to be stable based on the number of vocalizations heard throughout the study site over multiple years ranging from 2000 to 2008 (pers. obs.). Stuckert et al. (2009) suggested *I. picadoi* may be a potential vector of vertical stream-to-canopy *Bd* zoospore transfer as well as stream-to-terrestrial dispersal. However, their study did not present evidence of *Bd* infection in *I. picadoi*, nor any correlation between infection in *I. picadoi* and presence of *Bd* in phytotelmata. In this study, we set out to determine: 1) whether *Bd* is detectable in the population of *I. picadoi* at the study site described by Stuckert et al. (2009) and Cossel and Lindquist (2009); and if so, 2) the prevalence of infection; and 3) whether any connection exists between *Bd* infections in individual frogs and phytotelmic water sources.

We studied a population of *I. picadoi* immediately north of Guadalupe Arriba, Chiriquí Province, in the Republic of Panama (8.869444°N, 82.566806°W) between 3 and 29 January 2008 [same population as Stuckert et al. (2009)]. Study sites included primary, secondary, and transitional riparian humid forest, ranging in elevation from 1,950 to 2,300 m elevation. Sites were located in a private forest preserve owned by Los Quetzales Lodge and Spa, and in a small forest tract in the Finca Dracula, owned by Andrés Maduro. Both properties border the Parque Internacional La Amistad and Parque Nacional Volcán Barú.

We located *I. picadoi*, via two techniques: 1) randomly searching bromeliads (leaf axils and phytotelmata) at both day and night; and 2) triangulating male nocturnal position immediately after vocalization. Epiphytic bromeliads and mosses were searched at heights ranging from 0 to 33.5 m

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above the ground. Trees and epiphytes were searched using three methods: ground searches, ladder searches, and climbs using the Single Rope Technique (SRT) (Maher 2006). Ground searches entailed examining fallen bromeliads or those within standing reach. Ladder climbs employed a 7.3 m extension ladder to access higher bromeliads. Tree climbs using the SRT, which safely reached heights up to 33.5 m, were used to sample bromeliads otherwise inaccessible to ground and ladder searches. For a more detailed discussion of searching methods, data, and three-dimensional forest position in this species, see Stuckert et al. (2009).

Clean nitrile gloves were used when capturing frogs and were changed between handling different individuals. After capture, frogs were kept outside in individual bags to collect any shed skin for 24 h in order to assess individual health. All were kept at ambient temperature, yet protected from rain and potential predation. No frogs exhibited any of the typical symptoms of chytridiomycosis as described in Berger et al. (1999) such as abnormally high epidermal sloughing, reddening of ventral surfaces, lethargy, or loss of righting reflex. Individual frogs were systematically processed as given in Stuckert et al. (2009) and skin swabbing protocols followed Brem et al. (2007). Individual frogs were swabbed dorsally, ventrally, and along limbs and digits with wooden-handled non-adhesive cotton swabs, as suggested by Livo (2004). Although Lee and Cooper (1995) have suggested that the use of wooden medium inhibits PCR amplification, Retallick et al. (2006) did not find this to be the case (both studies used wooden toothpicks to swab their samples). Additionally, *Bd* cultures also were swabbed with wooden-handled non-adhesive cotton swabs and all yielded positive results, indicating that PCR amplification was not inhibited in our study. Therefore we are confident that the swabbing protocol we used did not contribute to false negatives. The cotton tips were removed from the wooden handle of all swabs and placed into a 2 ml screw capped vial with 70% ETOH and labeled. Samples were refrigerated upon return to the United States.

Traditional PCR and qPCR analyses were conducted. DNA from samples containing shed epithelial fragments was prepared from the fragments using genomic extraction protocols outlined by Boyle et al. (2004). Traditional PCR methods, described by Annis et al. (2004), were utilized to detect and amplify *Bd* sequences with the following changes to the PCR reaction: PCR amplifications were performed in 50µl consisting of 0.4 µM of each primer, 1x Roche FastStart *Taq* buffer with 2mM $MgCl_2$, 0.2 mM of each dNTP, and 2.5 U of Roche FastStart *Taq* polymerase enzyme.

Swab samples were prepared for real-time qPCR analysis according to the procedure outlined by Boyle et al. (2004) and Kriger et al. (2006a). However, samples returning positive in singlicate analyses were subsequently analyzed in triplicate to determine relative infection intensity as suggested by Kriger et al. (2006b). Due to the larger-sized swabs used with our collection protocols, nucleic acids were extracted using 75 µl PrepMan Ultra to ensure sufficient supernatant for analysis. We used an Applied Biosystems StepOne™ real-time PCR system to detect and quantify *Bd* sequences. TaqMan Exogenous Internal Positive Control Reagents were used as internal positive controls (VICTM dye, Applied Biosystems No. 4308323, Hyatt et al. 2007) to ensure there was no inhibition of amplification. Positive controls for the amplification of *Bd* DNA were achieved by using standards as described by Boyle et al. (2004) and a negative water control was run on every 48-well PCR plate.

We caught and swabbed 32 individual *I. picadoi*: 15 males, 3 females and 14 juveniles. Preliminary sample analyses using traditional PCR methods indicated the presence of *Bd* in one swab sample which contained visible, but minor shed epithelial fragments. This was similar to other individuals that had similar amounts of epithelial shedding, but not unusually high amounts that would have indicated clinical chytridiomycosis. Independent quantitative PCR analyses confirmed the presence of *Bd* in the same sample (individual), but in none of the other 31 swabs, indicating an infection detection prevalence of 3.125% in our study (7.91×10^{-4}, 1.62×10^{-1}; 95% exact binomial CI). The mean number of zoospore equivalents calculated from triplicate samples drawn from the infected frog was 366.50 ± 150.82 (SE). The sole infected individual was a large adult male (SVL = 34.3 mm/SUL = 32.85) found in a bromeliad 1.5 m off the ground.

Stuart et al. (2008) cite chytridiomycosis as a likely cause of observed declines in *Isthmohyla* and Lips (1998) observed a dying *Isthmohyla calypsa* individual in Costa Rica during the beginning of a local *Bd* epidemic. Although not tested for chytridiomycosis, this individual was likely infected. Further, species distribution modeling by Lötters et al. (2010) has shown that *I. calypsa* and a number of critically endangered congeners (*I. angustilineata, I. debilis, I. graceae, I. rivularis,* and *I. tica*) have geographical ranges that overlap with known localities of *Bd* and their rapid enigmatic decline is associated with chytridiomycosis. Although *Bd* has been implicated in other *Isthmohyla* declines, to our knowledge *Bd* has only been confirmed in *I. pseudopuma* from populations near Monteverde, Costa Rica (Picco and Collins 2007; Puschendorf et al. 2006; JOC, unpubl. data). These findings represent a confirmed second *Isthmohyla* species infected with *Bd* and provide support to the suggestion that amphibians of this genus are susceptible to infection (Lötters et al. 2010). These findings are also significant because they corroborate findings from Cossel and Lindquist (2009) that demonstrated the presence of *Bd* in both lotic and lentic environmental water sources at the same site which has been heavily impacted by *Bd*.

The detection of *Bd* in an extant species in this region has some notable implications. First, the persistence of *I. picadoi* in the Chiriquí highlands of Panama may simply be associated with the species' arboreal life history. The prevalence of infection may be lower in *I. picadoi* than in stream breeding congeners because *I. picadoi* not only lives in bromeliads, but breeds in them as well. Thus, they rarely if ever come into contact with lotic bodies of water such as streams which are shared by many different amphibian species. This species' life cycle and microhabitat usage might explain why *I. picadoi* persists while formerly sympatric riverine species such as *Rana warszewitschii* and *Atelopus chiriquiensis* were extirpated or may have gone extinct, respectively (Lips 1999). This could also explain why populations of *I. picadoi* seem to remain stable (pers. obs.) despite living in sympatry with *Bd* while congeners that are more closely linked to streams (like *I. calypsa*) are declining or have completely disappeared (Lips 1998). The one frog that tested positive for *Bd* was found in a bromeliad with a significantly elevated zoospore load of 6,780 ± 85 Eq/L (Cossel and Lindquist 2009). The study by Cossel and Lindquist (2009) only found *Bd* in one other bromeliad (4.2% of all bromeliads sampled were *Bd* positive). This bromeliad was near another captured *I. picadoi*; however, *Bd* was not detected on this frog. The low prevalence of *Bd* in bromeliads (Cossel and Lindquist 2009) and the positive *Bd* association between frogs and bromeliads may further support the notion that the canopy presents lower, but not completely eliminated, potential *Bd* exposure risks. The *Bd* positive frog and bromeliad this frog was found in were located roughly 200 m away from the nearest stream (also positive for *Bd*) and raises the possibility that *I. picadoi* may serve as a vector and/or reservoir for *Bd* (although we cannot fully rule out some other vector). Second, an apparently low level of *Bd* prevalence occurs in *I. picadoi*, perhaps suggesting some adaptive and/or innate immune response exists. A discussion of immunity scenarios has been explored in detail by Richmond et al. (2009), and good evidence of antimicrobial peptide and symbiotic cutaneous bacteria in some species exists in the literature (Lam et al. 2010; Rollins-Smith et al. 2002, 2005, 2006). Further evidence is provided by Carver et al. (2010), who have shown that individuals initially infected and showing signs of clinical chytridiomycosis may be able to fully recover, and although aclinical, may still be infected with the pathogen. Finally, some species have been shown to be able to behaviorally thermoregulate, likely to fight *Bd* infections (Richards-Zawacki 2010). Local or regional *Bd* persistence may be explained by reservoir amphibian species that are sublethally infected (Briggs et al. 2005; Daszak et al. 2004; Davidson et al. 2003; Garner et al. 2006; Woodhams et al. 2007) and additionally, not all species that come into contact with the fungus are at risk of clinical chytridiomycosis (Gascon et al. 2007; Stuart et al. 2008). The one frog which tested positive for *Bd* did not show signs of clinical chytridiomycosis and appeared healthy. However, we did not keep frogs long enough to see if they developed clinical chytridiomycosis.

The presence of *Bd* in this canopy-dwelling species provides evidence that some canopy amphibians may serve as vectors for the fungus (Stuckert et al. 2009). Further, it emphasizes the suggestion by Cossel and Lindquist (2009) that arboreal sites may serve as environmental reservoirs, facilitating the persistence of *Bd* in local environments.

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Prevalence and Distribution of *Batrachochytrium dendrobatidis* at Montane Sites in Central Washington State, USA

The fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) causes mortality in some amphibians (Berger et al. 1998; Nichols et al. 2001) and has been implicated as one cause of amphibian declines (Pounds et al. 2006; Stuart et al. 2004). Recent studies have found *Bd* in Oregon, Alaska, and Idaho, USA, as well as in British Columbia, Canada (Adams et al. 2007; Garner et al. 2006; Pearl et al. 2007; Reeves 2008; http://www.spatialepidemiology.net/Bd-Maps/), but few data are available on its distribution in Washington, USA. *Bd* has been detected in samples collected in western, central and eastern Oregon but was absent from two sites in Washington (Pearl et al. 2007). *Bd* has been detected in the Oregon Spotted Frog (*Rana pretiosa*) in two other sites in southwestern Washington (Hayes et al. 2009; Pearl et al. 2009). In addition, the fungus has been isolated from amphibians associated with large die-offs in the Cascade Range of Washington (Snoqualmie Pass area; R. S. Wagner and J. E. Johnson, unpubl. data). We investigated the prevalence and distribution of *Bd* on Table Mountain in the Blewett Pass area of central Washington (Fig. 1) to assess the presence of *Bd* in the region and to determine the prevalence for local anurans.

We collected anurans from three sites on Table Mountain, Washington (elevation 1430–1550 m), between June and September 2008. The area is characterized by dry coniferous forest with heavy snowfalls (typically 2–3 m). Species collected were the Columbia Spotted Frog (*Rana luteiventris*), Cascades Frog (*Rana cascadae*) and Northern Pacific Treefrog (*Pseudacris regilla*). Animals were hand collected during visual surveys and held individually in clean plastic bags until processing. The sample size at each site was determined by plotting the cumulative number of sampled individuals within a species (x-axis) versus cumulative infection rate (y-axis) for that site. Sampling ended once this plot had stabilized at a plateau, because further sampling would have had little effect on the overall estimate of prevalence.

After capture, skin cells were collected from each frog by swabbing its ventral surface vigorously for fifteen seconds. Swabs were stored in sterile 1.5 ml mirocentrifuge tubes filled with 70% ethanol, and kept at -20°C until they were processed. We also recorded snout–vent length, sex, presence of secondary sexual characteristics, and the presence of typical signs of *Bd* infection (e.g., redness, skin lesions, lethargy, etc.; as in Pessier et al. 1999) for each individual. In addition, the digit second from the outside on the right hind limb of each frog was removed to prevent resampling. Toes were preserved in 70% ethanol and frozen at -80°C. Field gear was sterilized between sites and a clean pair of powder-free latex gloves was used per frog to prevent the spread of infection.

To identify the presence of *Bd* in the samples, skin cells were dislodged from swabs by vortexing for 15 sec. The swabs were removed and the remaining mixture was centrifuged at 13,400 rpm for 7 min. The supernatant was removed and the pellet was resuspended in 20 mL distilled water. Approximately 10 ml of this mixture was then mounted on a glass slide and examined using differential interference contrast microscopy for *Bd* zoosporangia. A sample was considered

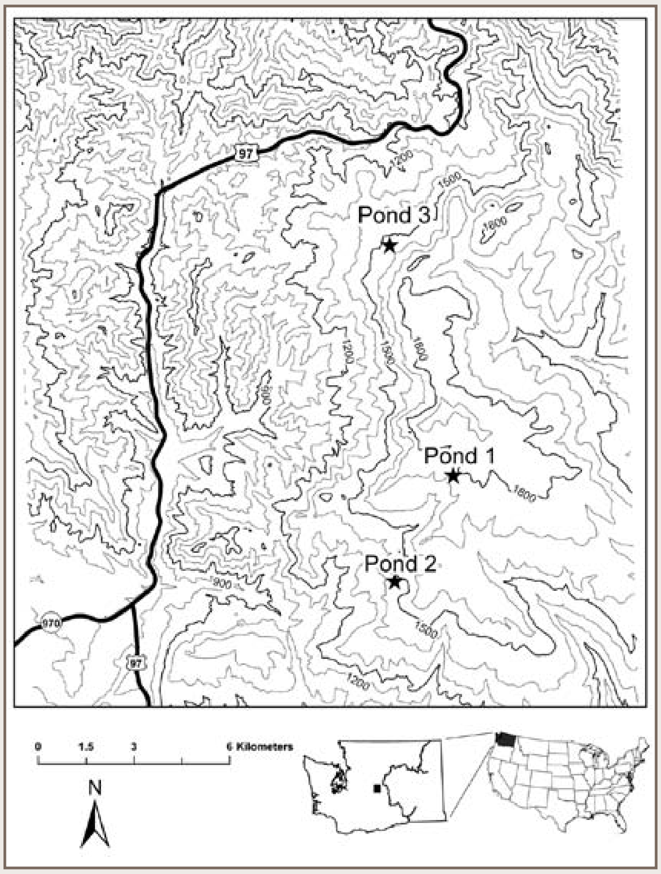

FIG. 1. Sites surveyed for *Batrachochytrium dendrobatidis* on Table Mountain in central Washington, USA, west of the Columbia River (see inset) and east of Highway 97.

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Table 1. Adult and juvenile amphibians that tested positive (+) or negative (–) for *Batrachochytrium dendrobatidis* in central Washington, USA. Species were *Rana cascadae* (RACA), *Rana luteiventris* (RALU), and *Pseudacris regilla* (PSRE).

Site	Latitude / Longitude	Elevation (m)	Total Sample Size	Species	No. Adults +	No. Adults –	No. Juveniles +	No. Juveniles –
Pond 1	47.14223°N, 120.34485°W	1760	39	RACA	12	10	2	7
				PSRE	3	5	0	0
Pond 2	47.12467°N, 120.36016°W	1430	22	RACA	0	5	11	4
				PSRE	0	0	1	1
Pond 3	47.18142°N, 120.35890°W	1540	35	RACA	10	8	0	2
				RALU	7	6	1	**1**

negative if no *Bd* structures were found within 10 min. of searching.

We found *Bd* at all sites and in all species sampled. Overall, 49% of the anurans tested positive for *Bd* (Table 1). *Pseudacris regilla* had the lowest infection rate of 40%, whereas *R. cascadae* and *R. luteiventris* had infection rates of 52% and 53%, respectively. Fifty percent of juveniles and 52% of adults tested positive for *Bd*. Across sites, the adult infection rate ranged between 50% and 63%, and the juvenile infection rate ranged between 22% and 50%. None of the differences in infection rate between species, sex, pond site, and life stages were significantly different when compared using contingency tables. No frogs showed the typical signs of infection (i.e., redness, bleeding, lethargy, etc.) and no dead frogs were found during collection.

We report some of the first published accounts of *Bd* in central Washington State, USA and our data are consistent with other studies within the state (Hayes et al. 2009; Pearl et al. 2009), but we observed a higher prevalence than samples from the Northeastern USA (Longcore et al. 2007). Histological methods that sample from clipped toes are known to be less sensitive than PCR methods for detection of *Bd* (Hyatt et al. 2007). We maximized sensitivity by swabbing ventral skin, where zoosporangia are more likely to be found (Berger et al. 2005). Whereas our methods are very unlikely to yield false positives, it is possible that false negatives occurred when infection loads were very light. Considering our conservative methods, our infection rates are very high and consistent with the data of Pearl et al. (2009) for *R. pretiosa*. The high infection rates are very similar between the sites and among the species used in our study. More study is needed to determine if any significant differences exist in *Bd* prevalence at larger spatial and temporal scales (Kriger and Hero 2007). Given that the infected individuals appeared asymptomatic and no dead frogs were found (again similar to the observations of Pearl et al. 2009), the current impact of *Bd* on Washington amphibians is unclear; more study is needed to accurately determine the extent of the threat posed by this pathogen.

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First Detection of Ranavirus in *Lithobates pipiens* in Quebec

Ranaviral disease and chytridiomycosis are emerging infectious diseases implicated in mortality events among wild and captive amphibians (Chinchar 2002; Daszak et al. 1999; Longcore et al. 1999). Ranaviral disease is caused by infection with members of the genus *Ranavirus* and afflicts both larval and adult amphibians (Gray et al. 2009). Chytridiomycosis is a cutaneous disease caused by the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) that occurs only in postmetamorphic amphibians, although larvae can be infected (Berger et al. 1998). Both were recently listed as notifiable diseases by the World Organization for Animal Health (Fisher et al. 2009; Gray et al. 2009).

In Canada, amphibian die-offs associated with ranaviruses have occurred in the provinces of Saskatchewan, Manitoba, Ontario, and New Brunswick (Bollinger et al. 1999; Charbonneau 2006; Greer et al. 2005; Forzàn et al. 2009; Jancovich et al. 2005; Schock et al. 2008). *Bd* is present in several Canadian provinces and may have caused population declines in the past (Carey et al. 1999; Deguise and Richardson 2009; Ouellet et al. 2005; Schock et al. 2009). This report describes the incidental detection of ranaviral infection in frogs during their collection for experimental use, the first record of infection of this type in amphibians from Quebec, Canada.

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Methods.—In late July 2007, Northern Leopard Frogs (*Lithobates pipiens*) intended for experimental use were caught with nets, in grass and near a pond situated in a privately-owned wildlife preserve in Boucherville, Quebec (45.6477°N, 73.4350°W). Upon capture, small groups were temporarily held in moistened cotton bags and transferred to iceboxes containing pond water. A total of 400 metamorphs and 5 adults were screened for deformities, and except for four unilaterally anophthalmic (missing one eye) and two ectromelic (missing leg below the femur) metamorphs (Table 1), all animals appeared clinically healthy. As only 175 young-of-the-year frogs were required for the planned experiment, these were measured (mean snout–vent length ± SD: 29.95 ± 1.31 mm), transferred to a single icebox holding pond water, and transported to the laboratory. The additional animals were released on site.

In a laboratory held at 22 ± 0.9°C, the froglets were housed in groups of 10 inside tilted 33-L aquariums that contained 2 L of dechlorinated water, to acclimate prior to experimental use. Feces were removed and live crickets were provided daily. Within three days of capture, 7 out of 175 frogs (4%) died; five among them exhibited erythema (i.e., reddening) of the thighs and ventrum. To stabilize the animals, the survivors were individually isolated in 1.84-L plastic shelters containing 50 ml of dechlorinated water, along with platforms to allow them to exit the water. They were also fed crickets injected with tetracycline (50 mg/kg frog weight dissolved in double distilled water) to eliminate potential pathogenic bacterial infections. However, frogs only received half of the recommended dose (i.e. once rather than twice daily) due to time constraints. Mortality reached 40% (70 out of 175 frogs) within eight days of capture, then slowed and was not recorded.

In early August 2007, 100 more juvenile Northern Leopard Frogs were collected from the same site, and they all

Table 1. Prevalence (%) of infection by two pathogens and of two types of deformities in juvenile Northern Leopard Frogs (*Lithobates pipiens*) collected in the Parc de la Frayère located in Boucherville, Quebec, Canada, in 2007.

Occurrence	N	Prevalence (%)
Ranavirus	20	85
Batrachochytrium dendrobatidis	20	0
Unilateral anophthalmia	500	0.8*
Ectromelia	500	0.4*

* Five adult frogs that were captured did not exhibit deformities.

appeared healthy. The first 20 were captured by hand, immediately isolated for transport in individual Ziploc® containers holding dechlorinated water, and used only for disease testing; separate gloves were always worn to handle each individual. The other 80 were captured and transported together in an icebox as before, and used to replace dead frogs for the planned experiment.

In the laboratory, the 20 isolated test frogs were swabbed three times over the abdomen, back, thighs, vent, and plantar surfaces of all feet with two sterile cotton swabs. They were immediately killed by immersion in 0.8% tricaine-methanosulfonate (MS-222) and frozen for later necropsy. The swabs were inserted into autoclaved Eppendorf tubes for PCR analysis, to test for ranaviral and *Bd* infections. The other 80 frogs were immediately housed in separate containers, prophylactically administered tetracycline using the same methods and dosage frequency (i.e., once daily) as before, and monitored for signs of disease.

Frog swabs were rehydrated in nuclease-free water for 2 h, vortexed at high speed for one minute and centrifuged briefly. Sample homogenates were then extracted using a QIAamp DNA mini kit (Qiagen, Canada) following manufacturer's specifications. To test for *Bd*, a real-time PCR assay designed to target the ITS1 gene of the fungus (Boyle 2004) was run using an Agpath ID PCR kit (Applied Biosystems, Canada). To test for ranavirus, a conventional PCR assay targeting the major capsid protein (MCP) gene of frog ranavirus (GENBANK Accession Number M19872) was performed using illustra puReTaq RTG PCR beads (GE Healthcare, Canada), and primers designed using DNASTAR software (DNASTAR Inc., USA), at the Department of Veterinary Pathology, Western College of Veterinary Medicine, Saskatoon, Saskatchewan (Anita Quon, pers. comm.). Each bead was hydrated in a total volume of 25 µl containing 1 µl each of forward primer MCP-1 (5'-GCA GGC CGC CCC AGT CCA-3') and reverse primer MCP-2 (5'-GGG CGG TGG TGT ACC CAG AGT TGT-3'). The PCR reaction produced a 482 base pair product which was resolved on a 2% agarose gel and visualized using UV light.

Selected samples that tested positive for frog ranavirus DNA were sequenced by first cleaning the PCR products with a microcon column system (Millipore, Canada). Samples were then diluted 1:10 and run using a Big Dye Terminator v.3.1 cycle sequencing reaction followed by a BigDye Xterminator purification reaction. Purified sequencing samples were run on an Applied Biosystems 3130 genetic analyzer.

Results.—Within 9 weeks of capture, 22 of the 80 (27.5%) newly-captured frogs intended for experimental use died (N = 17) or were killed (N = 5) due to severe ulceration. Signs of disease that the 22 frogs exhibited included anorexia (N = 16), erythema of the hind limbs (N = 16), ulceration on the limbs (N = 5) exposing bone tissue in one case, papillary constriction (N = 1), excessive shedding of the skin (N = 1), petechiation (pinpoint intradermal hemorrhaging) on the chest, and loss of the righting reflex (N = 1). Immediate necropsy of 3 of these frogs revealed white hepatic foci in one case.

Necropsy of the 20 test frogs revealed no signs of disease. However, while the results of the PCR analyses indicated that none of the frogs were infected by *Bd*, 17 of 20 (85%) were infected with a ranavirus (Table 1). DNA sequencing determined the three sequenced viruses to be a 100% match to FV3 (accession number DQ897669) over the PCR target segment.

Discussion.—Our results provide the first documentation of ranavirus infections in Quebec, and suggest that ranavirus can reach a high prevalence (85%) in juvenile Norther Leopard Frogs. While our swab-based screening may have underestimated ranavirus infections, which at least initially may be internal, thus producing false negatives (Gray et al. 2009), the chances of false positives due to surface contamination by virions (Gray et al. 2009) are minimal since the metamorphs were captured on land, where virus persistence outside of hosts is limited, and they were immediately isolated. Our results also suggest, although we cannot be definitive, that these ranavirus infections can be quite lethal. In two groups of metamorphs brought into the laboratory, a sizeable fraction (40% and 27.5%, respectively) died, often with signs that are consistent with ranavirus infection. Only in the latter group was ranavirus identified, and even then we cannot be sure that it was the cause of the mortality, but it is known that *L. pipiens* are susceptible to ranavirus infection (Granoff et al. 1965; Schock et al. 2008), so this seems to be a reasonable hypothesis.

While none of the 20 test frogs tested positive for infection by *Bd*, we were not able to establish that the population was *Bd*-free. Assuming a large population of Northern Leopard Frogs in the area (e.g., 10,000), and given the fact that only 20 frogs were tested for *Bd*, a prevalence of infection as high as 13.9% could have gone undetected in this case (Cannon and Roe 1982). In the surrounding regions of Quebec, prevalence of infection by *Bd* may fall below this level in amphibian populations during the summer and winter months (Ouellet et al. 2005). Thus, although our result may reflect an absence of *Bd* infection in this population (Tennessen et al. 2009; Woodhams et al. 2008), it may also reflect insufficient sampling effort (Speare et al. 2005) or seasonal patterns of infection prevalence (Ouellet et al. 2005).

We recorded four incidences of unilateral anophthalmia among 500 (0.8%) examined froglets. This appears to be a rare condition in Northern Leopard Frogs, and in amphibians generally (Harris et al. 2001; Hoppe 2000; Johnson et al. 1999; Ouellet et al. 1997; Schoff et al. 2003). Although we did not examine the afflicted eyes for a causal mechanism of the malformation, the ranavirus FV3 was recently associated with reduced eye size in a metamorphic Green Frog (*Lithobates clamitans*) (Burton et al. 2008). Hence, an investigation into possible links between ocular malformations and ranaviral infection may be worthwhile.

In conclusion, juvenile Northern Leopard Frogs from a population in Quebec, Canada tested positive for ranaviral infection without manifesting signs of disease. Untested frogs from the same population developed signs of ranaviral disease (Gray et al. 2009), and some among them died. We cannot affirm ranaviral infection as the cause of death, as a full veterinary diagnostic analysis was not conducted on the dead frogs. It is also not known whether the stress of transport and the captive conditions exacerbated the infections, whether the virus is persistent in this population, or what impact it may be having. It is nonetheless important to note this as the first detection of a ranavirus in an amphibian population from Quebec, making this the fifth Canadian province in which a virus of this type has been found.

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Occurrence of *Batrachochytrium dendrobatidis* in Amphibians of Wise County, Virginia, USA

Batrachochytrium dendrobatidis (*Bd*) has been implicated as a deadly pathogen at least partially responsible for global amphibian declines (Berger et al. 1998; Daszak et al. 1999; Stuart et al. 2004). Despite this fungal pathogen being considered as an invasive species (Weldon et al. 2004), we lack knowledge regarding its geographic distribution in many regions (e.g., www.Bd-maps.net). In addition, there is a significant knowledge gap concerning which amphibian species are infected by *Bd* (Steiner and Lehtinen 2008). We address these knowledge gaps by assessing the occurrence of *Bd* in amphibians of Wise County, Virginia, USA. Wise County is located in southwest Virginia, in the heart of the Appalachian Mountains. Amphibian biodiversity, particularly caudate species richness, is high in this region (Lannoo 2005). It is of particular importance to assess the occurrence of *Bd* in the areas of high amphibian biodiversity and endemism because these areas could be more vulnerable to cross-contamination and potential losses. One previous study of *Bd* in Virginia, conducted in the Appalachian Mountains in Warren County, detected *Bd* on only one of 211 salamanders sampled (Gratwicke et al. 2011).

We sampled for *Bd* by collecting toe clips from Wise County, Virginia amphibians from April to September 2010. Toe clips, once collected in the field, were immediately preserved and stored in 1.0 ml of 70% ethanol in 2.0 ml screw-cap vial. In order to avoid cross contamination between toe clippings, all equipment and tools used for toe collection were rinsed in a 10% bleach solution. In addition, nitrile gloves were replaced between each amphibian collected and sampled. Once back in the laboratory, DNA extractions were completed using Promega® Wizard Genomic DNA Purification Kits (Promega® Corporation, Madison, Wisconsin, USA), following the manufacturer's instructions. Amplification of extracted DNA samples was completed using Fisher® BioReagents exACTGene PCR Kits (Fisher Scientific®, Fair Lawn, New Jersey, USA), using specific PCR primers for *Bd* (Bd1a and Bd2a) as reported by Annis et al. (2004). PCR was performed under the following conditions: an initial denaturation of 94°C for 5 min; 30 cycles of denaturation (94°C for 45 sec), annealing (50°C for 45 sec), extension (72°C for 1 min); and a final extension of 72°C for 5 min. PCR products, including both a *Bd* positive and *Bd* negative control, were visualized on ethidium bromide stained 1.0% agarose gel dissolved in 1X TAE buffer under ultraviolet light. A positive *Bd* test was confirmed by the presence of an approximately 300 kb band.

We collected 119 samples from 18 amphibian species (Table 1). Overall, 21 of 119 (17.6%) amphibians tested positive for *Bd*. Specifically, 15 of 21 (71.4%) *Bd*-positive samples were caudates and 6 of 21 (28.6%) were anurans.

To our knowledge, this is the first published report of *Bd* in amphibians of Wise County, Virginia. In addition, we are the first to report *Bd* in several caudate species, including *E. longicauda*, *E. lucifuga*, and *P. cinereus* (although, *Bd* has been documented to infect *P. cinereus* under laboratory settings; Becker and Harris, 2010). *Bd* occurrence here, despite being low, is not altogether surprising given that it has been

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reported in Virginia (Gratwicke et al. 2011; Rothermel et al. 2008), Pennsylvania and Tennessee (Groner and Relyea 2010; Todd-Thompson et al. 2009; Venesky and Brem 2008). What is interesting is the comparatively high *Bd* occurrence rate between our study and a recent study conducted in Warren County, Virginia. For example, Gratwicke et al. (2011) report an overall occurrence rate of approximately 2.1% in several caudate species, some of which were sampled for in our study, yet we report an overall occurrence rate of 17.6%. One possible explanation for this difference lies within *Bd* sampling methods. Gratwicke et al. (2011) used cotton-tipped swabs for sample collection, while our study collected tissue samples via toe clipping. Future studies could examine whether there is a *Bd* detectability difference between skin surface swabs versus tissue collection via toe clipping. *Bd* surveillance and amphibian population monitoring should continue in this region to determine the extent and polarity (whether increasing or decreasing over time) of infection in amphibians of the Appalachian Mountains, and potential effects of this infection. Amphibian population losses are alarming; but, in an area of high amphibian endemism such as the Appalachian Mountains, the potential loss of biodiversity is potentially further magnified.

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Table 1. Prevalence of *Batrachochytrium dendrobatidis* in amphibians of Wise County, Virginia, USA.

Species	No. infected / total sampled	Prevalence of infection
Caudata		
Desmognathus fuscus	2 / 12	0.167
Desmognathus monticola	1 / 12	0.083
Desmognathus ochrophaeus	1 / 1	1
Desmognathus quadramaculatus	1 / 3	0.333
Eurycea cirrigera	5 / 21	0.238
Eurycea longicauda	1 / 3	0.333
Eurycea lucifuga	1 / 4	0.25
Notophthalmus viridescens	1 / 9	0.111
Plethodon cinereus	1 / 3	0.333
Plethodon glutinosus complex	1 / 15	0.067
Plethodon richmondi	0 / 5	0
Anura		
Anaxyrus americanus	1 / 6	0.167
Hyla chrysoscelis	3 / 9	0.333
Pseudacris crucifer	0 / 2	0
Lithobates catesbeianus	0 / 10	0
Lithobates clamitans	0 / 1	0
Lithobates palustris	1 / 2	0.5
Lithobates sylvaticus	1 / 1	1
Total	21 / 119	0.176

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Batrachochytrium dendrobatidis in *Siren intermedia* in Illinois, USA

We report the first case of *Batrachochytrium dendrobatidis* (*Bd*) in a wild-caught *Siren intermedia* from Illinois, USA. We add to the growing list of amphibian species susceptible to *Bd* infection in North America (Adams et al. 2007; Longcore et al. 2007; Ouellet et al. 2005; Pearl et al. 2007). Examples of fully aquatic salamanders with *Bd* originate from wild populations (*Cryptobranchus alleganiensis*, Briggler et al. 2007, 2008; *Andrias japonicus*, Goka et al. 2009), the pet trade (*Necturus maculosus* and *Siren lacertina*, Speare and Berger 2000), and zoos (*C. alleganiensis*, Briggler et al. 2007; *A. japonicus*, Goka et al. 2009). Internal parasitic helminth infections (McAllister et al. 1994) and two external copepod parasites (Frick 1999; Graham and Borda 2010) have been reported for Sirenidae, but our report is the first infectious disease of any kind reported in a wild-caught animal for this family (Hendricks 2005; Leja 2005; Moler 2005a, 2005b).

We sampled in a roadside ditch along Route 3 in Jackson County, Illinois (37.7241°N, 89.4634°W) on 9 March 2009 (1800–1830 h). Emergent vegetation and accumulated sediments were present, typical of *Siren* habitat (Petranka 1998; Wells 2007). Temperatures of the sampling date varied from 0°C (daily low) to 18°C (daily high); water temperature at time of sampling was 17°C. We captured two *S. intermedia* (SVL_1 = 132.1 mm, $Mass_1$ = 18.5 g; SVL_2 = 75.4 mm, $Mass_2$ = 3.9 g).

We handled sirens with latex powder-free gloves, and kept them in clean plastic sandwich bags filled with on-site water until we completed all data collection on site at which point we released all animals. We gently wiped each animal with a standard rayon-bud swab along their body lengths' ventral surfaces, as well as the front limbs (Hyatt et al. 2007). We stored the swab at room temperature in 70% ethanol until we ran real-time quantitative PCR analysis for *Bd*.

We used standard *Bd* DNA extraction and real-time PCR protocols (Hyatt et al. 2007), except we ran single samples instead of in triplicate to reduce costs (Kriger et al. 2006). Running single samples instead of triplicate is currently accepted as a reliable practice for *Bd* assessment (e.g., Vredenburg et al. 2010; Kriger et al. 2006). We used standards (i.e., 100, 10, 1, and 0.1 zoospore equivalents) and negative controls to ensure repeatability and continuity between runs.

The larger of the two *S. intermedia* that we captured tested positive for *Bd* (3.14 zoospore equivalents) while the other had no infection.

Because of their secretive nature (Petranka 1998) and the lack of population information (Leja 2005), the effect of *Bd* on Sirenidae populations is not known. Previous research on populations of fully aquatic salamanders in natural habitats is limited to *A. japonicus* in Japan (Goka et al. 2009) and *C. alleganiensis* in the Ozark Highlands, USA (Briggler et al. 2008). The former represents a commensal relationship that may have co-evolved with *Bd* over a long time period (Goka et al. 2009), while the latter identifies populations that have experienced declines likely resultant from synergistic negative effects of widespread *Bd* and other biotic and abiotic factors (e.g., habitat degradation, chemical contamination, introduced species, and commercial exploitation) (Briggler et al. 2008). We show that an individual *S. intermedia* carries a low-level *Bd* infection in Illinois. Future research should focus on if the fatal effects of chytridiomycosis are realized in Sirenidae.

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Low Prevalence of *Batrachochytrium dendrobatidis* Detected in Appalachian Salamanders from Warren County, Virginia, USA

Salamanders are one of the most important features of America's vertebrate fauna and the Appalachian region of the United States is a global salamander biodiversity hotspot (Young et al. 2004). Despite numerous studies of their biology at the species level, we have a poor understanding of overall threats to salamander biodiversity (Gratwicke 2008). We also have a poor understanding of the susceptibility of different salamander species to diseases, such as the fungus *Batrachochytrium dendrobatidis* (*Bd*). To date, there has been no systematic threat assessment of *Bd* on Appalachian salamanders, but several Appalachian salamander species are known to be susceptible to *Bd* in the wild including: *Ambystoma tigrinum* (Davidson et al. 2003); *Cryptobranchus alleganiensis* (Briggler et al. 2008); *Desmognathus conanti* (Timpe et al. 2008); *D. quadramaculatus* (Bartkus 2009); *D. fuscus* and *D. monticola* (Hossack et al. 2010); *Eurycea bislineata* (Grant et al. 2008); *E. cirrigera* (Byrne et al. 2008) and *Notophthalmus viridescens* (Bakkegard and Pessier 2010; Chatfield et al. 2009; Rothermel et al. 2008; Timpe et al. 2008; J. Ware and K. Duncan, unpubl.data; www.Bd-maps.net). *Bd* can also infect *D. monticola* and *Plethodon metcalfi* (Vazquez et al. 2009); *D. orestes* and *P. glutinosus* (Chinnadurai et al. 2009); and *P. cinereus* (Becker and Harris 2010; Becker et al. 2009) in laboratory settings. The effects of *Bd* on salamanders in both wild

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Table 1. Salamanders encountered and swabbed to test for *Batrachochytrium dendrobatidis* (*Bd*) as part of the 2009 salamander bio-blitz on the Smithsonian Conservation Biology Institute in Warren County, Virginia, USA.

	Total Counted	Total Swabbed	*Bd* Positives	Number of Sites
Eurycea bislineata	13	13	0	4
Desmognathus fuscus	4	4	0	2
Desmognathus monticola	134	25	1	5
Gyrinophilus porphyriticus	3	3	0	1
Plethodon cinereus	225	142	0	25
Plethodon cylindraceus	21	19	0	7
Pseudotriton ruber	4	4	0	4
Total	404	211	0	34

and laboratory settings, however, are extremely variable depending on temperatures, salamander species, and skin flora (Becker and Harris 2010).

There has been no systematic effort to monitor *Bd* throughout Virginia, although the disease has been detected on amphibians in: 1) Virginia at Mountain Lake Biological Research Station and Upham Brook (Rothermel et al. 2008); 2) the Shenandoah National Park (Grant, unpubl. data); and 3) on A*cris crepitans*, *Lithobates catesbeianus*, *L. clamitans*, *L. spenocephalus*, and *N. viridescens* in Richmond and Charles Counties (J. Ware and K. Duncan, unpubl.data; www.Bd-maps.net). In order to investigate the status of *Bd* and its potential impact on wild salamanders, we surveyed the *Bd* status of salamanders on the 3200-acre Smithsonian Conservation Biology Institute, Front Royal site (SCBI-FR) in Warren County, Virginia (38.893279°N, 78.152381°W). SCBI-FR occupies a low point (elevation range ~300–600 m asl) on the western slope of the Blue Ridge Mountains of Virginia, with a topography characterized by a series of rolling hills and small valleys. Wooded areas are mainly covered by mature secondary Eastern mixed deciduous forest, with Tulip Poplar (*Liriodendron tulipifera*), Pignut Hickory (*Carya glabra*), Black Gum (*Nyssa sylvatica*), Mockernut Hickory (*C. alba*), Red Oak (*Quercus rubra*), and White Oak (*Q. alba*) being the major dominant canopy species.

On 9 May 2009, a salamander bio-blitz event was held for 40 volunteer participants recruited from various local natural history and herpetology groups. Teams surveyed a total of seven stream sites that were selected by dividing each stream on the property into 500-m segments and then selecting stream segments for survey using a random number table. At each survey site, two 25-m transects were sequentially established along one stream bank and all cover objects 1 m either side of the transect line were searched. An additional 27 terrestrial transects were established by dividing the wooded portion of the property (excluding animal enclosures) into 1-km^2 blocks and using a random number generator to select 50 blocks; the transect was placed in the center of each block. At each site, two parallel 25-m transects were established 10-m apart from each other, running in a randomly assigned cardinal direction. All cover objects within 1 m of either side of the transect line were searched. Amphibians encountered in either survey were captured and identified to species level, and fresh powder-free nitrile gloves were used for each animal handled. The first 10 individuals of each species at each site were swabbed for *Bd* by rubbing a cotton-tipped swab 15 times in both directions along the salamanders' ventral surfaces and five times on each foot. Exact GPS coordinates for each specimen were recorded.

Swabs were stored dry at room temperature for four weeks before analysis. Anywhere from one to three swabs were incubated together in an oscillating thermal incubator at 56°C and 30 rpm in 400 µl of lysis buffer and 30 µl proteinase K (Qiagen) for 24 h. After incubation, DNA was extracted from the lysate solutions using a Qiagen Biosprint 96 DNA Blood Kit according to the instructions. Testing for the presence of *Bd* was performed using Qiagen's QuantiTect SYBR Green PCR Kit, using the primers ITS1-3Chytr and 5.8sChytr, developed by (Boyle et al. 2004). Positive and negative controls were included in both the extraction and the realtime-PCR reactions. A melt-curve analysis was used to ensure only *Bd* DNA was amplified. No contamination was present in the DNA or subsequent analysis of these swabs.

Seven salamander species (404 individuals) were encountered in the survey transects, and 211of these individuals were swabbed (Table 1). Only a single *D. monticola* swab tested positive for *Bd* (georeference 38.895383°N, 78.151369°W). Other amphibian species encountered on the property that day during unconstrained searches, but were not swabbed include: *Ambystoma maculatum; Anaxyrus americanus; Anaxyrus fowleri*; *Hyla versicolor*; *Lithobates catesbeianu;*, *Lithobates palustri;*, *Lithobates clamitans*; *Lithobates sylvaticus*; and *Pseudacris crucifer.*

We used a binomial distribution calculator (http://faculty.vassar.edu/lowry/binomialX.html) to calculate the maximum prevalence rate using a 95% confidence limit with our sample of 1 infected swab (success) from 211 salamanders (trials). Assuming 100% detectability on all animals swabbed, we estimate that overall prevalence rates in the combined aquatic and terrestrial salamander assemblage are lower than 2.1%. We did not have sufficient sample sizes to conduct species-specific prevalence rates.

Bd is present in salamanders at very low prevalence rates in Warren County, Virginia. Other studies testing for *Bd* on salamanders in the Appalachians found very low occurrences (Bartkus 2009). The actual level of threat that *Bd* poses to wild Appalachian salamander populations remains an unresolved question. *Bd* is very temperature dependent and varies seasonally, therefore, spring was selected as a time of year when temperatures are optimal for *Bd* (Longcore et al. 2007). The observed prevalence levels of less than 2.1% on the 3200-acre SCBI property at a time of year optimal for detecting the pathogen means that it is unlikely that *Bd* is significantly affecting the salamander populations at that site. Furthermore, our observations in Virginia are consistent with observations elsewhere in the Appalachian region, where others have found that although *Bd* appears to be widely distributed, it is found at low prevalence rates in aquatic salamanders (Bartkus 2009; Byrne et al. 2008; Hossack et al. 2010), but is uncommon in terrestrial salamanders (e.g., Chatfield et al 2009).

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Batrachochytrium dendrobatidis on the Endemic Frog *Litoria raniformis* in South Australia

Since the end of the 1970s, many mass mortalities and population declines of amphibians in Australia have been attributed to the chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*; Berger et al. 1998, 2004; Longcore et al. 1999). To date, 29% of 223 (62 native and one introduced species from four families) Australian amphibian species have been found to be infected with *Bd* (Murray et al. 2010). The pathogen is considered to be established in Queensland, New South Wales, Australian Capital Territory, Victoria, Tasmania, and Western Australia, however very little is known about its distribution in South Australia (Murray et al. 2010; Simpkins and Hero 2010; Speare and Berger 2005).

The Southern Bell Frog, *Litoria raniformis*, was once a common frog from southeastern South Australia, the Murray Darling Basin, most of Victoria, the Australian Capital Territory, southwestern New South Wales, and eastern and northern Tasmania (Cogger 1975). However, there are reports of serious declines and local extinctions in New South Wales and Tasmania (Obendorf and Dalton 2006; Wassens 2008), likely due to many factors including increased levels of ultra-violet radiation, possible changes in drought incidence and intensity, predation by the introduced mosquito fish, wetland drainage, and *Bd* (Pyke 2002; Wassens 2008). The species is listed as vulnerable both nationally and in South Australia. In South Australia, *Bd* infection of *L. raniformis* was reported from a captive specimen from Adelaide sampled in 1988 (Speare and Berger 2005) and from a wild-caught specimen from Mount Compass in the Mount Lofty Ranges sampled in 1998 (Murray et al. 2010). In Tasmania the presence of *Bd* in wild populations coincided with the locations of population declines of *L. raniformis*, and the species has been considered highly susceptible to chytrid infection (Obendorf and Dalton 2006; Speare and Berger 2005). Hence the existence of *Bd* in *Litoria raniformis* populations in other bioregions is expected. Also, in a preliminary molecular genetic survey of *L. raniformis*, Vörös et al. (2008) found two distinct genetic groups, one with an inland distribution and a second with a coastal distribution including Tasmania. The two groups have differences in their behavior and ecology (S. Wassens, pers. comm.) and hence could show different environmental sensitivity, including susceptibility to pathogens such as *Bd* (Daszak et al. 1999).

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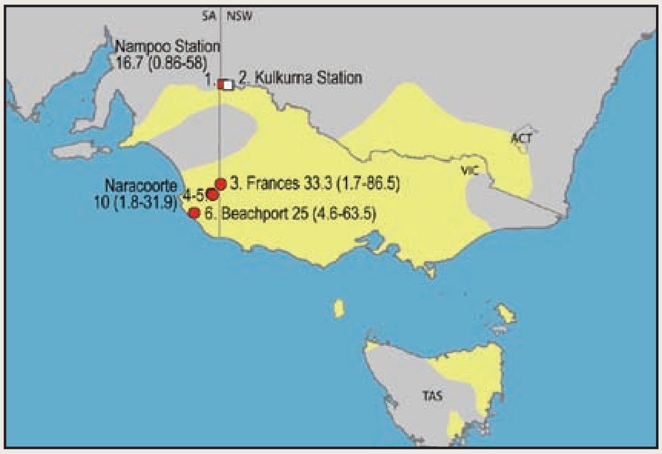

FIG. 1. Historical distribution of *Litoria raniformis* (yellow area) in Australia (after DEWHA 2008 and Thomson et al. 1996), and sampling locations in the Murray Darling Basin (□) and southeastern South Australia (●). Lines represent state borders between South Australia (SA), New South Wales (NSW), Victoria (VIC), Australian Capital Territory (ACT), and Tasmania (TAS). Numbers refer to localities indicated in Table 1. Locations where *Bd* was detected are marked with red and related prevalence and confidence intervals are presented.

Pounds et al. (2006) hypothesized that *Bd* is most prevalent in areas with cool temperature close to the fungus' optimum temperature of 23°C and the constant presence of free water. Hence, within the range of *L. raniformis*, the level of *Bd* infection is expected to be lower in the inland Murray Darling Basin, due to higher maximum temperature and recent extended serious drought conditions, than in coastal populations which have more maritime, cooler and moister, climate conditions (Kriger et al. 2007). The aim of our study was to conduct a pilot survey of the distribution of *Bd* on *Litoria raniformis* in two bioregions in South Australia, the Murray Darling Basin ("Lower Murray") and southeastern (SE) South Australia, representing the two different genetic groups described by Vörös et al. (2008).

We sampled both the Lower Murray and SE South Australia (Fig. 1) regions in early December 2008 and early February 2009. Because *L. raniformis* is active between November and March, our sampling represented the breeding season when frogs gathered in water bodies, which might facilitate the transmission of aquatic chytrid zoospores (Rowley and Alford 2007), and also allowed us to examine metamorphs before they left the water. In the Lower Murray, we sampled

Table 1. Prevalence of *Batrachochytrium dendrobatidis, Bd*, in adult and metamorph *Litoria raniformis* from six locations in two bioregions of South Australia, sampled in December 2008[a] and February 2009[b]. Location numbers are shown in Fig. 1.

Location	No. Analyzed (No. Positive) % Positive (95% CI)		Mean No. *Bd* Zoospores (SD)	
	Adults	Metamorphs	Adults	Metamorphs
Lower Murray - total	8 (1) 12.5 (0.64–50)	70 0 (0–5.36)	403.05 (8.83)	0
1. Nampoo Station (34.03°S, 141.15°E)	6 (1)[a] 16.7 (0.86–58)	0	403.05 (8.83)	0
2. Kulkurna Station (34.02°S, 141.03°E)	2[b] 0 (0–77.6)	70[b] 0 (0–5.36)	0	0
SE South Australia - total	35 (5) 14.3 (5.8–29.7)		2634.69 (5677.25)	
3. Frances (36.71°S, 140.95°E)	3 (1)[a] 33.3 (1.7–86.5)	0	157.95 (18.31)	0
4. Naracoorte airport road (36.98°S, 140.74°E)	4[a] 0 (0–52.7)	0	0	0
5. Naracoorte crayfish farm (36.97°S, 140.72°E)	20 (2)[a,b] 10 (1.8–31.9)	64[b] 0 (0–5.8)	101.325 (51.02)	0
6. Beachport (37.40°S, 140.12°E)	8 (2)[a] 25 (4.6–63.5)	0	6406.4 (9027.2)	0

frogs from the Murray River in New South Wales at two sites about 10 km apart at Nampoo Station, in December, and at Kulkurna Station, in February. Unfortunately, low population sizes, especially at Nampoo Station, limited our sampling. In SE South Australia, we sampled frogs from dams or weirs where the number of adult specimens was low. The largest population of *L. raniformis* was found in ponds in a crayfish (*Cherax destructor*) farm on private land in Naracoorte, where we were able to capture 13 adult specimens. Altogether we sampled 8 adults and 70 metamorphs in the Lower Murray (6 adults in December, 2 adults and 70 metamorphs in February), and 35 adults and 64 metamorphs in SE South Australia (28 adults in December, 7 adults and 64 metamorphs in February). We did not find larvae during either sampling period.

We collected samples from adult and juvenile frogs with skin swabs using sterile, single-use 7.5 cm applicators from Defries Industries Pty Ltd (Keysborough, Victoria, Australia). We used new gloves or plastic bags when handling each frog in order to prevent cross-contamination. Each frog was swabbed five times on the back, side, abdomen, groin, and webbing area. The swabs were stored frozen until processing (Van Sluys et al. 2008).

We used real-time PCR (Boyle et al. 2004) to detect *Bd*; this method allowed us to quantify the abundance of zoospores within a sample. We ran every sample in duplicate with a dedicated internal positive control (TaqMan Exogenous Internal Positive Control Reagents) for each sample that helps to identify inhibitors present in the DNA extractions. We considered a sample to contain *Bd* DNA only if both amplifications gave positive results. The templates were run and analyzed on a *Rotor-Gene 6000* real-time rotary analyzer (Corbett Life Science). Genomic equivalents (GE) for all positive samples were estimated from standard curves based on known positive controls, considering 0.1 as the minimum value indicative of infection. We estimated prevalence for each population as the proportion of individuals testing positive with 95% confidence intervals for each prevalence rate using the software Quantitative Parasitology (Rózsa et al. 2000). The same software was used to conduct a Chi-Square test to compare prevalence between the two regions, and a bootstrap 2-sample t-test (with 2000 bootstrap replications) for comparing mean abundances of zoospores between the two regions, separately for adults and metamorphs.

We detected *Bd* from 1 of 8 adults in the Lower Murray, and from 5 of 35 adults in SE South Australia (Table 1). No metamorphs were *Bd*-positive. We detected inhibition in extracts from three samples. All *Bd*-positive samples were collected in December, and all samples collected in February were *Bd*-negative. *Bd*-prevalence of the adult specimens did not differ between the two regions ($\chi^2 = 0.017$, $P = 0.895$), and the abundances of zoospores between the regions were similar ($P = 0.434$).

Although we detected *Bd* at low levels in natural *L. raniformis* populations in both bioregions of the species distribution in South Australia, the Lower Murray and SE South Australia, our sample sizes were generally low. Skerratt et al. (2008) recommended that sample sizes >59 be used when prevalence is low. Only two of our metamorph samples met this criterion, and *Bd* was not detected on these animals.

Several studies have shown that elevated temperatures and desiccation may limit the spread of the disease (Berger et al. 2004; Laurance et al. 1996). We studied two populations in two sites in the Lower Murray, where habitats are much more exposed to desiccation than in SE South Australia. One site was sampled in December where we detected one *Bd*-positive individual , and one site in February, which seemed to be free from *Bd*. In SE South Australia, which is a coastal bioregion with lower temperature and higher rainfall, a preferred habitat type of *Bd* (Berger et al 2004), we sampled four sites in December. *Bd* was present in 3 of 4 sites. At one site (Naracoorte crayfish farm) we managed to swab both in December (7 adults) and in February (13 adults and 64 metamorphs). Only adult specimens swabbed in December carried *Bd* (2), and no positive samples were found among the adults or metamorphs examined at the end of the summer. This finding is consistent with the hypothesis that summer high temperatures or low rainfall could reduce *Bd* abundance in the environment and on the frogs (Kriger et al. 2007). A more comprehensive assessment of *Bd* on *L. raniformis* is warranted, including a survey across its life cycle incorporating an assessment of seasonal and regional climate influences (Kriger and Hero 2007).

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Ranavirus Outbreaks in Amphibian Populations of Northern Idaho

Ranavirus outbreaks, caused by pathogens in the genus *Ranavirus* (Family Iridoviridae), were the largest single cause of reported amphibian mass mortality events in the United States from 1996–2001 (Green et al. 2002). Mortality events associated with ranaviruses have been documented on five continents and throughout the latitudes and elevations where amphibians occur (Gray et al. 2009). However, the threat of ranaviruses to amphibian and reptile populations in specific regions is still largely unknown (Chinchar 2002; Gray et al. 2009).

In Idaho, ranavirus was first documented as the cause of death for Tiger Salamanders (*Ambystoma tigrinum*) in 2000 near Yellowstone National Park (USGS 2001); however mass mortality events have not been reported since by the USGS National Wildlife Health Center (NWHC) in Idaho or the eastern parts of neighboring Washington and Oregon. In the Palouse region of north Idaho, multiple species of amphibians and aquatic reptiles, including Long-toed Salamanders (*A. macrodactylum*), Tiger Salamanders, Columbia Spotted Frogs (*Rana luteiventris*), Sierran Treefrogs (*Pseudacris sierra*), Western Toads (*Anaxyrus boreas*), Rough-skinned Newts (*Taricha granulosa*), and Painted Turtles (*Chrysemys picta*), co-occur at small man-made ponds where ranavirus could potentially be a threat. Here we report ranavirus outbreaks in two amphibian species (Columbia Spotted Frogs and Sierran Treefrogs) at two ponds in north Idaho during the summer and fall of 2009.

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In 2009, we visually-surveyed and trap-surveyed seven ponds in Latah County, Idaho, USA for amphibians during three seasons (spring, summer, and fall). All footwear and field equipment were disinfected using 10% bleach solution between pond visits to inactivate pathogens and prevent transmission of disease between ponds (Bryan et al 2009). During our survey period, we observed mortality events at two of the seven ponds, one documented on 17 July 2009 at Latah Trail Pond (46.4423°N, 116.4818°W) and one documented on 4 October 2009 at Mort Pond (46.4811°N, 116.5838°W).

We collected 14 dead amphibians (Table 1) for disease diagnostics. A new pair of nitrile gloves was used to handle and place each specimen separately in a new container. Specimens were preserved within 1 h of collection; those analyzed using PCR were preserved in 95% ethanol, and those used for histological analysis were preserved in 10% buffered formalin for 25 hours and then transferred into 70% alcohol. Unpreserved samples for inoculating cell lines were processed on the day of collection.

Dead specimens were analyzed by one of three laboratories to employ multiple methods for diagnostics and obtain independent evidence for causes of death. The NWHC

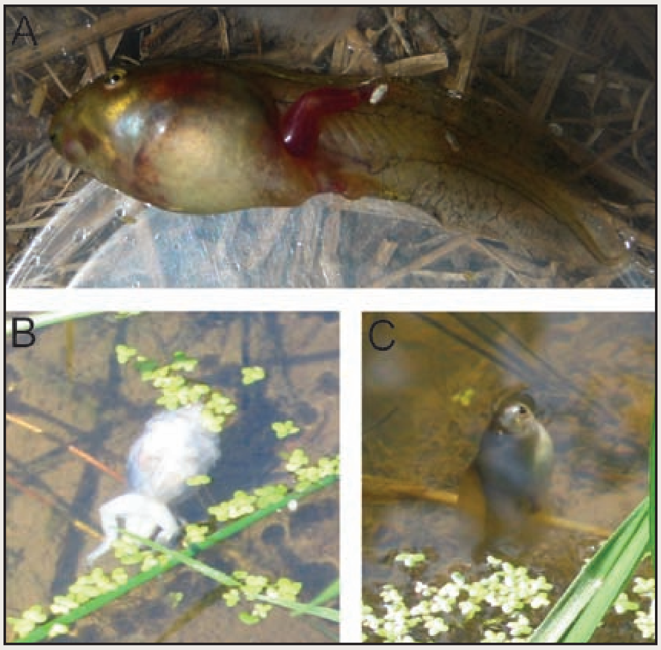

Fig. 1. Tadpoles with ranavirus infection, Latah County, Idaho, USA, 18 July 2009. (A) Columbia Spotted Frog with leg hemorrhage, (B) dead Sierran Treefrog, (C) moribund, bloated Columbia Spotted Frog.

analyzed five specimens using histology. At the NWHC, diagnostics for ranavirus were based on characteristic histological changes in the livers, spleens, mesonephroi, and blood vessels of the frogs. The U.S. Fish and Wildlife Service Idaho Fish Health Center (IFHC) analyzed five specimens using cell culture and PCR. At the IFHC, liver tissue was removed aseptically, ground with a Hank's balanced salt solution (HBSS), spun down, and incubated for 24 hours. Samples were then plated on *Epithelioma papulosum cyprini* (EPC), fathead minnow (FHM), and CHSE-214 (derived from Chinook Salmon) cell lines to culture virus. Ranavirus infection was confirmed using PCR with nested FV3 primers (Bollinger et al 1999; Kattenbelt et al 2000). The Laboratory of Conservation and Ecological Genetics (LCEG) at the University of Idaho analyzed three specimens using PCR and sequencing. To confirm the strain of ranavirus, DNA was extracted from tail-clips of three tadpole samples using a DNeasy Tissue Kit (Qiagen, Inc., Valencia, CA). DNA was amplified using MCP4 and MCP5 primers (Mao et al. 1997), and the resulting 508 base pair PCR product was sequenced with the amplifying primers using a 3130xl Genetic Analyzer (Applied Biosystems, Foster City, CA). Resulting sequences were compared with those in the GenBank database.

On the day before the mortality event was first observed at Latah Trail Pond, we had set 15 minnow traps throughout the pond overnight. We repeated trap sampling on 24 July 2009 at this location to compare amphibian captures seven days after the mortality event was first documented. In addition to trapping, we conducted visual surveys at this pond every other day during the mortality event where one person walked the perimeter of the pond for 5 minutes.

We observed a mass mortality event totaling approximately 200 Columbia Spotted Frog and Sierran Treefrog tadpoles, at least five Long-toed Salamander larvae, and at least seven adult Columbia Spotted Frogs at Latah Trail Pond on 17 July 2009. Another mortality event involving at least 12 adult Columbia Spotted Frogs was observed at Mort Pond on October 4, 2009. Due to the extremely small population sizes of the Columbia Spotted Frog in this system (Davis and Verrell 2005), we also consider the Mort Pond event a mass mortality. The probable cause of death in both cases was infection by ranavirus (Table 1). At Latah Trail Pond, dead and dying amphibians had clinical signs of ranavirus disease, specifically bloated abdomens, leg hemorrhaging, and irregular swimming (Bollinger et al.1999; Docherty et al. 2003; Jancovich et al. 1997; Fig. 1). Histological analyses indicated characteristic changes in livers, spleen, mesonephros, and blood vessels of frogs. DNA sequence for the major capsid protein gene was identical to several frog virus 3 (FV3) sequences (Tan et al 2004), including one from a Northern Leopard Frog (*R. pipiens*; Holopainen et al. 2009) and the *Terrapene carolina* ranavirus (TV3, Mao et al. 1997).

The mass mortality event at Latah Trail Pond lasted at least seven days, with the majority of carcasses found on the first day of observations. By the third day, the majority of amphibian carcasses were gone. Minnow traps at Latah Trail on 17 July captured 63 Long-toed Salamander larvae, 40 Sierran

Table 1. Dead amphibians collected from ponds and tested for ranavirus in Latah County, Idaho, following mass mortality events. Species are: Columbia Spotted Frog (CSF) and Sierran Treefrog (ST). Laboratory tests were conducted at the USGS National Wildlife Health Center (NWHC - full necropsy and viral cultures), the Idaho Fish Health Center (IFHC – viral cultures and PCR), and the Laboratory of Conservation and Ecological Genetics (LCEG - PCR and sequencing).

Pond	Date	Species	Age	N	Laboratory	Result
Latah Trail	18-Jul-09	CSF	Tadpole	3	LCEG	Ranavirus
Latah Trail	20-Jul-09	CSF	Metamorph	2	IFHC	Ranavirus
Latah Trail	20-Jul-09	ST	Tadpole	2	IFHC	Ranavirus
Latah Trail	20-Jul-09	CSF	Adult	2	IFHC	Ranavirus
Latah Trail	20-Jul-09	CSF	Adult	2	NWHC	Ranavirus
Mort	4-Oct-09	CSF	Adult	2	NWHC	Ranavirus
Mort	4-Oct-09	CSF	Adult	1	NWHC	Reproductive tract disease

Treefrog tadpoles, and 16 Columbia Spotted Frog tadpoles. Resampling on July 24 yielded only one tadpole and one adult Columbia Spotted Frog. In addition to amphibian mortality, one Painted Turtle at Mort Pond was found alive but lethargic, had difficulty breathing, and was unresponsive to handling, which are consistent with signs of ranaviral disease in turtles with TV3 (De Voe et al. 2004).

This study describes two mass mortality events due to ranavirus in north Idaho. Diagnostic tests indicated that this infectious disease was the cause of mass mortality of Columbia Spotted Frog tadpoles and adults and Sierran Treefrog tadpoles. The presence of sick and dead Long-toed Salamanders and a moribund Painted Turtle during the outbreak suggests that the virus may have affected additional species, however, we did not conduct diagnostic tests on these species. We identified the north Idaho ranavirus as FV3 using sequence from the major capsid protein. Ranaviruses identified as FV3 are multi-host pathogens with a large geographic range in North America (Schock et al. 2008).

Our trapping data indicate that the summer ranavirus outbreak we observed may have removed much of the reproductive output for Latah Trail Pond in 2009. While the drop in trap captures could have been due to metamorphosis during the weeklong mortality event, most tadpoles were several stages from metamorphosis at the beginning of the outbreak (Fig. 1), making this unlikely. As long as ponds in the area do not experience mass mortality events simultaneously or continuously, the high amount of gene flow between sites (Goldberg and Waits 2010) should help maintain population persistence for Columbia Spotted Frogs. Gene flow, however, may also indicate high potential for pathogen transmission. Columbia Spotted Frogs in this region experience a range of stressors and have low numbers of breeding adults (Davis and Verrell 2005). Local populations are subject to aerial spraying of pesticides, disturbance by cattle [which has been shown to increase prevalence of FV3 in Green Frog (*Rana clamitans*) tadpoles (Gray et al. 2007)], and infection by *Bd* (since at least 2004 for Latah Trail and 2005 for Mort; CSG and LPW, unpublished data), among other factors. Additional population monitoring will be required to detect any long-term impacts of the observed mass mortality events on these populations.

Our observations underscore the difficulties of detecting ranavirus outbreaks. Due to variation in timing of metamorphosis and the short time frame in which the visual evidence of mortality was gone (ca. 2 days), it could be difficult to distinguish a mass mortality event from a metamorphosis and dispersal event. Ranavirus outbreaks are therefore likely underreported and may represent a greater threat to native amphibians than currently recognized.

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HERPETOCULTURE

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Effects of Captivity on Female Reproductive Cycles and Egg Incubation in Ball Pythons (*Python regius*)

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Although published studies on reproductive data from wild populations of snake species are widely available (Brown and Shine 2007b; Farrell et al. 2009; Luiselli et al. 1996; Madsen and Shine 1996; Slip and Shine 1988), comparatively few publications have presented reproductive data from large populations of captive snakes over multiple years. Specifically in pythons, the studies that have been published on captive populations have generally been on small sample sizes (N < 30 clutches), and have been limited to reporting averages and ranges for reproductive traits (Barker and Barker 2006; de Vosjoli et al. 1994; Ross and Marzec 1990). The larger sample sizes and correlative data generated in studies on wild snake populations have provided researchers with the ability to study various aspects of reproduction such as: optimal clutch size (Aubret et al. 2003; Brown and Shine 2007b), repeatability of reproductive traits (Brown and Shine 2007b; Farrell et al. 2009; Ford and Seigel 2006), non-linear correlation between female size and snout–vent length (Brown and Shine 2007a; Luiselli et al. 1996; Madsen and Shine 1996), and female reproductive frequency (Farrell et al. 2009; Madsen and Shine 1996; Slip and Shine 1988). Comparable research in captive populations could provide a foundation for the development of captive breeding programs to increase reproductive efficiency. Knowledge such as this has been used to significantly increase breeding efficiencies in livestock animals for decades (reviewed in Hackmann and Spain 2010; Harris 1998). Moreover, an enhanced understanding of python reproductive traits and the correlations between them could increase success in reproducing endangered species, and other species that have been problematic to breed in captivity; such as the Black Python (*Morelia boeleni*) (Austin et al. 2010).

A commercial reptile breeding company, The Snake Keeper, Inc. (Spanish Fork, Utah) has been breeding Ball Pythons (*Python regius*) in captivity for over 20 years. Since 2002 they have been collecting reproductive data on their Ball Python breeding colony. During this time they have collected data on 5344 eggs from 783 clutches. A review of these extensive data provides novel information about Ball Python reproduction and how various reproductive traits are associated with each other. Data presented in the present study on the duration of reproductive events in Ball Pythons are similar to data that have been published previously (Barker and Barker 2006; de Vosjoli et al. 1994; Ross and Marzec 1990). Novel data presented in this study supply information about age at first reproduction, frequency of female reproduction, effects of desiccation on hatch rate, and optimal clutch size. A correlation matrix for reproductive traits is also provided. These data provide a foundation for the design of future experiments, and for enhancing efficiencies of current and future breeding programs.

Materials and Methods.—Adult Ball Pythons were housed in individual cages measuring 81 cm L x 43 cm W x 18 cm H with mesh tops within rack systems (Fig. 1). The substrate used in the caging was chipped aspen bedding. Water was available *ad libitum* and whole prey was offered each week. During the warm months (March to October), the rodents offered were approximately 95 g, and during the breeding season (November to February) they were approximately 65 g. The ambient temperature was controlled from March to October to prevent it from exceeding 29.5°C, and November to February from dropping below 21°C. Throughout the year, a hot spot was available in each cage that was 32°C during the day and 29.5°C at night. Humidity was maintained in the breeding facility at approximately 60% year round by a Humidifirst MP15 ultrasonic humidifier (Humidifirst, Inc., Boynton Beach, Florida).

From November to June, females >1500 g were placed in the cages of males >500 g for one to two days and any observed breeding activity was recorded. An attempt was made to ensure that each female was bred at least once each month during this time. Once females were gravid, they were no longer placed with males. The date was also recorded for the following reproductive events when they were observed: ovulation, post ovulation shed, oviposition, and hatching.

Fig. 1. Rack system used to house adult Ball Pythons.

Fig. 2. Female Ball Python brooding a clutch of eggs in which one egg was excluded from her coils.

Gravid females were checked daily for eggs once they were 30 days past their post-ovulation shed. Eggs were removed immediately from each female, weighed as a clutch, counted, separated, weighed individually, measured (length and width), and placed into an incubation box that was then placed in the incubation room. Each female was also weighed at this time, and a relative clutch mass (RCM) was calculated by dividing the mass of the clutch by the post oviposition mass of the female. The age of the sire and dam at the time of oviposition, when known, was also recorded. From these data, the age at first reproduction was recorded for all the breeders that first reproduced in 2003 or later. In addition, for each female that laid two or more clutches between 2003 and 2009, the number of years between reproductive events (inter-oviposition interval) was recorded as the female reproductive frequency.

The incubation boxes used were Styrofoam shipping containers that measured 28.5 cm L x 39 cm W x 18 cm H externally and were 2.4 cm thick. The incubation medium used in these boxes was a mixture of one part perlite and two parts vermiculite. Five parts incubation medium to one part water by volume was then mixed, and the box was placed in the incubation room several days prior to incubating eggs in order to allow the contents of the box to reach incubation temperatures. The top of each incubation box was covered with a 1 cm thick pane of glass. The incubation room was temperature controlled by a Helix DBS 1000 (Helix Control Systems, Inc, Vista, California) to stay between 31.4°C and 31.7°C from 2002–2005, and between 30.9°C and 31.1°C from 2006–2009.

Data were also collected per egg on whether the egg was infertile, died during incubation, contained a fully formed embryo that was dead in the egg, embryo was live but deformed, or contained a healthy hatchling. For the eggs that hatched, the hatch date was recorded for each egg and each hatchling was weighed. After hatching, a hatch rate was calculated for each clutch. For the calculation of average oviposition and hatch dates over the years, both oviposition date and hatch date are reported as number of weeks of the year.

GraphPad Prism 5.0 was used for all statistical analyses performed in this study. All traits were analyzed for normality and homoscedasticity and transformations were made when needed. Female mass and clutch mass were log-transformed prior to use in any statistical analyses.

Results.—Data were collected on 5344 eggs from 783 ball python clutches between 2002–2009. Novel information from these data include sire and dam age at first reproduction, dam reproductive frequency, and duration from last copulation to oviposition. A comprehensive summary of clutch, breeder, reproductive event, and egg data is presented in Table 1.

Table 1. Mean, standard error (SE), minimum, maximum, and sample sizes for the data collected.

	Mean	SE	Min	Max	N
Clutch Info					
Clutches/Year	97.88	22.73	34	192	8
Week Laid	23.90	0.19	4	52	708
Clutch Size	6.83	0.06	3	14	783
Clutch Mass (g)	604.61	6.69	91	1270	775
Female Mass (g)	1464.97	11.29	830	2874	759
RCM	0.42	0.004	0.07	0.71	758
Breeder Info					
M Age	4.30	0.08	1	13	605
M Age at 1st Rep	2.25	0.04	1	6	354
F Age	6.08	0.09	2	18	771
F Age at 1st Rep	3.96	0.06	2	8	321
F Rep Frequency	1.97	0.05	1	6	251
Reproduction Events (days)					
Last Copulation to Oviposition	97.18	1.06	46	174	558
Ovulation to Shed	19.64	0.29	12	32	125
Shed to Oviposition	31.36	0.25	15	46	321
Ovulation to Oviposition	51.52	0.48	37	78	155
Shed to Hatch	90.35	0.31	78	111	285
Oviposition to Hatch	58.87	0.07	53.25	66	582
Ovulation to Hatch	110.84	0.58	99.71	137	139
Egg Info					
Egg Length (mm)	75.71	0.24	42.08	99.8	759
Egg Width (mm)	45.39	0.14	24.15	54.4	757
Week Hatched	32.37	0.18	19	51	597
Hatchling Weight (g)	62.20	0.31	27.25	90.2	685
Infertile/Clutch	0.77	0.06	0	10	783
Egg Died/Clutch	0.35	0.03	0	7	783
Dead in Egg/Clutch	0.10	0.03	0	12	783
Deformed/Clutch	0.13	0.02	0	4	783
Healthy Offspring/Clutch	5.49	0.09	0	12	783
Hatch Rate	0.81	0.01	0	1	783

During this study, 27 clutches (3.4%) were recorded as having been found late (> 24 h post oviposition). The clutch mass, RCM, number of healthy offspring, hatch rate, egg length, egg width, and hatchling mass averages were compared between these 27 clutches and averages from all the clutches from this study (Table 2). Student's *t*-test was used on all data except hatch rate for which Mann Whitney test was used due to extreme non-normality.

Oviposition anomalies, such as exclusion of eggs from the dam's coils or early laying of eggs, occasionally occur during the laying season (Fig. 2). Excluded eggs or early eggs were found in 15 (1.9%) and 7 (0.89%) of the clutches, respectively. The RCM, female mass, and clutch mass averages from clutches with one or more eggs found outside the coils of the female and those laid > 24 h prior to the rest of the clutch were compared to the averages from all the clutches from this study (Student's *t*-test) (Table 3). Figure 3 presents the hatch rates calculated for: eggs that were found outside the female's coils (OE), clutches that had eggs pushed outside the coils (OC), eggs that were inside the coils from outside egg clutches (OC - OE), eggs that were laid early (EE), clutches with eggs that were laid early (EC), the eggs that were laid with the majority of the clutch from laid early clutches (EC - EE), and all clutches in this study (ALL). Statistical differences were calculated using the Mann-Whitney test due to extreme non-normality.

In order to analyze relationships between the reproductive traits measured in this study, a Pearson correlation matrix was generated (Table 4). Strengths of correlations are termed as follows: 0.0 to 0.2, negligible; 0.2 to 0.4, weak; 0.4 to 0.7, moderate; 0.7 to 0.9, strong. Among the

28 correlations, 25 (89%) were significant at the $P < 0.05$ level, and 16 (57%) were above negligible strength ($r > 0.2$).

Discussion.—Information regarding reproductive traits of captive snakes is sparse. Published reports on pythons are limited to small sample sizes, and to discussing averages and ranges for reproductive traits. Previous studies specifically on ball pythons have reported average clutch sizes, duration from ovulation to post-ovulation shed, duration from post-ovulation shed to oviposition, RCM, egg length, egg width, egg mass, and duration of incubation (Barker and Barker 2006; de Vosjoli et al. 1994; Ross and Marzec 1990; Van Mierop and Bessette 1981). These data have been widely used by private and professional python breeders in order to increase breeding efficiencies. Similar data presented in this study (Table 1) provide larger sample sizes for these traits, and the results are similar to those published previously (Barker and Barker 2006; de Vosjoli et al. 1994; Ellis and Chappell 1987; Ross and Marzec 1990). In addition, this study provides data on the time duration from last copulation to oviposition.

For the 783 clutches studied from 2002 to 2009, an average of 97.88 clutches were laid per year. Although ball pythons in this study appeared to generally be pulse breeders, clutches were laid during all weeks of the year except the first three

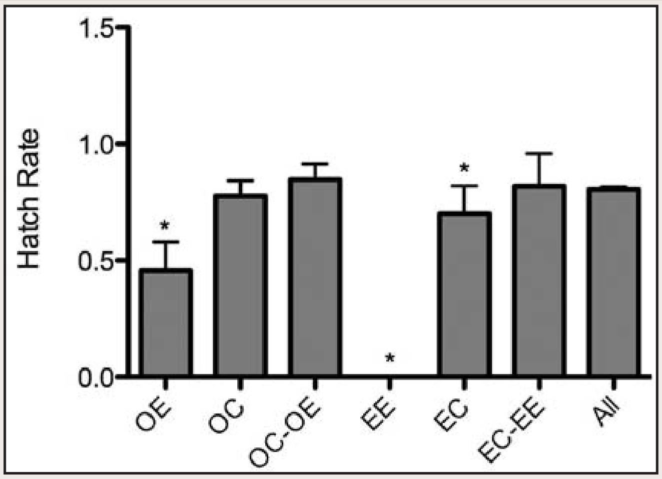

FIG. 3. Hatch rates for eggs that were found outside the female's coils (OE), clutches that had eggs pushed outside the coils (OC), eggs that were inside the coils from clutches with some eggs laid outside the coils (OC - OE), eggs that were laid early (EE), clutches with eggs that were laid early (EC), eggs that were laid with the majority of the clutch from clutches where some eggs were laid early (EC - EE), and all clutches in this study (All). Asterisks denote hatch rates that are significantly different from the overall hatch rate for all clutches from this study (Mann-Whitney test). Bars above columns represent the standard errors of the means.

TABLE 2. P-values for comparisons between clutches found >24 h after being laid and all clutches from this study (Student's *t*-test and Mann-Whitney test).

Trait	P-value
Clutch Mass	0.003
Relative Clutch Mass	0.009
Healthy Offspring	0.002
Hatch Rate*	0.002
Egg Length	0.057
Egg Width	0.038
Female Mass	0.409

P-values in bold were significant at the $P < 0.05$ level.
*Mann-Whitney test used due to extreme non-normality.

TABLE 3. P-values for relative clutch mass (clutch mass divided by female mass), mass of the female post oviposition (female mass), and mass of the clutch (clutch mass) for clutches with one or more eggs that were not within the dam's coils for maternal incubation and those in which eggs were laid early compared to all clutches (Student's *t*-test).

Trait	Outside Coils	Laid Early
Relative Clutch Mass	**0.004**	**0.012**
Female Mass	0.3	0.199
Clutch Mass	0.179	**0.01**

P-values in bold were significant at the $P < 0.05$ level.

TABLE 4. Pearson correlation matrix of the following reproductive traits: number of healthy offspring per clutch (Healthy Offspring), post-oviposition mass of each female (Female Mass, Fe Ma), age of the female at time of oviposition (Age), number of eggs per clutch (Clutch Size, CL Size), mass of each clutch (Clutch Mass, CL Ma), relative clutch mass (RCM), egg length (EL), and egg width (EW). Strengths of correlations are termed as follows: 0.0 to 0.2, negligible; 0.2 to 0.4, weak; 0.4 to 0.7, moderate; 0.7 to 0.9, strong.

	Fe Ma	Age	Cl Size	Cl Ma	RCM	EL	EW
Healthy Offspring	**0.18**	-0.01	**0.53**	**0.72**	**0.69**	**0.11**	**0.60**
Female Mass		**0.38**	**0.56**	**0.50**	**-0.14**	**-0.09**	**0.27**
Age			**0.13**	**0.12**	**-0.12**	0.05	0.05
Clutch Size				**0.73**	**0.50**	**-0.46**	**0.27**
Clutch Mass					**0.76**	**0.17**	**0.81**
RCM						**0.17**	**0.67**
EL							**0.48**

Correlations in bold were significant at the $P < 0.05$ level.

weeks in January (Table 1). Further, preliminary data suggest that the week of the year a Ball Python female lays her eggs in captivity is heritable and is significantly affected by both maternal and permanent environmental effects (unpublished data). Reproduction throughout the majority of the year in captive Ball Pythons is in stark contrast to what has been reported to occur in nature. Wild Ball Pythons in southern Togo, Africa generally lay their eggs during one month of the year (Aubret et al. 2003). The fact that female Ball Pythons can proceed through their reproductive cycles at almost any time during the year in captivity could have important implications for those trying to reproduce other python and snake species. Methods such as follicle palpation and ultrasound may significantly enhance success in reproducing these species in captivity by helping to identify times during which males should be introduced to females for copulation. This would be especially important in situations in which keepers are attempting to breed multiple females with single males.

The age at first reproduction (age when oviposition of first clutch occurs) for males in this study varied from 1 to 6 years (average 2.25 years), and for females it varied from 2 to 8 years (average 3.96 years) (Table 1). The average reproductive frequency for females was 1.97 years. Although no data has been published on captive or wild ball pythons for these traits, reproductive frequency has been studied and discussed for other python species. Captive Reticulated Pythons (*Python reticulatus*) and Diamond Pythons (*Morelia spilota spilota*) have been shown to reproduce every other year (Fitch 1970; Harlow and Grigg 1984). Slip and Shine (1988) provided evidence that the reproductive frequency of wild Diamond Pythons was also likely to be every other year, or potentially even longer. In wild Water Pythons (*Liasis fuscus*) reproductive frequency is closer to being yearly (Madsen and Shine 1996). Therefore, a reproductive frequency of every other year in captive Ball Pythons is similar to that found in other python species.

Aubret et al. (2005) incubated Ball Python clutches from wild-bred females by three different methods: maternal brooding until hatching (N = 10), maternal brooding for the first 15 days of incubation followed by artificial incubation (N = 10), and artificial incubation only (N = 10). They observed that the more time clutches were artificially incubated, the more desiccated they became, and hatching success decreased. They concluded that artificial incubation led to desiccation and decreased hatching success. During the current study, 27 clutches were not found until they had been laid for 24 h or more. When the eggs were found, the dam was brooding them. They were then removed from the females and artificially incubated for the remainder of the incubation period. Statistical analysis on averages for clutch mass, RCM, healthy offspring, hatch rate, egg length, egg width, and hatchling mass between these 27 clutches and all the clutches from this study showed evidence for desiccation and decreased hatching success in the clutches that were found late (Table 2). All the traits measured were statistically lower ($P < 0.05$) in the clutches that were found late, except egg length and hatchling mass. Data that suggested desiccation had occurred in clutches that were found late include decreased clutch mass, decreased RCM, and decreased egg width. The decreased hatch rate and number of healthy offspring per clutch suggest lower hatching success in these clutches. In assessment of Aubret et al. (2005), Barker and Barker (2006) suggested that desiccation itself, independent of incubation type, is the cause of decreased hatching success. Because clutches that were found late in this study were desiccated and suffered decreased hatching success even though they were artificially incubated for the majority of the incubation period, these data support the assessment of Barker and Barker (2006).

A previous study by Aubret et al. (2003) assessed optimal clutch size in Ball Pythons. In their study, wild-bred gravid females were caught and brought to a holding facility. Then, ten unmanipulated clutches, nine artificially enlarged clutches (added eggs to increase initial clutch size by 50%), and nine artificially reduced clutches (removed eggs to decrease initial clutch size by 42%) were set up for maternal incubation. Hatching success and hatchling fitness were assessed for the clutches in these three groups. For the clutches that were artificially decreased in size, no benefit to the dam or offspring was detected. However, artificially increasing clutch sizes did significantly decrease hatching success. Therefore, the data from this study suggest that a female's ability to cover her entire clutch is important to hatching success. During the current study, clutch sizes were reduced by the dam when one or more eggs were laid early, or one or more eggs were excluded from the dam's coils during brooding. Although the female mass average from females that produced these reduced clutches was not significantly different from the overall female mass average from all clutches laid in this study, clutch mass was significantly higher in clutches that were laid early, and RCM was significantly higher in both types of reduced clutches (Table 3). Therefore, clutches were reduced in size when they were large in comparison to female mass (higher RCM), which would potentially lead to females experiencing difficulty in covering the proportionately larger clutches. Also, the hatch rate for clutches that had eggs laid early was significantly lower than the hatch rate for all clutches in this study, but the hatch rate for these same clutches once they were reduced (i.e. not including eggs that were laid early) was not significantly different than the overall average (Fig. 3).

Many conclusions can be drawn from the correlations presented in Table 4, but a few we find particularly interesting. Age was correlated at the level of $r > 0.2$ only with female mass, while female mass was also correlated at $r > 0.2$ with clutch size, clutch mass, and EW. This suggests that the mass of the female is more important than age for predicting reproductive output. Further, because female mass was correlated at $r > 0.2$ with clutch size and clutch mass, but not RCM, it seems that the proportion of energy allocated to a clutch is independent of the mass of the female even though both the mass of the clutch and the number of eggs in the clutch are moderately correlated with the mass of the female (0.50 and 0.56, respectively). Also of interest, EW was correlated at $r > 0.2$ with all traits in the matrix except age. Therefore, EW could be a useful predictor of reproductive output. Lastly, the moderate negative correlation between EL and clutch size, and the weak positive correlation between EW and clutch size support previous research suggesting that as clutch sizes get larger, the eggs get smaller and more round in shape (Brown and Shine 2007b; Ford and Seigel 1989; Madsen and Shine 1996).

The large sample sizes attained in this study have allowed us to study certain aspects of ball python captive reproduction. Novel data presented in this study provide a foundation for the design of future studies, and for the development of more efficient breeding plans for propagating captive pythons. In addition, some specific information presented here can be of immediate use for python propagation. Results from this study suggest that female ball pythons in captivity ovulate in all months of the year. Also, during this study the female reproductive frequency was every other year. Our results also show that desiccation, even for periods of time as short as only a few days, at the beginning of incubation may significantly decrease hatching success. Taking these findings into account, those attempting to propagate pythons in captivity should do the following: 1) Become proficient in techniques such as follicle palpation and ultrasound in order to assess the reproductive stages of females throughout the year; 2) Understand that the reproductive frequency of python females in captivity may be every other year, or even every third year and not push females to reproduce every year; 3) Make provisions in breeding procedures to decrease the risk of subjecting eggs to desiccation at any time during incubation. With further study of some of the correlations presented in this study (e.g. EW correlations), additional information regarding selection parameters to increase breeding efficiencies may be derived as well. Such knowledge will likely lead to increased success in breeding endangered and otherwise rare and difficult to breed python species in captivity.

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HERPETOCULTURE NOTES

CROCODYLIA — CROCODILIANS

***CROCODYLUS RHOMBIFER* (Cuban Crocodile). MATING BEHAVIOR.** Courtship and mating of captive 2.2 m long male and 1.7 m long female *Crocodylus rhombifer* were observed in Zoo Miami (Miami, Florida, USA, 25.60°N, 80.40°W) in 2010. The animals were kept in a 20 m^2 concrete pool within a grassy enclosure.

The animals were observed almost daily from 20 March to 15 April, 2010, between 0700–1100 h, from outside the enclosure. All courtship and mating activity was observed between 0830–1000 h from 23–30 March. During seven days of observation with no rain, the male produced six roars (no more than one per day). The roars were produced at the edge of the pool in arched-back posture, and accompanied by body vibrations and "water dance" effect indicative of brief infrasound pulse, as described for Nile (*C. niloticus*) and American (*C. acutus*) Crocodiles (Garrick et al. 1978. Bull. Am. Mus. Nat. Hist. 160:153–192). One of these six roars was followed by a headslap. On one rainy day (when the water temperature was probably lower than usual) the male produced four roars on land. All roars produced in the water were immediately followed by approaches and courtship behavior by the female. In five such cases the male eventually responded with courtship behavior and then mating. The courtship behavior included not only snout- and chin-touching, but also rides around the pool by the female on the back of the male, which were observed on four occasions, and lasted for up to one minute (Fig. 1). Such rides have never been reported for any crocodilian species.

I thank Steven Conners (Zoo Miami) for assistance and the observation permit.

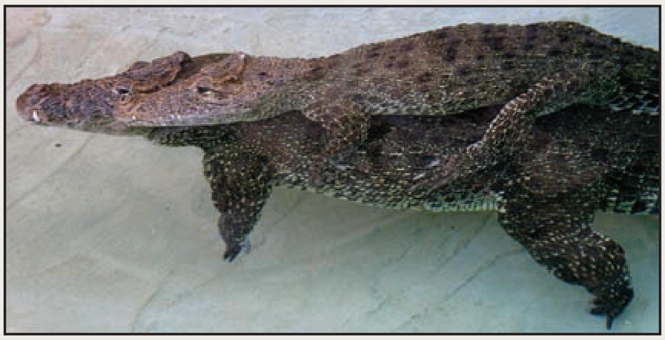

Fig. 1. Female *Crocodylus rhombifer* riding on the male's back during courtship.

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TESTUDINES — TURTLES

***INDOTESTUDO FORSTENII* (Forsten's Tortoise). REPRODUCTION.** *Indotestudo forstenii*, a crepuscular tortoise found only on the islands of Sulawesi and Halmahera, is officially listed by the Convention on International Trade of Endangered Species (CITES) Appendix II and by the International Union for Conservation of Nature (IUCN) as an endangered species (Halvorsen 2009. The North American Regional Studbook for the Sulawesi Tortoise, *Indotestudo forstenii*. 2nd ed. West Palm Beach Zoo, West Palm Beach, Florida. 23 pp.). Most of the captive population in zoos consists of wild caught individuals, but a few successful captive breedings have occurred. On 19 March 2010 a wild-caught female housed at the Memphis Zoo with a wild-caught male laid two eggs. Although one of the eggs died, one pipped on 14 August 2010. Six days prior to pipping, a translucent white circle appeared on the egg. Similar translucent patches were observed five, six, and eleven days prior to pipping on three *Gopherus polyphemus* (Gopher Tortoise) eggs that were incubated at the University of Southern Mississippi (pers. obs.). These observations suggest that the appearance of these translucent circles are related to the hatching process and could be used as a way to predict when an egg will hatch. Because zoos attempt to breed tortoise species whose incubation parameters—including incubation duration—are relatively unknown or are widely variable, an indicator of impending pipping would be a useful husbandry tool.

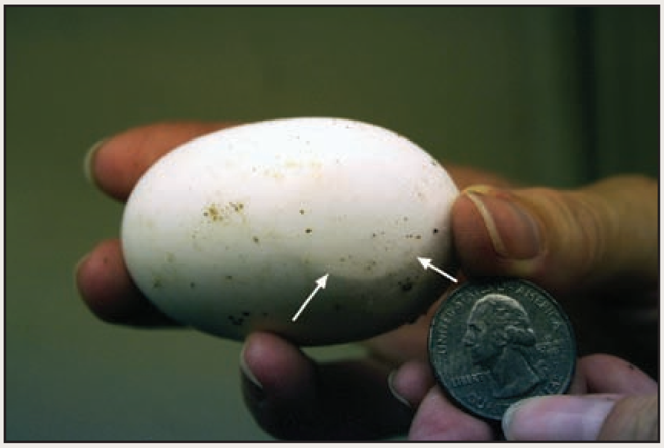

PHOTO BY CHRIS BAKER

Fig 1. Arrows indicate lower margin of clear circle on egg.

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***KINOSTERNIDAE* (Mud and Musk Turtles). GROOMING BEHAVIOR.** Herein, I report multiple instances of self-performed grooming behaviors in captive individuals of at least eight kinosternid taxa in the genera *Sternotherus*, *Kinosternon*, and *Staurotypus*. Behaviors consisted of biting at fore- and hindlimbs, carapacial margins, and areas of reachable skin (all underwater). These taxa have long slender necks with thin loose skin (providing flexibility), and kinetic plastral forelobes that likely facilitate the behaviors described here.

Two adult *Sternotherus minor minor* (1 male, 1 female) were observed on seven occasions (within a month after capture) attempting to remove small turtle leeches (*cf. Placobdella* sp.) from the underside of the nuchal along the ventral scale margin.

FIG. 1. Self-performed grooming session in an adult male *Sternotherus carinatus*. Top) gentle forelimb biting; Center and bottom) biting at skin between the neck and forelimb. This individual has been observed biting at its own nuchal margin and achieving over 180 degrees of head rotation in the process.

FIG. 2. Gentle forelimb biting in an adult male *Kinosternon subrubrum steindachneri*. This individual has been observed removing and eating shedding skin from anterior portions of the body.

Leeches can accumulate in large numbers in this region of the body on *S. m. minor*. Turtles demonstrated the capability of orienting the head 180° laterally through hyperextension and rotation of the neck, so that the nostrils were directed towards the posterior of the body. This enabled the turtles to position their head and jaws under the nuchal margin, and bite, scrape, and even remove leeches from themselves with their jaws. It is unknown if leeches were subsequently consumed, however leeches were observed attached on the inside of the turtles' mouths on the palate and lingual portions of the mandible.

Five adult male *Sternotherus carinatus* were also observed performing similar grooming behaviors, but in the absence of leeches on their bodies. For example, on more than sixteen occasions a large (140 mm CL) individual was observed grooming all reachable portions of its body, including achieving ≥180º head orientation as described above for *S. m. minor*. In such instances, the turtle would repeatedly bite at the anterior margin of its carapace including the outer rim of the nuchal, and gently scrape its lower jaw along the underside of the carapacial rim. During one observation, this turtle began by rotating its head to the left, gently biting at the skin between the neck and forelimb (as seen in Fig. 1), and then biting the margin of the carapace at left marginal scales 1 and 2. It then proceeded to rotate its head even further, biting at the cervical and anterior-most portion of Vertebral Scale 1. This turtle eventually accomplished >180º head orientation, having turned its head to the left side and bitten at right marginal scale 1. Forelimb and hindlimb grooming were most commonly observed in male *S. carinatus*, and pieces of thin sloughing skin were removed and consumed through gentle biting. Hindlimb biting was observed in three individuals and accomplished through hyperextension of the neck either laterally or directly under the body. Standing on the bottom of the enclosure, turtles would straighten out their limbs to position the body off of the substrate. The head and neck were then extended to bite at a hindlimb, often lifting the hindlimb off the substrate in concert to reach the foot. Grooming behaviors lasted between 7–120 seconds.

Six (4 males, 2 females) captive adult *Kinosternon s. steindachneri* were observed briefly self-biting at marginals 1–3 as well as removing shedding skin from forelimbs, the latter being more commonly observed (Fig. 2). Shedding skin was consumed in forelimb biting. This species frequents xeric wetland habitats that are prone to periods of drought, and it is possible that skin consumption is a resourceful response to this situation. Leeches (cf. *Placobdella* sp.) have also been observed on *K. s. steindachneri* (pers. observ.).

Short bouts of forelimb biting was seen in multiple captive adult individuals of *S. odoratus*, *Staurotypus salvinii*, and *S. triporcatus*, a male and two female *K. l. leucostomum*, and at least three instances in a young male *K. flavescens*. Grooming intervals for these specimens tended to be relatively short (less than 15 seconds).

Intentional rubbing of the carapace against limestone rocks and cypress wood placed within enclosures was exhibited by four *S. carinatus* on at least six occasions, however these instances lasted for only a few seconds. More passive scraping was also noted when turtles would repeatedly burrow or try to retreat under or adjacent to those objects.

In addition to the taxa reported here, self-performed grooming behavior has been documented for the side-necked turtle *Hydromedusa* (Novelli et al. 2009. Herpetol. Rev. 40:435–436) and it is likely that grooming is (at least in part) a response to heavy ectoparasite loads often borne by many turtle species in the wild. Bottom-dwelling species such as Wood Turtles (*Glyptemys insculpta*), Snapping Turtles (*Chelydra serpentina*), Flattened Musk Turtles (*Sternotherus depressus*), and *S. minor* (Ernst and Lovich 2009. Turtles of the United States and Canada, 2nd ed., Johns Hopkins University Press, Baltimore, Maryland; pers. observ.) often are hosts to dense concentrations of leeches, and *Sternotherus odoratus* has been reported to carry over 20 times the number of leeches as (more commonly) aerial basking species such as the Northern Map Turtle (*Graptemys geographica*) (Ryan and Lambert 2005. J. Herpetol. 39:284–287). The presence of leeches on *Sternotherus* species could be presumed to be energetically costly for such relatively small-sized turtles given that these parasites have been found to consume blood and bone tissues of the host (Siddall and Gaffney 2004. J. Parasitol. 90[5]:1186–1188).

I thank K. Krysko, M. Nickerson, D. Ehret, and A. Hastings (Florida Museum of Natural History) and J. Harding (MSU) for helpful comments on this manuscript. All turtles mentioned here are captive specimens in the private collection of the author and treated under humane conditions.

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SQUAMATA — LIZARDS

***SCINCUS SCINCUS* (North African Sand Skink). LONGEVITY.** *Scincus scincus* is a common lizard of Egypt, Libya, and Morocco. The natural life span of this species is currently unknown, but Hughes (1988. J. Herpetol. Assoc. Africa 34:20–24) reported a captive longevity of 5 years, 3 months for this species. Schleich et al. (1996. Amphibians and Reptiles of North Africa. Koeltz Scientific Books, Koenigstein, Germany. 630 pp.) reported a captive life span of 10 years for this species, but gave no specific information to support this.

At the North Carolina Zoological Park, we maintained a female *Scincus scincus* from 27 May 1993 to 5 May 2010. This specimen was obtained from an animal dealer on 27 May 1993 as an adult and was euthanized on 5 May 2010 due to deteriorating health related to old age. At the time of euthanasia the individual had lived at the North Carolina Zoological Park for a period of 16 years, 11 months, and 8 days. This specimen was housed in a 75.6 L. aquarium filled to a depth of 102 mm with loose sand. A heat pad was provided under its off-exhibit enclosure and a 100W incandescent bulb was above the enclosure to provide a basking area. No UV lighting was provided to this animal given its fossorial nature. Water was provided in a shallow dish at all times and the enclosure was misted twice daily to maintain moisture in the sand. Prey items were offered three times/week and consisted of adult crickets, meal worms, and wax worms. All prey items were dusted with several vitamin and mineral supplements (Walkabout Farm's dietary products and Reptivite®) at different times during this period. Because age at time of acquisition was unknown, we cannot estimate age at death although it may have been in the range of 18–20 years.

Three other lizards of the same species that were obtained at the same time from the same source lived for periods of 3 years, 3 months, and 24 days; 5 years, 7 months and 17 days; and 8 years, 8 months, and 9 days. Based on these longevity records, this species may have a natural average life of 10 years as reported by Schleich et al. (1996, *op. cit.*).

We thank Frank Slavens and Roy W. McDiarmid for their help with this note.

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GEOGRAPHIC DISTRIBUTION

CAUDATA — SALAMANDERS

***AMBYSTOMA TIGRINUM* (Tiger Salamander)**. USA: MINNESOTA: Le Sueur Co.: In private pasture 600 m E of 367th Avenue ca. 6.00 km SW of Kasota, MN. (44.24266667°N, 93.99916667°W; WGS 84). 02 July 2010. James Ford Bell Museum (JFBM P379a–b; photographic records). Verified by Kenneth H. Kozak and Christopher E. Smith. Observed by Andrés F Morantes, Otto T Gockman, and Scott A Milburn. First county record updating a pre-1960 voucher from Le Sueur Co. (Oldfield and Moriarty 1994. Amphibians & Reptiles Native to Minnesota. University of Minnesota Press. Minneapolis. 237 pp.). Found under cover board.

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***ECHINOTRITON ANDERSONI* (Anderson's Crocodile Newt)**. JAPAN: RYUKYU ARCHIPELAGO: Amami Island Group: Ukejima Island (28.0333°N, 129.2166°E, ca. 250 m elev.). 5 and 29 March 2010. M. Honda. Graduate School of Human and Environmental Studies, Kyoto University (KUHE) 50691–50693. First island record with voucher. Individuals found inactive underneath pile of withered weeds. Species previously known from Amamioshima and Tokunoshima Islands of the Amami Group, and Okinawajima, Sesokojima and Tokashikijima Islands of the Okinawa Group (Hayashi et al. 1992. Herpetologica 48:178–184), and from Taiwan on the basis of three skeletal specimens deposited in MCZ (Zhao and Adler 1993. Herpetology of China. Contributions to Herpetology [10]. SSAR, Oxford, Ohio. 522 pp. + 48 pl. + 1 folding map). However, this latter record needs verification (Matsui and Ota 1995. Herpetologica 51:234–250). Ukejima Island (13.3 km^2 in area, 398 m elev.) was referred to as another island inhabited by *E. andersoni* but on basis of single photograph, lacking date and locality (Ota and Okada 2003. Reptiles and amphibians. *In* Kagoshima Red Data Book for Animals, pp. 82–116. Kagoshima Environmental Research and Service, Kagoshima, Japan [in Japanese]).

Sampling was conducted under permission from Kagoshima Prefectural Board of Education (reference no. 48 2009; to HO), and supported by grant from Japan Ministry of Education, Science, Sports, Culture and Technology (C-19510238 to MH).

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***NOTOPHTHALMUS VIRIDESCENS* (Eastern Newt)**. USA: MICHIGAN: Charlevoix Co.: South end of Hog Island, Eastern Lake Michigan Archipelago (45.76667°N, 85.366667°W; WGS 84). 24 May 2008. Kenneth D. Bowen. Verified by Fred Janzen. Iowa State University Research Collection (ISUA201101; digital image). New record for Hog Island (Bowen and Gillingham 2004. Michigan Acad. 35:213–223).

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***NOTOTRITON BRODIEI* (NCN)**. GUATEMALA: IZABAL: Sierra Caral: near Cerro Pozo de Agua (15.39367°N, 88.69183°W; WGS84), 850 m elev. 1 October 2010. Carlos R. Vásquez-Almazán and Jeffrey W. Streicher. Verified by David Wake. Museo de Historia Natural de la Universidad de San Carlos (USAC 2737). This is only the sixth known individual of the species and the locality has the lowest recorded elevation to date; previous low was 1125 m (Campbell and Smith 1998. Sci. Pap. Nat. Hist. Mus., Univ. Kansas 6:1–8). Thus, the elevational distribution of *N. brodiei* is now known to range from 850 m through 1590 m (Kolby et al. 2009. Herpetol. Rev. 40:444), so preserving natural habitats in that range zone is a necessity for its conservation and continued survival. The salamander was caught at ca. 2100 hrs while it was walking across low-lying vegetation in secondary growth forest that was previously covered with tropical deciduous forest.

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***OEDIPINA LEPTOPODA* (Narrow-footed Worm Salamander)**. HONDURAS: CORTES: 1.5 km N of Los Pinos (14.866861°N, 87.900197°W; WGS84). 710 m elev. January 2010. José Mario Solis. Verified by David Wake. MVZ 263988. First record for Cortés, extending its range ca. 75 km SW of nearest known locality, ca. 32 km W of Yoro, Yoro (McCranie et al. 2008. Zootaxa 1930:1–17). The salamander was found during the late rainy season in dry leaf litter of early secondary growth forest in an area originally a mixture of pine and broadleaf forest.

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ANURA — FROGS

***ANAXYRUS AMERICANUS* (American Toad)**. USA: INDIANA: Jennings Co.: Calli Nature Preserve: (39.0031°N, 85.60918°W; NAD 83). 13 July 2010. Sarabeth Klueh, Jason Mirtl, and Tim Shier. Verified by Chris Phillips, Illinois Natural History Survey (INHS 2010k). New county record for Indiana (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii+404 pp.)

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***ANAXYRUS FOWLERI* (Fowler's Toad)**. USA: INDIANA: Jennings Co.: Calli Nature Preserve: (38.99789°N, 85.60726°W; NAD 83). 13 July 2010. Sarabeth Klueh, Jason Mirtl, and Tim Shier. Verified by Chris Phillips, Illinois Natural History Survey (INHS 20101). New county record for Indiana (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.)

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***ATELOGNATHUS REVERBERII*.** ARGENTINA: RIO NEGRO: Departamento 25 de Mayo: El Caín: Meseta de Somuncurá (41.68461°S, 68.19228°W; WGS 84; elev. 1050 m). 02 February 1999. J. Muzón and P. Marino. Herpetological collection, Centro Nacional Patagónico, Puerto Madryn, Chubut, Argentina (CNP-L 201–202); CHUBUT: Departamento Telsen: Gan Gan (42.51042°S, 67.97728°W; WGS 84; elev. 920 m). 09 March 2000. N. G. Basso and L. Alcalde (CNP-L 204–208). All verified by Jorge D. Williams. Previously known only from the type locality, Laguna Minuelo, Meseta de Somuncurá, Río Negro Province (Cei 1969. J. Herpetol. 3:1–18) and closely surrounding lagoons. Verification supported with mitochondrial data from control region (D-loop), cytochrome b (CytB) and cytochome oxidase subunit one (COI) genes (Basso, Martinazzo, and Úbeda, unpubl. data). Specimens collected were found under stones surrounding small lagoons in the arid Patagonian steppe, in sympatry and syntopy with the frog *Pleurodema bufoninum*. These vouchers extend the range 130 km airline W in the province of Rio Negro and 150 km airline SW from the type locality, being the first record for the province of Chubut.

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***CRAUGASTOR CHARADRA* (Ranita de Arroyo de la Montaña Noroeste)**. HONDURAS: SANTA BÁRBARA: tributary of Río Listón (15.533336°N, 88.35014°W; WGS84), 405 m elev. 12 November 2008. James R. McCranie and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 573827–573829. First records for Santa Bárbara (McCranie 2007. Herpetol. Rev. 38:35–39), with the closest known locality being ca. 10 km NE at El Cusuco, Cortés (McCranie 2006. Smithson. Herpetol. Inform. Serv. [137]:ii + 39). The specimens were active at night along a stream surrounded by relatively undisturbed broadleaf forest.

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***CRAUGASTOR RANOIDES* (NCN)**. COSTA RICA: GUANACASTE: Municipality of La Cruz: Península de Santa Elena; Area de Conservación Guanacaste, Quebrada Pedregal 1 (10.9025°N, 85.741667°W; WGS84), 100 m elev. 25 March 2006. H Zumbado-Ulate and F. Soley. UCR 18208. Quebrada Pedregal 2 (10.905278°N, 85.747778°W; WGS84), 80 m. elev. 25 March 2006. H. Zumbado-Ulate and F. Soley. UCR18209. Quebrada Cachimbo (10.908333°N, 85.748333°W; WGS 84), 30 m elev. 19 January 2009. H. Zumbado-Ulate and B. Willink. UCR20555. Quebrada La Amanda (10.532211°N, 85.726111°W; WGS84), 90 m elev. 19 January 2009. H. Zumbado-Ulate and B. Wilink. UCR 20556. Río Canelo (10.912222°N, 85.749167°W; WGS84), 30 m elev. 19 January 2009. H. Zumbado-Ulate and B.Willink. UCR20554. Quebrada Casa de Zinc (10.8375°N, 85.697222°W; WGS84), 150 m elev. 1 May 2009. H. Zumbado-Ulate and B. Willink. UCR20681. All verified by F. Bolaños. First records for the municipality, located ca. 5 km W of the closest known localities in the Municipality of Liberia within the Río Murciélago region (Zumbado-Ulate et al. 2007. Herpetol. Rev. 38:184–185; Zumbado-Ulate et al. 2009. Herpetol. Rev. 40:201). This previously common species throughout Costa Rica has had its populations decimated in recent years due to unknown factors (Puschendorf et al. 2005. Herpetol. Rev. 36:53), so its presence along several rivers and streams within the Península de Santa Elena provides hope that it can be adequately protected; it is considered an endangered species by IUCN. All frogs were found on boulders along slow flowing rocky streams in tropical dry forest.

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***HADDADUS BINOTATUS* (Clay Robber Frog)**. BRAZIL: MATO GROSSO DO SUL: Corumbá, Capim Gordura port (18.806871°S, 57.578821°W, datum WGS84), in forested area on the banks of the Paraguay River, about 45 km upstream from the urban area of Corumbá. 27 November 1993. Collected by J. C. Louzan. Coleção Zoológica de Referência da Universidade Federal de Mato Grosso do Sul, Campo Grande, Mato Grosso do Sul, Brazil (ZUFMS AMP0628). Verified by C. F. B. Haddad. *Haddadus binotatus* occurs in eastern and southern Brazil, from southern Bahia state to Rio Grande do Sul state (Brassaloti et al. 2010. Biota Neotrop. 10[1]:275–291; Feio and Caramaschii 2002. Phyllomedusa 1[2]:105–111; Machado and Maltchik 2007. Neotrop. Biol. Cons. 2[2]:101–116; Machado et al. 1999. Rev. Bras. Zool. 16[4]:997–1004; Van Sluys and Rocha 2008. IUCN Red List of Threatened Species, ver. 2010.4. http://iucnredlist.org/). First state record, extends the distribution ca. 840 km W of the Parque Estadual Mata dos Godoy, municipality of Londrina, state of Paraná

(Machado et al. 1999, *op. cit.*) and ca. 920 km W of the Estação Ecológica dos Caetetus, between the municipalities of Gália and Alvilândia, state of São Paulo (Brassaloti et al. 2010, *op. cit.*).

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***HYLA CINEREA* (Green Treefrog)**. USA: GEORGIA: Dekalb Co.: approximately 0.8 km from intersection of SR 29 and Leeshire Rd. (33.86352ºN, 84.18267ºW; WGS 84; elev. 289 m). 08 May 2009. Deborah Ashley. Verified by John Jensen. Photographic vouchers UTADC 6846–6847. New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.); previously documented from neighboring Gwinnett, Rockdale, Clayton, and Henry counties. Specimen was found in a residential garden resting on a lily leaf (*Lilium* sp.) along the edge of a storm water retention pond.

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***HYLA GRATIOSA* (Barking Treefrog)**. USA: GEORGIA: Baldwin Co.: Browns Crossing Road NW (33.074277°N, 83.377750°W; WGS84). 28 September 2010. Dennis Parmley. Florida Museum of Natural History photo voucher (UF 162272). Verified by John B. Jensen. New county record but within expected range (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). Single adult found on road during heavy rain. Road passed though mixed pine-deciduous forest.

HOUSTON C. CHANDLER and **DENNIS PARMLEY** (e-mail: dennis.parmley@gcsu.edu), Department of Biological and Environmental Sciences, Georgia College and State University, Milledgeville, Georgia 31061, USA.

***HYLORINA SYLVATICA* (Emerald Forest Frog)**. CHILE: XI REGION DE AYSÉN: 10 km NE of Villa O'Higgins (48.37153°S, 7249727°W, datum WGS 84; 426 m elev.). Adult male 43.25 mm SVL, collected under logs in Chilean temperate rain forest dominated by *Nothofagus* at the border of Mayer River. 28 January 2010. H. Díaz-Páez. Collection of the Museum of Zoology of the University of Concepción, Concepción, Chile (MZUC-UCCC 36285). Verified by M. Vidal. Species is distributed in Chile from Golfo de Arauco (40.00°S, 72.00°W; Veloso and Navarro 1988. Bull. Mus. Reg. Nat. Torino 6:481–539) to Laguna San Rafael (46.73°S, 73.93°W; Díaz-Páez et al. 2002. Bol. Mus. Nac. Hist. Nat., Chile 51:135–145), and is also reported from the Pacific border of Chiloé Archipielage to Wellington Island (Rabanal and Nuñez 2009. Anfibios de los Bosques Templados de Chile. Universidad Austral de Chile, Valdivia. 206 pp.). This new continental record in the Aysen Region extends the range of the species ca. 220 km SE from Laguna San Rafael and places it on the eastern side of the Patagonian Icefields.

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***INCILIUS CAMPBELLI* (Sapo del Bosque Noroeste)**. HONDURAS: SANTA BÁRBARA: trubutary of Río Listón (15.51689°N, 88.350086°W; WGS84), 560 m elev. 12 November 2008. James R. McCranie and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 573736. First record for Santa Bárbara (McCranie 2007. Herpetol. Rev. 38:35–39) and helps bridge a distributional gap between localities in the departments of Cortés and Copán (McCranie 2006. Smithson. Herpetol. Inform. Serv. [137]:ii + 39). The specimen was active mid morning on the ground in relatively undisturbed broadleaf forest.

LEONARDO VALDÉS ORELLANA, Gerente General de "Hondufauna," Investigador Privado, Colonia América, Bloque 9, Casa 1806, Comayagüela, MDC, Honduras (e-mail: leovalor@hotmail.com); **JAMES R. McCRANIE**, 10770 SW 164th Street, Miami, Florida 33157–2933, USA (e-mail: jmccrani@bellsouth.net).

***LITHOBATES CLAMITANS* (Green Frog)**. USA: INDIANA: Gibson Co.: Patoka River National Wildlife Refuge and Management Area (38.37256°N, 87.33124°W; NAD 83; Zone 16N). 27 March 2009. Alisha Maves and Randall Haken. Verified by Chris Phillips, Illinois Natural History Survey (INHS 2009ag). New county record (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.). Single individual caught in a small inundated depression created by a fallen tree.

ALISHA MAVES, **RANDALL HAKEN**, and **LINDSEY LANDOWSKI**, US Fish and Wildlife Service, Patoka River National Wildlife Refuge, 510 1/2 West Morton Street, PO Box 217, Oakland City, Indiana 47660, USA (e-mail: Lindsey_Landowski@fws.gov).

***LITHOBATES CLAMITANS* (Green Frog)**. USA: TENNESSEE: Smith Co.: Hurricane Creek adjacent to Maggarte Road ca. 2.5 km N of Hwy US 70N (36.227797°N, 85.841232°W; WGS 84). 21 March 2011. M. Anderson and A. Carey. Verified by Brian T. Miller. Herpetology Collection at Middle Tennessee State University (MTSU 352A). New county record (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. Misc. Publ. No. 12. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. 94 pp. Internet version [http://www.apsu.edu/amatlas] contains links to information regarding Tennessee distribution of amphibians recorded since 1996; accessed 28 March 2010). Adult found in creek.

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***LITHOBATES SYLVATICUS* (Wood Frog)**. USA: INDIANA: Pike Co. (38.37114°N, 87.15238°W; NAD83). 22 June 2010. Sarabeth Klueh, Jason Mirtl, Tim Shier, and Lindsey Landowski. Verified by Chris Phillips. Illinois Natural History Survey (INHS 2010o). New county record (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.). A juvenile was found in a wooded upland area.

SARABETH KLUEH (e-mail: sklueh@dnr.IN.gov), **JASON MIRTL**, **TIM SHIER**, Wildlife Diversity Section, Indiana Department of Natural Resources Division of Fish and Wildlife, 553 E. Miller Drive, Bloomington, Indiana 47401, USA; **LINDSEY LANDOWSKI** (e-mail: Lindsey_Landowski@fws.gov), US Fish and Wildlife Service, Patoka River National Wildlife Refuge, 510 1/2 West Morton Street, PO Box 217, Oakland City, Indiana 47660, USA.

***OSTEOPILUS SEPTENTRIONALIS* (Cuban Treefrog)**. TURKS AND CAICOS ISLANDS: North Caicos: east of Kew Town (21.919°N, 72.012°W; WGS84), 25 m elev. 10 August 2008. R.

Graham Reynolds and Matthew L. Niemiller. Color photo voucher (APSU 19024). Providenciales, National Environmental Centre (21.7819°N, 72.212°W; WGS84), 12 m elev. 17 March 2010. Brian M. Riggs. Color photo voucher (APSU 19027). Both verified by A. C. Echternacht. First records for Turks and Caicos Islands. The closest known locality is on Great Inagua Island (Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. xvi + 720 pp.).

Research funded by the Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville Summer Research Grant Program (RGR and MLN) and the University of Tennessee W. K. McClure Scholarship for the Study of World Affairs (RGR).

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***TLALOCOHYLA LOQUAX* (Rana Trepadora Sonorense; Mahogany Treefrog)**. HONDURAS: EL PARAÍSO: Mapachín (13.9830°N, 86.4910°W, WGS84), 830 m elev. 8 July 2010. Alexander Gutsche, James R. McCranie, and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 565832–33. First record for El Paraíso (McCranie 2007. Herpetol. Rev. 38:35–39). The closest known locality in Honduras is ca. 55 km W at Cerro Uyuca, Francisco Morazán (McCranie 2006. Smithson. Herpetol. Inform. Serv. 137:1–38). The frogs were calling at night from small trees next to a pond surrounded by pastures. Fieldwork of A. Gutsche was supported by the Adolf and Hildegard Isler Foundation.

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TESTUDINES — TURTLES

***APALONE SPINIFERA SPINIFERA* (Eastern Spiny Softshell)**. USA: OHIO: Allen Co.: Amanda Township: Auglaize River 100 m S of State Route 117 (40.707233°N, 84.272914°W; WGS84). 12 September 2010. Cincinnati Museum Center (CMC 12094). Harrison Co.: North Township: Conotton Creek (40.41768°N, 81.14656°W; WGS84). 04 September 2010. CMC 12115. Jefferson Co.: Saline Township: Brush Creek along Pine Grove Road (40.54996°N, 80.71447°W; WGS84). 04 September 2010. CMC 12118. Shelby Co.: Clinton Township: Tawawa Creek 200 m upstream from its confluence with the Great Miami River (40.24918°N, 81.14499°W; WGS84). 12 July 2010. CMC 12095. All specimens were collected by Jeffrey G. Davis and Paul J. Krusling and verified by John W. Ferner. New county records (Wynn and Moody 2006. Ohio Turtle, Lizard and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10. iv + 81 pp.).

JEFFREY G. DAVIS (e-mail: anura@fuse.net) and **PAUL J. KRUSLING** (e-mail:pkrusling@gmail.com) Geier Research and Collections Center, Cincinnati Museum Center, 1301 Western Avenue, Cincinnati, Ohio 45203, USA.

***CHELUS FIMBRIATUS* (Matamata Turtle)**. BRAZIL: MARANHÃO: Tocantins River Basin, Municipality of Estreito (ca. 6.51°S, 47.38°W; datum: SAD 69; 150 m elev.). November 2009. G. Nunan. Museu Nacional, Rio de Janeiro, RJ, Brazil (MNRJ 19411). Verified by U. Caramaschi. This new record is within the Cerrado biome. Species was previously known from the states of Amapá, Amazonas, Pará, Rondônia (on frontier with Bolivia), Mato Grosso, Tocantins e Goiás in Brazil, along the Amazon and north of the Cerrado, and also in Venezuela, Guiana, French Guiana, Colombia, Ecuador, Peru, and Bolivia (Iverson 1992. A Revised Checklist with Distribution Maps of the Turtles of the World. Privately printed, Richmond, Indiana xiii + 363 pp.; Pritchard 2008. *In* Rhodin et al. Chelonian Research Monographs 5:020.1–020.10; Pritchard and Trebbau 1984. The Turtles of Venezuela. SSAR, Oxford, Ohio. vii + 403 pp.). First record for the state of Maranhão in Brazil and the easternmost record, filling a gap along the Tocantins River Basin ca. 570 km S from Belém region (Pará state) and 570 km NE from Luciária / Santa Terezinha region (Mato Grosso state) (Iverson, *op. cit.*; Pritchard, *op. cit.*).

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***CHRYSEMYS PICTA MARGINATA* (Midland Painted Turtle)**. USA: OHIO: Allen Co.: Amanda Township: Auglaize River at Bice Road bridge (40.70035°N, 84.25469°W; WGS84). 13 July 2010. Cincinnati Museum Center Herpetological Photodocumentation Collection (CMC HP 5249). Jefferson Co.: Brush Creek Township: farm pond on State Park Mooretown Rd. (40.59604°N, 80.83760°W; WGS84). 05 September 2010. CMC HP 5247–5248. Both specimens collected by Jeffrey G. Davis and Paul J. Krusling, and verified by John W. Ferner. New county records (Wynn and Moody 2006. Ohio Turtle, Lizard and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10. iv + 81 pp.).

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***DERMATEMYS MAWII* (Central American River Turtle)**. MÉXICO: YUCATÁN: Municipality of Progreso: El Corchito, ca. 31 km N of Mérida (21.281111°N, 89.643056°W; WGS84), ca. sea level. 30 April 2010. Juan Chablé-Santos. Verified by David Lazcano. Photo vouchers, Universidad Autónoma de Yucatán Herpetological Collection (FMVZ-UADY-CH 00001–000028). First record for Yucatán and a 239 km range extension NE of the nearest record at Champotón, Campeche (Lee 1996. The Amphibians and Reptiles of the Yucatán Peninsula. Comstock Publ. Assoc., Cornell University Press. New York. xii + 500 pp.). The turtle was live-captured by hand, photographed, and then released back into a freshwater spring located within a mangrove swamp system.

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***GRAPTEMYS GEOGRAPHICA* (Northern Map Turtle)**. USA: OHIO: Van Wert Co.: Washington Township: Little Auglaize River at Township Road 199 bridge (40.858133°N, 84.3975750°W;

WGS84). 13 July 2010. Jeffrey G. Davis and Paul J. Krusling. Verified by John W. Ferner. Cincinnati Museum Center Herpetological Photodocumentation Collection (CMC HP 5259). New county record (Wynn and Moody 2006. Ohio Turtle, Lizard and Snake Atlas. Ohio Biol. Surv. Misc. Contr. No. 10. iv + 81 pp.). Adult and sub-adult basking on emergent log.

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MESOCLEMMYS GIBBA. BRAZIL: PARÁ: Municipality of Parauapebas: Alto dos Carajás (ca. 6.03°S, 50.29°W; datum SAD 69). 16 March 2009. D. F. M. Victor. Museu Nacional / UFRJ, Rio de Janeiro, RJ, Brazil (MNRJ 18105–18108). Verified by U. Caramaschi. This new record is located with the Amazonia biome. The species was previously recorded in Venezuela, Guiana, Suriname, French Guiana, Colombia, Ecuador, and Peru, and in a few localities in the states of Roraima, Amazonas, Acre, and Pará in Brazil (Bour and Pauler 1987. Mesogee 47:3–23; Mittermeier et al. 1978. Herpetologica 34:93–100; Schneider et al. 2009. Herpetol. Rev. 40:236). This new record extends the known geographic distribution of the species about 480 km S of Corcovado, Breves, Pará, the nearest previously reported population (Mittermeier et al., *op. cit.*).

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***PSEUDEMYS CONCINNA CONCINNA* (Eastern River Cooter).** USA: ALABAMA: Crenshaw Co.: Patsaliga Creek at U.S. Hwy 331 N of Luverne (31.72469°N, 86.27813°W). 12 September 2010. Collected by Sean Graham, David W. Hunt, Lindsay V. Adams, and Nicholas C. Craig. Verified by Craig Guyer. AHAP-D 272–273. New county record (Mount 1975. The Reptiles and Amphibians of Alabama. Univ. Alabama Press, Tuscaloosa. 287 pp.). We thank Sean Graham for helping us collect the specimen on our field trip.

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***TERRAPENE CAROLINA* (Eastern Box Turtle).** USA: GEORGIA: Baldwin Co.: approximately 0.5 km W of Oconee River (33.046236°N, 83.203739°W; WGS84). 01 September 2010. Houston C. Chandler and Dennis Parmley. Florida Museum of Natural History photo voucher (UF 162271). Verified by John B. Jensen. New county record, but within expected range (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). Single adult male found on forest floor of mixed pine-deciduous forest along Oconee River floodplain.

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***TERRAPENE CAROLINA* (Eastern Box Turtle).** USA: INDIANA: Dearborn Co.: Lubbe Nature Preserve (38.99411°N, 85.11732°W; NAD 83). 12 June 2010. Illinois Natural History Survey (INHS 2010n). Jennings Co.: Calli Nature Preserve (39.00311°N, 85.60933°W; NAD 83). 13 July 2010. (INHS 2010m). Both specimens collected by Sarabeth Klueh, Jason Mirtl, and Tim Shier, and verified by Chris Phillips. New county records (Minton 2001. Amphibians and Reptiles of Indiana. 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.).

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***TRACHEMYS SCRIPTA ELEGANS* (Red-eared Slider).** TURKS AND CAICOS ISLANDS: Providenciales: leeward highway near golf course (21.798°N, 72.160°W; WGS84), 10 m elev. 1 October 2009. Brian M. Riggs. Verified by Brian T. Miller. Color photo voucher (APSU 19021). First record from Turks and Caicos Islands (Henderson and Powell. 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Florida Press Florida, Gainesville. xvii + 495 pp.; Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History, Univ. Florida Press, Gainesville. xvi + 720 pp.).

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SQUAMATA — LIZARDS

***ANOLIS EQUESTRIS* (Knight Anole).** Turks and Caicos Islands: Providenciales: Grace Bay (21.7874°N, 72.1965°W; WGS84), 7 m elev. 29 April 2009. Brian M. Riggs. Verified by A.C. Echternacht. Color photo vouchers (APSU 19025, 19026). First record from the Turks and Caicos Islands (Schwartz and Henderson, 1991, Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. xvi + 720 pp.; Henderson and Powell. 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Florida Press, Gainesville. xvii + 495 pp.).

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***ANOLIS (NOROPS) SAGREI* (Brown Anole).** USA: LOUISIANA: St. Tammany Parish: Slidell, Garden Spot Nursery, 770 Robert Boulevard (30.29543°N, 89.76388°W; WGS84). 11 August 2010. C. Thawley. Verified by Kenneth L. Krysko. AUM AHAP-D 297 (digital photograph). New parish record (Dundee and Rossman 1989. The Amphibians and Reptiles of Louisiana. Louisiana State University Press, Baton Rouge. 300 pp.). Adult, captured by hand. Observed in a plant nursery with other adults and juveniles, suggesting presence of breeding population. Corroborates earlier reports that nursery transport is an important vector for invasive *A. sagrei* in Louisiana and elsewhere (Steffen and Birkhead 2007. Herpetol. Rev. 38:353; Williams and Comeaux 2008. Herpetol Rev. 39:366). *Anolis sagrei* has been recorded from six other parishes across southern Louisiana (Meshaka et al. 2009. J. Kansas Herpetol. 32:13–16); the nearest locality is 47 km SW in Orleans Parish (Boundy et al. 2004. Herpetol. Rev. 35:194–196). This new record is only 11 km W of the Mississippi state line, but 304 km W of the nearest easterly locality in Fort Walton Beach, Florida (Bishop 2005. Herpetol. Rev. 36:336).

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***CELESTUS BIVITATUS* (NCN)**. HONDURAS: OCOTEPEQUE: El Portillo de Cerro Negro (15.350114°N, 88.633603°W; WGS84), 2100 m elev. 19 August 2008. James R. McCranie and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 573885–86). First records for Ocotepeque. The closest reported locality in Honduras is from ca. 70 km ESE at 18.1 km NW of La Esperanza, Intibucá (see map in McCranie and Wilson 1996. Rev. Biol. Trop. 44:259–264) and ca. 100 km W in Guatemala from near Potrero Carillo, Jalapa (Campbell and Camarillo 1994. Herpetologica 50:193–209). The lizards were active midday in rock crevices on a steep embankment above a trail in cutover broadleaf cloud forest.

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***ENYALIUS BIBRONII* (NCN)**. BRAZIL: MINAS GERAIS: Taiobeiras: 15.867°S, 42.132°W, SAD 69). 6 August 2003. R. N. Feio. Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil (MZUFV 409). Joaíma, Fazenda Ramaiana: 16.708°S, 40.816°W. 26 April 2001. R. N. Feio. MZUFV 307. Cristália: 16.749°S, 42.834°W. 1 December 1989. MZUFV 251. Berilo: 16.951°S, 42.463°W. 9 January 1989. MZUFV 249. All verified by M. Trefaut Rodrigues. This species is known to occur in relictual forests of northeastern Brazil, from Ubajara (3.854°S, 40.921°W), state of Ceará to the north, southward to Montezuma, state of Minas Gerais (15.172°S, 42.4973°W) (Jackson 1978. Arq. Zool. 30[1]:1–79; Gogliath et al. 2010. Check List 6[4]:652–654). All new localities are farther south than the previous southernmost records, now updated to Berilo municipality, ca. 195 km straight-line S from Montezuma. Specimens reported here were collected inside forested areas in the Atlantic Forest (MZUFV 307) and ecotonal zones between the Atlantic Forest and the Cerrado morphoclimatic domains (MZUFV 251, 249, and 409).

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***HEMIDACTYLUS BROOKII* (NCN)**. HONDURAS: ISLA DEL CISNE: Isla Grande (17.4059°N, 83.9421°W; WGS 84), 12 m elev. 28 April, 5 May 2007, respectively. Jorge A. Ferrari. Verified by Konrad Klemmer. Forschungsinstitut Senckenberg (SMF 90456–57). First records for Isla del Cisne (Powell and Maxey 1990. Cat. Amer. Amphib. Rept. 493.1–493.2). SMF 90456 was caught at night on the walls of a house; SMF 90457 was encountered on a stack of old wood panels.

GUNTHER KÖHLER, Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, 60325 Frankfurt a.M., Germany (e-mail: gkoehler@senckenberg.de); **JORGE A. FERRARI**, Organización de Rescate y Protección de Reptiles y Anfibios de Honduras, Tegucigalpa, Honduras (e-mail: herpetoking@yahoo.com).

***HEMIDACTYLUS FLAVIVIRIDIS* (Yellow-green House Gecko)**. INDIA: NAGALAND: Kohima (25.6685°N, 94.1056°E, 1432 m elev.). Arya Vidyapeeth Collage Zoological Museum (AVC A1047). 24 September 2010. Verified by S. Sengupta. First record for Nagaland. In India, distributed throughout northern India and westwards but not extending to east of Bengal (Smith 1935. The Fauna of British India, Ceylon and Burma, Including the Whole of the Indo-Chinese Region. Vol. III. Sauria. Taylor & Francis, London. xiii + 440 pp. + 1 pl.). Recent record from Manipur (Harit 2007. Cobra 1[4]:30–32) and Assam (Purkayastha and Das 2009. Herpetol. Rev. 40:451–452), with an assumption of anthropogenic introduction. Observed in a market place, again pointing to a probable human-mediated introduction. Not included in Dasgupta and Raha (2006. Reptilia. *In* J. R. B. Alfred [ed.], Fauna of Nagaland, pp. 433–460. State Fauna Series 12. Zoological Survey of India, Kolkata) indicates a recent introduction. Thanks are due to Kaushik Deuti, ZSI, Kolkata, and Arunabha Bhattacharjee, ZSI, Shillong, for literature support

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***HEMIDACTYLUS FRENATUS* (Common House Gecko)**. MÉXICO: BAJA CALIFORNIA SUR: Municipality of Mulegé: Santa Rosalía, Hotel El Morro (27.19580°N, 112.14994°W; WGS84), 15 m elev. 25 May 2010. J. B. Granados. Verified by Patricia Galina. Herpetological collection, Centro de Investigaciones Biológicas del Noroeste, La Paz, Baja California Sur, México (CIBNOR 1306–1307). First records for the municipality, extending the known range of this exotic species 197 km N of Loreto (Grismer 2002. Amphibians and Reptiles of Baja California: Including Its Pacific Islands and the Islands in the Sea of Cortez. Univ. of California Press, Berkeley, California. xiv + 399 pp.). Both lizards were collected at night on the hotel wall, along with observing more than 20 other adults, thus indicating a well-established population.

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***HEMIDACTYLUS FRENATUS* (Common House Gecko)**. HONDURAS: VALLE: Amapala, Isla del Tigre (13.2928°N, 87.6520°W; WGS84), 10 m elev. 14 July 2010. USNM 565827. Isla Exposición (13.3150°N, 87.6741°W; WGS84), 7 m elev. 15 July 2010. USNM 565828–29. Alexander Gutsche, James R. McCranie, and Leonardo Valdés Orellana. All verified by George Zug. First records for Valle. The closest known locality is ca. 50 km E at Choluteca, Choluteca (USNM 570129). USNM 565828–29 were collected midmorning under discarded roof tiles in beach area vegetation, and USNM 565827 was active at night on a hotel wall; many others were observed at both localities. Fieldwork of A. Gutsche was supported by the Adolf and Hildegard Isler Foundation.

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***HEMIDACTYLUS FRENATUS* (Common House Gecko)**. HONDURAS: ISLA DE LA BAHÍA: Isla de Roatán, Lawson Rock housing development, 6.6 km E of West End (16.33841°N, 86.55511°W; WGS84), 9 m elev. 12 January 2008. Sean M. Rovito. Verified by Theodore Papenfuss. MVZ 263826. First record for Isla de Roatán (McCranie et al. 2005. The Amphibians & Reptiles of the Bay Islands and Cayos Cochinos, Honduras. Bibliomania!, Salt Lake City, Utah. xiii + 210 pp.). The gecko was found at night along with *Phyllodactylus palmeus* and *Sphaerodactylus rosaurae* on a rock wall along the edge of the housing development.

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***HEMIDACTYLUS PARVIMACULATUS* (Sri Lankan House Gecko)**. THAILAND: Bangkok, Suan Luang District (13.711778°N, 100.603986°E, 3 m elev.). Two females (THNHM 17952, 31 January 2011; THNHM 17953, 1 February 2011). Found under cover of a pile of concrete blocks on ground in open lot of urban area. Bangkok, Panthum Wan District, Lumpini Park (13.729047°N, 100.538439°E, 3 m elev.). THNHM 17954, male. 17 February 2010. Under concrete ground cover. Bangkok, Khlong Toei District (13.727208°N, 100.574161°E, 3 m elev.). THNHM 17955, female. 28 February 2011. Found among hedges along walkway of Sukhumwit Road. All specimens collected by Jonathan Hakim. Verified by Tanya Chan-ard. Previously considered a subspecies of *H. brookii*, and separated on basis of molecular (Bauer et al. 2010. Mol. Phylogen. Evol. 57:343–352) and morphological (Rösler and Glaw 2010. Spixiana 33:139–160) evidence. *H. brookii* was recorded from Thailand (Bauer et al. 2002. Herpetol. Rev. 33:322). Separation from *H. brookii* made on basis of number of nasals and of postanal tubercles. THNHM 17953 is gravid, with one developed egg; this along with the number of localities, previous sightings of adults, subadults, and hatchlings, constitute evidence of established population at first location. Other individuals were seen within ca. 150 m radius of first location. Populations in Bangkok likely inadvertently introduced, probably entering via major sea cargo port/sea cargo storage facilities in Khlong Toei District, within 3 km, 4 km, and 2 km of the populations, respectively. First record for Thailand and Southeast Asia. Other recorded localities are in Sri Lanka, southern India (Bauer et al. 2010. Herpetol. J. 20:129:138), and an introduced population in Mascarene Islands, Seychelles (Bauer et al. 2010, *op. cit.*).

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***HEMIDACTYLUS TURCICUS* (Mediterranean Gecko)**. USA: CALIFORNIA: Inyo Co.: Death Valley National Park, Furnace Creek Ranch Hotel, 0.5 km W of Hwy 190 (36.45604°N, 116.87041°W; WGS83; elev. -56 m). 21 April 2007. Ian W. Murray. Verified by Neftali Camacho. Natural History Museum of Los Angeles Co. (LACM PC 1545–1546). New county record (Stebbins 2003. A Field Guide to Western Reptiles and Amphibians. 3rd ed. Houghton Mifflin, Boston, Massachusetts. 533 pp.). Between 2006 and 2008 multiple *H. turcicus* were seen nocturnally active on building walls here. The aforementioned specimen was found while actively foraging on the illuminated wall of a hotel building. In their detailed survey of Death Valley National Park amphibians and reptiles, Persons and Nowak (2006. Inventory of Amphibians and Reptiles at Death Valley National Park. Report to National Park Service. USGS Colorado Plateau Research Station, Flagstaff, Arizona) list *H. turcicus* as being a species of possible occurrence, and discuss a third party sighting of an unidentified gecko climbing a wall at Scotty's Castle, Death Valley as probably being a *Coleonyx variegatus* after repeated searches failed to document *H. turcicus* .

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***IGUANA IGUANA* (Common Green Iguana)**. TURKS AND CAICOS ISLANDS: Providenciales: east side of island, near Long Bay (21.780°N, 72.166°W; WGS84), 11 m elev. 1 October 2009. Brian M. Riggs. Verified by A. C. Echternacht. Color photo voucher (APSU 19019). First record for Turks and Caicos Islands. The closest reported localities in the West Indies are from the Cayman Islands and Puerto Rico (Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. University of Florida Press, Gainesville. xvi + 720 pp.)

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***LEPIDOPHYMA MAYAE* (Maya Night Lizard)**. HONDURAS: SANTA BÁRBARA: tributary of Río Listón (15.533336°N, 88.350144°W; WGS84), 405 m elev. 12 November 2008. James R. McCranie and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 573973. First record for Santa Bárbara and only the second record from Honduras; the other locality is from ca. 95 km SSW at San Isidro, Copán (McCranie 2004. Herpetol. Bull. 90:10–21). The lizard was inside a rotten log overhanging a stream surrounded by relatively undisturbed broadleaf forest.

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***LIOLAEMUS XANTHOVIRIDIS* (Rawson Lizard)**. ARGENTINA: CHUBUT: Escalante Department: Provincial Route 27, 33.1 km N junction with Provincial Route 25, 55.1 km N Nollman Bridge over Río Chico (44.93433°S, 68.02661°W; WGS84; elev. 381 m.). 4 November 2008. L. J. Avila and M. Nicola. Herpetological collection of Centro Nacional Patagónico, Puerto Madryn, Chubut, Argentina (LJAMM-CNP 11078–11080). Escalante Department: Provincial Route 27, 60 km N junction with Provincial Route 25 (44.72872°S, 67.90667°W; WGS84; elev. 349 m.). 10 February 2008. L. J. Avila, C. H. F. Pérez, M. F. Breitman, and N. Feltrin. LJAMM-CNP 10296–10303. All verified by C. H. F. Pérez. The type locality is 18 km SW from Dos Pozos (Chubut Province) and the species occurs on the xerophytic coast between northern Río Chubut and southern Bahía Santa Cruz, extending inland to the Gran Laguna Salada (Mártires Department) basin through the flat embossment of Meseta de Montemayor and extends to about 44°S near Cabo Raso (Florentino Ameghino Department), on the Atlantic shore (Cei and Scolaro 1980. Herpetology 14[1]:37–43). Although the geographic range of this species is poorly known, present confirmed distribution includes Rawson, Gaiman, and Florentino Ameghino departments (Abdala 2007. Zootaxa 1538:1–84). Vouchered specimens from inland localities for this species are scarce. The present records are the first for Escalante Department, extending the known distribution about 235 airline km SW from the nearest vouchered record (FML 17033; Abdala 2007, *op. cit.*), and are the southwestern most localities for Chubut Province and for Argentina.

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***MESOSCINCUS MANAGUAE* (NCN)**. HONDURAS: VALLE: Isla Exposición (13.3150°N, 87.6741°W, WGS84), 7 m elev. 15 July 2010. Alexander Gutsche, James R. McCranie, and Leonardo Valdés Orellana. Verified by Steve W. Gotte. USNM 565830–31). First records for Valle. The closest known locality in Honduras is about 19 km E at Punta Ratón, Cortés (Cruz et al. 1979. Herpetol. Rev. 10:26). The lizards were collected midday in heavily disturbed deciduous forest; one was under a log and the other was sunning on a tree stump. Fieldwork of A. Gutsche was supported by the Adolf and Hildegard Isler Foundation.

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***PLESTIODON FASCIATUS* (Common Five-lined Skink)**. USA: ILLINOIS: Calhoun Co.: McCully Heritage Project, 70 m N of Crawford Creek Hollow Rd., 1.15 km W of Hwy 100 (39.282653°N; 90.622480°W; WGS84 datum). 11 April 2009. C. E. Montgomery and P. J. Muelleman. Verified by Chris Phillips. Illinois Natural History Survey collection (INHS 2009.08 photo voucher). First county record since 1954, re-establishing the presence of the species in Calhoun Co. (Philips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Natural History Survey, Champagne, Illinois. 282 pp.). One individual was captured under a board, adjacent to an equipment shed. Permits issued by the Illinois Department of Natural Resources (NH08.5174; NH08.5173). We thank the McCully Heritage Project.

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SQUAMATA — SNAKES

***AGKISTRODON CONTORTRIX* (Copperhead)**. USA: MISSOURI: Grundy Co.: 200m S of NW 15th St., 1 km W of Hwy 190 (40.083292°N, 93.742302°W; WGS84). 24 May 2010. P. J. Muelleman. Verified by Chad Montgomery. Photo voucher deposited in the Dean E. Metter Memorial Collection, University of Missouri, Columbia (UMC 1843P). First county record. Partially fills a distributional gap in northern Missouri (Daniel and Edmond 2010. Atlas of Missouri Amphibians and Reptiles for 2009. <http://atlas.moherp.org/pubs/atlas09.pdf>). A 67.0 cm (SVL) adult male was captured, photographed, and released on a forested rocky hillside. A copulating pair was captured and released at this site on 29 April 2010 but no photo was taken. Collected under Missouri Department of Conservation wildlife collector's permit #14509.

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***AGKISTRODON CONTORTRIX* (Copperhead)**. USA: TENNESSEE: Robertson Co.: South of Shiloh Road, 0.2 mi SSW of junction TN 76E and Distillery Road (36.469600°N, 086.763233°W, NAD 83). 25 April 2009. Gregory T. Barrass. David H. Snyder Museum of Zoology, Austin Peay State University (APSU 18990). Verified by A. Floyd Scott. New county record (Scott and Redmond 2008. Atlas of Reptiles in Tennessee. The Center of Excellence for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available from http://apsu.edu/reptatlas/ [updated 1 February 2011, accessed 20 March 2011]). Found lethargic, beneath a log pile, approximately 23m N and 15m above Sulphur Fork Creek.

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***CARPHOPHIS AMOENUS AMOENUS* (Eastern Wormsnake)**. USA: GEORGIA: Dekalb Co.: Henderson Park: ~ 0.25 km from parking lot at end of Henderson Park Rd. (33.86667°N, 84.23106°W; WGS 84), elev. 306 m. 03 November 2010. Robert L. Hill. Verified by Joseph R. Mendelson. AUM AHAP-D 299–300. New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. Univ. of Georgia Press, Athens. 575 pp.); documented previously in all counties adjacent to Dekalb. Specimen found under log at junction of two foot paths ~52 m SW of the north end of Lake Erin.

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***CONIOPHANES MELANOCEPHALUS* (Black-headed Stripeless Snake)**. MÉXICO: MICHOACÁN: Municipality of Taretan: Hoyo del Aire (19.266667°N, 101.866667°W; WGS84), 887 m elev. 15 July 2006. Marco Antonio Domínguez de la Riva, Rubén Alonso Carbajal Márquez, and Eric Rivas Mercado. Verified by Luis Canseco-Márquez. Herpetological Collection, Universidad Autónoma de Aguascalientes (UAA-CV-0323). First record for Michoacán, extending its range ca. 268.54 km (air) northwest of closest known locality at Huajintlán, Morelos (Ponce-Campos and Smith 2001. Bull. Maryland Herpetol. Soc. 37:10–17). The snake was found at 2230 h crawling next to a stone wall near a small stream in subtropical dry forest.

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***LAMPROPELTIS GETULA* (Common Kingsnake)**. USA: MISSOURI: Adair Co.: approximately 200 m E of Big Creek

Conservation Area north parking lot on W. Michigan St. (40.184028°N, 92.618975°W). 6 April 2010. Anthony J. Wilmes. Verified by Richard Daniel. Voucher specimen deposited in the University of Missouri Columbia Museum (UMC 8750). A single sub-adult male DOR (64 cm SVL, 10 cm TL, 135 g). First vouchered specimen from Adair Co. (Daniel and Edmond. 2010. Atlas of Missouri Amphibians and Reptiles for 2009. <http://atlas.moherp.org/pubs/atlas09.pdf>). Collected under Missouri Department of Conservation wildlife collector's permit #14509 issued to PJM.

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***LAMPROPELTIS MEXICANA* (Mexican Kingsnake)**. MEXICO: NAYARIT: Mesa de Nayar (22.4283861°N, 104.8460944°W; WGS84), 2220 m elev. 23 August 2010. C. Rodriquez and C. Grünwald. Verified by Robert W. Bryson, Jr. University of Texas Arlington Digital Collection (UTADC 6833–6835, photo vouchers). New state records, extending the range 110 km S from southern Durango (42 mi. S of Cd. Durango [UCM 21061]; Gehlbach and McCoy 1965. Herpetologica 21:35–38), which represents the southernmost locality for the western portion of the Sierra Madre Occidental. The three snakes, phenotypically similar to populations of *L. m. "greeri"* from Durango, along with several shed skins, were located under rocks within pine-oak forest.

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***MICRURUS LATICOLLARIS* (Balsan Coralsnake)**. MEXICO: JALISCO: Municipality of Tecolotlán: 1 km N Tecolotlán (20.23289°N, 104.06000°W; WGS84) , 1300 m elev. 30 June 2009. Iván T. Ahumada-Carrillo. Verified by Eric N. Smith. UTADC 6253. First record for municipality and northernmost record for the species, extending the range ca. 85 km (airline) N from the closest known localities in southern Jalisco (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere, Vol. I. Comstock Publ. Assoc., Cornell Univ. Press, Ithaca, New York. 475 pp.). The snake was found in tropical deciduous forest.

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***NERODIA ERYTHROGASTER* (Plain-bellied Watersnake)**. USA: ALABAMA: Crenshaw Co.: 8.69 km E of US 331 on CR 6 (31.6722°N, 86.18972°W; WGS84; elev. 97 m). 22 April 2006. Michael E. Welker. Verified by Craig Guyer and Robert Makowsky. University of Alabama Herpetological Collection (UAHC 15643). New county record and range extension (Mount 1975. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. 347 pp.). This DOR adult male specimen weighing 209 g helps fill a distributional gap in south-central Alabama. The closest documented locality for this species occurs southeast of this specimen in extreme northwestern Coffee Co.

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***NERODIA ERYTHROGASTER FLAVIGASTER* (Yellow-bellied Watersnake)**. USA: ALABAMA: Pickens Co.: 5.15 km N of CR 2 on CR 63 (33.13613°N, 87.92922°W; WGS84; elev. 68 m). 04 July 2006. Michael E. Welker. Verified by Craig Guyer and Robert Makowsky. University of Alabama Herpetological Collection (UAHC 15644). New county record and range extension (Mount 1975. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. 347 pp.). This DOR adult male specimen weighing 230 g helps fill a distributional gap in western Alabama along the Mississippi border. The closest records for this species are unpublished specimen records from the UAHC database that occur in Greene, Tuscaloosa, and Fayette counties (R. Makowsky, pers. comm.).

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***OPHEODRYS AESTIVUS AESTIVUS* (Northern Rough Greensnake)**. USA: ALABAMA: Hale Co.: 12.87 km E of CR 708 on NFR 708A (32.950889°N, 87.450389°W; WGS84; elev.115 m). 15 July 2006. Michael E. Welker and Scott Altnether. Verified by Craig Guyer and Robert Makowsky. University of Texas Arlington (UTA R 55651). New county record and range extension (Mount 1975. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. 347 pp.). The closest documented locality record to this DOR adult specimen occurs in adjacent Perry Co.

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***PANTHEROPHIS GUTTATUS* (Red Cornsnake)**. TURKS AND CAICOS ISLANDS: Grand Turk: south of Cockburn Town, near cruise ship terminal (21.430°N, 71.145°W; WGS84), 5 m elev. 1 October 2009. Brian M. Riggs. Verified by A. C. Echternacht. Color photo voucher (APSU 19020). First record from the Turks and Caicos Islands, but was also introduced to the Cayman Islands (Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Florida Press, Gainesville. xvii + 495 pp.; Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History, Univ. Florida Press, Gainesville. xvi + 720 pp.).

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***PANTHEROPHIS GUTTATUS* (Red Cornsnake)**. USA: TENNESSEE: Chester Co.: Rabbit Ranch Rd. ca 1.4 km W of Glendale Rd. 35.2817°N, 88.3340°W; WGS 84). 03 May 2009. Jonathan W. Stanley. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 19064). First county record (Scott and Redmond 2008. Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. http://www.apsu.edu/reptatlas [updated 13 October 2010; accessed 03 January 2011]).

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PITUOPHIS MELANOLEUCUS MELANOLEUCUS **(Northern Pinesnake)**. USA: ALABAMA: Hale Co.: 2.7 km E of CR 53 on CR 50 (32.954944°N, 87.482222°W; WGS84; elev. 85 m). 08 July 2006. Michael E. Welker and Scott Altnether. Verified by Craig Guyer and Robert Makowsky. University of Texas Arlington (UTA R 55651). New county record and range extension (Mount 1975. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. 347 pp.). DOR adult female (474 g; 134.5 cm TL) extends the known range of this species 12 km SW from the closest documented locality (AUM 23790)and brings the known range of *Pituophis m. melanoleucus* to within one county of *P. m. lodingi*.

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REGINA GRAHAMII **(Graham's Crayfish Snake)**. USA: MISSOURI: Grundy Co.: DOR, Hwy 6, 0.3 mi. W of Trenton (40.07013°N, 93.627236°W; WGS84). 24 May 2010. Chad E. Montgomery. Verified by Richard Daniel. University of Missouri-Columbia (UCM 1846P). First county record (Daniel and Edmond 2010. Atlas of Missouri Amphibians for 2009. <http://atlas.moherp.org/pubs/atlas09.pdf>). Single adult collected DOR surrounded by agricultural fields in the Thompson River floodplain. Collected under Missouri Department of Conservation wildlife collector's permit #14509 issued to PJM.

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RENA **(=** ***LEPTOTYPHLOPS*****)** ***DULCIS*** **(Texas Threadsnake)**. MÉXICO: HIDALGO: Municipality of Tasquillo: Dangu (20.50014°N, 99.25008°W; WGS84), 2230 m elev. 22 September 2008. Luis Alberto Trejo-Corona. Verified by Aurelio Ramírez-Bautista. Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo (CIB 2185). New municipality record that reaffirms the occurrence of *R. dulcis* in Hidalgo, whose taxonomic allocation within the state had been questioned by Lemos Espinal and Smith (2007. Anfibios y Reptiles del Estado de Coahuila, México. CONABIO, México, D.F. xii + 550 pp.) and Dixon and Vaughn (2003. Texas J. Sci. 55:3–24). Most recently, Ramírez-Bautista et al. (2010. Lista Anotada de los Anfibios y Reptiles del Estado de Hidalgo, México. Universidad Autónoma del Estado de Hidalgo, y CONABIO, México, D.F. x + 104 pp.), without taxonomic comment, listed the species as occurring in two municipalities within the state (Huautla [Tamoyón] and Metztitlán [Las Casita; Presa de Apanco]). All known records to date from Hidalgo indicate that *R. dulcis* occurs in xeric to moist lowland and highland habitats ranging in elevation from about 500 to 2300 m.

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RHAMPHOTYPHLOPS BRAMINUS **(Brahminy Blindsnake)**. TURKS AND CAICOS ISLANDS: Grand Turk: south end of island (21.439°N, 71.137°W; WGS84), 5 m elev. 16 June 2009. Jewel Batchasingh. Verified by A. C. Echternacht. Color photo voucher (APSU 19022). First record from Turks and Caicos Islands (Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Florida Press, Gainesville. xvii + 495 pp.; Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. xvi + 720 pp.).

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RHINOCHEILUS LECONTEI **(Long-nosed Snake)**. MÉXICO: AGUASCALIENTES: Municipality of Calvillo: 930 m NE La Rinconada (21.795083°N, 102.790889°W; WGS84), 1587 m elev. 5 July 2010. Rubén Alonso Carbajal Márquez, Zaira Yaneth González Saucedo, and José A. de Jesús González Barajas. Verified by Luis Canseco Márquez. Herpetological Collection, Universidad Autónoma de Aguascalientes (UAA-CV 0321). First official record for Aguascalientes, extending the known range ca. 8.3 km NE from the closest known locality in southwestern Zacatecas; its occurrence in Aguascalientes was expected by both Frost and Aird (1978. Herpetol. Rev. 9:62) and McCranie and Wilson (2001. Cour. Forsch.-Inst. Senckenberg 230:1–57). The specimen was found in an area covered by tropical deciduous forest.

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SENTICOLIS TRIASPIS **(Green Rat Snake)**. MÉXICO: VERACRUZ: Municipality of Córdoba: Finca Biozoo (18.8837°N, 96.9455°W, WGS84), 875 m elev. 12 November 2004. Edith Batista. Verified by Julio Lemos Espinal. Colección de Anfibios y Reptiles, Facultad de Ciencias Biologicas y Agropecuarias, Universidad Veracruzana (HFBUV-0473). First record for the Municipality of Córdoba. The closest reported localities are in Veracruz from near San Andrés Tuxtla, ca. 190.5 km to the east (Pérez-Higareda and Smith 1991. Publ. Espec. 7, Instit. Biol. UNAM) and Alto Lucero, 84.6 km to the north (Colección Nacional de Anfibios y Reptiles de México [CNAR 3414-A]). The snake was found in a coffee plantation.

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SISTRURUS CATENATUS **(Massasauga)**. USA: NEW MEXICO: De Baca Co.: 5.31 rd km S jct. NM 294 and Roosevelt Co. Rd 3 on Gunsmoke Rd (34.1670151°N, 103.9969887°W, NAD 83; elev. 1295 m). 11 May 2010. M. T. Hill. Verified by J. T. Giermakowski. Museum of Southwestern Biology (MSB 78054). New county record (Degenhardt et al. 1996. Amphibians and Reptiles of New Mexico. University of New Mexico Press, Albuquerque. 431 pp.). The closest known specimen of *S. catenatus* (MSB 74669) is from Chaves Co., 31.74 km S of the new locality.

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TANTILLITA LINTONI **(Linton's Dwarf Short-tailed Snake, Culebrita Enana de Linton)**. HONDURAS: ISLAS DE LA BAHÍA: Isla de Utila, Utila, Iguana Station (16.10056°N, 86.885833°W; WGS84), elev. 40 m. 24 February 2010. Andrea Martinez. Verified by James R. McCranie. UNAH 5571. First record for Isla de Utila, Islas de la Bahía (McCranie et al. 2006. Amphibians and Reptiles of the Bay Islands and Cayos Cochinos, Honduras. Bibliomania, Salt Lake City, Utah. xii + 210 pp.). The snake was found under a rock.

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THAMNOPHIS MELANOGASTER **(Mexican Black-bellied Gartersnake)**. MÉXICO: MORELOS: Municipality of Huitzilac: Parque Nacional Lagunas de Zempoala (19.051139°N, 99.31325°W; WGS84), 2832 m elev. 24 September 2010. Adriana J. González Hernández. Verified by Víctor Hugo Reynoso. Colección Nacional de Anfibios y Reptiles, Instituto de Biología, UNAM (CNAR-IBH 24541). First record from Morelos, extending its known range 30 km S of Tlalpan, Distrito Federal, and an upward elevation extension of 287 m (Ramírez-Bautista et al. 2009. Herpetofauna del Valle de México. UAEH-CONABIO, México, D.F. xxiv + 213 pp.; Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. Oklahoma Press, Norman, Oklahoma. xx + 332 pp.). The snake was basking on tree branches adjacent to a lagoon.

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THAMNOPHIS SIRTALIS **(Common Gartersnake)**. USA: MICHIGAN: Charlevoix Co.: South end of Hog Island, Eastern Lake Michigan Archipelago (45.76667°N, 85.383333°W; WGS84). 24 May 2008. James C. Gillingham. Verified by Fred Janzen. Iowa State University Research Collection (ISUA 201102; digital image). New record for Hog Island (Bowen and Gillingham 2004. Michigan Acad. 35:213–223).

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Noteworthy Records of Amphibians from Western Panama

In view of its relatively small size, Panama supports one of the most diverse amphibian faunas in Central America (Jaramillo et al. 2010; Ibáñez et al. 2001; Myers and Duellman 1982). The global amphibian crisis has lead to serious population declines throughout the world, with almost all amphibian families being affected (Stuart 2004). This has been especially the case in Panama (Jaramillo et al. 2010). The major threat to amphibians is habitat loss as measured by high deforestation rates in all of Central America and other hotspots of biodiversity (Wilson and Johnson 2010; Wilson and Townsend 2010; Brooks et al. 2002). Another cause for concern is the chytrid fungal pathogen, *Batrachochytrium dendrobatidis*, which has caused mass mortalities and amphibian diversity loss in most highland amphibian populations in western Panama (Brem and Lips 2008; Crawford et al. 2010a; Lips 1999; Lips et al. 2006). However, recent amphibian species descriptions (e.g., Bolaños and Wake 2009; Crawford et al. 2010b; Köhler et al. 2007; Mendelson et al. 2008; Mendelson and Mulcahy 2010; Ryan et al. 2010; Wake et al. 2005, 2007) and continual reports on range extensions (e.g., Köhler et al. 2008) demonstrate that the amphibian inventory for Panama is still far from complete. A checklist and bibliography on the Panamanian

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herpetofauna prepared by Auth (1994) listed 170 species of amphibians. Later, Young et al. (1999) published a list that contained 171 species of amphibians and additional information on provincial records and conservation status. Ibañez et al. (2001) updated the list to 176 species, and most recently Jaramillo et al. (2010) registered 199 species from Panama, including two introduced forms.

During field work from May through August 2008, we visited different sites in the Cordillera Central of western Panama in the provinces of Chiriquí, Bocas del Toro, Veraguas and the Comarca Ngöbe-Buglé, an indigenous, autonomous territory that was established in 1997 (Fig. 1). During that period, we collected 233 specimens of amphibians representing 51 species. The purpose of this paper is to report noteworthy findings among the collected material. For frogs, we present a first country record and four distributional range extensions, all of which represent first province records. We also provide new morphological and ecological information on two rarely observed salamanders.

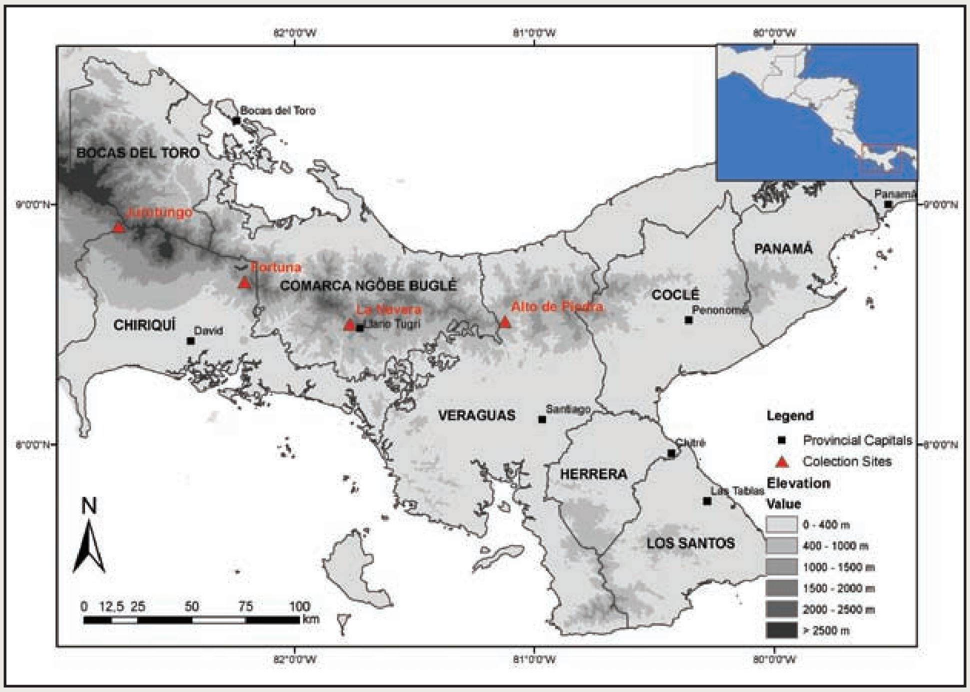

Fig. 1 Map of collection localities in western Panama denoted by red triangles, from west to east: Jurutungo, Chiriquí; Reserva Forestal La Fortuna, Chiriquí; La Nevera, Comarca Ngöbe-Buglé; Alto de Piedra, Veraguas.

All vouchers were verified by Javier Sunyer. Locality and elevational data were recorded using a GPS receiver with an integrated barometric altimeter, Garmin Etrex Summit; map datum used was WGS84. The map (Fig. 1) was created using ArcMap 10 and the shapefiles provided by the Smithonian map server at http://mapserver.stri.si.edu/. All voucher specimens are deposited in the collection of Senckenberg Forschungsinstitut und Naturmuseum (SMF). Common names were generated consulting the online database of Frost (2010), except for *Oedipina fortunensis*, which was named by translating the scientific name.

ANURA — FROGS

Hylidae

***AGALYCHNIS ANNAE* (Blue-Sided Leaf Frog)** (Fig. 2). COMARCA NGÖBE-BUGLÉ: ca. 6.3 km W of La Nevera and 10.5 km NNW of Hato Chamí (8.5353°N, 81.8081°W), 1600 m elev. 10 May 2008. Andreas Hertz and Gunther Köhler. SMF 89791. First record for Panama, extending the known distribution ca. 230 km SE from the nearest collection site at Moravia de Chirripó, Costa Rica (Duellman 2001, who also assumed it would be found on the Caribbean slopes of western Panama). *Agalychnis annae* has suffered serious population declines and has disappeared from most of its known geographic range; it is now listed as endangered by the IUCN (Pounds et al. 2008). The only population in Costa Rica that seems to persist is found around San José (Pounds et al. 2008), thus this new record from Panama should play an important role in shaping future conservation actions.

***HYLOSCIRTUS COLYMBA* (La Loma Treefrog)** (Fig. 3). VERAGUAS: Alto de Piedra, ca. 4 km W of Santa Fé (8.5129°N, 81.1220°W), 880 m elev. 11 July 2008. Leonard Stadler and Nadim Hamad. SMF 89794. First record for Veraguas that fills the gap between the species' nearest collection sites; Reserva Forestal Fortuna, Chiriquí; 120 km W (Lips 1999) and El Copé, Coclé; ca. 45 km E (Crawford et al. 2010). However, at both of those neighboring sites it has become extremely rare after serious declines and is listed as critically endangered by IUCN (Solis et al. 2008). Martínez and Rodríguez (1992) and Martínez et al. (1994) were the first to present inventories of the herpetofauna of the Santa Fé, Veraguas region, and mentioned finding various unidentified hylid frogs. We cannot rule out that they discovered *H. colymba* around Santa Fé, but that has become an irresolvable point because the voucher specimens were lost before they could be identified (V. Martínez, pers. com.).

Craugastoridae

***CRAUGASTOR MONNICHORUM* (Dunn's Robber Frog)** (Fig. 4). COMARCA NGÖBE-BUGLÉ: La Nevera, Caribbean slopes, ca. 6 km NNW of Hato Chamí (8.4953°N, 81.7672°W), 1800 m elev. 14 August 2008. Andreas Hertz and Sebastian Lotzkat. SMF 89801.

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

PHOTO BY AH

FIG. 2. *Agalychnis annae*, La Nevera, Comarca Ngöbe-Buglé.

PHOTO BY AH

FIG. 3. *Hyloscirtus colymba*, Alto de Piedra, Veraguas.

PHOTO BY SL

FIG. 4. *Craugastor monnichorum*, La Nevera, Comarca Ngöbe-Buglé.

First record for Comarca Ngöbe-Buglé, extending the known distribution in Panama, ca. 60 km E of the formerly eastern-most collecting site at Quebrada Frank, Reserva Forestal Fortuna (Tejera and Dupuy 2003). The large female was situated ca. 30 cm above ground on a mossy liana situated in elfin woodland on the crest of a mountain ridge.

PHOTO BY AH

FIG. 5. *Hyalinobatrachium talamancae*, La Nevera, Comarca Ngöbe-Buglé.

Centrolenidae

***HYALINOBATRACHIUM TALAMANCAE* (Talamanca Glass Frog)** (Fig. 5). COMARCA NGÖBE-BUGLÉ: La Nevera, Caribbean slope, ca. 6 km NNW of Hato Chamí, (8.4987°N, 81.1195°W), 1550–1600 m elev. 16 August 2008. Andreas Hertz and Sebastian Lotzkat. SMF 89798–89800. First record for Comarca Ngöbe-Buglé that fills the gap between the species' nearest collection sites at Reserva Forestal Fortuna, Chiriquí; ca. 53 km W (Kubicki et al. 2008) and Parque Nacional Altos de Campana, Panama province; ca. 195 km SE (Ibañez et al. 1996). Furthermore, this record exceeds the known elevational limit known for this species by about 484 m (Taylor 1952).

Hyalinobatrachium talamancae is often confused with *H. vireovittatum*, as both show a characteristic green mid-dorsal line and are similar in respect to their morphology, ecology, and mating calls (Kubicki 2007). However, in the latter species the mid-dorsal green line is bordered by two clearly distinguishable yellow stripes that are lacking on specimens from La Nevera. Kubicki (2007) reviewed specimens referred to as *H. vireovittatum* in the collection of the Círculo Herpetológico de Panama in 2004 and considered all to be *H. talamancae*. Moreover, in 2005 he found a population in El Valle, Coclé, that apparently is the only record of *H. vireovittatum* currently known from Panama. Nevertheless, the possibility exists that *H. vireovittatum* is a synonym of *H. talamancae* (Kubicki 2007).

Strabomantidae

***PRISTIMANTIS MORO* (La Hondura Robber Frog)** (Fig. 6). VERAGUAS: Alto de Piedra, ca. 4 km W of Santa Fé (8.5142°N, 81.1195°W), 1060 m elev. 1 August 2008. Leonard Stadler and Nadim Hamad. SMF 89796. First record for Veraguas that fills the gap between the two nearest published localities, about 360 km NW to La Hondura, San José, Costa Rica and ca.110 km SE to Valle de Antón, Coclé, Panama (Crawford et al. 2010). This

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

PHOTO BY NH

FIG. 6. *Pristimantis moro*, amplectant pair, Veraguas.

PHOTO BY AH

FIG. 7. *Bolitoglossa sombra*, Jurutungo, Chiriquí.

PHOTO BY SL

FIG. 8. *Oedipina fortunensis* with automized tail, La Fortuna, Chiriquí.

rarely observed species uses epiphytic bromeliads during daylight hours (Savage 1965, 2002). We found an amplecting pair at night on a leaf about 1.2 m above the ground in premontane wet forest. Unfortunately, the female escaped the next day, but left nine eggs inside the collection bag.

CAUDATA — SALAMANDERS

Plethodontidae

***BOLITOGLOSSA SOMBRA* (Shadowy Web-footed Salamander)** (Fig. 7). CHIRIQUÍ: Jurutungo, on the Pacific slopes of Cerro Pando, near the Costa Rican border (8.9075°N, 82.7336°W), 1850–1965 m elev. 12–13 July 2008. Andreas Hertz and Sebastian Lotzkat. SMF 89792–89793. The locality is within the known range of this recently described species (Hanken et al. 2005), but because of its rarity in collections, we here add information on morphological characteristics and ecology.

On two rainy nights, we found several of these large black salamanders, but only collected one large male and one large female. Some were found in pristine lower montane wet forest while they were walking on tree trunks; a single juvenile was inside a rotten log on the forest floor; and others were located inside a cow paddock while positioned on top of rocks. When disturbed, the salamanders were able to move astonishingly fast. Most morphometric data and tooth counts are within the documented range of variation of this species (Hanken et al. 2005). However, the two secured specimens represent the largest individuals so far reported for this species; SMF 89792, a male, has a standard length of 70 mm and SMF 89793, a female, has a standard length of 84.5 mm. The largest individuals reported before were 61.5 mm (males) and 82.7 mm (females), respectively.

***OEDIPINA FORTUNENSIS* (Fortuna Worm Salamander)** (Fig. 8). CHIRIQUÍ: Reserva Forestal Fortuna, near Río Hornito (8.677°N, 82.209°W), 1300 m elev. 18 June 2008. Andreas Hertz and Sebastian Lotzkat. SMF 89795. Our record is only the second known individual of this species reported since its description by Köhler et al. (2007), and the site is located near the type locality. The male specimen was found near the riverbank of the Río Hornito on a trail through a former citrus plantation. The salamander was on the ground and had shed its tail, probably due to our disruptive pursuit, but the extremity was retrieved for inclusion with morphological comparison to the holotype. Because of the lack of comparative statistics with the male holotype, we herein present morphometric data and tooth counts from the additional specimen; holotype values are in parentheses and abbreviations for standard measurements are those of Köhler et al. (2007): SVL 32.5 mm (33.5 mm); TL 39.0 mm, incomplete (46.5 mm); SVL/TL 0.80 (0.72); HL 5.4 mm (6.5 mm); SVL/HL 6.0 (5.2); HW 4.1 mm (3.9 mm); SVL/HW 7.9 (8.6); HHL 5.6 mm (4.3 mm); SVL/HHL 5.8 (7.8); HAW 0.9 mm (1.2 mm); SVL/HAW 36.1 (27.9); HFW 1.2 mm (1.7 mm); SVL/HFW 27.1 (19.7). A single large premaxillary tooth is distinctly offset, almost piercing the lip (same in holotype); maxillary teeth 16 (right) - 18 (left) (13-14); vomerine teeth 7 (right) - 6 (left) (7-7). The above values reasonably favor the contention that SMF 89795 is conspecific with the holotype of *O. fortunensis*.

Based on information presented by Brame (1968), the high total number of maxillary teeth (27–34) distinguishes *O. fortunensis* from other members of the subgenus *Oedopinola* in lower Central America, except *O. complex* (16–40 in males). Generally however, adult males of *O. complex* are larger (SVL: 36.6–39 mm versus 32.5–33.5 mm in *O. fortunensis*), have a slightly broader head (SVL/HW: 8.5–9.6 versus 7.9–8.6), and more vomerine teeth (17–28 versus 13–14). Nevertheless, since both species overlap in some morphometric characters, tooth counts, geographical range, and that *O. fortunensis* presently contains only two specimens for comparison, it cannot be ruled out that *O. fortunensis* is a junior synonym of *O. complex*.

Coloration in life of SMF 89795, interpreted from Smithe (1975, 1981) (color code numbers in parentheses), was recorded as follows: Dorsal ground color of body, head, and tail Russet (34) with Warm Buff (118) mottling; dorsal surface of head and upper legs with Buff (124) blotches; lower legs and lateral surfaces of body and head Fuscous (21), merging into Sepia (119) ventrally; venter with dirty white mottling.

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Additional Distributional Records of Amphibians and Reptiles in Georgia, USA

Since the publication of *Amphibians and Reptiles of Georgia* (Jensen et al. 2008), numerous records of amphibians and reptiles from counties not represented in the book's species-distribution maps have been submitted to the Georgia Department of Natural Resources. These new records, as well as recent records obtained by the authors, are provided herein. Unless otherwise indicated, geo-coordinates are based on datum NAD 83. Vouchers indicated as "AHAP-D" are digital photos housed in the Auburn University Herpetological collections. Identifications were verified by Lance D. McBrayer unless indicated otherwise.

CAUDATA — SALAMANDERS

***AMBYSTOMA MACULATUM* (Spotted Salamander).** Appling Co.: 4.5 km NW of Davis on Moody Forest Natural Area Preserve (31.930833°N, 82.283333°W). 14 March 2009. D. Stevenson and E.

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Grunwald. GSU 2252. First museum voucher specimen for county. Adult found under debris in Altamaha River floodplain bottomland forest, further demonstrating that this species extends its range into the lower Coastal Plain of southeastern Georgia along this prominent hardwood corridor adjacent to the river. Coffee Co.: Flat Tub Wildlife Management Area, 10.2 km NE of Relee (31.802465°N, 82.837232°W). 07 January 2008. D. Stevenson. GSU 2249. Adult under log in hardwood forest along Ocmulgee River. First museum record for county. MONTGOMERY Co.: State Hwy. 280/30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.192261°N, 82.625411°W). 23 March 2009. D. Stevenson. GSU 2250. One of five specimens found beneath logs in hardwood forest along Oconee River. Treutlen Co.: State Hwy. 46 at Oconee River, ca. 4.0 km SSW of Barnhill (32.301508°N, 82.694247°W). 28 March 2009. D. Stevenson. GSU 2251.One of three specimens found beneath logs in hardwood forest along Oconee River.

***AMBYSTOMA OPACUM* (Marbled Salamander)**. Montgomery Co.: State Hwy. 280/30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.195089°N, 82.628717°W). 23 March 2009. D. Stevenson. GSU 2253. Adult found beneath log in hardwood forest along Oconee River. Treutlen Co.: State Hwy. 46 at Oconee River, ca. 4.0 km SSW of Barnhill (32.301508°N, 82.694247°W). 28 March 2009. D. Stevenson. GSU 2254. Adult found beneath log in hardwood forest along Oconee River. Wheeler Co.: State Hwy. 46 at Oconee River, ca. 5.5 km SSW of Barnhill (32.295222°N, 82.699933°W). 28 March 2009. D. Stevenson. GSU 2255. Adult found beneath log in hardwood forest along Oconee River.

***AMBYSTOMA TIGRINUM* (Tiger Salamander)**. Thomas Co.: AOR Whitney Camp Road 3.2 km S of Boston (30.762314°N, 83.785417°W). 21 December 2006. J. Young. Verified by Kenneth L. Krysko. UF 156845. Turner Co.: South side of State Hwy.107, 10.0 km E of jct. of State Hwys.107/112 (31.720478°N, 83.480383°W). 06 March 2009. D. Stevenson. GSU 2256. Larva dip-netted from borrow pit wetland adjacent to State Hwy. 107.

***AMPHIUMA MEANS* (Two-toed Amphiuma)**. Wheeler Co.: 2.3 km SW of Jordan, seepage area in xeric sandhills E of Alligator Creek. (32.018342°N, 82.683306°W). 06 May 2009. D. Stevenson. GSU 2257.

***EURYCEA GUTTOLINEATA* (Three-lined Salamander)**. Candler Co.: Canoochee River E of Stillmore on Stillmore-Metter Road (32.425661°N, 82.160944°W). 08 July 1976. J. Cadle. Verified by Ned Gilmore. ANSP 30811. Treutlen Co.: 6.6 km SW of Nunez, State Hwy. 297 at Ohoopee River (32.439522°N, 82.384017°W). 26 August 2009. D. Stevenson. GSU 2277. Two adults found in hardwood swamp adjacent to Ohoopee River. Twiggs Co.: Stone Creek access trail at Bond Swamp National Wildlife Refuge (32.739264°N, 83.567042°W). 27 March 2008. J. Jensen. Verified by Elizabeth McGhee. GMNH 50103. Several individuals found under logs in floodplain forest.

***EURYCEA LONGICAUDA* (Long-tailed Salamander)**. Catoosa Co.: Chickamauga and Chattanooga National Military Park (34.91267°N, 85.23374°W). 26 May 2009. S. Graham and J. Jensen. Verified by Craig Guyer. AHAP-D 229. Two individuals found under logs adjacent to small stream.

***EURYCEA QUADRIDIGITATA* (Dwarf Salamander)**. MONTGOMERY Co.: US Hwy. 280/State Hwy. 30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.192261°N, 82.625411°W). 23 March 2009. D. Stevenson. GSU 2279. Adult found beneath log in hardwood forest along Oconee River.

***GYRINOPHILUS PORPHYRITICUS* (Spring Salamander)**. Polk Co.: Thompson Creek Gorge (33.956592°N, 85.024212°W). 03 April 2008. M. Elliott and C. Camp. Verified by Elizabeth McGhee. GMNH 50101.

***NOTOPHTHALMUS VIRIDESCENS* (Eastern Newt)**. Lamar Co.: St. George's Episcopal School Campus, Milner (33.117475°N, 84.198389°W). 16 May 2007. C. Muise and T. Muise. Verified by Kenneth L. Krysko. UF 156846. MONTGOMERY Co.: US Hwy. 280/State Hwy. 30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.195089°N, 82.628717°W). 23 March 2009. D. Stevenson. GSU 2295. Adult dipnetted from pool in hardwood forest along Oconee River. Rockdale Co.: Panola Mountain State Park (33.634103°N, 84.173528°W). 12 June 2009. H. Davis. Verified by Kenneth L. Krysko. UF 156847. Treutlen Co.: State Hwy. 46 at Oconee River, ca. 4.0 km SSW of Barnhill (32.301508°N, 82.694247°W). 28 March 2009. D. Stevenson. GSU 2293. Adult dipnetted from pool in hardwood forest along Oconee River. Wayne Co.: 4.5 km NNE of Mt. Pleasant, Sansavilla Wildlife Management Area (31.456181°N, 81.656503°W). Beaver (*Castor canadensis*) wetland adjacent to NW side of Howard Road. 15 March 2009. D. Stevenson and B. Willis-Stevenson. GSU 2294.

***PSEUDOTRITON RUBER* (Red Salamander)**. Telfair Co.: 1.1 km N of State Hwy. 117 at Fishing Creek (31.899402°N, 82.758076°W). 13 June 2009. D. Stevenson, W. Dopson and F. Snow. GSU 2304. Adult found in seepage area on N side of Fishing Creek.

***SIREN INTERMEDIA* (Lesser Siren)**. Bacon Co.: State Hwy. 32 at Hurricane Creek, 2.0 km E of Alma (31.540425°N, 82.445125°W). 19 June 2009. D. Stevenson. GSU 2308. Adult from seepage wetland on E side of Hurricane Creek. Telfair Co.: 3.3 km ENE of Jacksonville, State Hwy. 117 at Lampkin Branch (31.816883°N, 82.944207°W). 13 July 2009. D. Stevenson. GSU 2307. Juvenile found in seepage area.

***SIREN LACERTINA* (Greater Siren)**. Coffee Co.: Bay Meadows subdivision 7.7 km SW of Douglas (31.468833°N, 82.920620°W). 10 April 2009. R. Preston, Jr. GSU 2309. Found in ditch.

***URSPELERPES BRUCEI* (Patch-nosed Salamander)**. Habersham Co.: Just W of Stephens county line in a tributary of Panther Creek (exact locality withheld due to rarity of species and vulnerability to over-collection). 13 August 2009. C. Camp. Verified by Elizabeth McGhee. GMNH 50121. Represents only the second county from which this recently described species has been found in Georgia.

ANURA — FROGS

***ACRIS CREPITANS* (Northern Cricket Frog)**. Telfair Co.: Mopani Preserve at Ocmulgee River (31.846856°N, 82.792507°W). 28 September 2009. D. Stevenson, J. Bauder, and W. Taylor. GSU 2244. Toombs Co.: 10.7 km SE of Uvalda; Gray's Landing at Altamaha

River (31.966389°N, 82.428889°W). 10 July 2009. D. Stevenson. GSU 2243. This record further demonstrates that this species extends its range into the lower Coastal Plain of southeastern Georgia along a prominent bottomland hardwood corridor adjacent to the Altamaha River.

***ANAXYRUS AMERICANUS* (American Toad)**. Talbot Co.: AOR River Road in Big Lazar Creek Wildlife Management Area, 100 m from confluence of Lazar Creek and Flint River (32.809287°N, 84.401516°W; WGS 84). 11 June 2009. S. Graham. Verified by Craig Guyer. AHAP-D 219.

***GASTROPHRYNE CAROLINENSIS* (Eastern Narrow-mouthed Toad)**. Lamar Co.: Private residence on Eady Creek Road, Barnesville (33.126083°N, 84.138528°W). 28 August 2008. C. Muise and T. Muise. Verified by Kenneth L. Krysko. UF 156848.

***HYLA CINEREA* (Green Treefrog)**. Catoosa Co.: Small spring pond along Graysville Road (34.97809°N, 85.14338°W). 26 May 2009. J. Jensen and S. Graham. Verified by Craig Guyer. AUM 34834. Forsyth Co.: Private residence on Lillie Lane, Cumming (34.292669°N, 84.150822°W). 26 May 2009. J. Flynn. Verified by Kenneth L. Krysko. UF 156849. Murray Co.: Marsh on east side of Fox Bridge Road ca. 3.0 km N of State Hwy 225, near Holley (34.677108°N, 84.838894°W). 18 September 2007. J. Spence. Verified by Elizabeth McGhee. GMNH 50094. This species is apparently expanding its range northward, and all three county records likely represent new occurrences rather than cryptic, long-established populations.

***LITHOBATES CLAMITANS* (Green Frog)**. Catoosa Co.: Small spring pond along Graysville Road. (34.97809°N, 85.14338°W). 26 May 2009. J. Jensen and S. Graham. Verified by Craig Guyer. AUM 34835.

***LITHOBATES HECKSCHERI* (River Frog)**. McIntosh Co.: 11.1 km SW of Townsend; boat ramp at Old Fort Barrington Landing (31.470588°N, 81.605802°W). 02 August 2009. D. Stevenson and B. Willis-Stevenson. GSU 2286. Larvae found in backwater river slough.

***LITHOBATES SPHENOCEPHALUS* (Southern Leopard Frog)**. Catoosa Co.: Floodplain of Chickamauga Creek. (34.95374°N, 85.12226°W). 26 May 2009. S. Graham and J. Jensen. Verified by Craig Guyer. AHAP-D 224. Lamar Co.: St. George's Episcopal School Campus, Milner (33.117475°N, 84.198389°W). Spring 2008. C. Muise and T. Muise. Verified by Kenneth L. Krysko. UF 156850. MONTGOMERY Co.: US Hwy. 280/State Hwy. 30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.195089°N, 82.628717°W). 23 March 2009. D. Stevenson. GSU 2287.

***PSEUDACRIS ORNATA* (Ornate Chorus Frog)**. Telfair Co.: 15.8 km SW of Lumber City on State Hwy. 117 (31.861181°N, 82.8121°W). 01 March 2009. D. Stevenson and C. Jenkins. GSU 2300. Adult male captured while calling from roadside ditch. Turner Co.: South side of State Hwy.107, 10.0 km E of jct. State Hwys.107/112 (31.720478°N, 83.480383°W). 09 April 2009. D. Stevenson. GSU 2301. Larvae dip-netted from borrow pit wetland adjacent to State Hwy. 107.

***SCAPHIOPUS HOLBROOKII* (Eastern Spadefoot)**. Wheeler Co.: 3.7 air km N of Lumber City; xeric sandhills on E side of Little Ocmulgee River and N of State Hwy. 19 (31.96585°N, 82.684811°W). 02 May 2009. D. Stevenson and M. Wallace. GSU 2305. Larvae found in ephemeral, depressional wetland.

TESTUDINES — TURTLES

***APALONE FEROX* (Florida Softshell)**. Brantley Co.: DOR 3.5 km NNE Hoboken on Raybon Rock Road (31.211078°N, 82.119353°W). 12 September 2009. D. Stevenson. GSU 2259. TOOMBS Co.: Cedar Crossing Road, 0.2 km W of US Hwy. 1/State Hwy. 15/4 (31.970331°N, 82.360319°W). 06 May 2009. D. Stevenson. GSU 2261.

***APALONE SPINIFERA* (Spiny Softshell)**. Camden Co.: Satilla River opposite Big Oak (31.061694°N, 81.930829°W). 04 September 2009. D. Stevenson and G. Rogers. GSU 2268. Evans Co.: 3.3 km SW of Groveland; Canoochee River S of State Hwy. 280 (32.131444°N, 81.777190°W). 06 September 2009. D. Stevenson and B. Willis-Stevenson. GSU 2262. Jeff Davis Co.: 12.3 km NE of Hazlehurst; Altamaha River at Bullard Creek Wildlife Management Area (31.952807°N, 82.511408°W). 10 June 2009. D. Stevenson. GSU 2264. MONTGOMERY Co.: County Rte. 95 at Oconee River; Public boat launch area on Dead River Road (31.981825°N, 82.551294°W). 06 May 2009. D. Stevenson. GSU 2266. Pierce Co.: 5.3 km N of Blackshear. Alabaha River at State Hwy. 121/15 (31.350986°N, 82.237467°W). 19 June 2009. D. Stevenson. GSU 2263. Stewart Co.: Singers Pond on private plantation near Lumpkin. 19 October 2008 (31.970781°N, 84.748481°W). J. Young. Verified by Kenneth L. Krysko. UF 156852. Wheeler Co.: 2.7 km WSW of Jordan; County Rte. 197 at Alligator Creek (32.626014°N, 82.695625°W). 09 May 2009. D. Stevenson. GSU 2265.

***CHELYDRA SERPENTINA* (Snapping Turtle)**. Catoosa Co.: DOR State Hwy 2 (34.93364°N, 85.19046°W). 26 May 2009. S. Graham and J. Jensen. Verified by Craig Guyer. AHAP-D 230. Haralson Co.: Tallapoosa River, approximately 225 m S of US Hwy 78 (33.73946°N, 85.33691°W). 28 August 2009. Greg Greer and Gregory B. Pauly. Verified by Kenneth L. Krysko. UF 156853. Upson Co.: AOR Logtown Road, Yatesville (32.905661°N, 84.143372°W). 07 June 2009. C. Muise. Verified by Kenneth L. Krysko. UF 156854.

***CLEMMYS GUTTATA* (Spotted Turtle)**. Wheeler Co.: 4.1 km E of State Hwy. 19 on County Rte. 95; 0.8 km E of Mill Creek Rd. (31.959206°N, 82.612831°W). 02 May 2009. D. Stevenson and M. Wallace. GSU 2272. Adult female found DOR.

***DEIROCHELYS RETICULARIA* (Chicken Turtle)**. Wheeler Co.: 5.6 km E of State Hwy. 19 on County Rte. 95 (31.972947°N, 82.578653°W). 12 February 2009. D. Stevenson. GSU 20064. Adult female found AOR.

***KINOSTERNON BAURII* (Striped Mud Turtle)**. Laurens Co.: 10.7 km SE of Dublin; Riverbend Wildlife Management Area (32.460269°N, 82.840839°W). 26 August 2009. D. Stevenson. GSU 2282. Adult found in backwater river slough.

***KINOSTERNON SUBRUBRUM* (Eastern Mud Turtle)**. Lamar Co.: DOR US Hwy. 341, ca. 1.5 km N of Monroe County line

(32.860906°N, 84.082608°W). 14 June 2009. C. Muise. Verified by Kenneth L. Krysko. UF 156855. MONTGOMERY Co.: US Hwy. 280/State Hwy. 30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.192261°N, 82.625411°W). 23 March 2009. D. Stevenson. GSU 2283. Adult dip-netted from pool in hardwood forest along Oconee River. Taylor Co.: AOR jct. of State Hwy. 137 and State Hwy. 128 (32.666017°N, 84.104081°W). 05 May 2009. J. Jensen and S. Castleberry. Verified by Kenneth L. Krysko. UF 156856.

***PSEUDEMYS CONCINNA CONCINNA* (Eastern River Cooter).** Jones Co.: Ocmulgee River just downstream of State Hwy. 18 bridge (32.015839°N, 83.728194°W). 26 August 2009. J. Jensen and D. Stevenson. Verified by Kenneth L. Krysko. UF 156857. Laurens Co.: Oconee River 11.3 km SE of Dublin, Riverbend Wildlife Management Area (32.454620°N, 82.837125°W). 26 August 2009. D. Stevenson. GSU 2302.

***STERNOTHERUS MINOR* (Loggerhead Musk Turtle).** Catoosa Co.: Found on bank of Chickamauga Creek (34.95374°N, 85.12226°W). 26 May 2009. S. Graham and J. Jensen. Verified by Craig Guyer. AHAP-D 225-226.

***STERNOTHERUS ODORATUS* (Eastern Musk Turtle).** MONTGOMERY Co.: US Hwy. 280/State Hwy. 30 at Oconee River, 1.3 km W of Mt. Vernon city limits (32.195089°N, 82.628717°W). 23 March 2009. D. Stevenson. GSU 2313. Juvenile dip-netted from pool in hardwood forest along Oconee River. Wheeler Co.: County Rte. 95 at Oconee River (31.980000°N, 82.547814°W). 04 June 2009. D. Stevenson. GSU 2312. Adult male AOR adjacent to swampy river floodplain.

***TERRAPENE CAROLINA* (Eastern Box Turtle).** TOOMBS Co.: State Hwy. 147 at Cobb Creek (31.971648°N, 82.322175°W). 13 June 2009. D. Stevenson and B. Willis-Stevenson. GSU 2315.

***TRACHEMYS SCRIPTA* (Pond Slider).** Lamar Co.: City Pond reservoir (33.120703°N, 84.119397°W). 06 September 2009. C. Muise, T. Muise, and A. Muise. Verified by Kenneth L. Krysko. UF 156858.

SQUAMATA — LIZARDS

***ANOLIS CAROLINENSIS* (Green Anole).** Twiggs Co.: Stone Creek access trail at Bond Swamp National Wildlife Refuge (32.739264°N, 83.567042°W). 27 March 2008. J. Jensen. Verified by Elizabeth McGhee. GMNH 50100. Adult found in floodplain forest.

***ANOLIS SAGREI* (Brown Anole).** Ware Co.: Laura Walker State Park (31.143475°N, 82.214586°W). 25 March 2009. J. Carter. Verified by Kenneth L. Krysko. UF 156859. Numerous individuals of this non-native species observed.

***HEMIDACTYLUS GARNOTII* (Indo-Pacific House Gecko).** Glynn Co.: Private residence on Sunset Boulevard, Brunswick (31.216342°N, 81.471456°W). 10 September 2006. M. Butler and B. Winn. Verified by Elizabeth McGhee. GMNH 50088. First confirmed, established population of this non-native species in the state. Multiple individuals observed on house, and population has survived at least two winters (B. Winn, pers. comm.).

***HEMIDACTYLUS TURCICUS* (Mediterranean House Gecko).** Clarke Co.: Fowler Products Company warehouse building on Collins Industrial Boulevard (33.979067°N, 83.359700°W). 14 August 1975. J. Cadle. Verified by Ned Gilmore. ANSP 30881. Evans Co.: Private residence on West Railroad Street, Claxton (32.159781°N, 81.915339°W). 09 September 2009. P. McDonald. Verified by Kenneth L. Krysko. UF 156860. Species first observed at residence approximately 15 years prior, and multiple individuals of various sizes have been seen annually since then (P. McDonald, pers. comm.). Telfair Co.: Private residence on S 2nd Avenue, McRae (32.067660°N, 82.899615°W). 12 June 2009. W. Dopson. GSU 2280. Adult female found on dwelling; five additional adult specimens observed in the vicinity.

***PLESTIODON FASCIATUS* (Common Five-lined Skink).** Twiggs Co.: Stone Creek access trail at Bond Swamp National Wildlife Refuge (32.739264°N, 83.567042°W). 27 March 2008. J. Jensen. Verified by Elizabeth McGhee. GMNH 50099.

***PLESTIODON INEXPECTATUS* (Southeastern Five-lined Skink).** Turner Co.: South side of State Hwy.107, 10.0 km E of jct. State Hwys.107 and 112 (31.720478°N, 83.480383°W). 09 April 2009. D. Stevenson. GSU 2298.

***SCELOPORUS UNDULATUS* (Eastern Fence Lizard).** Lamar Co.: Private residence on Eady Creek Road, Barnesville (33.126083°N, 84.138389°W). 21 September 2008. C. Muise. Verified by Kenneth L. Krysko. UF 156861.

***SCINCELLA LATERALIS* (Little Brown Skink).** Coffee Co.: Private residence 11.3 km WSW of Douglas (31.482556°N, 82.965020°W). 11 April 2009. F. Snow. GSU 2306. Captured in yard beneath pine straw. Lamar Co.: St. George's Episcopal School Campus, Milner (33.117475°N, 84.198389°W). 05 September 2008. C. Muise and T. Muise. Verified by Kenneth L. Krysko. UF 156903.

SQUAMATA — SNAKES

***AGKISTRODON CONTORTRIX* (Copperhead).** Coffee Co.: New Hope Baptist Church, 1.44 km NW of Ambrose, GA (31.602934°N, 83.025112°W). 08 June 2001. D. Paulk. GSU 2248. Lamar Co.: Private residence on Eady Creek Road, Barnesville (33.126083°N, 84.138389°W). 17 May 2009. C. Muise. Verified by Kenneth L. Krysko. UF 156862. Rockdale Co.: Panola Mountain State Park (33.640667°N, 84.156194°W). 28 August 2009. C. Muise and V. Lane. Verified by Kenneth L. Krysko. UF 156935. Telfair Co.: State Hwy 117 at State Hwy 132 near Temperance (31.881148°N, 83.139010°W). 25 October 2009. Billy Kellner. GSU 2321. AOR adult. Treutlen Co.: 2.3 km SW of Barnhill; State Hwy. 46 at Oconee River Road (32.312883°N, 82.687419°W). 09 May 2009. D. Stevenson. GSU 2247.

***AGKISTRODON PISCIVORUS* (Cottonmouth).** Bartow Co.: Green Pond at Henderson Mountain (34.269241°N, 84.918324°W). 27 July 2009. T. Morris, M. Moffett, S. Raper, and T. McCuean. Verified by Kenneth L. Krysko. UF 156863. Coffee Co.: 100 m from jct. Hwy 441 and Hwy 221, Douglas (31.490907°N, 82.851215°W). 13 May 2009. R. Preston, Jr. GSU 2245. Coweta Co.: Hutchinson Lake, Senoia (33.320069°N, 84.549319°W). July 2001. R. McCarthy.

Verified by Kenneth L. Krysko. UF 156864. McDuffie Co.: State Hwy. 17 0.8 km N of Little Brier

Creek/Warren Co. line (33.347324°N, 82.460063°W). 8 October 2009. D. Stevenson and B. Willis-Stevenson. GSU 2325. Telfair Co.: 3.3 km ENE of Jacksonville; State Hwy. 117 at Lampkin Branch (31.816883°N, 82.944207°W). 13 July 2009. D. Stevenson. GSU 2246.

***CARPHOPHIS AMOENUS* (Eastern Wormsnake).** Catoosa Co.: Found under bark of rotten stump near Chickamauga Creek (34.95374°N, 85.12226°W). J. Jensen and S. Graham. 26 May 2009. Verified by Craig Guyer. AHAP-D 227-228.

***CEMOPHORA COCCINEA* (Scarlet Snake).** Coffee Co.: DOR Entrance to Westwood Heights subdivision at State Hwy. 158; 3.9 km WSW of Douglas, GA (31.493121°N, 82.889002°W). 24 August 2009. R. Preston, Jr. GSU 2269. Heard Co.: Private residence in Centralhatchee (33.35333°N, 85.11000°W). 25 August 2009. M. Terry and R. McCarthy. Verified by Kenneth L. Krysko. UF 156865. Lamar Co.: Private residence on Oliver Road, Barnesville (33.050092°N, 84.099083°W). August 2009. B. Cherry. Verified by Kenneth L. Krysko. UF 156866. Pulaski Co.: Found at Sandy Hammock on bank of Ocmulgee River. (31.140401°N, 83.366332°W). 09 February 1991. F. Snow. GSU 2271. Taylor Co.: Black Creek Natural Area, ca. 1.5 km SSW of Howard (32.571356°N, 84.406653°W). 14 June 2008. N. Klaus. Verified by Kenneth L. Krysko. UF 156867. Telfair Co.: 5.2 km NW of Lumber City on State Hwy. 341/27 (31.959519°N, 82.720458°W). 2 May 2009. D. Stevenson and M. Wallace. GSU 2270.

***COLUBER* (= *MASTICOPHIS*) *FLAGELLUM* (Coachwhip).** Bacon Co.: State Hwy. 203 N at Brown Thrasher Drive, 2.7 km SW of Appling County line (31.571311°N, 82.331094°W). 09 August 2009. D. Stevenson. GSU 2289.

***CROTALUS ADAMANTEUS* (Eastern Diamond-backed Rattlesnake).** Cook Co.: 2.0 km SW of New Lois, W of Withlacoochee River (31.057744°N, 83.290406°W). 10 December 2008. D. Stevenson, C. Powell, M. Ravenscroft, and K. Ravenscroft. GSU 20065. MONTGOMERY Co.: Adult DOR South Old River Road at State Hwy. 221/135 (31.987425°N, 82.510467°W). 14 May 2009. D. Stevenson. GSU 2275.

***CROTALUS HORRIDUS* (Timber Rattlesnake).** Coffee Co.: DOR jct. of Mora Road and Tractor Trail (31.420710°N, 83.007422°W). 25 August 2009. A. Safer and F. Snow. GSU 2276.

***DRYMARCHON COUPERI* (Eastern Indigo Snake).** Cook Co.: Turkey Oak Trail at Reed Bingham State Park (31.169633°N, 83.535297°W). February 2007. C. Powell. Verified by Elizabeth McGhee. GMNH 50097.

***FARANCIA ABACURA* (Red-bellied Mudsnake).** Jenkins Co.: State Hwy. 17 0.3 km S of Buckhead Creek, just outside Millen (32.800772°N, 81.958425°W). 21 April 1974. J. Cadle. Verified by Ned Gilmore. ANSP 30904.

***HETERODON PLATIRHINOS* (Eastern Hog-nosed Snake).** Echols Co.: US 129/Hwy 11 E between County Rte. 10 and County Rte. 12 (30.763517°N, 83.004248°W). 15 March 2009. A. Safer and J. Safer. GSU 2281. Habersham Co.: Downtown Demorest (34.56609°N, 83.54460°W). 22 September 2008. C. Camp. Verified by Kenneth L. Krysko. UF 156868.

***LAMPROPELTIS GETULA* (Common Kingsnake).** Jeff Davis Co.: AOR 0.4 km S of Carvers Chapel (31.689806°N, 82.804209°W). December 1991. F. Snow. GSU 2284. Wheeler Co.: 5.0 km S of Jordan on State Hwy. 19 (31.992642°N, 82.64215°W). 02 May 2009. D. Stevenson and M. Wallace. GSU 2285.

***NERODIA ERYTHROGASTER* (Plain-bellied Watersnake).** Long Co.: 16.0 km W of Townsend (31.554132°N, 81.687387°W). 29 July 2009. D. Stevenson and K. Morris. GSU 2291. Adult found in Altamaha River floodplain swamp. Taylor Co.: Slough of Little Whitewater Creek just upstream from State Hwy. 137 bridge (32.525128°N, 84.311064°W). 25 August 2009. D. Stevenson and J. Jensen. Verified by Kenneth L. Krysko. UF 156869. Walker Co.: DOR just outside Chattanooga and Chickamauga National Military Park (34.90556°N, 85.27080°W). 26 May 2009. J. Jensen and S. Graham. Verified by Craig Guyer. AUM 34916.

***NERODIA TAXISPILOTA* (Brown Watersnake).** Evans Co.: 3.3 km SW of Groveland; Canoochee River S of State Hwy. 280 (32.131444°N, 81.777190°W). 06 September 2009. D. Stevenson and B. Willis-Stevenson. GSU 2292.

***OPHEODRYS AESTIVUS* (Rough Greensnake).** Telfair Co.: Adult DOR 7.9 km ENE of Jacksonville on State Hwy. 117 (31.826197°N, 82.896742°W). 04 June 2009. D. Stevenson. GSU 2297.

***PANTHEROPHIS ALLEGHANIENSIS* (Eastern Ratsnake).** Meriwether Co.: DOR State Hwy. 109 at jct. with Jones Mill Road (33.076059°N, 84.614137°W; WGS 84). 26 November 2007. S. Graham and S. Hoss. Verified by Craig Guyer. AUM 37596.

***PANTHEROPHIS GUTTATUS* (Red Cornsnake).** Chattooga Co.: DOR State Hwy. 157 2.7 km S of Walker Co. line (34.580504°N, 85.443711°W; WGS 84). 22 May 2009. S. Graham. Verified by Craig Guyer. AHAP-D 220.

***PITUOPHIS MELANOLEUCUS* (Pinesnake).** Jenkins Co.: State Hwy. 121 near Burke Co. line (32.916356°N, 81.964642°W). 11 April 1976. J. Cadle. Verified by Ned Gilmore. ANSP 30934. Pickens Co.: State Hwy. 53 ca. 1.5 km SW of Ludville (34.470814°N, 84.618497°W). 04 June 2007. S. Gravette. GMNH 50098.

***SISTRURUS MILIARIUS* (Pygmy Rattlesnake).** Atkinson Co.: Guest Mill Pond in East Flatwoods Swamp, 11.7 km SSE of Pearson (31.193483°N, 82.832963°W). 09 September 2000. D. Edwards. GSU 2311. McIntosh Co.: DOR 7.3 km SW of Townsend, Old Barrington Road at Cox Road (31.504396°N, 81.58680°W). 30 August 2009. D. Stevenson and B. Willis-Stevenson. GSU 2310.

***STORERIA DEKAYI* (DeKay's Brownsnake).** Appling Co.: 4.5 km NW of Davis on Moody Forest Natural Area Preserve (31.930833°N, 82.283333°W). 02 March 2009. D. Stevenson and C. Jenkins. GSU 2314. Adult found under debris in Altamaha River floodplain bottomland forest. Lamar Co.: St. George's Episcopal School Campus, Milner (33.117475°N, 84.198389°W). 05 September 2008. C. Muise and T. Muise. Verified by Kenneth L.

Krysko. UF 156871. Twiggs Co.: Stone Creek access trail at Bond Swamp National Wildlife Refuge (32.739264°N, 83.567042°W). 27 March 2008. J. Jensen. GMNH 50095. Adult found under log in floodplain forest.

***STORERIA OCCIPITOMACULATA* (Red-bellied Snake).** Jasper Co.: Private residence on State Hwy. 16 E, Monticello (33.298805°N, 83.662808°W). 09 May 2009. John B. Jensen. Verified by Kenneth L. Krysko. UF 155361. Meriwether Co.: Joe Kurz Wildlife Management Area (33.099433°N, 84.535967°W). 04 October 2008. H. Davis. Verified by Kenneth L. Krysko. UF 156872.

***TANTILLA CORONATA* (Southeastern Crowned Snake).** Taylor Co.: Black Creek Natural Area, ca. 1.5 km SSW of Howard (32.571356°N, 84.406653°W). 13 June 2008. N. Klaus. Verified by Kenneth L. Krysko. UF 156873.

***THAMNOPHIS SIRTALIS* (Common Gartersnake).** Coffee Co.: Old River Road (31.67977° N, 82.877807°W). 18 April 2009. A. Safer and F. Snow. GSU 2318. Tattnall Co.: Baxter Durrence Road at Mushmelon Creek, 9.2 km SSW of Glennville, by air (31.864556°N, 81.965542°W). 28 September 2009. D. Stevenson. GSU 2316. Telfair Co.: 3.7 km ESE of Jacksonville in Ocmulgee River swamp (31.800094°N, 82.942388°W). 10 June 2009. D. Blanton. GSU 2317.

***VIRGINIA STRIATULA* (Rough Earthsnake).** Ben Hill Co.: Mobley Bluff Road boat landing on Ocmulgee River (31.775100°N, 83.007956°W). 09 June 2009. B. Hudson, C. Camp, and D. Stevenson. GSU 2319. Adult found under debris in floodplain bottomland forest.

***VIRGINIA VALERIAE* (Smooth Earthsnake).** Coffee Co.: Walking trail 2.4 km N of South Georgia College campus between Gordon Street and Franklin Street, Douglas (31.513653°N, 82.852946°W). 30 September 2009. R. Preston, Jr. GSU 2320. Forsyth Co.: Private residence on Ivey Wood Court (34.199514°N, 84.240542°W). 24 June 2009. G. McCreary. Verified by Kenneth L. Krysko. UF 156874. White Co.: Rocky Mountain, near summit (~1200 m), E of Hwy 17 (Unicoi Gap), ca. 8.4 km N of Helen (34.798086°N, 83.729514°W). 20 September 2008. B. Hudson and C. Camp. Verified by Kenneth L. Krysko. UF 156875.

Acknowledgments.— We thank all individuals who sent us verifiable county records to further our understanding of herpetofaunal distributions in the state. Special thanks are given to the students of St. George's Episcopal School who were responsible for discovering many of the Lamar County records. We appreciate museum curators Lance McBrayer, Kenneth Krysko, and Elizabeth McGhee for verifying and accessioning specimens and photographs in a very timely manner.

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Additional Geographic Distribution Records for Amphibians and Reptiles from Georgia, USA

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Since the publication of *Amphibians and Reptiles of Georgia* (Jensen et al. 2008), a number of new geographic distribution records have been documented for the state, including those reported by Stevenson et al. (2009) and Jensen et al. (2011). Herein, we report 34 additional distribution records based on field collections made during 2009–2010. Geo-coordinates are based on datum NAD 83. All identifications were verified by Lance D. McBrayer.

CAUDATA — SALAMANDERS

***AMBYSTOMA TALPOIDEUM* (Mole Salamander).** Atkinson Co.: County Rd. 38, 15.8 km SSE Willacoochee (31.203401°N, 82.999898°W). 16 March 2010. D. Stevenson and K. Stohlgren. GSU 11881. Larvae dipnetted from roadside ditch.

***AMPHIUMA MEANS* (Two-toed Amphiuma).** Coffee Co.: Flat Tub Wildlife Management Area at Flat Tub Landing Road (31.793549°N, 82.843021°W). 14 August 2010. D. Stevenson, R. Kazmaier, and D. Riedle. GSU 11882; Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy. 221(31.968274°N, 82.477741°W). 3 September 2010. D. Stevenson and J. Bauder. GSU 11883; Telfair Co.: 3.3 km ENE Jacksonville. State Hwy. 117 at Lampkin Branch (31.816883°N, 82.944207°W). 22 July 2010. K.

Stohlgren and D. Stevenson. GSU 11884. Juvenile found in seepage area. Toombs Co.: State Hwy 147 at Cobb's Creek (31.974867°N, 82.323675°W). 19 August July 2010. D. Stevenson. GSU 11885.

***SIREN INTERMEDIA* (Lesser Siren)**. Ben Hill Co.: State Hwy 107/319 at Sturgeon Creek (31.773471°N, 83.054068°W). 28 July 2010. K. Stohlgren and D. Stevenson. GSU 11886.

ANURA — FROGS

***ACRIS CREPITANS* (Northern Cricket Frog)** Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy. 221(31.965610°N, 82.482357°W). 3 September 2010. D. Stevenson and J. Bauder. GSU 11887

***HYLA AVIVOCA* (Bird-voiced Treefrog)**. Telfair Co.: Orianne Indigo Snake Preserve at Ocmulgee River floodplain (31.846856°N, 82.792507°W). 2 June 2010. K. Stohlgren. GSU 11888. Adult male captured while calling from bottomland forest.

***LITHOBATES CLAMITANS* (Green Frog)**. Telfair Co.: Orianne Indigo Snake Preserve at Ocmulgee River (31.846856°N, 82.792507°W). 2 May 2010. J. Bauder and K. Stohlgren. GSU 11889.

***LITHOBATES HECKSCHERI* (River Frog)** Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy 221(31.965610°N, 82.482357°W). 5 September 2010. D. Stevenson and M. P.. Wallace. GSU 11890; Montgomery Co.: State Hwy 221 at the Altamaha River (31.958062°N, 82.516793°W). 10 September 2010. D. Stevenson. GSU 11891.

***PSEUDACRIS FERIARUM* (Upland Chorus Frog)**. Telfair Co.: Orianne Indigo Snake Preserve at Ocmulgee River floodplain (31.846856°N, 82.792507°W). 27 November 2009. K. Stohlgren, M. Ravenscroft and K. Ravenscroft. GSU 11892. Adult male captured while calling from bottomland forest

***PSEUDACRIS ORNATA* (Ornate Chorus Frog)**. Wheeler Co.: 5.4 km NE McRae, State Hwy 280/30 at Co. Rte. 126 (32.085298°N, 82.847111°W). 30 March 2010. W. Taylor, K. Stohlgren, and D. Stevenson. GSU 11893. Larvae dipnetted from depressional wetland.

TESTUDINES — TURTLES

***APALONE FEROX* (Florida Softshell)**. Coffee Co.: 11.7 km SW Douglas on State Hwy 135 (31.414629°N, 82.906530°W). 24 April 2010. E. Schlimm and K. Stohlgren. GSU 11894. Adult DOR, cypress wetland nearby; Tattnall Co.: State Hwy 144 at Watermelon Creek (31.928053°N, 82.003155°W). 28 September 2010. D. Stevenson. GSU 11914.

***APALONE SPINIFERA* (Spiny Softshell)**. Coffee Co.: 7.4 air km NE Relee; Flat Tub Wildlife Management Area at the Ocmulgee River (31.787834°N, 82.861011°W). 28 July 2010. D. Stevenson and K. Stohlgren. GSU 11895; Laurens Co.: 17.8 km SSE Dublin; Oconee River at Rock Springs Road boat landing (32.399131°N, 82.798492°W. 28 June 2010. D. Stevenson. GSU 11896; Ware Co.: Waycross. State Hwy 84 at the Satilla River (31.238512°N, 82.323216°W). 17 June 2010. D. Stevenson. GSU 11897.

***DEIROCHELYS RETICULARIA* (Chicken Turtle)**. Atkinson Co.: County Road 38 at Cty. Rd. 36, 14.5 km SSE of Willacoochee (31.214153°N, 83.007461°W). 16 March 2010. D. Stevenson and K. Stohlgren GSU 11898.

***KINOSTERNON BAURII* (Striped Mud Turtle)** Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy 221(31.965610°N, 82.482357°W). 5 September 2010. D. Stevenson and M. P. Wallace. GSU 11899.

***PSEUDEMYS CONCINNA FLORIDANA* (Coastal Plain Cooter)**. Telfair Co.: 2.5 km SW Lumber City on State Hwy 117 (31.912864°N, 82.697977°W). 2 June 2010. K. Stohlgren. GSU 11900. Adult female AOR, man-made impoundment nearby.

***STERNOTHERUS MINOR* (Loggerhead Musk Turtle)**. Montgomery Co.: Bell's Ferry Rd. at the Oconee River (31.980202°N, 82.553902°W). 20 May 2010. D. Stevenson. GSU 11901. Toombs Co.: Gray's Landing at the Altamaha River (31.96613°N, 82.428422°W). 27 July 2010. D. Stevenson. GSU 11902.

***STERNOTHERUS ODORATUS* (Eastern Musk Turtle)**. Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy 221(31.968274°N, 82.477741°W). 5 September 2010. D. Stevenson and M. P. Wallace. GSU 11915–16.

SQUAMATA — LIZARDS

***PLESTIODON FASCIATUS* (Common Five-lined Skink)**. Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy 221(31.965610°N, 82.482357°W). 10 September 2010. D. Stevenson. GSU 11903.

SQUAMATA — SNAKES

***AGKISTRODON PISCIVORUS* (Cottonmouth)**. Toombs Co.: Providence Church Rd. at Bell's Mill Creek (31.954659°N, 82.244034°W). 24 September 2010. D. Stevenson. GSU 11904.

***CROTALUS ADAMANTEUS* (Eastern Diamond-backed Rattlesnake)**. Atkinson Co.: County Rd. 38, 7.0 km S Willacoochee (31.279601°N, 83.026359°W). 16 March 2010. D. Stevenson and K. Stohlgren. GSU 11905. Adult found at Gopher Tortoise (*Gopherus polyphemus*) burrow in xeric sandhill.

***CROTALUS HORRIDUS* (Timber Rattlesnake)**. Decatur Co: State Hwy 253, 16.8 km NNE Bainbridge (31.04973°N, 84.52710°W). 25 July 2010. Juvenile found DOR. E. Schlimm and K. Stohlgren. GSU 11906.

***FARANCIA ERYTROGRAMMA* (Rainbow Snake)**. Tattnall Co.: State Hwy 178 at the Ohoopee River, 18.0 air km W Glennville (31.922805°N, 82.118758°W).1 June 2010. D. Stevenson. GSU 11907. Adult female found in shallow water of the Ohoopee River at 1330 h. It was attempting to eat an American Eel (*Anguilla rostrata*).

***NERODIA ERYTHROGASTER* (Plain-bellied Watersnake)**. Montgomery Co.: Bell's Ferry Rd. at the Oconee River (31.980202°N, 82.553902°W). 14 July 2010. D. Stevenson. GSU 11908; Telfair

Co.: Orianne Indigo Snake Preserve at Ocmulgee River floodplain (31.846856°N, 82.792507°W). 20 July 2010. K. Stohlgren. GSU 11909.

***NERODIA TAXISPILOTA* (Brown Watersnake)**. Jeff Davis Co.: Bullard Creek Wildlife Management Area at State Hwy 221 (31.956723°N, 82.479082°W). 24 September 2010. D. Stevenson. GSU 11911; Toombs Co.: Gray's Landing at the Altamaha River (31.96613°N, 82.428422°W). 27 July 2010. D. Stevenson. GSU 11910.

***THAMNOPHIS SAURITUS* (Eastern Ribbonsnake)**. Telfair Co.: 5.6 km ENE Jacksonville; DOR on Hwy 117 (31.820534°N, 82.919978°W). 24 July 2010. K. Stohlgren. GSU 11913.

Acknowledgments. —We thank Christopher L. Jenkins, John B. Jensen and Lance D. McBrayer for their assistance and support.

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ART IN HERPETOLOGY

SUBJECT: California red-legged frog (*Rana draytonii*) SIZE: Painted area is approx. 8” x 9” on 11” x 14” paper

Cindy Hitchcock earned a BA in Fine Arts emphasizing in drawing and painting and a MS in Biology, emphasizing herpetology and amphibian decline. Cindy was formerly a graphic designer for Pepsi Cola Company and Lennox China, but later worked as a biologist for US Geological Survey and Aspen Environmental Group in Southern California. She now resides in Reseda, California with her husband (herpetologist Robert Espinoza) and two children (Max and Olivia). For archival prints of the featured paintings or for biological illustration services please contact cindyhitchcock@yahoo.com.

NATURAL HISTORY NOTES

CAUDATA — SALAMANDERS

***BOLITOGLOSSA PLATYDACTYLA* (Broad-footed Mushroom-tongued Salamander). MAXIMUM ELEVATION.** *Bolitoglossa platydactyla* is known to inhabit an elevational distribution of 0–1300 m (Duellman 1999. Patterns of Distribution of Amphibians. A Global Perspective. The Johns Hopkins University Press. Baltimore and London. 633 pp.). Within the state of Hidalgo, México, the maximum elevation previously known for *B. platydactyla* was 148 m in rainforest (Hernández-Salinas et al. 2008. Herpetol. Rev. 39:231). On 12 February 2010, an adult *B. platydactyla* was captured under a stone in the cloud forest in the municipality of San Bartolo Tutotepec (20.40442°N, 98.22689°W; WGS 84) at an elevation of 1510 m. This record provides information on the potential elevation of this species, and is the first record of *B. platydactyla* for cloud-forest habitat in Mexico.

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***NOTOPHTHALMUS VIRIDESCENS* (Eastern Newt). NECROPHILIA AND CANNIBALISM.** On 22 March 2010, in a wetland located in Pickens Co., South Carolina, USA, we observed a pair of adult *Notophthalmus viridescens* engaged in what appeared to be amplexus and a third adult *N. viridescens* attempting interference of the mating pair. Upon closer examination, we saw that a male *N. viridescens* was mounting a decapitated female *N. viridescens*. The third *N. viridescens* was feeding on the exposed soft tissue of the decapitated female *N. viridescens*. We do not know if the decapitation occurred prior to amplexus or after. *Notophthalmus viridescens* are opportunistic feeders and the cannibalism of larvae by adults has been documented (Burton 1977. Copeia 1977:139–143). This coincidence of necrophilia and cannibalism of an adult *N. viridescens* appears to be unique.

Notophthalmus viridescens amplexus can last for up to three hours, and thus represents a substantial energetic investment in reproduction (Verrell 1985. Behaviour 94:244–253). Trauth et al. (2000. J. Arkansas Acad. Sci. 54:154–156) posited that by engaging in or continuing amplexus with a dead female, a male amphibian may diminish his reproductive output due to increased energetic costs and wasting gametes.

Amplexus between live male and dead female anurans has been documented for several species (Mollov et al. 2010. Biharean Biol. 4:121–125; Trauth et al. 2000, *op. cit.*) and death of female anurans as a result of mating activities has been observed for Wood Frogs, *Lithobates sylvaticus* (Trauth et al. 2000, *op. cit.*). Amplexus may represent a time of increased female vulnerability that can lead to mortality.

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***PLETHODON CINEREUS* (Eastern Red-backed Salamander). WILDFIRE SURVIVAL.** *Plethodon cinereus* is an entirely terrestrial plethodontid salamander at the northeastern extreme of its natural distribution in Nova Scotia, Canada (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 587 pp.). On 30 April 2009, a wildfire of anthropogenic origin was ignited on the periphery of Halifax, Nova Scotia, Canada (44.60147°N, 63.59264°W), fueled by downed trees remaining from a 2003 hurricane. This stand-replacing fire ultimately consumed 800 ha of Acadian forest including above-ground vegetation, woody debris, and the organic soil layer, removing critical salamander habitat. *Plethodon cinereus* was the most commonly observed terrestrial amphibian in the study area before the fire (pers. obs.). Most studies of fire effects on herpetofauna address low-severity burns (Dechant 2007. Low-Intensity Prescribed Fire does not Affect Salamanders in an Oak-Hickory Woodland. M.Sc. Thesis, Univ. Michigan, Ann Arbor. 29 pp.), and few address the effects of stand-replacement wildfire (Bury 2004. Cons. Biol. 18:968–975) due to difficulties in measurement, frequency, and experimental manipulation. A single *P. cinereus* was observed under rocky debris on an unburned rock outcrop (44.58486°N, 63.55519°W) on 9 May 2009, 302 m from the nearest unburned area. Based on their small territories (0.16–0.33 m^2) (Petranka 1998, *op. cit.*) and dispersal distances of less than 2 m per year (Ousterhout and Liebgold 2010. Herpetologica 66:269–275), it is unlikely that *P. cinereus* migrated across the burned zone in the nine days following the fire. Taub (1961. Ecology 42:681–698) demonstrated a large reservoir of *P. cinereus* in the soil and some individuals never moved to the surface. *Plethodon cinereus* have limited burrowing abilities, restricting them to soft substrates such as leaf litter (Heatwole 1960. Ecology 41:661–668). *Plethodon cinereus* residing in the leaf litter and organic soil layer or under woody debris at this location probably perished in the fire, but individuals could potentially have survived in unburned rock piles which provided refuge from combustion and extreme temperatures. Multiple searches of the surrounding area and monitoring of artificial cover objects over the next four months did not result in any further observations of *P. cinereus* on burned soils. This observation indicates that 1) wildfire adversely affects *P. cinereus* populations immediately following the fire; and 2) amphibian recolonization of extensively burned landscapes may occur from unburned refugia within the fire zone.

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SIREN LACERTINA **(Greater Siren). DIET.** On 20 Oct 2010 a dead *Siren lacertina* was found in a minnow trap in Southern Landing, a 1.4-acre constructed wetland on the Florida Southern College campus in Lakeland, Florida, USA. Once collected from the trap, the siren was placed in tap water and kept overnight in the laboratory at 10°C until it was dissected on 21 Oct 2010. Upon dissection, a *Nerodia taxispilota* (Brown Water Snake), in the later stages of digestion, was recovered from the siren's small intestine. The *N. taxispilota* was partially intact (i.e., the bones and scales were poorly digested) and had a TL of ca. 17 cm. In addition to the snake, the siren had consumed large amounts of muddy vegetation that contained snails, fingernail clams, amphipods, and chironomid larvae. The siren was 483 mm SVL, 650 mm TL, and its mouth had a vertical gape of ca. 12 mm with a horizontal opening of ca. 17 mm. The Greater Siren has been known to consume small fish (Hanlin 1978. Copeia 1978:358–360) and salamanders (Luhring 2007. Herpetol. Rev. 38:317), however this is the first account of consumption of a reptile by *S. lacertina*.

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ANURA — FROGS

HYLA ARENICOLOR **(Canyon Tree Frog). MISSING LIMBS.** Severe deformities have been reported in several species of amphibians, in which supernumerary and ectromelia are the most common (Blaustein and Johnson 2003. Front. Ecol. Environ. 1:87–94). Here, I report an apparently high occurrence of *Hyla arenicolor* with completely missing hindlimbs.

On two field trips (9 and 22 Oct 2004) to the Sierra de Nanchititla, State of Mexico, Mexico (18.8241944°N, 100.42772°W; elev. 1435 m), I sampled a total of 12 adult and 40 tadpole *H. arenicolor*. Individuals were collected next to Nanchititla Falls in two different temporary ponds. Three adults had completely missing hindlimbs (ectromelia). Tadpoles did not show any sign of deformity.

Potential sources of missing limbs include both abiotic and biotic factors (Blaustein and Johnson 2003. Sci. Amer. 288(2):60–65). A detailed study, including frequencies of deformities in this and other species, and the sources of such deformities in this relatively isolated and protected area are needed.

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HYLARANA MALABARICA **(Fungoid Frog). PREDATION.** On 7 August 2009 at 0030 h, we located a breeding congregation of *Hylarana malabarica* in a temporary water pool surrounded by *Ipomoea carnea* in Judia Farm, Keonjhar district, Odisha, India (21.949475°N, 84.3600861°E; 400 m elev.; WGS 84). As we photographed a calling male sitting on a stump, the frog jumped into water and was immediately caught by a giant water bug (*Belostoma indicum*) (Fig. 1). The frog was grasped laterally near the groin with a tight grip of its legs, uttered a distress, and died within 15 minutes of capture. *Belostoma indicum* in its nymphal stage is known to kill subadult *Hoplobatrachus tigerinus* by strangulation (Mitra 1975. J. Bombay. Nat. Hist Soc. 72[2]:599–600). However, during our observation the frog was killed while the *B. indicum* had a tight grip on its groin region. *Hylarana malabarica* is distributed in Western Ghats, Eastern Ghats, and Peninsular India and it lives in tree holes, below leaf litter, under boulders, and in caves (Dutta et al. 2009. Amphibians and Reptiles of Similipal Biosphere Reserve. Regional Plant Resource Centre, Bhubaneswar, Orissa, India. 174 pp.). During the monsoon season, breeding congregations are found near ponds and temporary water pools syntopic with B. indicum.

Although predation of amphibians by arthropods has been reported by many workers (e.g., Barej et al. 2009. Herpetol. Notes 2:137–139; Forti et al. 2007. Braz. J. Biol. 67:583–584; Figueiredo-de-Andrade et al. 2010. Herpetol. Notes 3:53–54), this is the first record of predation of *H. malabarica* by *B. indicum* in nature.

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COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

Fig. 1. *Hylarana malabarica* being attacked by a giant water bug (*Belostoma indicum*).

LEPTOBRACHIUM HASSELTII **(Hasselt's Litter Toad). ANTI-PREDATOR BEHAVIOR.** *Leptobrachium hasseltii* is a megophryid toad occurring in the southern part of Sumatra, Java, Bali, and

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FIG. 1. Antipredator behavior exhibited by *Leptobrachium hasseltii*—posterior body elevation, hind limbs outstretched, and head flexed downward.

several adjacent islands of Indonesia (Hamidy and Matsui 2010. Zootaxa 2395:24–44; Iskandar 1998. The Amphibians of Java and Bali. Research and Development Centre for Biology-LIPI, Bogor. xix + 117 pp.). The antipredator behavior of *Leptobrachium* has been reported for *L. smithi* from Thailand (Chuaynkern et al. 2007. Herpetol. Rev. 38:323–324). The behavior in that species includes arching of the back with its head elevating ca. 90°, and the bulging of eyes with prominent display of the contrasting orange and black eye colors (Chuaynkern et al. 2007, *op. cit.*). Here, we observed a different pattern of antipredator behavior of *Leptobrachium*. We collected a female *L. hasseltii* from Banyuwindu, Ungaran, Central Java (2.442°N, 103.242°E, 111 m elev.) on 29 July 2010. As we photographed the specimen, it performed an antipredator behavior by elevating the posterior part of the body, outstretching the hind limbs, and flexing its head downward (Fig. 1). This type of antipredator behavior has been reported for several bufonids including *Bufo bufo* (Beebee 1985. Frogs and Toads. Whittet Books, London. 121 pp.), *Epidalea clamaita* (Noble 1931. The Biology of the Amphibia. Dover Publications Inc., New York. 577 pp.), and *Rhinella marina* (Tyler 1976. Frogs. William Collins Ltd., Sydney. 256 pp.), as well as a microhylid *Phrynomantis bifasciatus* (Duellman and Trueb 1986. Biology of Amphibians. The John Hopkins Univ. Press, Baltimore. 670 pp.), and is thought to increase apparent body size. The different antipredator behaviors exhibited by *L. smithi* and *L. hasseltii* might be related to different predator pressures, although similar predators are present in their respective ranges. Because species of this genus are characterized by their disproportionately large head (Inger and Stuebing 1997. A Field Guide to the Frogs of Borneo. Natural History Publications Sdn. Bhd., Kota Kinabalu. ix + 205 pp.), behavior seen in *L. hasseltii* seems to be effective, while the "Unken-reflex" (Noble 1931, *op. cit.*) displayed by *L. smithi* is otherwise uncommon in species of this genus. Bright ventral coloration and potent skin secretions are unknown in this group.

The specimen reported here is deposited in the Graduate School of Human and Environmental Studies, Kyoto University (KUHE 44305). Field work was financed by Monbukagakusho to AH for his doctoral scholarship.

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***LEPTODACTYLUS BUFONIUS* (Vizcacheras' White-lipped Frog). SPAWNING BEHAVIOR.** *Leptodactylus bufonius* is a typical frog from the arid Chaco, and is included in the *L. fuscus* group (Heyer 1978. Bull. Los Angeles Co. Mus. Nat. Hist. 29:1–85). It occurs in southern Bolivia, northern Argentina, Paraguay, and Central Brazil (Mato Grosso do Sul state) (Frost 2010. Amphibian Species of the World. Electronic database accessible at <http://research.amnh.org/vz/herpetology/amphibia/>, American Museum of Natural History, New York). Species in this group exhibit an intermediate reproductive mode, from the aquatic to terrestrial, with terrestrial clutches and aquatic tadpoles. Males construct subterranean chambers close to streams or ponds, and eggs embedded in foam nests are deposited inside the chambers. Subsequent to rains or floods, tadpoles complete development in the water (Heyer 1969. Evolution 23:421–428). Studies on the reproductive biology of *L. bufonius* throughout its geographic distribution are scarce (Crump 1995. Herpetol. Rev. 26:97–98; Reading and Jofré 2003. Amphibia-Reptilia 24:415–427) and nonexistent for Brazilian populations. Herein, we describe some aspects of the spawning behavior of *L. bufonius* in a temporary pond (21.7°S, 57.717°W), in the municipality of Porto Murtinho, Mato Grosso do Sul state, western Brazil. The study site is located in the southern Pantanal, the only Brazilian region under the influence of the Chaco biome, where annual floods are common in the summer (Prado et al. 1992. *In* Furley et al. [eds.], Nature and Dynamics of Forest-Savanna Boundaries, pp. 451–470. Chapman and Hall, London; Silva and Abdon 1998. Pesq. Agropec. Bras. 33:1703–1711). Climate is "Aw" type, according to Köppen's classification, with a hot and wet summer (Oct–Apr) and a dry and cold winter (May–Sep).

On 3 Dec 2009, 2230 h, we observed a pair of *L. bufonius* in amplexus inside a chamber, but spawning had not started. At 2232 h, another male entered the same chamber and immediately they started spawning. At 2300 h, with the foam nest already formed, the female (Coleção Zoológica de Referência da Universidade Federal de Mato Grosso do Sul – ZUFMS -CH593) left the chamber. Both males remained inside the chamber until 2344 h, when one of the males left the chamber (ZUFMS-CH594), followed by the other male at 2355 h (ZUFMS-CH595). On 6 Dec 2009 we observed another male being followed by a female and both entered the chamber at 2120 h. After five minutes, the male left the chamber and remained motionless for 35 minutes, ca. 10 cm from the chamber entrance. During this period, the female remained with her head out of the chamber. At 2205 h, both returned to the chamber and amplexed. After 20 minutes they started spawning. At 2245 h, another female (ZUFMS-CH598) approached the chamber and, at 2307 h joined the pair that was spawning. After seven minutes, this second female left. Thirty minutes later, another male approached and entered in the chamber. The three individuals (two males and one female) remained inside the chamber for almost 40 minutes (until 0028 h), when the female left. At 0047 h one male (ZUFMS-CH599) left and at 0100 h the other male (ZUFMS-CH600) also left the chamber. We were able to recognize males and females because of the presence/absence of vocal sacs; behavioral observation was possible through the chamber entrance. Observations of chambers containing more than a male and female have been reported for *L. bufonius* (Philibosian et al. 1974. Herpetologica 30:381–386; Pisanó et al. 1993. Rev. Fr. Aquariol. 19:125–126; Reading and Jofré 2003, *op. cit.*). Philibosian et al. (1974, *op. cit.*) suggested that *L. bufonius* may exhibit polyandrous behavior or males may use chambers of other males. The second scenario seems more plausible for the population studied in Argentina by Reading and Jofré (2003, *op. cit.*). These authors stated that the available evidence did not support polyandry. Given that *L. bufonius* individuals occur in high densities at our study site, and that the region is subjected to floods which may shorten the reproductive period because of lack of suitable sites to construct the chambers, we suggest that the occurrence of multimale and perhaps multifemale spawning behavior seems plausible for this population. Polyandry has rarely been reported for South American frogs (Prado and Haddad 2003. J. Herpetol. 37:354–362; Prado et al. 2006. Herpetol. Rev. 37:206–207). In species with external fertilization, as most anurans, one of the ways to increase fertilization success is increasing quantity of sperm released (Gross 1985. Nature 313:47–48). Thus, selection may favor males with larger testes (Prado and Haddad 2003, *op. cit.*). Studies on the reproductive effort (gonad mass relative to body mass) of *L. bufonius* males, as well as studies addressing offspring paternity, are needed to help understand the behaviors described herein.

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***LIMNONECTES PALAVANENSIS* (Smooth Guardian Frog). ALTITUDE.** *Limnonectes palavanensis* is a small (to 40 mm SVL) raniform anuran with conspicuous tympanum and supratympanic folds, smooth reddish to chocolate brown on top of the head and dorsum except for a distinctive inverted V-shaped ridge between the shoulders and two unbroken folds from behind the eyes to the lower back, several posterior dorsolateral dark spots, immaculate orange yellow venter, and half-webbed toes with faintly dilated tips (Inger 2005. The Systematics and Zoogeography of the Amphibia of Borneo. Natural History Publications [Borneo] Sdn. Bhd. Kota Kinabalu. 402 pp.; Malkmus et al. 2002. Amphibians and Reptiles of Mount Kinabalu [North Borneo]. A.R.G. Gantner Verlag K.G. Ruggell. 424 pp.). *Limnonectes palavanensis* occurs in Palawan of the Philippines, and Borneo (Sabah and Sarawak of Malaysia, Brunei Darussalam, and Kalimantan of Indonesia) (Das 2007. A Pocket Guide: Amphibians and Reptiles of Brunei. Natural History Publications [Borneo] Sdn. Bhd. Kota Kinabalu. viii + 200 pp.; Inger 2005, *op. cit.*; Inger 2007. Systematics and Zoogeography of Philippine Amphibia. Natural History Publications [Borneo] Sdn. Bhd. Kota Kinabalu. vi + 370 pp.). Previous publications reported the altitudinal range for the species to be from near sea level to 1300 m elev. (Inger and Stuebing 2005. A Field Guide to the Frogs of Borneo, 2nd ed. Natural History Publications [Borneo] Sdn. Bhd. Kota Kinabalu. viii + 201 pp.; Malkmus et al. 2002, *op. cit.*). Herein we report a new altitude limit for *L. palavanensis*.

On 11 Dec 2008, between 1900 and 2200 h, an adult *L. palavanensis* (26 mm SVL, 1.7 g) was sampled via opportunistic examination at Geludu Trail on Geludu Hill (6°N, 116.5375°E; 1502 m elev.), Bundu Tuhan, Ranau District, West Coast Division, Sabah, Bornean Malaysia. The male anuran was found on the forest floor among dead leaves, and was not guarding eggs or carrying tadpoles. Air temperature was 16.2°C, and relative humidity was 88.1%. Geludu Hill is densely forested with elevation of 1200–1550 m. The hill houses other anuran species associated with forest floor such as *Ansonia longidigita*, *Leptobrachella baluensis*, *Leptobrachium montanum*, *Leptolalax dringi*, and *Chaperina fusca*, as well as with primary forest: *Philautus aurantium*, *P. bunitus*, *P. petersi*, and *Rhacophorus angulirostris*. The locality represents an extension of habitat for *L. palavanensis* from submontane to the montane zone. The specimen (HEP00913) was deposited in BORNEENSIS, the Bornean reference collection of the Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah. On the same night, an additional *L. palavanensis* was sampled at Geludu Hill at 1478 m elev. (HEP00912: SVL 37 mm, mass 5.1 g).

We are grateful to Agnes James Lintanga for permission to sample on her land on Geludu Hill, and for assistance in the field. We thank Haleluyah Retreat Centre for lodgings support. We also thank the Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah for support.

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***LITHOBATES AREOLATUS CIRCULOSUS* (Northern Crawfish Frog). WINTERKILL.** Herein we report the first documented instance of winterkill in *Lithobates areolatus*, a state endangered species in Indiana and a species thought to be threatened throughout its range (Parris and Redmer 2005. *In* Lannoo [ed.] Amphibian Declines: Conservation Status of United States Species, pp. 526–528. Univ. California Press, Berkeley, California.). Our study population is located at the Hillenbrand Fish and Wildlife Area, in Greene Co. in southwestern Indiana (Lannoo et al. 2009. Diversity 1:118–132). This population is about 40 km SSE of the northernmost known extant population in Indiana, and probably at this point in time, the species. At this latitude, Crawfish Frogs overwinter obligately in burrows—one frog per burrow—excavated by crayfish (*Cambarus diogenes*, *C. polychromatus*, or *Fallicambarus fodiens*; Heemeyer and Lannoo 2010. Herpetol. Rev. 41:168–179). These burrows are small-bore—about the width of the frog—and long, extending a meter, perhaps more, down into the water table (Thompson 1915. Occ. Pap. Mus. Zool. Univ. Michigan 9:1–7). Crawfish Frogs spend the

Fig. 1. Flooded Crawfish Frog burrow; feeding platform is the muddy area immediately to the left and below the entrance in this photograph. Photo taken on 14 October 2009, after several days of heavy rains. Burrow entrance is about 8 cm in diameter.

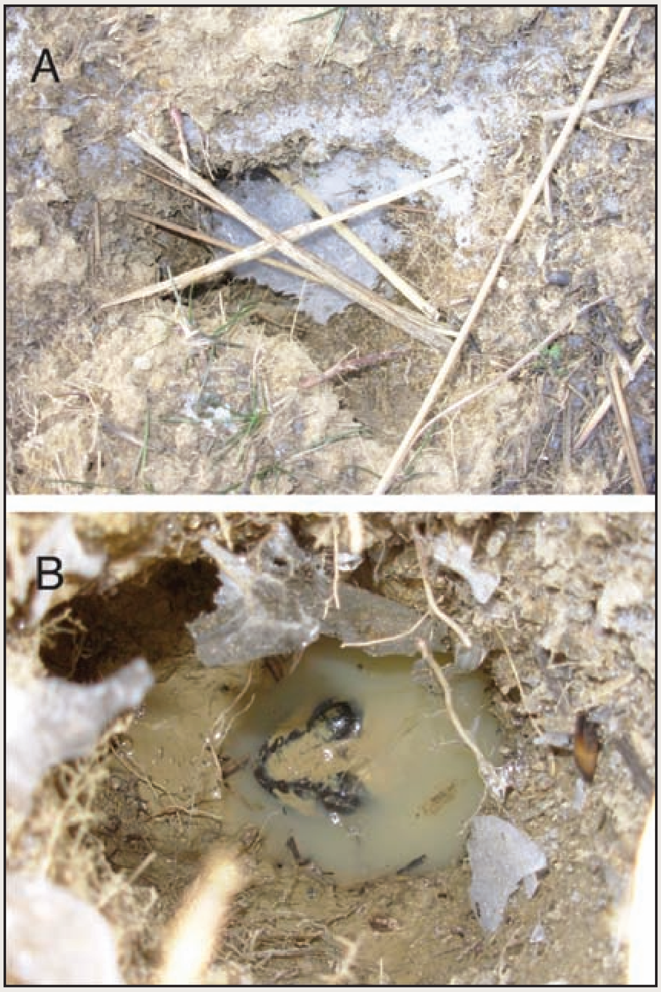

Fig. 2. A) A thin incomplete ice cap covering the burrow of Crawfish Frog 9. Burrow entrance about 14 cm across. B) A magnified view of Frog 538 (headwidth 40 mm) partially submerged sitting in the water of her burrow after the ice cap had been broken and cleared. Distance from ice cap to the water was approximately 10 cm. Photos taken on 10 Dec 2009.

winter in or near the water at the bottom of their burrow, either partially submerged with their nostrils above the water or completely submerged with occasional emergence (especially under warm conditions). Crawfish Frogs will drown if submerged for extended periods of time (Heemeyer and Lannoo 2010, *op. cit.*).

During the winter of 2009–2010 we monitored 14 Crawfish Frogs on a weekly basis until 1 March, when we resumed daily monitoring. We observed frogs at the entrance or out of their burrows during every month of the winter. Temperature and precipitation data were recorded every 10 min throughout the winter using a HoboWare weather station located at a secure site 4.4 km NW of our study area. October 2009 was unusually wet (114 mm of rain, 28.7 mm above the 10-yr monthly average), with heavy rains coming on the 8^{th}, 9^{th}, and 14^{th}. These rains raised the water table to the soil surface and inundated Crawfish Frog burrows (Fig. 1). For much of the winter (December was also wet) the water table remained near the soil surface. Throughout the winter we noticed a general pattern of rain leading a cold front, which led to burrow inundation with ice formation over the burrow entrance, followed by a fast or slow percolation of water out of burrows. This drainage created an air pocket between the ice and the water surface (Fig. 2). Burrows did not drain evenly in the clay-capped mine spoil soils of our study site (Lannoo et al. 2009, *op. cit.*). Later warming produced thawing and open burrow entrances. At no time during the winter was there enough persistent snow to provide insulation to retain ground heat.

January and February were cold, with a minimum recorded temperature of –20.4°C. On 21–22 February it rained 2.6 cm, and from 23–25 February a cold snap froze the entrances to many burrows, and in particular the burrow of Crawfish Frog number 9. Frog 9 was a large male (119 mm SUL, 152 g minus the transmitter [3.8 g]) whose burrow was situated on a south-facing hillside, in deep clay, in a pocket shaded by several large clusters of Big Bluestem (*Andropogon gerardii*). As a consequence of being sheltered and in thick clay, the ice at the entrance to this burrow was thick (centimeters), the water in the burrow did not drain to form an air pocket, and the ice over the burrow did not thaw quickly. When it did, on 7 March, we saw Frog 9 below the water level, something that is not unusual and typically not cause for alarm. On 9 March we realized Frog 9 had not moved and JLH extracted him. The carcass was fresh, and necropsy followed by consultation with Alan Pessier, D.V.M., suggested death by either drowning or asphyxiation. Among all (14) burrows surveyed, Frog 9's burrow had the thickest ice, was the last to thaw, and had the highest water table relative to the ground surface.

Frog 9 was the only monitored frog to die over the winter, and over the course of this study (16 months to date) has been only the second Crawfish Frog in a burrow to die (Engbrecht and Heemeyer 2010. Herpetol. Rev. 41:197). In the absence of heavy fall rains, we expect the winter water table to be close to or below the frost line (76 cm), and for Crawfish Frogs sheltered (water has a higher thermal inertia than air) in the water at the bottom of crayfish burrows to be relatively protected from the several potential consequences of freezing temperatures.

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***LITHOBATES SYLVATICUS* (Wood Frog). PREDATION.** *Lithobates sylvaticus* are prey to mammals, large birds, snakes, fish, leeches, and salamander larvae (Baldwin et al. 2007. Herpetol. Rev. 38:194–195; Dorcas and Gibbons 2008. Frogs and Toads of the Southeast. Univ. Georgia Press, Athens, Georgia. 238 pp.). *Lithobates sylvaticus* eggs and tadpoles may also be an important seasonal prey item for *Notophthalmus viridescens*. During March–April 2010, *N. viridescens* was observed actively feeding on *L. sylvaticus* eggs and tadpoles at five separate temporary wetlands located within Oconee and Pickens counties in South Carolina. *Notophthalmus viridescens* would either approach egg masses from the sides or from underneath and consume eggs from these areas. In all cases, a minimum of three *N. viridescens* at a time were observed actively feeding on *L. sylvaticus* eggs. We also observed the consumption of *L. sylvaticus* tadpoles by *N. viridescens*. However, *L. sylvaticus* tadpoles appeared to avoid predation by purposefully positioning themselves on top of the remaining egg masses (i.e., tadpoles were observed swimming from other areas of the wetland to the top of the egg masses then remained there with minimal body movement for at least the duration of our observations). This observation may represent an example of active predator avoidance behavior by *L. sylvaticus* tadpoles. *Notophthalmus viridescens* were not observed in these wetlands prior to the *L. sylvaticus* breeding season and few were observed in these wetlands after *L. sylvaticus* eggs and tadpoles were no longer present. This pattern suggests that *N. viridescens* may seasonally occupy temporary wetlands following *L. sylvaticus* reproduction.

We extend our gratitude to the South Carolina State Parks, Upstate Forever, South Carolina Department of Natural Resources, and John Garten for assistance in locating wetlands. We thank the Clemson students who participated in field work. Funding was provided by the Environmental Protection Agency Region 4 WPDG. Research was approved by Clemson University IACUC (AUP2009-103).

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***RHINELLA POMBALI* (Pombal's Toad). PREDATION.** The capture of animals by drift fences with pitfall and funnel traps can be a source of artificial aggregation of individuals and thus may attract potential predators. Spiders have been recorded preying on lizards of the genus *Enyalius* inside traps (Gomides et al. 2010. Herpetol. Rev. 41:221–222).

Rhinella pombali is distributed throughout the Atlantic Rainforest and its transitional areas with the cerrado, in the State of Minas Gerais and part of State of Rio de Janeiro (Baldissera et al. 2004. Arq. Mus. Nac. Rio J. 62[3]:255–282; Silveira et al. 2009. Biotemas 22[4]:231–235).

In this note we report the predation of *R. pombali* by army ants, *Labidus* sp. (Ecitoninae), within a funnel trap installed in the Reserva Biológica Municipal Santa Cândida (21.754917°S, 43.396833°W, WGS 84; 783 m elev.), an Atlantic Rainforest patch, in the municipality of Juiz de Fora, State of Minas Gerais, southeastern Brazil. The predation was observed by SCG and CHVR on 21 Jan 2009, at about 1600 h, who saw the column of ants (about 10 m long and 3 m wide) walk across the leaf litter and on vegetation along the drift fence. In one of the funnel traps a *R. pombali* was eaten by ants. When first observed, the individual was already dead, and consumption was complete in less than one hour. In Lajinha Municipal Park in the municipality of Juiz de Fora (21.792417°S, 43.380889°W; WGS84, 893 m elev.) on 28 Jan 2009, there was also a colony of *Labidus* observed to walk along the drift fences, but these ants encountered no amphibians or reptiles.

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***SCAPHIOPUS HOLBROOKII* (Eastern Spadefoot). LOCOMOTION.** Alternate-leg swimming patterns are considered to be a unique behavioral characteristic of the primitive frog families Leiopelmatidae and Ascaphidae, with more advanced families of frogs using a synchronous-leg swimming pattern (Abourachid and Green 1999. J. Herpetol. 33:663–674). All of the more advanced anuran species reported by Abourachid and Green (1999, *op. cit.*) exhibited the typical, and more efficient, synchronous-leg swimming. In this familiar form of aquatic locomotion, both hind legs simultaneously move through a rapid extension propulsion stroke, which is then followed by a synchronized recovery stroke where both hind legs are simultaneously pulled back up to the body. Similar to the more advanced anurans (suborder Neobatrachia) used in the study, the primitive species *Bombina variegata* (suborder Archeobatrachia, family Bombinatoridae) also exhibits a synchronized swim kick pattern.

Here we report that *Scaphophus holbrookii* swims with the alternate-leg kick pattern exhibited by the most morphologically archaic extant species of frogs (Green and Cannetella 1994. Ethol. Ecol. Evol. 5:233–245). Field observations of *S. holbrookii* swimming in vernal pools in Cape May Co., New Jersey, USA, on the evening of 20 March 2010 (by DMG) and in Charles City Co., Virginia, USA, on the evening of 29 March 2010 (by JDK) confirm that this species swims with the same alternate-leg swimming pattern described by Abourachid and Green (1999, *op. cit.*). *Scaphiopus holbrookii* alternates the movements of its hind limbs and extends its forelimbs out in front of its body when swimming. Because *S. holbrookii* is in the suborder Mesobatrachia, this observation raises questions about the evolutionary point at which a synchronized pattern of aquatic locomotion became prominent in anurans.

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TESTUDINES — TURTLES

***CHELONIA MYDAS AGASSIZII* (East Pacific Green Seaturtle). DIET.** The East Pacific Green Turtle is considered the most carnivorous of all Green Turtle subpopulations worldwide (Bjorndal 1997. *In* Lutz and Musick [eds.], The Biology of Sea Turtles, pp. 199–231. CRC press, Boca Raton, Florida). Novel green turtle diet items have been reported, including consumption of the sea pen, *Ptilosarcus undulatus* (Seminoff et al. 2002. Copeia 2002:266–268), pelagic red crabs, *Pleuroncodes planipes* (Lopez-Mendilaharsu et al. 2005. Aquatic Conserv: Mar. Freshwater Ecosyst. 15:259–269), tunicates and crustaceans (Amorocho and Reina 2007. Endang. Species Res. 3:43–51), hydrozoans, scyphozoans, nematodes, annelids, molluscs (Carrion-Cortez et al. 2010. J. Mar. Biol. Assoc. U.K. 1–9), and sponges, *Craniella* sp. and *Suberites aurantica* (Rodriguez-Baron 2010. MS thesis. Centro Interdisciplinario de Ciencias Marinas [CICIMAR-IPN]. 98 pp.). It has been suggested that such dietary diversity is a response to the energy requirements of these animals in the early life stages, facilitating nutritional (e.g., protein) gains for development and maturation (Bjorndal 1985. Copeia 1985:736–751) and optimizing digestion time (Amorocho and Reina 2008. J. Exp. Mar. Biol. Ecol. 360:117–124). It has also been noted that *C. mydas* diet is influenced by resource availability (Balazs 1980. NOAA Tech. Memo. NOAA-TM-NMFS-SWFS-7; Garnett et al. 1985. Wildl. Res. 12:103–112) and that diet selection is linked to the composition and capacity of the hind-gut microflora, which may change as turtles grow and/or occupy different habitats (Bjorndal 1980. Mar. Biol. 56:147–154).

During two field trips in 2009 we collected food samples from the esophagi of 21 Green Turtles (body mass 14–65 kg, and straight carapace length [SCL ± 0.1 cm] from 40.3–73.4 cm; mean SCL = 54.83 ± 83.6 cm) captured at Laguna Ojo de Liebre (LOL; 27.5908333–27.9166667°N and 113.9983333–114.1666667°W) located in the El Vizcaino Biosphere Reserve, Baja California Sur, Mexico. The anemone *Palythoa ignota* was present in 18 of the total samples, and it comprised 68.76% of the total volume. Turtle mean body condition index (BCI) was 1.48 (range = 1.25–2.06), similar to the values reported in previous studies (Seminoff et al. 2003. J. Mar. Biol. Assoc. U.K. 83:1355–1362; Koch et al. 2007. Mar. Biol. 153[1]:35–46) and indicative of good health of the animals (Bjorndal et al. 2000. Ecol. Appl. 10:269–282).

To our knowledge this is the first report of targeted anenome consumption by Green Turtles. The fact that *P. ignota* occurred in such high proportion among a substantial number (85.7%) of turtles suggests that this colonial cnidarian is a major food resource for Green Turtles at LOL, and that these turtles have the capacity to assimilate nutrients from this invertebrate species (Bjorndal 1990. Bull. Mar. Sci. 47[2]:567–570).

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***CHELONIA MYDAS AGASSIZII* (Black [Pacific] Seaturtle). EPIBIONT BARNACLES.** The taxonomy of *Chelonia mydas* is controversial; some authors reject the designation of subspecies (e.g., Ernst and Lovich 2009. Turtles of the United States and Canada, 2nd ed., Johns Hopkins Univ. Press) but traditionally *Chelonia m. agassizii* Bocourt 1868 is the form recognized in the Pacific and Indian Oceans. A melanistic (black) form, *C. mydas carrinegra*, was described from the coast of Baja California (Caldwell 1962. Los Angeles Co. Mus. Contrib. Sci. 50:1–8) but black turtles are now known from other regions of the Pacific, including Japanese waters (Abe and Minami 2008. Nippon Suisan Gakkaishi 74:230–233). Three species of sea turtles are known to nest on the Japanese coast: *Caretta caretta*, *Chelonia mydas* (non-melanistic), and *Eretmochelys imbricata*, and the commensal barnacles of those sea turtles were listed by Hayashi (2009. Umigame Newsletter of Japan 81:2–17). There are apparently no previous records of the barnacles attached to black *C. mydas* from Japan. Additionally, few records exist for epibionts on Black Seaturtles anywhere (Green 1998. NOAA Tech. Mem. NMFS-SEFSC-412. p. 63; Lazo-Wasem et al. 2007. Bull. Peabody Mus. Nat. Hist. 48:153–156; Nichols 2003. Biology and Conservation of Sea Turtles in

Fig. 1. The barnacle *Platylepas hexastylos* on carapace and plastron of *Chelonia mydas agassizii.*

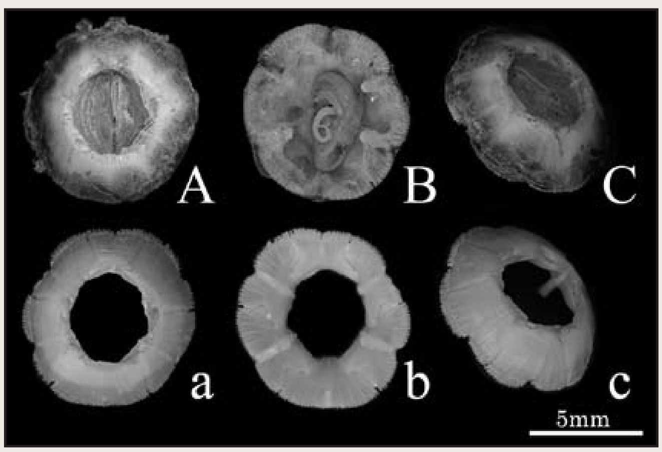

Fig. 2. Close-up of the barnacles *Platylepas hexastylos* found on *Chelonia mydas agassizii.*

Baja California, Mexico. PhD dissertation, University of Arizona, Tucson. 474 pp.; Zullo 1991. *In* M. J. James [eds.], Galápagos Marine Invertebrates: Taxonomy, Biogeography, and Evolution in Darwin's Islands, pp. 173–192. Plenum Press, New York). In this note, we report the epibiont barnacles found on a Black Seaturtle from Japanese waters. This report also represents the northernmost record of a Black Seaturtle and the first record of barnacles attached on a Black Seaturtle in the western Pacific.

On 7 September 2009, a black *C. mydas* was caught in a fishing net at Miyako, Iwate, Japan (39.40°N, 141.58°E). This turtle was measured (standard carapace length, 53.8 cm; standard carapace width, 43.8 cm) and tagged (Sea Turtle Association of Japan [STAJ] plastic tags, No. 64800 on the right hind flipper and No. 64801 on the left hind flipper), and a sample of barnacles were collected and preserved in 99% ethanol solution, and identified in the laboratory. Materials examined were deposited in Fujukan, the Museum of the University of Ryukyus, under accession numbers RUMF-ZC 02009–02011. After investigation, the animal was released but unfortunately it was stranded the next day (fishermen in Kyofuku-Maru, Fisheries Cooperative Association of Funakoshi Bay, pers. comm.). This turtle had many barnacles (>100 individuals) attached on the carapace, plastron, and flippers. All of these barnacles were identified as *Platylepas hexastylos* (Fabricious, 1798) (Fig. 1). Previous studies reported the occurrences of *Platylepas decorata* Darwin 1854, *Stomatolepas praegustator* Pilsbry 1910, *Cylindrolepas darwiniana* Pilsbry 1916, and *Platylepas hexastylos* on Black Seaturtles in the eastern Pacific. *Platylepas hexastylos* is cosmopolitan and known to attach to various species of sea turtles; phylogeography and population genetics of this species might provide information on the macro scale distribution and migration of sea turtles.

The field study was assisted by STAJ, and supported by grants from National Geographic, the Japan Society for the Promotion of Science (19255001), and JSPS Research Fellowship for Young Scientists (21-7432). We gratefully acknowledge the Hidejima set net fishermen in the Fisheries Cooperative Association of Miyako for providing the living Black Seaturtle specimen.

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CHELYDRA SERPENTINA **(Common Snapping Turtle). BIFID TAIL.** Regeneration can be defined as the ability to reproduce relatively complicated organs or structures after they have been lost through injury (Kuchling 2005. Chelon. Cons. Biol. 4[4]:935–937). The best examples of tail regeneration are found in extant reptiles that exhibit caudal autotomy, for example, lizards (with the exception of most agamids, a few iguanids, and the varanids) and tuataras (*Sphenodon*). Turtles do not exhibit caudal autotomy and very little is known about their tail regeneration. Kuchling (2005, *op. cit.*) reports the occurrence of bifid tail regeneration in an individual adult male *Emydura* sp. in Western Australia, which indicates that the tails of chelonians may have some regenerative capacity. Herein, I report a bifid tail, and possible tail regeneration, in an individual *Chelydra serpentina* found in a pond in New York City. This is apparently the first published report of a bifid-tailed turtle in North America.

I captured an adult male *Chelydra serpentina* (straight-line carapace length = 414 mm, plastron length = 330 mm, carapace width = 376 mm) with a bifid tail in a baited hoop trap in a 0.4-ha pond in Alley Pond Environmental Center, Queens, New York, USA, on 25 September 2007. The tail of the turtle was much shorter than is typical. The tip of the tail was bifurcated in the horizontal plane with mirror duplication and the bifurcation point was positioned 55 mm posterior from the cloaca. The same individual was recaptured several times in 2008 and 2009 as a part of a long term mark-recapture study.

Turtles have demonstrated the capacity to regenerate their shells but the regenerative capability of the turtle tail is poorly known. Etheridge (1967. Copeia 1967:699–721) suggested that in non-autotomous lizards, extensive tail regeneration only occurs after tail loss involving damage to vertebrae (*in* Kuchling 2005, *op. cit.*). Previous research suggests that the bifid or multiple regeneration of a tail most likely results from damage to a vertebra. Records of bifid tail regeneration have been published for several lizards (*in* Mata-Silva 2010. Herpetol. Rev. 41:352–353). However, not all cases of multiple tail occurrences can attributed to regeneration; cases of developmental axial bifurcation have also been reported (Kuchling 2005, *op. cit.*). Kuchling (2005, *op. cit.*) demonstrated that the bifid tail of the *Emydura* sp. was a case of regeneration, based on a radiograph. Because there was no radiographic or histological examination on the bifid-tailed *Chelydra serpentina* reported here, it cannot be determined whether this specimen was an example of a regeneration phenomenon or represents a case of axial bifurcation. Further investigations are needed to better understand tail regeneration in turtles.

I acknowledge the staff of Alley Pond Environmental Center and Peter Warny, who provided valuable support and logistics in the field. I thank Anders Rhodin who kindly provided literature sources and Gerard Kuchling for providing valuable comments on the manuscript.

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CHELYDRA SERPENTINA **(Snapping Turtle). OVERWINTER TISSUE NECROSIS.** On 15 April 2007, an unusually warm spring day (24°C), several large Snapping Turtles were surface basking in shallow water in the northwest corner of Gimlet Lake, Crescent Lake National Wildlife Refuge, Garden County, Nebraska, USA. The site was a flooded pool ca. 10 m × 20 m, fed by small artesian springs along the shore, and was the probable overwintering site for these turtles. I was able to hand-capture one individual, a male of 36 cm carapace length. Subsequent cold weather and dispersal of the snappers from the pool prevented capture of other individuals in the area. Closer inspection of the turtle revealed considerable tissue damage and necrosis only to the tongue, roof of the mouth, and the extremities (Figs. 1A–C), and was consistent with severe frostbite. This was my first observation of this condition among >2000 captures of snappers on the Refuge over thirty years. Following processing, this turtle was released at the capture site, and has not been recaptured, but it is not known whether the turtle survived this condition. It is also not clear how this damage was incurred, but it was consistent with terrestrial activity during sub-freezing activity. Winter temperatures had been erratic (December, 3.2°C above normal; January, 0.9°C below; February, 1.6°C below; March, 5.2°C above; and April, 0.3°C below), and perhaps this turtle had been active during March (the warmest March in at least 40 years), and

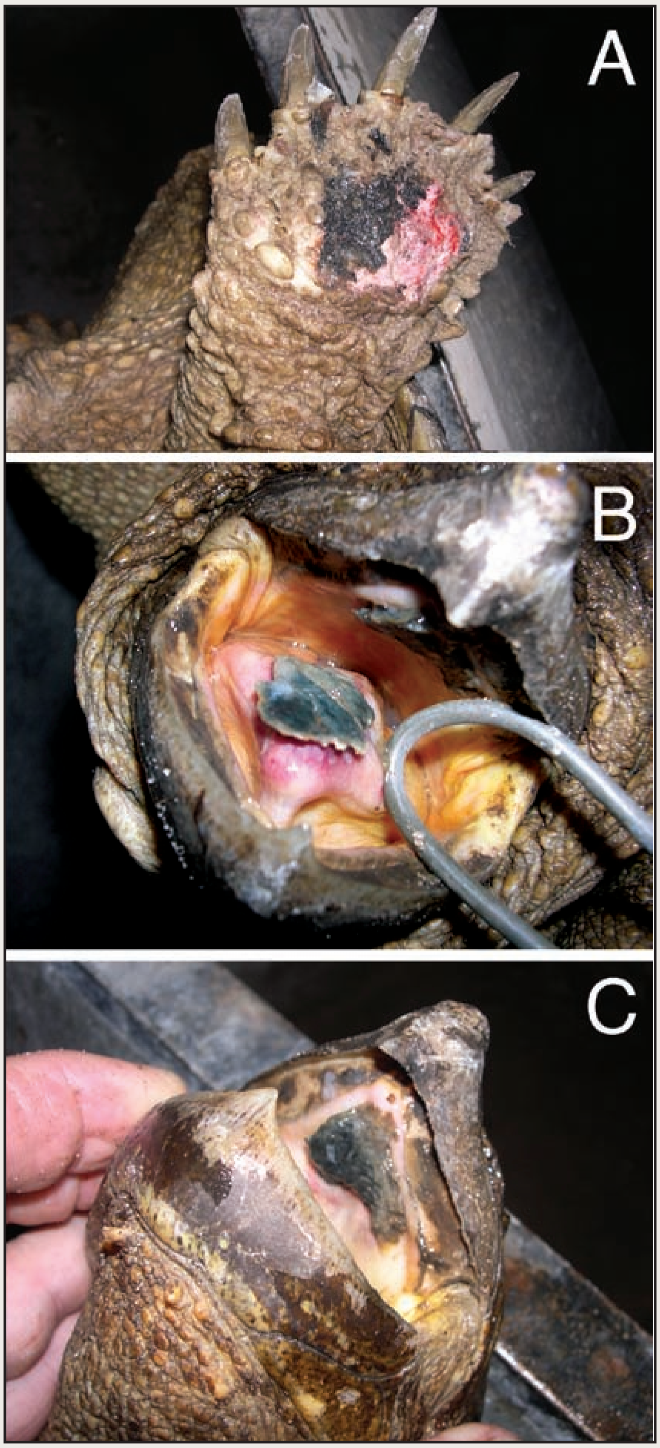

FIG. 1. Severe necrosis of ventral surface of right rear foot (A, top), dorsal surface of tongue (B, middle), and ventral surface of the palate (C, bottom) on a Nebraska Snapping Turtle captured 15 April 2007.

subsequent cold weather forced its terrestrial (or over-ice) migration to warmer water.

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***GOPHERUS AGASSIZII* (Desert Tortoise). NON-NATIVE SEED DISPERSAL.** Sahara Mustard (*Brassica tournefortii*) is a non-native, highly invasive weed species of southwestern U.S. deserts. Sahara Mustard is a hardy species, which flourishes under many conditions including drought and in both disturbed and undisturbed habitats (West and Nabhan 2002. *In* B. Tellman [ed.], Invasive Plants: Their Occurrence and Possible Impact on the Central Gulf Coast of Sonora and the Midriff Islands in the Sea of Cortes, pp. 91–111. University of Arizona Press, Tucson). Because of this species' ability to thrive in these habitats, *B. tournefortii* has been able to propagate throughout the southwestern United States establishing itself in the Mojave and Sonoran Deserts in Arizona, California, Nevada, and Utah. Unfortunately, naturally disturbed areas created by native species, such as the Desert Tortoise (*Gopherus agassizii*), within these deserts could have facilitated the propagation of *B. tournefortii.* (Lovich 1998. *In* R. G. Westbrooks [ed.], Invasive Plants, Changing the Landscape of America: Fact Book, p. 77. Federal Interagency Committee for the Management of Noxious and Exotic Weeds [FICMNEW], Washington, DC). However, Desert Tortoises have never been directly observed dispersing Sahara Mustard seeds. Here we present observations of two Desert Tortoises dispersing Sahara Mustard seeds at the interface between the Mojave and Sonoran deserts in California.

On 24 May 2010, we observed several Sahara Mustard seeds on the carapace of two male Desert Tortoises at our study site, a utility-scaled renewable energy wind park (33.95168°N, 116.667295°W, WGS84) in southern Riverside County, California. One tortoise had six *B. tournefortii* seeds adhered to the cervical scute and first vertebral scute, the seam between the first right marginal and the cervical scute, and on the dried epoxy holding the radio antenna to the carapace (Fig. 1). Another tortoise had a single Sahara Mustard seed on the second vertebral scute. Interestingly, Sahara Mustard has several modes of seed dispersal including, when moist, adhering to mobile organisms by a sticky substance (Minnich and Sanders 2000. *In* Bossard et al. [eds.], Invasive Plants of California's Wildlands, pp. 68–72. University of California Press, Berkeley, California), which explains our observations. Sahara Mustard seed's primary dispersal mechanism

FIG. 1. A male *Gopherus agassizii* with five visible red seeds of *Brassica tournefortii* adhered to its carapace.

includes wind (i.e., tumbleweed action) and rodents that collect, cache, and consume them (Bangle et al. 2008. West. N. Amer. Nat. 68:334–342). Although the observations reported here provide evidence that Desert Tortoises can also disperse seeds of Sahara Mustard, this mechanism, unlike wind and similar to rodent dispersal, has the potential for specifically introducing the non-native species in disturbed habitats, such as burrow aprons. Others have also reported the potential for Desert Tortoises to disperse other non-native species, such as Red Brome (*Bromus madritensis rubens*; Medica and Eckert 2007. Herpetol. Rev. 38:446–448).

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***MAUREMYS RIVULATA* (Balkan Terrapin). ANOPHTHALMIA.** Congenital defects of the eye, such as anophthalmia, microophthalmia, and cyclopia have been reported in many species of mammals (e.g., Fantes et al. 2003. Nat. Gen. 33:462–462), birds (Berger and Howard 1968. Condor 70:386–387), reptiles (Frye 1991. Biomedical and Surgical Aspects of Captive Reptile Husbandry, Volume II. Krieger Publ. Co., Malabar, Florida; Hindebrand 1930. J. Elisha Mitchell Sci. Soc. 46:41–53; Millichamp 1990. Proc. Amer. Assoc. Zoo Vet., American Association of Zoo Veterinarians, South Padre Island, Texas, pp. 297–301) and amphibians (e.g., Cheong et al. 2000. J. Comp. Pathol. 123:110–118; Millichamp 1990, *op. cit.*; Schoff et al. 2003. J. Wildl. Dis. 39:510–521), but reports of these conditions are uncommon, especially in the wild.

During a recent fieldtrip in the Southern Cyclades (Greece) in 2009, we examined 814 *Mauremys rivulata* specimens and found one (0.00123%) juvenile specimen near the barrage of Steno, in Livadi on Serifos Island, expressing this deficiency. This specimen clearly lacked eyes (Figs. 1, 2) and also possessed a reduced dental bone. We analyzed the skull dimensions with a portable RX-apparatus (AJEX 9020H, X-ray equipment Verachtert, Antwerp, Belgium). Comparison with a normal turtle (Figs. 1–2) of similar size clearly showed overall skull malformations of the examined specimen. The specimen with bilateral anophthalmia clearly has an enlarged os dentale, reduced maxilla and premaxilla. Additionally, the os nasale, os frontale, and the parietal bones do not appear to be ossified.

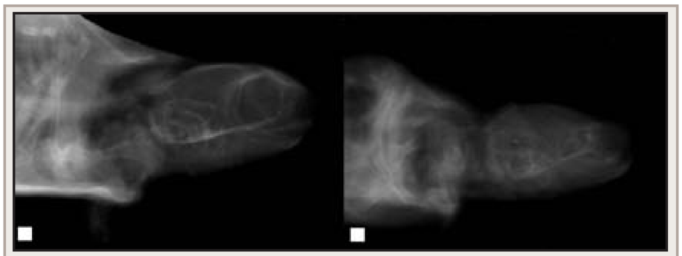

Fig. 1. Radiographic pictures of *Mauremys rivulata* with normal head (left) and with bilateral anophthalmia (right). The white square on the bottom left of each picture represents 1 mm.

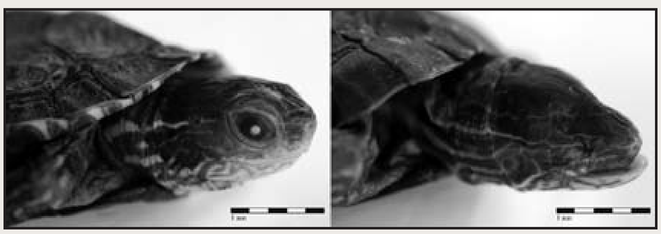

Fig. 2. Photographic pictures of specimen with normal head (left) and with bilateral anophthalmia (right). The black and white bars on the scale represent 1 mm each, for a total bar length of 5 mm.

Bilateral anophthalmia is the most rare and severe form of structural eye malformation. Causes of this anomaly can both be induced by genetic mutations (e.g., Fantes et al. 2003, *op. cit.*) or by physical conditions during development (e.g., pathological shortening of the embryonic axis; Ewert 1985. Biology of the Reptilia, Vol. 14, Development A, pp. 75–267. Wiley, New York), but is usually undetermined (e.g., Millichamp 1990, *op. cit.*). All research was conducted under permits provided by the Greek Herpetological Society and the Greek Ministry of Agriculture. All procedures followed were approved by the University of Antwerp Animal Care and Use Committee. Jonathan Brecko is funded by a PhD. grant of the Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen (Institute for the Promotion of Innovation by Science and Technology in Flanders).

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***PELODISCUS SINENSIS* (Chinese Softshell Turtle). EXTRALIMITAL WINTER SURVIVAL.** *Pelodiscus sinensis* is a medium-sized softshell turtle that ranges from from extreme southeastern Siberia (between the Ussuri and the Amur River drainages) and adjacent Korea through central and southern China, Vietnam, and the islands of Hainan and Taiwan. It has been introduced into the Hawaiian Islands, Guam, one of the Mariana Islands, one of the Bonin Islands, Timor, and California (Lever 2003. Naturalized Amphibians and Reptiles of the World. Oxford University Press, New York; Ernst and Barbour 1989. Turtles of the World. Smithsonian Press, D.C.). *Pelodiscus sinensis* is the most common turtle species bred in turtle farms in Asia (Haitao et al. 2008. Oryx 42[1]:147–150. They are exported to United States and are often sold in Asian food markets of New York City. Here, we report winter survivorship of an individual *Pelodiscus sinensis* in New York City.

We captured an adult male *Pelodiscus sinensis* at Windmill Pond, Alley Pond Environmental Center, Queens, New York (40.4542°N, 73.4516°W) (Fig. 1). Photographs were verified by Balazs Farkas, Hungarian Natural History Museum, Budapest, Hungary. Windmill pond is approximately 0.4 ha, 1.5 m deep, muddy-bottomed, and has abundant aquatic vegetation. Non-native *Trachemys scripta elegans* are the most common turtles in this pond, followed in abundance by native *Chelydra serpentina* and *Chrysemys picta*. Turtle trapping was conducted in this pond starting in 2007 for a long term study. The *P. sinensis* was captured on 24 July 2009 (carapace length = 238 mm; plastron length = 172 mm; weight = 1620 g) and recaptured on 27 July 2010, essentially unchanged. The turtle was captured in a baited hoop net on both occasions. The recapture site was less than 10 m from the original capture site. The turtle was photographed on each capture and we confirmed it as the same individual based on scar marks on carapace, injury mark on lower jaw, and unique pattern of dark blotches on plastron. The turtle was missing part of its lower jaw, in both 2009 and 2010, but otherwise appeared healthy and in good condition. The turtle had plastral blotches, which suggest that it is probably originated from central Vietnam or a turtle farm anywhere in Vietnam or China (B. Farkas, pers. comm.,13 August 2010) The northernmost population of *P. sinensis* in northern China and Russian Far East hibernate over winter, where the summer temperatures in the hottest month barely exceed 20°C. There are reports of *P. sinesis* in Central and Prospect Parks in New York City but this is the first known report of overwinter survivorship in New York, indicating that they are capable of surviving the local climatic conditions of that area.

Fig. 1. Lateral (top) and ventral (bottom) view of *Pelodiscus sinensis* found in Windmill Pond, Queens, New York.

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STERNOTHERUS MINOR MINOR **(Loggerhead Musk Turtle). DIET.** The diet of *Sternotherus minor minor* has been well-documented in the literature and includes crayfish, snails, plant material, insects, millipedes, clams, fish, aquatic invertebrates, carrion, small vertebrates, algae and other aquatic plants, small turtles, and *Goniobasis* snails (Ernst and Lovich 2009. Turtles of the United States and Canada, 2nd ed. Johns Hopkins University Press, Baltimore, Maryland). *Sternotherus minor peltifer* has been reported to consume insects, snails, filamentous algae, vascular plants, riverweed (*Podostemum*), clams, crayfish, spiders, fish, bits of rock, and detritus (Ernst and Lovich 2009, *op. cit.*). Herein I report evidence of *S. m. minor* consuming fruits of the Sugarberry Tree, *Celtis* cf. *laevigata*.

On 2 January 2006 an adult male *S. m. minor* (11–12 cm carapace length) was captured along the Itchetucknee River in north-central Florida. The turtle was placed in a 5-gallon bucket of shallow water until it could be photographed. Shortly after capture, the turtle defecated in the bucket. The fecal sample consisted almost exclusively of the crushed remains of endocarps of *C.* cf. *laevigata*. Only crushed (no whole) fruits were found in this sample.

Subsequent investigation of preserved (pre-dissected only) *Sternotherus m. minor* housed in the FLMNH Division of Herpetology collection also yielded small amounts of *Celtis* endocarps within their digestive tracts. Most endocarps found had been crushed (e.g., UF 71608 and UF 71604), but a whole seed was also found in the intestine of one turtle (UF 71604).

As a result of these findings, ca. 14 *C. leavigata* fruits were added to the enclosure of two captive *S. m. minor*. Both floating and sunken fruits were readily consumed by the captive turtles within minutes of deposition. The fruits were manipulated in the turtles' jaws until the hard endocarps were broken, indicated by a loud popping sound, after which the turtles would swallow. Any fragments of exocarps and/or endocarps inadvertently expelled during intake were pursued and eaten.

Questions arise as to what frequency *Celtis* fruits are consumed by *Sternotherus m. minor*, what role *Celtis* seeds might play with regards to nutritional value, morphology, and habitat preferences of *S. m. minor*, as well as the role of *S. m. minor* acting as a potential seed disperser through the riparian systems it occupies. The expanded alveolar surfaces in *S. m. minor* are a presumed adaptation for durophagy—a diet comprised primarily of mollusks such as snails and clams (Ernst and Lovich 2009, *op. cit.*). This adaptation also allows *S. m. minor* to completely crush the rigid seeds of *Celtis*. Crushed *Celtis* endocarps do resemble crushed gastropod shells, and for this reason it is plausible that *Celtis* remains might have been overlooked or misidentified by investigators in previous dietary studies of *S. minor*, particularly if mixed with crushed gastropod shells. Because *Celtis* sp. endocarps contain high concentrations of calcium carbonate (Yanovsky et al. 1932. Science 75[1952]:565–566), future studies could explore the nutritional of these fruits in *S. minor*. Additionally, the range and associated riparian habitats of *C. laevigata* are strikingly similar to those of which were once referred to as the *Sternotherus carinatus* complex, which is currently recognized as *Sternotherus carinatus*, *Sternotherus depressus*, *S. m. peltifer*, and *S. m. minor*. Further work might explore the extent of any dependency or even interdependency between this group and *C. laevigata*.

I thank Donna Ruhl for help in identifying *Celtis* remains, K. Krysko for allowing me to examine preserved specimens in the FLMNH Division of Herpetology collection. K. Krysko, D. Ehret, A. Hastings, M. Nickerson, and J. Harding provided helpful comments on this manuscript.

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CROCODYLIA — CROCODILIANS

***ALLIGATOR MISSISSIPPIENSIS* (American Alligator). DIET.** *Alligator mississippiensis* inhabits swamps, marshes, and other freshwater bodies of water in the southeastern United States (Ambercrombie and Delaney 1986. J. Wildl. Manag. 50:348–353). It is an apex predator, an opportunistic eater, and it is considered a keystone species (Abercrombie and Delaney 1986, *op. cit.*). *Alligator mississippiensis* is known to prey upon crustaceans, such as Blue Crab (*Callinectes sapidus*), fish, snakes, turtles, birds, and mammals, such as Nutria (Valentine 1972. J. Wildl. Manag. 36:809–815). Cannibalism has also been observed in this species (Giles and Childs 1949. J. Wild. Manag. 13:16–28).

We collected and dissected 20 stomachs of *A. mississippiensis* to investigate stomach parasitism. Specimens had been captured and killed by hunters during the alligator harvesting and hunting season up to 24 h prior at a processing center from 26–29 August 2010. Alligators were caught in the East Zone, a geographic zone designated by the Louisiana Fisheries and Wildlife Department. Dissection of one of the stomachs yielded an intact specimen that was later identified as a Gulf Crayfish Snake (*Regina rigida sinicola*). Research has shown that crocodilians can digest prey items within 12 h if the prey is not large and does not contain bony plates or an exoskeleton (Diefenbach 1975. Comp. Biochem. Physiol. 51:259–265). Therefore, it may be inferred that the snake was ingested shortly before the capture of the alligator.

The snake was identified based upon scalation, morphology, and coloration (Fig. 1). This is the first report of *R. r. sinicola* as a prey item of *A. mississippiensis*, although the congeneric *Regina alleni* has been previously documented (Delany and Abercrombie 1986, *op. cit.*).

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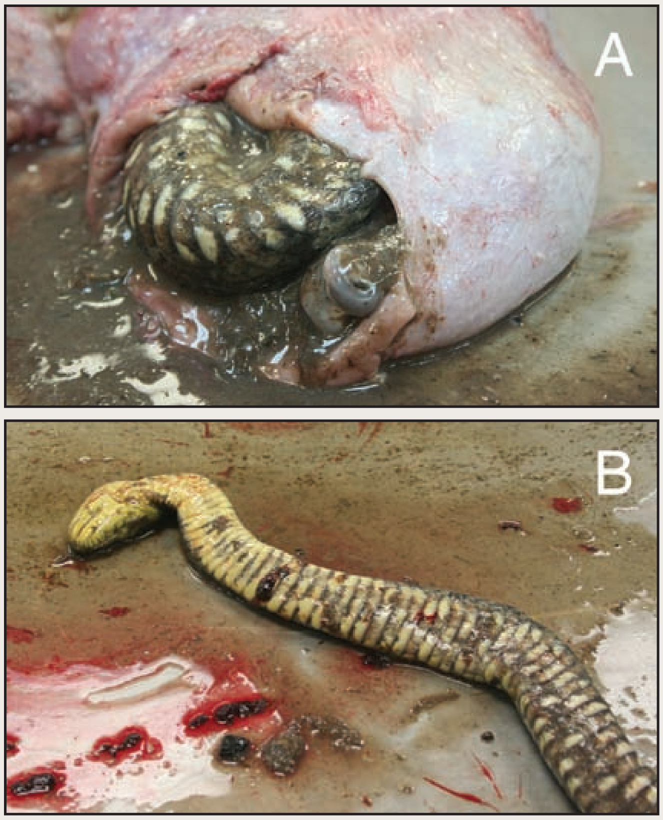

FIG. 1A. *Regina rigida sinicola* in the stomach of *Alligator mississippiensis*. 1B. Underside of *Regina rigida sinicola* after removal from stomach.

***CAIMAN CROCODILUS* (Spectacled Caiman). PREY.** Crocodilians are top predators adapted to aquatic habitats (Shyrley et al. 2009. Oryx 43:136–145). The diet of *Caiman crocodilus* has been reported to consist of terrestrial invertebrates, such as freshwater crabs and coleopterans, more so than terrestrial vertebrates, such as mammals, reptiles, and anurans (Magnusson et al. 1987. J. Herpetol. 21:85–95; Thorbjarnarson. 1993. Herpetologica 49:108–117).

We conducted spotlight surveys from a boat to evaluate crocodilian populations at Sapucuá Lake (between 1.75°N, 56.31°W and 1.86°N, 55.98°W) in the municipality of Oriximiná, in the northern part of the state of Pará, Brazil. On 26 May 2010 at 1900 h, one *Caiman crocodilus* (estimated SVL 39.5 cm) was observed with a Marine Toad (*Rhinella marina*; SVL = 95 mm; mass = 80 g) in its mouth biting down on the toad's parotoid glands. The caiman escaped before it could be captured for data collection, leaving the dead toad behind. The amphibian was collected and deposited at the herpetological collection of Museu de História Natural Capão da Imbuia at Curitiba, Paraná state, Brazil (MHN-CI 7186).

Parotoid glands contribute to anuran protection against predators and parasites (Almeida et al. 2007. Contrib. Zool. 76:145–152; Sakate and Lucas de Oliveira. 2000. J. Venom. Anim. Toxins 6:46–58), due to pharmacological activity. Indolealkylamine is the main compound found in the skins of bufonids (Cei et al. 1972. *In* W. F. Blair [ed.], Evolution in the Genus *Bufo*, pp. 233–243. University of Texas Press, Austin, Texas), acting as a vasoconstrictor, convulsant, hallucinogen, and cholinergic agent

(Maciel et al. 2003. Comp. Biochem. Physiol. B 134:641–649). In Australia, where *R. marina* was introduced, *Crocodylus johnstoni* individuals of intermediate size class died after the ingestion of the toads due to the absence of physiological adaptations against its highly toxic secretions (Letnic et al. 2008. Biol. Conserv. 141:1773–1782). However, *Crocodylus porosus*, which naturally coexist with *R. marina*, presented a better performance against the bufotoxin when compared to *C. johnstoni* during physiological tests (Smith and Phillips 2008. Pac. Conserv. Biol. 12:40–49). Predation behavior on *Rhinella marina* by Schneider's Dwarf Caiman (*Paleosuchus trigonatus*) was described in the state of Pará, Brazil (Assis and Santos 2007. Herpetol. Rev. 38:45); however, there are no data available regarding the interaction between *R. marina* and *C. crocodilus*. Among terrestrial vertebrates reported in the diet of *C. crocodilus*, anurans are few (Magnusson et al. 1987. J. Herpetol. 21:85–95; Thorbjarnarson 1993, *op. cit.*; Da Silveira and Magnusson 1999. J. Herpetol. 33:181–192). Percentage of prey occurrence analysis and relative digestibility can bias the presence of vertebrate prey items in the diet of *C. crocodilus* (Thorbjarnarson 1993, *op. cit.*). We believe that field observations on crocodilian foraging behavior can provide relevant data about predator-prey interactions. Meanwhile, captive experiments can help in understanding feeding habits and preferences as well as in investigating resistance to bufotoxins.

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***CROCODYLUS MORELETII* (Morelet's Crocodile). SMALL POND USE.** At 0047 h on 14 June 2008, during rainy conditions, we encountered a juvenile (571 mm SVL) female *Crocodylus moreletii* in a small pond (3.0 m × 4.3 m, 70 mm deep) in the middle of a small road surrounded by a brackish water wetland in Reserva de la Biosfera Los Petenes, Campeche, México (20.087032°N, 90.401258°W). At 0139 h, we observed another juvenile female *C. moreletii* (700 mm SVL) in a second small pond (1.4 × 3.0 m, 90 mm deep at 20.089948°N, 90.433983°W).

These observations are of interest since both ponds were in the middle of a small road surrounded by brackish water wetlands that are more indicative habitat for this species. We encountered another three *C. moreletti* (one adult, two juveniles) in open waters within the actual wetlands the same night. No previous reports exist of this behavior (Alvarez del Toro and Sigler 2001. Los Crocodylia de México. IMERNAR, PROFEPA, México 134 pp.). It is possible that the animals utilizing these smaller sites may take advantage of the low salinity in the rainwater filled ponds or the small ponds may provide food resources based on the potential prey we observed in similar ponds on this area (*Lithobates brownorum, Leptodactylus melanonotus, Ollotis valliceps, Smilisca baudinii*).

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SQUAMATA — LIZARDS

***AMEIVA CORAX* (Little Scrub Island Ground Lizard). FEEDING BEHAVIOR.** *Ameiva corax* is endemic to Little Scrub Island, off the northeast coast of Anguilla in the British West Indies (18.308°N, 62.967°W). It is reported to consume the eggs of seabirds that nest on the island (Hodge et al. 2003. The Reptiles and Amphibians of Anguilla, British West Indies. Anguilla National Trust, Anguilla. 72 pp.). Herein we report on an individual lizard of this species opening, partially consuming, and ultimately killing the chick of a Laughing Gull (*Larus atricilla*) nesting on the island (Fig. 1).

At 0904 h on 12 June 2009 we noticed a lizard in a gull nest attempting to open one of three eggs present. The egg was opened in less than one minute; it is unclear whether the lizard cracked the egg or whether it had already been cracked by an emerging chick. We have observed other lizards cracking and consuming the contents of gull eggs in earlier stages of development, but since it appeared to be near hatching, the chick may have cracked the egg itself. Nevertheless, the lizard successfully opened the egg and we monitored its activity from ca. 5 m away. Once the egg was opened, the lizard first consumed the yolk sac, then began to claw and bite at the lower abdomen of the chick, eventually opening a hole in the chick's skin, pulling out and consuming part of its intestinal tract. Although the lizard bit and clawed at other parts of the chick, particularly the legs and wings, it did not pierce the skin elsewhere. The lizard (individually identifiable by

Fig. 1. *Ameiva corax* consuming the intestinal tract of a Laughing Gull (*Larus atricilla*) chick.

its shedding skin pattern) left the nest and returned three times between 0910 and 0930 h. When the lizard left the nest at 0930 h, the chick was still alive and moving. An adult gull returned to the nest at 0930h and incubated the remaining eggs. We monitored the nest until 1000 h, at which point the chick was still alive and an adult gull was on the nest. The chick was dead at 1230 h when we next checked on it.

We thank the Government of Anguilla for allowing us to work on Little Scrub Island. We are particularly grateful to Karim Hodge and Rhon Conner in the Department of the Environment for their support, encouragement, and advice. We also thank Captain Nature Boy Webster for transporting us to and from the island every day.

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***AMEIVA LEPTOPHRYS* (Delicate Ameiva). ENDOPARASITES.** *Ameiva leptophrys* frequents lowland humid forests of southwestern Costa Rica and Panama to western Colombia (Savage 2002. The Amphibians and Reptiles of Costa Rica. A Herpetofauna Between Two Continents, Between Two Seas. Univ. Chicago Press, Chicago, Illinois. 934 pp.). There are, to our knowledge, no reports of helminths from *A. leptophrys*. The purpose of this note is to establish the initial helminth list for *A. leptophrys* as part of an ongoing survey of lizard helminths from Central America.

Six *A. leptophrys* (mean SVL = 112.3 mm ± 17.4 SD, range: 85–130 mm) from Costa Rica were examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California: Limón Province (LACM 174920); Puntarenas Province (LACM 174922–174924, 174927, 174928). Lizards were collected 1963–1967. The digestive tract was removed and the esophagus, stomach, small and large intestines were examined for helminths using a dissecting microscope. Nematodes and cystacanths were cleared in a drop of glycerol on a microscope slide, cover-slipped and studied using a compound microscope. Three species of Nematoda were found: *Physaloptera retusa* (stomach) prevalence, number infected/number examined × 100 = 83%, mean intensity, mean number helminths ± 1 SD = 49.8 ± 33.6 SD, range = 2–85; *Spinicauda spinicauda* (large intestine) prevalence = 67%, mean intensity = 3.8 ± 2.2 SD, range = 1–6 and two ascarid larvae (Angusticaecinae) (body cavity) prevalence = 17% and one species of Acanthocephala as 11 cystacanths (body cavity) prevalence = 17%. Helminths were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland: *Physaloptera retusa* (USNPC 103860); *Spinicaud spinicauda* (USNPC 103861); Ascarid larvae (USNPC 103862); Oligacanthorhynchid cystacanths (USNPC 103863).

Physaloptera retusa is widely distributed in the Western Hemisphere. Records are summarized in McAllister et al. (2010. Comp. Parasitol. 77:184–201). Physalopterid nematodes utilize insect intermediate hosts (Anderson 2000. Nematode Parasites of Vertebrates. Their Development and Transmission. CABI Publishing, Oxon, UK, 650 pp.). Lizards are infected through their diet. *Spinicauda spinicauda* is known from a variety of South American lizards (Baker 1987. Mem. Univ. Newfoundland, Misc. Pap. 11:1–325; Ramallo et al. 2009. J. Parasitol. 95:1026–1028). Lizards become infected when they ingest eggs; no intermediate host is utilized (Anderson 2000, *op. cit.*). Eggs of various species assigned to the order Ascaridida, Angusticaecinae will hatch in a variety of vertebrate intermediate hosts and develop into third-stage infective larvae (Anderson 2000, *op. cit.*). Because these larvae were in cysts, the possibility that *A. leptophrys* was serving as a transport (= paratenic host) must be considered. Cystacanths are larval forms infective to the definitive host (Kennedy 2006. Ecology of the Acanthocephala. Cambridge Univ. Press, Cambridge, UK. 249 pp.) and reach the lizard when it ingests an infected insect. No further development occurs in the lizard which serves as a paratenic transport host. *Physaloptera retusa*, *Spinicauda spinicauda*, ascarid larvae and oligacanthorhynchid cystacanths in *A. leptophrys* are new host records. Costa Rica is a new locality record for *S. spinicauda*.

We thank Christine Thacker (LACM) for permission to examine individuals of *A. leptophrys*, which are part of the Costa Rica Expeditions Collection donated to LACM in 1998 by Jay M. Savage. Cecilia Nava and Daisy Salguero (Whittier College) assisted with dissections.

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***ANOLIS ALTAE* (High Anole). ENDOPARASITES.** *Anolis altae* occurs in premontane and lower montane zones of the Cordillera de Tilarán, Cordillera Central and Cordillera de Talamanca of Costa Rica at elevations of 1220 to 2000 m (Savage 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. Univ. Chicago Press, Chicago, Illinois. 934 pp.). Five *A. altae* (mean SVL = 45.2 mm ± 1.6 SD, range: 44–48 mm) collected November 1963 and deposited in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA were examined for helminths (Costa Rica: Cartago Province, LACM 149056, 149063–149065, 169075).

The digestive tract was removed through a mid-ventral incision, and the esophagus, stomach and small and large intestines were examined for helminths under a dissecting microscope. Cestodes were found in the small intestine, nematodes were found in the small and large intestines. Cestodes were regressively stained in hematoxylin, dehydrated in ethanol and mounted in Canada balsam; nematodes were cleared in glycerol and cover-slipped on a microscope slide. Both preparations were studied under a compound microscope. The cestodes were identified as *Mathevotaenia panamaensis* (prevalence [number infected lizards/number lizards examined × 100] = 40%, mean intensity [mean number helminths per infected lizard ± 1 SD] = 36.0 ± 39.6, range: 8–64). The nematodes were identified as *Falcaustra costaricae* (prevalence = 40%, mean = 1.0). Helminths were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland: *Mathevotaenia panamaensis* (USNPC 103944); *Falcaustra costaricae* (USNPC 103945).

Mathevotaenia panamaensis was recently described from *Sceloporus malachiticus* from Panama by Bursey et al. (2010. Acta Parasitol. 55:53–57). *Anolis altae* is the second host to harbor this parasite although an unidentified species of *Mathevotaenia* was found in *Anolis humilis* from Nicaragua (Goldberg et al. 2010. Comp. Parasitol. 77:242–246). *Mathevotaenia panamaensis*, a member of the Anoplocephalidae, utilizes an arthropod as an intermediate host (Roberts and Janovy 2005. Gerald D. Schmidt

& Larry S. Roberts' Foundations of Parasitology, McGraw Hill Higher Education, Boston, Massachusetts. 702 pp.). *Falcaustra costaricae* was described from *Anolis* (as *Norops*) *tropidolepis* from Costa Rica (Bursey et al. 2004. J. Parasitol. 90:598–603). It has been reported from anurans (Goldberg and Bursey 2010. J. Nat. Hist. 44:1755–1787) and *Anolis lionotus* from Costa Rica (Bursey and Brooks 2010. Comp. Parasitol. 77:232–235). The life cycle of *Falcaustra costaricae* is unknown, but it is thought that larvae may utilize invertebrates as paratenic (= transport) hosts which are infective upon ingestion by lizards (Anderson 2000. Nematode Parasites of Vertebrates: Their Development and Transmission. CABI Publishing, Oxon, UK. 650 pp.). *Anolis altae* represents a new host record for *M. panamaensis* and *F. costaricae*. Costa Rica is a new locality record for *M. panamaensis*.

We thank C. Thacker (LACM) for permission to examine *A. altae* which are part of the Costa Rica Expeditions Collection donated to LACM by J. M. Savage in 1998.

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ANOLIS CYBOTES CYBOTES **(Hispaniolan Stout Anole) and *ANOLIS MARRON* (Jacmel Gracile Anole). PREDATION/PREY.** On 18 August 2009, at approximately 1400 h, while sampling anoles at a coastal locality near Marigot, Haiti (approximately 20 km E of Jacmel), we encountered a large adult male *Anolis c. cybotes* vertically perched with its head pointing upwards on the trunk of a coconut palm with the hindquarters of an adult female *A. marron* protruding from its mouth (Fig. 1). The *A. c. cybotes* held its ground as we moved around it and photographed it *in situ*, at one point partially extending its dewlap and doing a pushup. After photographing the *A. c. cybotes* with its prey we captured it using a noose and placed it in a cloth bag, which we subsequently stored in an empty plastic cooler inside an air-conditioned car for the remainder of the day. At some point during capture of the *A. c. cybotes*, the *A. marron* autotomized its tail, which we were not able to locate. At 2230 h (8.5 h after discovery and capture), the *A. c. cybotes* still had not fully swallowed the *A. marron* and the feet of the prey continued to protrude from its mouth. At this time, we euthanized the *A. c. cybotes*, extracted the *A. marron*, and measured, photographed, and preserved both specimens (Fig. 2). The *A. c. cybotes* measured 70 mm SVL and weighed 9.0 g. The *A. marron* measured 45 mm SVL and weighed 2.4 g. The predated anole was intact, but partially digested externally when removed from the stomach of its predator. The skin on the anterior half of the anole had been largely digested, and the skull and forelimbs of the anole showed considerable loss of structural integrity.

Although the conditions of its captivity were artificial, the fact that this large male *A. c. cybotes* failed to fully ingest the *A. marron* prey item over an 8.5 h period, and the fact that considerable digestion of the anterior portion of the *A. marron* took place over this period suggests that (1) this prey item was close to the maximum size possible for this anole, and (2) that *A. c. cybotes* may occasionally capture and eventually consume prey items that it may not fully ingest upon capture. It is possible that the progress of ingestion was correlated with the progress of digestion of the prey's anterior portion. However, it is also possible

FIG. 1. Male *Anolis cybotes cybotes* with female *A. marron* protruding from its mouth, photographed *in situ* immediately after discovery.

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

that these observations largely reflect the influence of the capture and containment of the predator. The *A. c. cybotes* was kept inactive at a slightly lower temperature than it was captured at, so we urge caution in interpreting its rate of digestion following capture.

Although intraguild predation events have been reported several times in *Anolis*, the sizes of the anoles involved have rarely been measured quantitatively (Gerber 1999. *Anolis* Newsletter V:28–39). This event is noteworthy in that the predator consumed a congener measuring 64.3% of its own SVL and approximately26.7% of its own body weight (possibly more, given the lost tail and partial digestion of the *A. marron* specimen at the time of measurement). To our knowledge, this is the highest

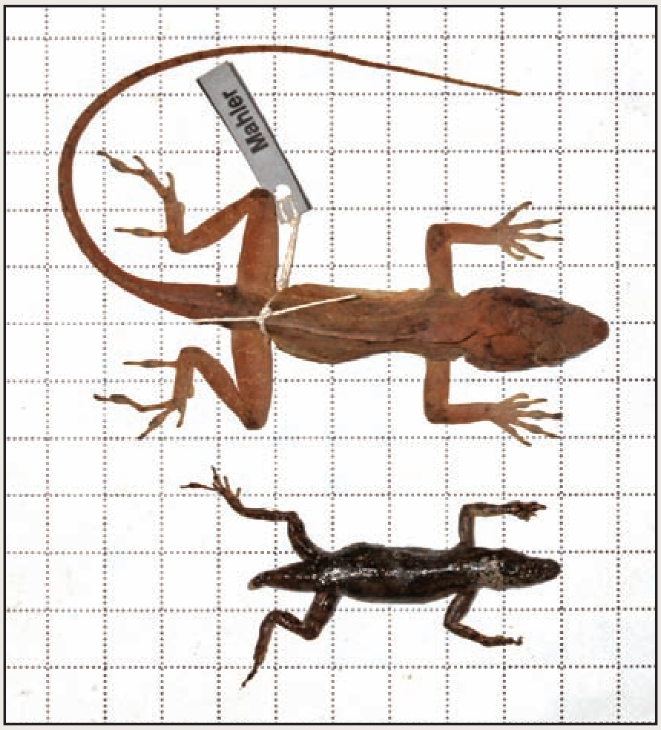

Fig. 2. Male *Anolis cybotes cybotes* (top) and female *A. marron* (bottom), immediately after the latter was extracted from the stomach and mouth of the former, but after at least 8.5 h of digestion. Grid unit = 1 cm.

prey:predator ratio quantified for anoles (Gerber 1999, *op. cit.*; Losos 2009. Lizards in an Evolutionary Tree. Univ. of California Press, California. 507 pp.). In experiments, *A. cybotes* is known to feed on juveniles of other anole species (e.g., *A. bahorucoensis*, *A. coelestinus*, and *A. distichus*), as well as juvenile *A. cybotes* (Fitch and Henderson 1987. Amphibia-Reptilia 8:69–80). Although previous natural predation of *A. cybotes* on *A. marron* has not been reported, *A. cybotes* has been documented to predate on a species closely related to *A. marron*, *A. distichus*. *Anolis marron* coexists with *A. cybotes* throughout the former species' entire range, and these two species clearly compete, often using the same food resources on a single tree (pers. obs.). This observation demonstrates that these two species interact as predator and prey as well as resource competitors.

These specimens are deposited in the Museum of Comparative Zoology at Harvard University (*A. c. cybotes* = MCZ R-188077; *A. marron* = MCZ R-188078).

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***ANOLIS EQUESTRIS* (Knight Anole). REPRODUCTION.** *Anolis equestris* is native to Cuba and has been introduced to Florida and Oahu, Hawaii (Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Press Florida, Gainesville. 495 pp.). Anecdotal information on reproduction is in Henderson and Powell (*op. cit.*), from Florida (Meshaka et al. 2004. The Exotic Amphibians and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida. 155 pp.; Meshaka and Rice 2005. *In* Meshaka and Babbitt [eds.], Amphibians and Reptiles Status and Conservation in Florida, pp. 225–230. Krieger Publ. Co., Malabar, Florida) and Hawaii (McKeown 1996. A Field Guide to Reptiles and Amphibians in the Hawaiian Islands. Diamond Head Publishing, Los Osos, California. 172 pp.). *Anolis equestris* was first noted in Oahu in 1981 (McKeown, *op. cit.*). The purpose of this note is to add to the knowledge on *A. equestris* reproduction from a histological examination of gonadal material from Hawaii.

A sample of 17 *A. equestris* from Oahu, Hawaii consisting of 10 adult males (mean SVL = 148.4 mm ± 4.1 SD, range: 115–157 mm), five adult females (mean SVL = 143.4 mm ± 3.9 SD, range: 140–148 mm), and two subadult females (mean SVL = 108.0 mm ± 31.8 SD, range: 85–130 mm) from Oahu, Hawaii was examined from the Bishop Museum (BPBM), Honolulu, Hawaii, USA: BPBM:11805, 12200, 12201, 12209, 13718, 14163, 14821, 14822, 14998, 16960, 16961, 20982, 20983, 25352, 31892, 31893, 33835. *Anolis equestris* were collected 1993 to 2009.

An incision was made on the lower left lateral side of the abdomen to expose the gonads. The left testis was removed from males and the left ovary was removed from females for histological examination. Oviductal eggs and enlarged follicles (> 4 mm) were counted. Tissues were embedded in paraffin; sections were cut at 5 µm and stained with hematoxylin followed by eosin counterstain. Histology slides are deposited in BPBM.

The only stage observed in the testicular cycle was spermiogenesis in which the lumina of the seminiferous tubules were lined by sperm or clusters of metamorphosing spermatids. Males undergoing spermiogenesis were found in the following months (sample size in parentheses): February (N = 2); April (N = 2); May (N = 4); July (N = 1); August (N = 1), indicating a prolonged period of spermiogenesis. The smallest reproductively active male (BPBM 14163) measured 115 mm SVL and was from May. The smallest reproductively active female (BPBM 16961) measured 140 mm SVL and was from April. Three adult females from April each contained oviductal eggs. In one, (BPBM 12200) the eggs were fused and could not be counted. The other two females contained evidence that consecutive clutches are produced as one of them (BPBM 11805) contained one oviductal egg and two follicles (> 4 mm) in both the right and left ovaries and the other (BPBM 16961) contained both one oviductal egg and one enlarging follicle (> 4 mm). *Anolis equestris* produces clutches of one to two eggs (Haselhaus and Schmidt 1995. Caribbean Anoles. T.F.H. Publ., Neptune City, New Jersey. 64 pp.). Two females (BPBM 20982, 20983) from December contained quiescent ovaries (no yolk deposition) suggesting some seasonality in the ovarian cycle of *A. equestris* in Hawaii.

I thank Pumehana Igada (BPBM) for facilitating my examination of *A. equestris*.

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***CTENOSAURA OEDIRHINA* (Roatán Spiny-tailed Iguana). SAUROPHAGY.** Here we report an instance of saurophagy by *Ctenosaura oedirhina* at Arch's Iguana Farm, French Harbour, Roatán, Honduras (16.3575°N, 86.441111°W). The farm is a rehabilitation center for *Iguana iguana* (Green Iguana). The *Iguana iguana* are free roaming but at an artificially high density. Wild *C. oedirhina* also occur at this site as it falls within their natural distribution, however this species is present in much lower numbers.

At ~1125 h on 17 August 2008 we observed an adult *Ctenosaura oedirhina* actively pursue and consume a juvenile *Iguana iguana*. The *I. iguana* was caught by the posterior region of its torso after a short chase, and after some maneuvering the *Ctenosaura* proceeded to swallow the *Iguana* whole from the rear. The entire predation event was very rapid, lasting only approximately three minutes from the initiation of the chase to complete ingestion.

To our knowledge this is the first account of saurophagy in *Ctenosaura oedirhina*. This is a relatively under-studied iguanid species, with very few reports concerning its dietary preferences. The most reliable of available accounts is found in the proposal for the inclusion of this species into CITES Appendix II (reference number CoP15 Prop. 11), where *Ctenosaura oedirhina* was "assumed to be mainly herbivorous and to feed opportunistically on small invertebrates."

It is possible that this predation was a unique event triggered by the artificially high density of *Iguana iguana* at this site. However, given that other closely related species of *Ctenosaura* have been documented to include saurian prey in their diet, with saurophagy observed in both *C. bakeri* (Dirksen and Gutsche 2006. Elaphe 14:51–52) and in *C. similis* (Henderson 1973. J.Herpetol. 7:27–33), it seems likely that this type of predation event might be more commonplace than is currently accredited to this genus.

Further study would be required to elucidate whether this observation represents an isolated opportunistic predation event or whether saurian prey comprise a regular part of the natural diet of *C. oedirhina*.

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CYCLURA CYCHLURA INORNATA **(Allen Cays Rock Iguana). MORTALITY.** Ingestion of unnatural or atypical food items (especially human-produced refuse) by reptiles in nature can have significant negative consequences (Mrosovsky et al. 2010. Mar. Pollution Bull. 58:287–289). Here we report the apparent death of a *Cyclura cychlura inornata* following the ingestion of a marine sponge (Porifera). On 18 May 2009, a marked female (15.7 years old; SVL ca. 28 cm) in a long-term study (Iverson et al. 2006. Biol. Cons. 132:300–310) was found dead and nearly mummified along the southwest coastline of Leaf Cay in the Allen Cays in the northern Exuma Islands (site detailed in Iverson et al. 2004. Herpetol. Monogr. 18:1–36). Although the carcass was nearly completely intact, detritivores had partially opened the ventral body wall, exposing the contents of her abdomen. The internal organs were mostly gone, but the space was completely filled with a large piece of dried marine sponge (ca. 4 cm × 2 cm × 1.5 cm; Fig. 1). It appeared that she had ingested the large sponge, but that it had obstructed her gastrointestinal tract, causing her death. Whether she ingested the sponge during natural foraging, or during a tourist feeding event on the nearby landing beach is unknown. For example, on 25 May 2009 one of us (CRK) observed an Exuma Islands Iguana (*Cyclura cychlura figginsi*) on Bitter Guana Cay in the central Exuma Islands foraging at the high tide line, and ingesting a small piece of marine sponge by its own choice (Fig. 2). In addition, we regularly observe both subspecies of iguana in the Exumas foraging among the wrack at the high tide line. However, we have also observed tourists throwing litter and beach wrack (from seaweed to sticks to dead sponges) toward iguanas almost daily on the Leaf Cay beach to induce them to come to feed. More specifically, we have occasionally observed the ingestion of sponges by Allen Cays Iguanas under these conditions. Our observations suggest that although dead sponges may occasionally be part of the natural diet of these iguanas, they may sometimes be hazardous to the iguana's health.

Fig. 1. Mummified carcass of Allen Cays Iguana that apparently died because of ingestion of a marine sponge.

Fig. 2. Exuma Island Iguana foraging on a marine sponge at high tide line.

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HEMIDACTYLUS AGRIUS **(Country Leaf-toed Gecko). REPRODUCTION.** Communal nesting has been recorded in several species of lizards, including the families Teiidae (Magnusson and Lima 1984. J. Herpetol. 18:73–75), Polychrotidae (Rand 1967. Herpetologica 23:227–230; Estrada 1987. Poeyana 353:1–9), and, in particular, Gekkonidae (Rand, *op. cit.*; Greer 1967. Breviora 268:1–19; Vitt et al. 1997. Copeia 1997:32–43). Rand (1967, *op. cit.*) suggested two possible explanations for communal egg laying: the attractiveness of sites suitable for oviposition and the relative scarcity of suitable places to spawn.

Communal nests have been found in litter, logs and fallen branches on the ground, holes in logs, termite mounds, rocky pools, anthropogenic debris and buildings, among others (Greer, *op. cit.*; Rand, *op. cit.*; Krysko et al. 2003. Amphibia-Reptilia 24:390–396). The genus *Hemidactylus* is characterized by oviposition of one or two eggs (Krysko et al., *op. cit.*). Herein we present a new record of communal nesting by *Hemidactylus agrius*. Little is known about this gecko's ecology and the data presented here contribute to the knowledge of the reproductive biology of this species.

On 26 September 2009, during field research in a semiarid area at the Fazenda Experimental Vale do Curu, near Pentecoste municipality, State of Ceará, Brazil (3.82145°S, 39.33824°W; datum WGS 84), we found a nest with five eggs of *Hemidactylus agrius*. The eggs were found aggregated and juxtaposed to one another, oviposited at ground level in a small brick house.

The eggs were handled carefully and taken to the laboratory of herpetology at the Núcleo Regional de Ofiologia da UFC (NUROF – UFC), where they were monitored until hatching so the identification of the species could be determined. Hatching occurred from 11–16 November 2009. Hatchling voucher specimens were placed in the Coleção Herpetológica da UFC – CHUFC (L 4105, L 4106, L 4107, L 4108 and L 4109).

Based on the number of eggs and hatching dates, we believe at least three females participated in oviposition at the nest. To our knowledge, this is the first known occurrence of communal egg laying in *H. agrius*.

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***HEMIDACTYLUS BROOKII* (Brook's Gecko). AVIAN PREDATION.** *Hemidactylus brookii* is one of the most common gekkonids in the Indian subcontinent (Smith 1943. The Fauna of British India, including Ceylon and Burma. Reptilia and Amphibia. Vol. III. Serpentes. Taylor and Francis, London. xii + 583 pp.; Daniel 2002. The Book of Indian Reptiles and Amphibians. Bombay Natural History Society. Oxford University Press; Sharma 2002. The Fauna of India and the Adjacent Countries–Reptilia (Sauria) Volume II, pp. 107–108. Director, Zoological Survey of India, Kolkata). *Hemidactylus brookii* is a crepuscular and nocturnal species. It occurs in many different habitats such as rocky areas and grassy plains. Despite its abundance and wide distribution, little is known about the ecology of this species or its natural predators. Here we report on the predation of this gecko by the Oriental Magpie Robin (*Copsychus saularis*), a typically insectivorous and diurnal forest bird.

On 31 July 2010 at 1715 h, we photographed an adult male *C. saularis* in Jiwaji University campus, Gwalior, Madhya Pradesh, India (26.63278°N, 77.864167°E; 119 m elev.) consuming an adult *H. brookii* after killing it by beating it several times on the forest floor (Fig. 1). The bird then consumed the lizard in small pieces.

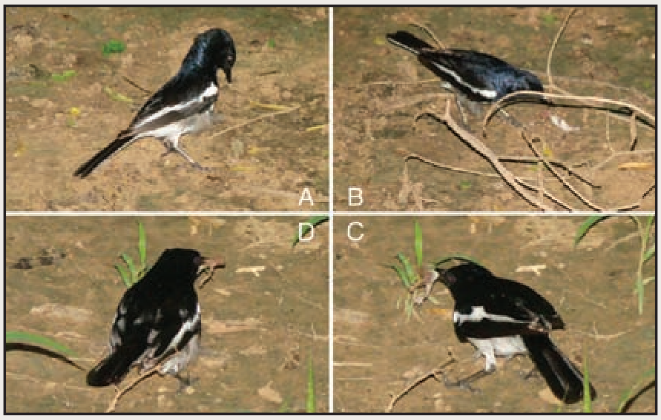

PHOTO BY VIVEK SHARMA

FIG. 1. The progressive steps (A, B, C, and D) of predation on *Hemidactylus brookii* by *Copsychus saularis*.

The Oriental Magpie Robin typically feeds on insects (Kazmierczak and Perlo 2006. A Field Guide to the Birds of India. Om Book Services, New Delhi, India. pp. 264). Our observations are the first photographic evidence of predation by this bird on a lizard. This note is of further interest as it reports a diurnal predator consuming a nocturnal prey species.

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***LYGODACTYLUS KLUGEI* (NCN). SEXUAL DIMORPHISM, HABITAT, DIET.** *Lygodactylus klugei* is a small-bodied, diurnal and arboreal gecko from the caatinga of northern South America. Here we provide data on sexual dimorphism, habitat use, and diet of *L. klugei* from the northernmost caatinga of Brazil. We captured 22 adults (11 males and 11 females) from 16 February to 3 March, 2010 at the Fazenda Experimental do Vale do Curu (FEVC), Pentecoste Municipality, Ceará State, Brazil (03.42°S, 39.33°W). We recorded perch height (PH) and perch circumference (PC) from the place each lizard was first sighted. In the lab, lizards were euthanized with an injection of sodium thiopental (Tiopental®) and fixed with 10% formalin. Next, we measured snout–vent length (SVL) and determined sex via inspection of gonads. Diet was determined by inspection of stomach contents (to taxonomic order for insects), and the volume of prey estimated by using the formula for a prolate spheroid. Diet niche breadth was calculated following Pianka (1973. Ann. Rev. Ecol. Syst. 4:53–74). We also calculated the standardized diet niche breadth by dividing the niche breadth value by the total number of prey categories, which allows for comparisons with other studies.

Males were smaller than females in SVL: males = 26.4 ± 1.6 mm, females = 28.4 ± 0.9 mm (*t*-test: $t = 3.51$, $P = 0.002$), as was found for *L. klugei* from Exu, Pernambuco, Brazil (Vitt 1986. Copeia 1986:773–786). All lizards were found on tree trunks. Neither PH nor PC differed between the sexes: PH males = 30 cm, females = 37.5 cm (Mann–Whitney *U*: 11, $P = 0.46$); PC males = 34.3 ± 13.9, females = 29.7 ± 7.8 cm (*t*-test: –0.91 P 0.37). At FEVC, stomach contents included six types of prey (Araneae, Coleoptera, Diptera, Hemiptera, Hymenoptera, and insect larvae). Coleopterans were the most prevalent prey item found in stomachs (89%), representing 55% of the total numerical prey frequency, followed by dipterans (22%). Volumetrically, coleopterans represented 48% and hymenopterans 28% of the prey eaten. Food niche breadth was 2.94 and standardized niche breadth was 0.49. Prey volume was not related to lizard SVL or to head width (all variables $\log_{10}$ transformed).

Lygodactylus klugei from FEVC seem to eat a relatively narrow range of prey with coleopterans and hemipterans accounting for the majority of the total prey volume. Vitt (1995. Occas. Pap. Oklahoma Mus. Nat. Hist. 1:1–29) found that *L. klugei* from Exu, Pernambuco, Brazil ate 25 prey types, but mainly termites and spiders. Diet niche breadth for *L. klugei* from Vitt's (1995, *op. cit.*) study was 8.33 (standardize niche breadth = 0.24). Thus, *L. klugei* from FEVC, despite the inclusion of fewer prey types, seems to exploit food resources more equitably compared to the population from Exu.

We are grateful to the administrative staff of the Fazenda Experimental do Vale do Curu for logistical support. We also thank R. Espinoza for reviewing this note. CABG benefitted from a grant from Conselho Nacional de Desenvolvimento Científico e Tecnológico proc. 35.0241/2008-2 and DZ received a grant from Fundação Cearense de Apoio ao Desenvlvimento Científico e Tecnológico BMD-0008-00060.01.14/10. The study was conducted under Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) permit 21551-1.

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***MABUYA DORSIVITTATA* (NCN). REPRODUCTION.** *Mabuya dorsivittata* is a viviparous scincid with a relatively wide geographical distribution in South America. The only available data on reproduction were based on a few specimens from a population in southeastern Brazil (Vrcibradic et al. 2004. Herpetol. J. 14:109–112). Here we expand upon the knowledge of the reproductive biology of this species.

A mark-recapture study was conducted from February 2001 to January 2004 using pitfall traps with drift-fencing in Santa Maria, Rio Grande do Sul, Brazil. In February 2001, a gravid female *Mabuya dorsivittata* was captured, measuring 65.21 mm snout–vent length (SVL); 129.31 mm tail length (TL), and weighed 4 g. Five young were born the same day of capture; two females and three males, all with the same weight (0.75 g). Measurements ranged from 29.07–32.26 mm SVL (mean = 31.8 ± 1.4) and 40.45 to 55.27 mm (TL) (mean = 46.6 ± 5.6). The neonate skinks were released three days after birth near the capture location of the mother, but none was recaptured until January 2004. The mother was recaptured only once, 10 months later, non-gravid. The brood size we report here differs from that recorded from southeast Brazil: 3.2 ± 0.45 embryos (Vrcibradic et al. 2004, *op. cit.*). This report is important for future studies on the reproductive aspects of *M. dorsivittata*, as only limited data on this species are available.

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***PLESTIODON OBSOLETUS* (Great Plains Skink). LIFE HISTORY.** Herein we report information on habitat, morphology, and activity from 813 captures of 505 individual *Plestiodon obsoletus* from riparian forest habitat along the middle Rio Grande in central New Mexico. We used toe-clipping during a mark-recapture study conducted from late May to mid-September each year from 2000 to 2006 to evaluate the effects of non-native plant and fuels removal on herpetofauna (Bateman et al. 2008. Restoration Ecol. 16:180–190). We monitored herpetofauna at 12 sites spanning 140 km of river from Albuquerque (35.008380°N, 106.681805°W) to Bosque del Apache National Wildlife Refuge (33.805122°N, 106.859980°W). The climate is semiarid to arid (Tuan 1962. Annals Assoc. Amer. Geograph. 52:51–68). Trapping arrays were located in riparian forests containing a mixture of native Rio Grande Cottonwood (*Populus deltoides wislizenii*) and willow (*Salix* spp.), and non-native plants, including saltcedar (*Tamarix chinensis* and *T. ramosissima*) and Russian Olive (*Elaeagnus angustifolia*).

Plestiodon obsoletus were captured by means of pitfall (5-gallon, 18.9 liter buckets) and funnel traps, 55% and 45%, respectively. Snout–vent length (SVL), vent–tail length (VTL), and mass were measured (Table 1). Sex was often difficult to determine and was confirmed only when experienced technicians were available. Skink hatchlings became active in July and captures peaked during the first half of August. For example, of the number of hatchlings captured for the first time, 3.2% (mean SVL = 38.4 mm, range = 36–41 mm, N = 7) occurred from 1–15 July, 32.7% (mean SVL = 37.9 mm, range = 31–64 mm, N = 72) from 16–31 July, 36.4% (mean SVL = 38.0 mm, range = 34–45 mm, N = 80) from 1–15 August, 23.2% (mean SVL = 40.8 mm, range = 36–58 mm, N = 51) from 16–31 August, and 4.5% (mean SVL = 48.2 mm, range = 38–58 mm, N = 10) from 1–15 September. Adult activity, in terms of total captures, peaked in the latter half of July. For example, of total number of adult captures, 7.5% (mean SVL = 91.7 mm, range = 63–111 mm, N = 39) occurred from 1–15 June, 20.0% (mean SVL = 93.7 mm, range = 61–115 mm, N = 104) from 16–30 June, 19.0% (mean SVL = 88.8 mm, range = 60–113 mm, N = 99) from 1–15 July, 23.5% (mean SVL = 89.1 mm, range = 63–124 mm, N = 122) from 16–31 July, 16.5% (mean SVL = 91.0 mm, range = 68–120 mm, N = 86) from 1–15 August, 10.4% (mean SVL = 87.6 mm, range = 67–120 mm, N = 54) from 16–31 August, and 3.1% (mean SVL = 88.6 mm, range = 71–117 mm, N = 16) from 1–15 September. Only 22% (114 of 505) of marked skinks were recaptured and most sightings occurred during the summer of marking, although some skinks were seen up to three summers later. For example, 25 skinks were recaptured the summer following first capture, 9 were recaptured two summers later, and 5 were recaptured three summers later. From these data, we documented that skinks grew the fastest in their first year and that growth slowed as skinks reached adult size. For example, skinks first encountered as hatchlings and recaptured the following summer grew by 60% in SVL (mean first summer SVL =

TABLE 1. Morphological characteristics of *Plestiodon obsoletus* captured during 2000–2006 from the riparian forest along the middle Rio Grande in central New Mexico. Data are summarized by captures of individuals < 5 g mass (hatchlings) and > 5 g mass (juveniles and adults). Data represent captures and individuals occur more than once in table.

	Hatchling (< 5 g)				Juvenile, Adult (> 5g)			
Sex	Number of captures	Mean SVL (mm)	Mean VTL (mm)	Mean Mass (g)	Number of captures	Mean SVL (mm)	Mean VTL (mm)	Mean Mass (g)
Female	6	44.3 (± 3.70)	53.8 (± 2.09)	2.2 (± 0.56)	129	88.2 (± 1.08)	120.2 (± 3.01)	16.8 (± 0.63)
Male	5	42.6 (± 2.82)	56.4 (± 5.78)	1.3 (± 0.34)	52	92.5 (± 1.89)	123.9(± 4.53)	19.5 (± 1.22)
Unknown	236	39.5 (± 0.32)	49.8 (± 0.93)	1.2 (± 0.05)	340	90.7 (± 0.60)	123.3 (± 1.68)	16.9 (± 0.36)

44.2 mm, range = 41–48 and one year SVL = 70.8 mm, range = 51–83, N = 10). Whereas skinks first encountered as adults and recaptured the following summer grew only 10% in SVL (mean first summer SVL = 88.6 mm, range = 63–113, and the following year SVL = 97.4 mm, range = 80–109, N = 19). We documented similar hatchling period and SVL compared to other locations in New Mexico (Belfit and Belfit 1985. Southwest. Nat. 30:612–614) and in Kansas (Hall and Fitch 1971. Kansas Acad. Sci. 74:93–98). However, this report summarizes lesser known growth rates for *Plestiodon obsoletus* tracked over time in a field setting.

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***POLYCHRUS GUTTEROSUS* (Berthold's Bush Anole). ENDOPARASITES.** *Polychrus gutterosus* occurs in lowland and lower premontane evergreen forests from northwestern Honduras and western Costa Rica to northwestern Ecuador at 6–700 m elevation (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 our knowledge there is one report of helminths from *P. gutterosus*; Bursey et al. (2007. Comp. Parasitol. 74:108–140) reported one species of trematode, *Parallopharynx arctus*, and two species of nematodes, adults of *Physaloptera retusa* and larvae of *Ophidascaris* sp., from *P. gutterosus* collected in Panama. The purpose of this note is to add new records to the helminth list for *P. gutterosus* collected in Costa Rica as part of an ongoing study of the biodiversity of helminths of amphibians and reptiles from Central America.

Three *P. gutterosus* (mean SVL = 141.7 mm ± 49.1 SD, range: 85–170 mm) deposited in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California from Costa Rica were examined: LACM 166772, from Heredia Province, collected December 1973; LACM 166773, from Alajuela Province, collected March 1966; LACM 166776, from Puntarenas Province, collected October 1974.

The body cavity was opened by a mid-ventral incision and the digestive tract was removed and opened. The esophagus, stomach and small and large intestines were examined for helminths. Only LACM 166772 contained helminths. Five digeneans were found in the small intestines (prevalence = number infected lizards/all lizards examined × 100 = 33%); mean = 5.0. One nematode (prevalence = 33%; mean = 1.0) was found in the large intestines. The digeneans were regressively stained in hematoxylin, mounted in Canada balsam, studied as whole mounts under a compound microscope and identified as *Mesocoelium monas*. The nematode was cleared in a drop of glycerol on a microscope slide, cover-slipped, studied under a compound microscope and identified as *Strongyluris panamaensis*. Voucher helminths were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, USA as *Mesocoelium monas* (USNPC 104037); *Strongyluris panamaensis* (USNPC 104038).

Mesocoelium monas is cosmopolitan in distribution and is known from a large number of hosts (Goldberg et al. 2009. Comp. Parasitol. 76:58–83). Infection occurs with the ingestion of an infected snail or vegetation supporting cysts (Thomas 1965. J. Zool. 146:413–446). *Strongyluris panamaensis* was described from *Anolis biporcatus* from Panama (Bursey et al. 2003. J. Parasitol. 89:118–123). It has also been reported in *Anolis* (as *Norops*) *limifrons* (Bursey and Goldberg 2003. J. Parasitol. 89:573–576), *Ctenosaura quinquecarinata*, and *Sceloporus variabilis* from Costa Rica (Bursey and Brooks 2010. Comp. Parasitol. 77:232–235). *Strongyluris panamaensis* is a member of the Heterakidae which do not utilize intermediate hosts in their life cycle (Anderson 2000. Nematode Parasites of Vertebrates. Their Development and Transmission. CABI Publ. Oxon, UK. 650 pp.). Lizards likely become infected when they ingest contaminated substrate while feeding. *Polychrus gutterosus* represents a new host record for *Mesocoelium monas* as well as *Strongyluris panamaensis*.

We thank C. Thacker (LACM) for permission to examine *P. gutterosus*, part of the Costa Rica Expeditions Collection donated to LACM in 1998 by J. M. Savage. Daisy Salguero (Whittier College) assisted with dissections.

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***RIAMA OCULATA* (NCN). PREHENSILE TAIL and NEW HABITAT TYPE.** The presence of prehensile tails or other arboreal

FIG. 1. *Riama oculata* demonstrating use of prehensile tail on first author's finger.

characteristics have not previously been documented in the semi-fossorial gymnophthalmnid genus *Riama* (Reyes-Puig 2008. Check List 4:366–372) and although there is no specific information on habitat preferences, all reports indicate capture in forested environments. *Riama oculata* is commonly encountered in the Santa Lucía Cloud Forest Reserve, Nanegal, Pichincha, Ecuador, with primary capture through the use of pitfall traps with drift fences (Maddock et al., unpubl. data). Here we present evidence of a prehensile tail in an individual *R. oculata* upon capture.

At 1550 h on 19 July 2010 an adult *R. oculata* was captured by hand as it moved along the ground inside the sugarcane plantation at the Santa Lucía Cloud Forest Reserve (00.11819°N, 078.60915°W; WGS 84). Upon capture the specimen wrapped its tail securely around the left index finger of its captor; the other hand was slowly moved away and the *R. oculata* remained attached hanging by its tail (Fig. 1). After examination in the field, the specimen was released back to the original location of capture.

These observations, including the presence of this species in a novel agricultural habitat and a prehensile tail, are new records for this poorly studied species and therefore increase knowledge of its natural history and behavior.

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FIG. 1. *Riama unicolor* with autotomized tail emerging from stomach following specimen examination.

***RIAMA UNICOLOR* (NCN). FEEDING and NEW ALTITUDINAL RANGE.** *Riama unicolor* is a small, semi-fossorial gymnophthalmnid found on the Pacific versant cloud forests of northwestern Ecuador between 2390–3300 m (Copping 1957. Brit. J. Herpetol. 2:54–56; Kizirian 1996. Herpetol. Monogr. 10:85–155). This species is known to prey on small invertebrates and maggots, although this information is based only on captive observations (Kizirian 1996, *op. cit.*). Here we report on an observation of *R. unicolor* consuming its recently autotomized tail and provide new data on the altitudinal range for the species.

At 1346 h on 1 July 2010 a *Riama unicolor* (SVL = 8.8 mm; weight = 1 g) was captured just below the surface of the ground by excavation at the Santa Lucia Community Reserve, Nanegal, Pichincha, Ecuador (0.11266°N, 78.61143°W; 1775 m elev.). Upon capture the specimen autotomized part of its tail (5.3 mm in length). Both the lizard and its tail were stored in a field container together until the following day. On the morning of 2 July 2010 the specimen was found dead in the container. Tissue was taken from the liver for future DNA analyses and upon inspection the tail was discovered inside the lizard's stomach (Fig. 1). The specimen was deposited at the Museo de Zoología QCAZ, Pontificia Universidad Católica del Ecuador (SC 32463).

This report increases our knowledge of this poorly understood species, extending its range down to altitudes as low as 1775 m and documenting a novel observation on its feeding behavior.

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***SCELOPORUS ORCUTTI* (Granite Spiny Lizard). MINIMUM SIZE AT REPRODUCTION.** *Sceloporus orcutti* ranges from the lower slopes of the Peninsular Range of southern California south to just north of the Cape of Baja California (Stebbins 2003. A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin Co., Boston, Massachusetts. 533 pp.). Reproduction of *S. orcutti* in California is known from a study by Mayhew (1963.

Copeia 1963:144–152) on a population in Riverside Co. The purpose of this note is to report *S. orcutti* reaches reproductive maturity at smaller sizes in Baja California Sur, Mexico, when compared to the southern California population.

Twenty males (mean SVL = 82.8 mm ± 10.4 SD, range = 67–96 mm) and four females (mean = 71.2 mm ± 9.0 SD, range = 63–84 mm) from Baja California Sur were examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California: LACM 97335, 97336, 128068–128089. Lizards were collected in 1967, 1975, and 1978. A small slit was made in the lower part of the abdomen and the left gonad was removed for histological examination. Gonads were embedded in paraffin and histology slides were cut at 5µm and stained by hematoxylin followed by eosin counterstain. Enlarged follicles (> 4 mm) or oviductal eggs were counted. Histology slides were deposited in LACM.

Mayhew (*op. cit.*) reported females and males of *S. orcutti* reached maturity at 85 and 90 mm SVL, respectively, in southern California. In Baja California Sur, the smallest mature *S. orcutti* female (LACM 128083) measured 70 mm SVL and contained five enlarged ovarian follicles (> 8 mm diameter); the smallest mature male (LACM 128070) measured 68 mm SVL (spermiogenesis in progress, seminiferous tubules lined by clusters of sperm or metamorphosing spermatids). Both *S. orcutti* were collected in May which is within the height of reproductive activity for this species (Mayhew, *op. cit.*) and are from San José de Comondú (26.0625°N, 56.6900°W; datum WGS 84), which is north of the range of the congeners *S. hunsakeri* and *S. licki* (Grismer 2002. Amphibians and Reptiles of Baja California, Including its Pacific Islands and the Islands in the Sea of Cortés. University of California Press, Berkeley. 399 pp.).

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***SPHAERODACTYLUS PACIFICUS* (Pacific Least Gecko). ENDOPARASITES.** *Sphaerodactylus pacificus* is endemic to Cocos Island (Isla de Cocos), 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.). There are, to our knowledge, no reports of helminths from *S. pacificus*. The purpose of this note is to establish the helminth lists for *S. pacificus* as part of ongoing studies of helminths in lizards from Central America.

Three *S. pacificus* (mean SVL = 40.0 ± 1.5 SD, range: 37–42 mm) deposited in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California: (LACM 147972, 147976, 147977), collected April 1965, from Cocos Island (5.533°N, 87.067°W; WGS 84, elev. 610 m), Puntarenas Province, Costa Rica were examined for helminths.

The digestive tract was removed through a mid-ventral incision and the digestive contents from the esophagus, stomach, small and large intestines were examined under a dissecting scope. Nematodes found in the large intestine were cleared in a drop of glycerol, studied under a compound microscope and identified as *Parapharyngodon cubensis*; prevalence (number lizards infected/number lizards examined × 100) = 67%, intensity (number helminths per infected lizard) = 1.0. The *Parapharyngodon cubensis* was deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, USA as (USNPC 103947).

Selected morphological characters of species within the genus *Parapharyngodon* were presented by Bursey and Goldberg (2005. J. Parasitol. 91:591–599) and we have assigned our specimens to *P. cubensis* based on those characters (i.e., spicule of 70 µm, 7 caudal papillae, smooth cloacal lip in the male, prebulbar ovary and stout tail spike in the female). *Parapharyngodon cubensis* has been found in a wide spectrum of reptiles throughout the West Indies (Dyer et al. 2001. Trans. Illinois State Acad. Sci. 94:161–165) and as a member of the Oxyuroidea, does not utilize an intermediate host (Anderson 2000. Nematode Parasites of Vertebrates. Their Development and Transmission. 2nd ed. CABI Publishing, Oxon, UK. 650 pp.). Transmission likely occurs by ingesting eggs from substrate while feeding. *Sphaerodactylus pacificus* represents a new host record. *Parapharyngodon cubensis* in Costa Rica is a new locality record.

We thank C. Thacker (LACM) for permission to examine *S. pacificus* which are part of the Costa Rica Expeditions Collection donated to LACM in 1998 by J. M. Savage.

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***TROPIDURUS ITAMBERE* (NCN). TONIC IMMOBILITY.** Tonic immobility, also known as "death feigning" or "thanatosis," is exhibited by a great variety of animals (Hoagland 1928. J. Gen. Physiol. 11:715–741). By simulating death, potential prey may inhibit the attack response of a potential predator. Locomotor escape, caudal autotomy, tail waving, and threat displays that may follow tonic immobility are considered secondary mechanisms of defense (Edmunds 1974. Defense in Animals. Longman Group, New York. 357 pp.). A widespread antipredator strategy, tonic immobility has been reported for virtually all vertebrate groups, including fishes (Wells et al. 2005. Mar. Freshwater Behav. Physiol. 38:71–78), snakes (Griffiths et al. 2007. J. Comp. Psychol. 121:123–129), birds (Hohtola 1981. Phys. Behav. 27:475–480) and mammals (Fraser 1960. Can. J. Comp. Vet. Sci. 24:330–334) In lizards, tonic immobility has been reported for species such as *Iguana iguana* (Prestrude and Crawford 1970. Anim. Behav. 18:391–395), *Anolis carolinensis* (Henning and Dunlap 1978. Behav. Ecol. 23:75–86), and *Carlia jarnoldae* (Langkilde et al. 2003. Herpetol. J. 13:141–148). Here, we provide for the first time a brief description of this behavior in *Tropidurus itambere*.

On 9 July 2010, we observed an adult male *T. itambere* (4.99 cm SVL) in a rocky field in the Cerrado bioregion, in the Reserva Biológica Unilavras – Boqueirão, municipality of Ingaí (21.34638°S, 44.99083°W, 1250 m elev.) in the state of Minas Gerais, Brazil. Upon capture, it exhibited tonic immobility for ca. 45 seconds. The behavior persisted after the animal was placed carefully on the ground. After ca. 1 min. the lizard righted itself and fled. During this observation of tonic immobility, the lizard kept its eyes closed and showed no external response to stimulation. The duration of this behavior varies among species and to a lesser degree for individuals within species (Hoagland 1928, *op. cit.*). Among Brazilian lizards, this behavior has been observed in the congeners *Tropidurus torquatus*, *T. hispidus*, *T. divaricatus*, *T. nanuzae* (Bertoluci et al. 2006. Herpetol. Rev. 37:472–473; Frost et al. 2001. Mol. Phylog. Evol. 21:352–371), as well as in *Liolaemus lutzae* (Rocha 1993. Cienc. Cult. 45:116–122), *Eurolophosaurus nanuzae* (Galdino and Pereira 2002. Herpetol. Rev. 33:54), and

E. divaricatus (Kohlsdorf et al. 2004. Herpetol. Rev. 35: 309–391), but has not been reported in *T. itambere* to our knowledge.

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SQUAMATA — SNAKES

***ACROCHORDUS GRANULATUS* (Marine File Snake). ABERRANT COLORATION.** *Acrochordus granulatus* is a coastal marine snake and one of three species in the family Acrochordidae. On 28 October 2009, while conducting research in collaboration with the Philippine National Museum, we observed a collection of twelve specimens in the pet trade that showed variation in color patterns and degree of pigmentation. The specimens were reported to have been collected from a single population in Quezon Province, Luzon Island, Philippines. Seven of the specimens possessed the normal color pattern observed for *A. granulatus* consisting of dark gray to black ground coloration with alternating lateral white bands that are discontinuous on the dorsal surface (Fig. 1C). Two specimens were observed to possess a leucistic color pattern, completely lacking pigmentation on the body, but still possessing dark eye pigmentation (Fig. 1A). The three remaining specimens possessed an intermediate color pattern of predominately white ground coloration and irregular dark gray to black dorsal blotches (Fig. 1B). This intermediate color pattern resulted in a "piebald" appearance, and was likely the result of partial leucism. To our knowledge, this is the first observation of full and partial leucism in *A. granulatus*.

FIG. 1. Two adult females and one adult male *Acrochordus granulatus* showing A) complete leucistic, B) partial ("piebald") leucistic, and C) normal color and pigmentation patterns.

Three specimens were donated to the Philippine National Museum, preserved, and deposited in the herpetological collections (CDS 5521 [female; total length = 550.6 mm; 48.0 g]: Fig. 1A; CDS 5539 [male; total length = 508.6 mm, 40.2 g]: Fig. 1B; CDS 5520 [female; total length = 536.7 mm; 40.0 g]: Fig. 1C).

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***BITIS GABONICA* (Gaboon Viper). DIET AND PREY SIZE.** *Bitis gabonica*, a large terrestrial African viperid, is a strict sit-and-wait predator that frequently remains motionless for days or weeks at ambush sites (Warner 2009. Conservation Biology of the Gaboon Adder [*Bitis gabonica*] in South Africa. Unpubl. MSc thesis. Univ. Witwatersrand, South Africa. 121 pp.). During a radiotelemetry study of *B. gabonica* in northeastern South Africa, on 5 March 2007, a female (SVL = 899 mm; total length = 959 mm; mass = 1242 g) was observed in ambush posture next to a thicket in open woodland habitat (28.27598°S, 32.47460°E, datum: WGS84). On 13 March 2007, 83 m (linear distance) from the previous location, we found the snake with a very large meal in its stomach. Because the study was near its end and the prey record

FIG. 1. Female *Bitis gabonica* with antelope prey (*Cephalophus natalensis*).

was potentially valuable, the individual was carefully removed from the field and transported to the lab to induce regurgitation. Approximately 15 minutes after removal, the snake was discovered dead. Although *Bitis* in captivity have died after consuming meals close to their own body mass (Haagner 1988. Koedoe 31:246), we attribute the snake's death to stress from transport. A post-mortem (Fig. 1) revealed that the snake had consumed a *Cephalophus natalensis* (Red Duiker). The antelope had been bitten in the lower abdomen, and a single fang was found entangled in its fur. The *C. natalensis* was 104% of the snake's body mass, which is the highest relative prey mass (RPM) recorded for *B. gabonica* and also the first record of ungulate predation by the species in South Africa.

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BOA CONSTRICTOR **(Boa Constrictor). FORAGING BEHAVIOR.** *Boa constrictor* is often referred to as a sit-and-wait or ambush forager that chooses locations to maximize the likelihood of prey encounters (Greene 1983. *In* Janzen [ed.], Costa Rica Natural History, pp. 380–382. Univ. Chicago Press, Illinois). However, as more is learned about the natural history of snakes in general, the dichotomy between active versus ambush foraging is becoming blurred. Herein, we describe an instance of diurnal active foraging by a *B. constrictor*, illustrating that this species exhibits a range of foraging behaviors.

At 1120 h on 25 May 2007, on Cayo Cochino Grande, Cayos Cachinos, Honduras (15.9711928037812°N, 86.4739467195224°W, NAD 83/WGS 84), we saw several *Artibeus jamaicensis* (Jamaican Fruit Bat) fly from a living Cohune Oil Palm (*Attalea cohune*, Arecaceae) approximately 8 m above the ground. We noticed that the bats were disturbed from their daytime roost (likely beneath a frond of the *A. cohune*) by a *B. constrictor* (male; SVL = 760 mm; total length = 118 mm; 268 g including prey). The snake fell to the ground while simultaneously constricting four bats and continued to constrict and kill all four bats on the ground. Over approximately 1.5 h we observed the snake consume two of the four individuals (one adult male and one adult female) headfirst and then take refuge under nearby palm fronds on the forest floor. The two bats that were abandoned by the snake were a female (42 g) and a male (29 g). After measuring, we released the *B. constrictor* at the point of capture without palpating the two bats it had consumed.

Boa constrictor is known to prey upon at least four species of bats (including *A. jamaicensis*; Esbérard and Vrcibradic 2007. Rev. Brasil. Zool. 24:848–853). Previous observations of bat predation by *B. constrictor* describe snakes entering caves or tree cavities to capture roosting bats during the day (Arendt and Anthony 1986. Carib. J. Sci. 22:219–220; Thomas 1974. J. Herpetol. 8:188). Bats roosting in caves and tree cavities would be a predictable prey source for *B. constrictor*. In contrast, although female *A. jamaicensis* nested in tree hollows and moved day roosts infrequently on Barro Colorado Island, males roosted in foliage and changed day roost sites frequently (every 3–13 days; Morrison 1978. Ecology 59:716–723). We observed this mixed-sex group of *A. jamaicensis* roosting in foliage suggesting a relatively ephemeral roost site. Thus our observations suggest that *B. constrictor* uses active, sometimes diurnal foraging to locate prey such as roosting bats. Additionally, this observation is the first to document a *B. constrictor* apprehending and constricting multiple bats simultaneously.

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BOIGA DENDROPHILA **(Mangrove Cat Snake). DIET.** *Boiga dendrophila* is a large (to 250 cm total length) colubrid snake, known from both primary and disturbed lowland forests and mangrove swamps of Southeast Asia (Das 2006. A Photographic Guide to the Snakes and Other Reptiles of Borneo. New Holland Publishers, Ltd., London. 144 pp.; David and Vogel 1996. The Snakes of Sumatra: An Annotated Checklist and Key with Natural History Notes. Edition Chimaira, Frankfurt am Main. 260 pp.). Its diet is known to include vertebrates such as frogs, lizards, birds, and rodents; one snake species (*Ahaetulla prasina*) has also been documented (Stuebing and Inger 1999. A Field Guide to the Snakes of Borneo, Natural History Publications, Sdn. Bhd. Kota Kinabalu. 235 pp.).

At 2000 h on 13 September 2009, an adult *B. dendrophila* (total length ca. 1 m) was encountered in tree branches on the bank of Sungei Bawang (01.0613°N, 110.1976°E, datum WGS84), a perennial stream flowing over granite-sandstone substrate at Kubah National Park at the Matang Range, Sarawak, East

COLOR REPRODUCTION SUPPORTED BY THE THOMAS BEAUVAIS FUND

Fig. 1. *Boiga dendrophila* consuming a *Parias sumatranus* in Kubah National Park, East Malaysia.

Malaysia (western Borneo). This individual was observed to attack, subdue, and swallow a juvenile (total length < 1 m) *Parias sumatranus*, a large (to 1.6 m) and dangerously venomous viper. The prey was approached while it was resting on a horizontal branch of a tree overhanging the stream, ca. 3 m from ground. It was then seized by the head, rapidly followed by the tail, which arched forward to grab the neck region of the prey, which was then swallowed in ca. 30 min (Fig. 1). This observation represents the first reports of foraging behavior in *B. dendrophila*, as well as the first record of a venomous snake in its diet.

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***BOIGA IRREGULARIS* (Brown Treesnake). PREDATION AND DIET.** Introduced *Boiga irregularis* on the Western Pacific island of Guam feed on a wide variety of vertebrate prey. Stomach contents of juvenile *B. irregularis* specimens include a large proportion of lizards, especially geckos and skinks (Savidge 1988. J. Herpetol. 22:275–282). Guam is also home to *Varanus indicus* (Mangrove Monitor), which reach an adult size of ca. 560 mm SVL (Wikramanayake and Dryden 1988. Herpetologica 44:338–344). *Varanus indicus* are opportunists that feed primarily on arthropods (Dryden 1965. Micronesica 2:72–76), but they may prey on *B. irregularis* (Fritts and Rodda 1998. Annu. Rev. Ecol. Sys. 29:113–140; McCoid and Witteman 1993. Herpetol. Rev. 24:105). Occasionally the roles are reversed and the snakes prey on monitor eggs (Savidge 1988, *op. cit.*), but in general, interactions between *V. indicus* and *B. irregularis* remain poorly documented.

While working at our main study site in northwestern Guam in the late morning of 12 May 2010, the first two authors observed a large (ca. 500 mm SVL) adult *V. indicus* perched ca. 4 m above ground in a large Fagot Tree (*Neisosperma oppositifolia*). On the ground was a fresh bolus containing the regurgitated remains of a large *B. irregularis*. We scanned the bolus for a PIT tag since virtually all adult snakes in our study population have been previously tagged. The bolus contained the PIT tag from a large male snake that had been captured 22 days previous to this observation. On that date of capture, it measured 1305 mm SVL, 1645 mm total length, and weighed 307 g. At that time, it was in good health and had an above-average condition index of 1.35 (1.00 is the long-term average for snakes across Guam), so we have no reason to suspect the monitor had scavenged a snake that was already dead. Assuming the monitor measured 500 mm SVL, its weight should have been ca. 2 kg (Wikramanayake and Dryden 1988, *op. cit.*). Hence, the snake's mass was approximately 15% of the monitor's mass.

We found evidence for predator-prey role reversal while searching for snakes in the same part of Guam on the evening of 17 May 2010. The third author captured a male *B. irregularis* that was 865 mm SVL and had a gross weight of 71 g, which included an obvious food bulge in its stomach. As part of a study on stomach contents and reproductive characteristics, it was brought to the lab for euthanasia and necropsy the following day. The prey item was found to be a juvenile *V. indicus* (head and neck partially digested, weight of remains 7.8 g, tail length 134 mm).

Predation on *B. irregularis* by *V. indicus* may be uncommon, as the former normally seeks diurnal shelter in arboreal vine tangles, tree hollows, or even underground refugia (unpubl. data); all of which may be difficult for an adult monitor to access. However, the snakes can probably access virtually any nocturnal refugium used by a juvenile monitor, and we suspect that predation pressure may affect recruitment of monitors.

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***BOTHRIECHIS SCHLEGELII* (Eyelash Palm-Pitviper). DIET.** *Bothriechis schlegelii* has been recorded feeding on a variety of small vertebrates including frogs, lizards, birds, and small mammals (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Comstock Publishing Associates, Ithaca, New York. 898 pp.). Given the nocturnal and arboreal habits of *B. schlegelii* it is not surprising that bats have been documented in their diet, yet records of chiropterophagy in this species are limited to only two accounts. In one case, a *B. schlegelii*, found in a shipment of bananas that was believed to have originated in Honduras, regurgitated the nectar-feeding bat, *Glossophaga soricina* (Groves 1961. Herpetologica 17:277). The other, a case from Costa Rica, involved a *B. schlegelii* that contained an unidentified bat in its stomach (Hardy 1994. Sonoran Herpetol. 7:108–113). Here we report the fist record of *B. schlegelii* consuming a *Myotis riparius*.

On 16 August 2008 at 1920 h, a subadult *B. schlegelii* (UF 155962; SVL = 40.6 cm; tail length = 6.8 cm) was found in the process of consuming a *M. riparius* (UF 31760; SVL = 3.6 cm). The incident was recorded by SLT and Juan Francisco López while walking a nocturnal transect, Pamka Buhna, in the Kipla Sait Tasbaika indigenous territory of Reserva de la Biósfera Bosawas, Departamento Atlántico Norte, Nicaragua (14.3653°N, 84.9349°W, datum: WGS84; elev. 186 m). The snake was encountered ca. 3 m above ground holding onto an epiphyte on the truck of a large tree, and was in the latter stages of consuming the bat. It took ca. 5 min for the snake to finish consuming the bat, after which, the snake was collected and later preserved. Both specimens were deposited in the Florida Museum of Natural History.

Approximately 20 species of snakes have been documented feeding on bats in the Neotropics, the majority being boiids and colubrids, with only four representatives of Viperidae (Esbérard and Vrcibradic 2007. Rev. Bras. Zool. 24:848–853). Esbérard and Vrcibradic (*op. cit.*) conclude that most documented cases of bat predation by snakes in the Neotropics are within or around the entrance of bat refuges, indicating the possibility that snakes are drawn to these areas due to the abundant concentration of prey. Hardy (*op. cit.*) stated that the *B. schlegelii* found with a bat in its stomach was encountered sitting near the opening of a tree trunk that led to a bat roost, which may suggest that this feeding strategy is also employed by this species. Although we did not witness the snake capture the bat in the predation event documented here, there was no evidence of a bat roost in the vicinity. Therefore, we suspect this event was an opportunistic prey capture.

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BOTHROPOIDES (= BOTHROPS) JARARACA **(Jararaca). DIET.** Predation on anurans by juvenile *Bothropoides jararaca* has frequently been reported (e.g., Sazima 1991. Copeia 1991:245–248; Sazima 1992. *In* J. Campbell and E. Brodie, Jr. [eds.], Biology of Pitvipers, pp. 199–216. Univ. Texas Press, Arlington; Sazima and Haddad 1992. *In* Morellato [ed.], História Natural da Serra do Japi, pp. 212–237. UNICAMP, Campinas; Hartmann et al. 2003. Phyllomedusa 2:35–41). Although records of lizards as prey are scarce, Sazima (1992, *op. cit.*), reported *Hemidactylus mabouia* as a prey item of two juvenile snakes and Sazima (1991, *op. cit.*) and Sazima and Haddad (1992, *op. cit.*) noted that lizards must be included in the diet of the species.

On 23 March 2003, during an expedition to the southern portion of the Atlantic Forest of Paraná State, Brazil, I collected a juvenile *B. jararaca* (SVL = 248 mm; 8.6 g) actively crawling along a forest edge at 1630 h. Examination of the specimen revealed the remains of an adult gymnophthalmid lizard, *Placosoma glabellum*, in the snake's stomach. The lizard had been swallowed head first and was partially digested, but comparisions with other specimens from the herpetological collection of Museu de História Natural Capão da Imbuia at Curitiba (MHNCI) suggested that it was larger than 40 mm SVL. Juvenile *B. jararaca* exhibit criptic coloration and are known to use caudal luring behavior to lure amphibians, but it is possible that they may also lure lizards and other arthropod predators, such as birds (Sazima 1991, *op. cit.*). This is the first record of an interaction between *B. jararaca* and a gymnophthalmid lizard, and confirms the suspicions that juvenile *B. jararaca* consume lizards. The snake and lizard were deposited at the herpetological collection of MHNCI (MHNCI 11117).

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BOTHROPS (= RHINOCEROPHIS) ALTERNATUS **(Urutu Pitviper). MICROHABITAT.** *Bothrops alternatus* is a widespread species that occurs primarily in humid habitats across Brazil, Paraguay, Uruguay, and Argentina (Campbell and Lamar 1989. The Venomous Reptiles of Latin America, Cornell Univ. Press, Ithaca, New York. 425 pp.). Although it is usually indicated to occur near wetlands, no precise information has been presented on specific microhabitats occupied in these particular situations. While conducting research at the Iberá wetlands, Corrientes province, Argentina, on 7 May 2000, we collected a specimen of *B. alternatus* 10 km inside the swamp, occupying a floating substrate locally known as "embalsado" (Fig. 1; Laguna Luna, 28.13778°S, 56.82222°W, datum: WGS 84). The "embalsado" is essentially a vegetated Histosol (organic soil type), of up to 2 m depth, consisting primarily of dead plant material that, depending on the water level, floats or rests on the bottom. At Iberá, these soils support sophisticated plant communities, mainly grasslands, but that in some locations can even include shrubs and trees. The *B. alternatus* was found basking at the base of a mat, in a small open spot (ca. 20 m wide) near the edge of a lagoon, in an area otherwise dominated by the tall and dense grass, *Rhynchospora corymbosa* (Ciperaceae). The open spot resembled a peat, characterized by the presence of puddles, open soil (mainly vegetation debris) and *Sphagnum* (Sphagnaceae) patches. The area was scattered with feces of *Cavia aperea* (Rodentia: Cavidae). The snake was a 109.5 cm SVL, severely emaciated, adult female. Dissection revealed that it had given birth recently, exhibiting a total of 18 elliptic oviducal scars. The specimen was deposited at the collection of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN 39628).

Fig. 1. *Bothrops alternatus* basking at the base of a mat of grass, upon a carpet of peat-mosses (*Sphagnum*), Iberá wetland, Argentina.

Although *B. alternatus* has been found in the vicinity of several types of wetlands in the Iberá area (Alvarez et al. 2003. *In* Alvarez [ed.], Fauna del Iberá, pp. 99–178. Editorial Universitaria de la Univ. Nacional del Nordeste, Corrientes, Argentina), it was not known to occur inside the swamp in the microhabitat described here. The significant distance from the shore and the evidence of reproduction suggests that some floating habitats at the Iberá wetland can harbor populations of this species, presumably sustained by locally dense rodent populations.

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BOTHROPS MOOJENI **(Brazilian Lancehead). DIET.** *Bothrops moojeni* is a large pitviper that inhabits riparian areas in central and southeastern Brazil throughout the Cerrado physiogeographic region (Borges and Araújo 1998. Rev. Bras. Biol. 58:591–601). The diet of *B. moojeni* consists of centipedes, frogs, lizards, snakes, birds, and mammals (Nogueira et al. 2003. J. Herpetol. 37:653–659). Here we report predation on an adult treefrog, *Scinax fuscovarius*, by a juvenile *B. moojeni*.

At 1100 h on 10 Jan 2008, at the edge of the Sucuriú River, Três Lagoas municipality, State of Mato Grosso do Sul, Brazil, a juvenile *B. moojeni* was observed grasping an adult *S. fuscovarius* by the rear legs. When disturbed by our presence, the snake retreated into vegetation.

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***CEMOPHORA COCCINEA COPEI* (Northern Scarletsnake). DIET.** *Cemophora coccinea* is a small fossorial snake thought to feed largely on the eggs of other reptiles (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 680 pp.). On 17 August 2007, while surveying a study site in Chesterfield Co., South Carolina, USA, I captured a female *C. coccinea* (349.25 mm total length; 8 g) crossing the road at night. Shortly after, I found a juvenile *Pantherophis guttatus* (total length = 279.4 mm; 5 g) that had recently been hit by a vehicle. Due to a lack of collection bags, I placed the dead *P. guttatus* in the same bag as the *C. coccinea*. Approximately 45 min later, I opened the bag and only found the *C. coccinea*; the *Cemophora* had eaten the *P. guttatus*. To our knowledge *P. guttatus* has not been documented in the diet of *C. coccinea* (Ernst and Ernst, *op. cit.*). Though ophiophagy has been reported in *C. coccinea* (Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Co., New York. 616 pp.), it is very uncommon and has not been documented in any accounts from North or South Carolina (Palmer and Braswell 1995. Reptiles of North Carolina. Univ. North Carolina Press, Chapel Hill. 412 pp.; S. Bennett, pers. comm.). The prey item comprised 62.5% of the *C. coccinea*'s body weight.


PHOTO BY NATHAN SHEPARD

FIG. 1. *Cemophora coccinea* regurgitating a juvenile *Pantherophis guttatus.*

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***CHIRONIUS EXOLETUS* (Vine Snake). REPRODUCTIVE BEHAVIOR.** Few data are available on the mating behavior of neotropical snakes in the wild (Greene 1997. Snakes: the Evolution of Mystery in Nature. University of California Press, Los Angeles. 351 pp.). In the Brazilian state of Rondônia, newborn *Chironius exoletus* have been found in November and February, and females with eggs and enlarged follicles have been observed from November through March (Bernarde and Abe 2006. S. Amer. J. Herpetol. 1:102–113).

On 6 September 2009 at 1730 h, in forest along the São Miguel River, Municipality of Seringueiras, Rondônia state, Brazil (12.0039722°S, 63.0351389°W; datum WGS84; elev. ca. 160 m), we observed a pair of *C. exoletus* on the ground engaged in courtship and mating (tactile-alignment, intromission, and coitus; Gillingham 1986. *In* Seigel et al. [eds.], Snakes: Ecology and Evolutionary Biology, pp. 184–209. McGraw Hill, New York). The duration of copulation was 27 min. Another unsexed adult *C. exoletus* was observed approximately 1 m away, resting about vegetation. The snakes were not captured.

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***COLUBER CONSTRICTOR* (North American Racer). CANNIBALISM AND DEFENSIVE BEHAVIOR.** Cannibalism by racers has been described in both field and laboratory conditions (Mitchell 1986. SSAR Herpetol. Circ. 15:1–37). Most reports are from stomach contents and lack behavioral observations. Cannibalism might occur as a byproduct of captive feeding, from a competitive interaction, or as direct consumptive behavior; therefore information describing these interactions is valuable. This observation is also the first documentation of an anchoring behavior used by *C. constrictor* as an attempt to avoid predation.

On 6 June 2008 at approximately 1030 h, I documented cannibalism between male *C. constrictor* at the Department of Energy's Savannah River Site, Aiken Co., South Carolina, USA. While driving on a gravel road, I observed a *C. constrictor* (SVL = 107 cm, total length = 143 cm) enter perpendicular to the road from the grassy edge in front of me. As I quickly halted the vehicle, the racer increased speed away from me parallel to the road's edge. The snake moved approximately 6 m and came to an abrupt stop at the road's edge where it attacked another smaller *C. constrictor* (SVL = 70 cm, total length = 98 cm). Following the attack and a short struggle, the larger snake and aggressor (hereafter Snake A) raised above the grass with the smaller snake (hereafter Snake B) in its grasp (~3 cm posterior to head). With raised anterior portions of body and Snake B in mouth, Snake A moved perpendicular and away from the road (~6 m away) into dense brush. Occasionally the snakes' bodies were entwined, biting one another. There were long periods of what appeared to be rest with slow biting movements followed by the occasional quick and aggressive struggles that lasted only seconds at a time. In defending itself, Snake B bit and coiled around Snake A and at one point it anchored to surrounding vegetation by biting itself. The anchoring was performed by extending the anterior region of its body over a vine and then biting itself. Snake B was thus secured to the vine and Snake A had difficulty pulling it free (with a "tugging" motion). While anchoring, Snake B worked its way down its own body and bit the bottom jaw of Snake A allowing brief freedom from the grasp of Snake A. After a nearly 60 min struggle, Snake A was able to overcome Snake B and consumed it within 10 min. During consumption, Snake A vigorously vibrated its tail, possibly in response to my presence. After consumption, I captured Snake A whereupon it regurgitated Snake B, which was still alive. Snake A was starting to shed within one day following capture and Snake B was close to shedding having nearly opaque eyes at the time of capture.

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***COLUBER CONSTRICTOR* (North American Racer). PREY SIZE.** *Coluber constrictor* is a large (to 191.1 cm total length) colubrid snake native to a variety of open habitats in North America (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington, DC. 668 pp.). It is a nonvenomous, nonconstricting dietary generalist that is known to consume a wide range of vertebrate and invertebrate prey items, including other snakes. Here we report a juvenile *C. constrictor* feeding on a relatively very large ophidian prey item, to our knowledge the largest relative prey mass reported for this species.

At 1300 h on 20 April 2010, a juvenile *C. constrictor* (female, SVL = 289 mm, 12.58 g) was found by a terrier among dry leaves in a grassy roadside at Rocky Branch Nature Preserve, Clark Co., Illinois, USA (39.46282°N, 87.77423°W, datum WGS 84). We noticed that the snake's body had a lumpy, kinked quality, and so returned it to the laboratory where it regurgitated an adult male *Diadophis punctatus* (Ring-necked Snake) measuring 265 mm SVL with a mass of 4.38 g, which had been swallowed headfirst. The mass of the racer without the prey item was 8.20 g, so the prey represented 53.4% of the predator's body mass and measured 91.7% of the body length.

Coluber constrictor is known to feed on other snakes, including *D. punctatus*, but generally consumes relatively small prey. Halstead et al. (2008. Copeia 2008:897–908) found a significant positive relationship between snake mass and prey mass for *C. constrictor* in Florida, with a mean relative prey mass of 6.8 ± 1.4%, although racers in their study had consumed no other snakes. Fitch (1982. *In* N. J. Scott, Jr. [ed.], Herpetological Communities: A Symposium of the SSAR and HL, August 1977. USFWS, Wildl. Res. Rep. 13. 239 pp.) found *D. punctatus* to be the fifth most common vertebrate prey item consumed by racers in Kansas and estimated that *C. constrictor* consumed on average 23 g/ha of *D. punctatus* annually, compared to >1500 g/ha of small mammals and almost 300 g/ha of insects. About 12% of racer stomach contents from Illinois contained reptiles, with a larger proportion containing insects (48%) and mammals (43.5%; Klimstra 1959. Copeia 1959:210–214).

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***COLUBER CONSTRICTOR MORMON* (Western Yellow-bellied Racer) and *PITUOPHIS CATENIFER DESERTICOLA* (Great Basin Gopher Snake). DIET.** Although some aspects of *Coluber constrictor mormon* and *Pituophis catenifer deserticola* ecology

TABLE 1. Diet items collected from *Coluber constrictor mormon* and *Pituophis catenifer deserticola* from Antelope Island State Park, Utah, USA, in 2005. (U) denotes an individual of unknown sex and (*) indicates a gravid female.

Species	Capture Method	Sex	SVL (cm)	Mass (g)	Stomach Contents
Coluber constrictor mormon	Trapped	F	68	162	*Microtus* sp.
		F*	73	160	*Microtus* sp.
		F	67	163	*Peromyscus* sp.
		F	71	162	*Peromyscus* sp.
	Road-Killed	M	41	—	three grasshoppers (Acridae)
		M	64	100	*Peromyscus* sp.
		U	—	—	cricket (Gryllidae)
		U	50	—	*Stenopelmatus* sp.
		F	56	—	*Sceloporus graciosus*
		F	55	65	two grasshoppers (Acrididae)
		M	44	42	two grasshoppers (Acrididae)
		F	42	40	cricket (Gryllidae), beetle (Coloeptera)
Pituophis catenifer deserticola	Hand captured	M	84	—	*Microtus* sp.
	Road Killed	M	—	—	*Microtus* sp.

have been studied within the Great Basin (Brown 1973. Ph.D. Diss., Univ. Utah, Salt Lake City; Parker and Brown 1980. Milwaukee Public Mus. Publ. Biol. Geol. 7:1–104), few studies have examined their feeding habits and there are no published records from any islands within the Great Salt Lake. This lack of basic natural history information is a major impediment to the conservation of these species, particularly in light of degradation of local island landscapes by exotic and invasive species. While conducting research to examine the effects of Cheatgrass (*Bromus tectorum*) on snake populations at Antelope Island (Hall et al. 2009. West. N. Am. Nat. 69:88–95) we gathered information on the diets of *C. c. mormon* and *P. c. deserticola*.

Data were collected from June through September 2005 at Antelope Island State Park in Davis Co., Utah, USA. Antelope Island is the largest of the ten islands found within the Great Salt Lake and covers over 113 km^2. Live snakes were captured using hardware cloth drift fences with funnel traps or by hand and freshly killed snakes were recovered from the island's roads. Live snakes were palpated to regurgitate recently ingested prey items and all dead snakes were dissected and their stomach contents were examined.

Diet information was obtained from 12 *C. c. mormon* and two *P. c. deserticola* (Table 1). Despite the large geographic ranges of *C. c. mormon* and *P. c. deserticola* we found that stomach contents were similar to those previously reported for these species (Fitch 1963. Univ. of Kansas Publ. Mus. Nat. Hist. 15:351–468; Rodriguez-Robles 2002. Biol. J. Linn. Soc. 77:165–183). The majority of prey items recovered from *C. c. mormon* were invertebrates, representing 65% of the total diet, whereas rodents represented 29% and a lizard was recovered from a single female. Although similar diet items have been recorded for *C. c. mormon*, the proportion of snakes with rodents was much higher than previously reported for the region (Brown 1973, *op. cit.*). This may be a consequence of the different methods used to acquire samples; diet of road-killed snakes included a larger proportion of invertebrates than diet of trapped snakes. Our data support previous findings that *C. c. mormon* prefer orthopterans among invertebrate prey and that larger females incorporate vertebrates into their diet (Shewchuk and Austin 2001. Herpetol. J. 11:151–155). The two *P. c. deserticola* examined both contained *Microtus* sp., as has been reported for this species in the Great Basin (Rodriguez-Robles, *op. cit.*).

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***COLUBER* (= *MASTICOPHIS*) *FLAGELLUM* (Coachwhip). UNUSUAL FEEDING BEHAVIOR.** Two of us (DK and DK) observed and photographed an unusual feeding event of an adult *Coluber flagellum piceus* (Red Racer), 5 km W of Wickenburg, Arizona, USA at 1145 h, 28 April 2007, elev. 670 m, air temperature 27–32°C. The snake, which seemed undisturbed by observers, started biting a dead branch of a tree. It then moved a few cm away from the branch for about 10 sec, returned and broke off a 2.5 × 1.3 cm piece of the branch and swallowed it (Fig. 1).

PHOTO BY DEBBIE KEISER

FIG. 1. *Coluber flagellum piceus* consuming small portion of stick after breaking it off the branch.

The piece of the stick eaten looks like a scaly lizard. Fenner et al. (2008. Herpetofauna 38:105–109) showed that *Pseudonaja textilis* (Australian Eastern Brown Snake) are attracted to motionless unscented models of *Tiliqua adelaidensis* (Pigmy Bluetounge Lizards), as well as live lizards, and suggested that the shape of the lizard is sufficient to elicit an attack. The stick in these observations of *C. flagellum* likely looked enough like a lizard for a snake to eat it. Alternately, it is possible that residual scent on the branch from a potential prey item could have elicited attack by the snake.

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***COLUBER* (= *MASTICOPHIS*) *LATERALIS EURYXANTHUS* (Alameda Striped Racer) and *LAMPROPELTIS GETULA CALIFORNIAE* (California Kingsnake). PREDATION AND MAXIMUM PREY LENGTH RATIO.** While most recent research on the federally threatened *Coluber lateralis euryxanthus* has focused on habitat use and demography, other ecological aspects such as causes of mortality in this subspecies remain poorly understood. Natural predation on the related *C. l. lateralis* was recorded by Fitch (1949. Am. Midl. Nat. 41:513–579) and included 50 occurrences by Red-tailed Hawks (*Buteo jamaicensis*), seven by Great Horned Owls (*Bubo virginianus*), and seven by Coyotes (*Canis latrans*). In addition, Jennings (1997. Herpetol. Rev. 28:205–206) observed a *C. l. lateralis* being carried away in the talons of an American Kestrel (*Falco sparverius*). All of these documented predators are found in the same habitats as *C. l. euryxanthus* and likely prey upon this threatened taxon as well. Herein, we describe two separate instances of predation on *C. l. euryxanthus* by a well-known ophiophage, *Lampropeltis getula californiae*, and discuss associated predator-prey length ratios.

On 26 May 2009, at 1230 h, M. Yacelga discovered an adult female *L. g. californiae* (SVL = 950 mm; total length = 1018 mm)

PHOTO BY M. YACELGA

FIG. 1. An adult *Lampropeltis getula californiae* consuming a *Coluber lateralis euryxanthus* from Contra Costa Co., California, USA.

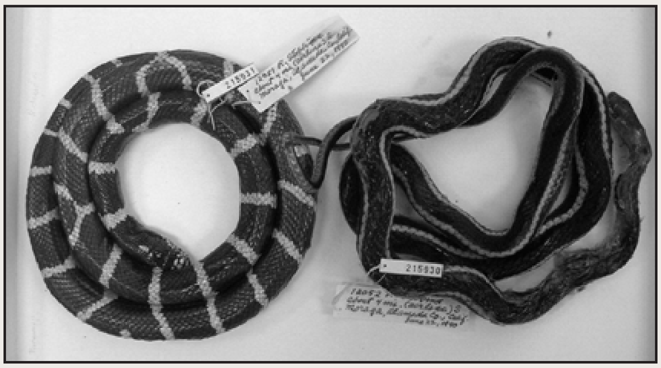

PHOTO BY K. D. WISEMAN

FIG. 2. An adult *Lampropeltis getula californiae* (MVZ 215931, left) that consumed a *Coluber lateralis euryxanthus* (MVZ 215930) from Alameda Co., California, USA.

in a drift fence funnel trap at the edge of coastal scrub/chaparral and grassland habitats approximately 2.3 km NW of Briones Reservoir, Contra Costa Co,, California, USA (37.950135°N, 122.217778°W, datum: WGS 84). When initially discovered, the kingsnake had already swallowed the anterior third of the body of an adult male *C. l. euryxanthus* (SVL = 832 mm; total length = 1157 mm; 134 g; Fig. 1). The racer had been initially captured and pit-tagged in September 2005 and was last recaptured on 8 May 2009. The kingsnake was removed from the trap for photographic documentation and left undisturbed while it continued to consume the racer. After approximately 30 min, the kingsnake had disappeared and the racer was not observed in the vicinity and had presumably been consumed by the kingsnake.

On 22 June 1990, an adult *L. g. californiae* (MVZ 215931; SVL = 839 mm; total length = 962 mm; 180 g [live]) was collected 1.1 km W of the corner of Brown Ranch Road on Old Airstrip Road (37.79259°N, 122.10416°W, datum: WGS 84), approximately 6.4 km S of Moraga, Alameda Co,, California, USA. The kingsnake had recently consumed an adult female *C. l. euryxanthus* (MVZ 215930; SVL = 838 mm, total length = 1150 mm; 129.2 g [preserved]) head-first (R.C. Stebbins, unpubl. field notes; Fig. 2).

Although the first instance of predation is complicated by the fact that the racer was confined within a funnel trap and could not have escaped the predator (or may have even attracted it), our second observation clearly demonstrates that *L. g. californiae* preys upon *C. l. euryxanthus* under natural conditions. Whipsnakes and racers (including *C. constrictor*, *C. lateralis*, *C. flagellum*, and *C. taeniatus*) are relatively common prey of *L. g. californiae* and account for approximately 5% of their overall diet, and 17% of the snake diversity consumed based upon the examination of 2,660 museum specimens, published literature, unpublished field notes, and personal communications (K. D. Wiseman, H. W. Greene, D. J. Long, and M. S. Koo, unpubl. data).

Jackson et al. (2004. Zoology 107:191–200) demonstrated that under captive conditions, *L. g. californiae* were capable of ingesting *Pantherophis guttatus* (Red Cornsnakes) with total lengths much greater than their own SVL. They accomplished this feat through several mechanisms: 1) anterior stretching of the stomach and esophagus, 2) bending the prey snake into longitudinal waves, and 3) folding of the tail tip (Fig. 2). A maximum length ratio (LR = prey total length/predator SVL) of 1.29 was accomplished by one kingsnake which completely digested its prey (Jackson et al., *op. cit.*). Three other kingsnakes completely ingested snakes with LR values of 1.07 to 1.21, however each regurgitated them after 4–7 days. Another kingsnake attempted to ingest a snake with an LR of 1.39, but regurgitated it before ingestion was complete. The kingsnake reported in our first observation (Fig. 1) had a LR of 1.22 and the second (MVZ 215931) had an LR of 1.37 (Fig. 2).

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CROTALUS MITCHELLII **(Speckled Rattlesnake) and *CROTALUS RUBER* (Red Diamond Rattlesnake). ECTOPARASITES.** *Crotalus mitchellii* and *C. ruber* occur in a wide variety of predominantly dry habitats in the southwestern United States and México (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Cornell Univ. Press, Ithaca, New York. 898 pp.). *Crotalus* spp. are known to be parasitized by several tick species including *Amblyomma dissimile*, and *Dermacentor* spp. (Klauber 1997. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind. Univ. California Press, Berkeley. 1533 pp.; Campbell and Lamar, *op. cit.*). Here we report novel tick-host relationships involving two species of rattlesnakes.

Rattlesnakes were captured at night, examined for ectoparasites and released at the site of capture. All visible ectoparasites were removed using forceps, preserved, and identified under a compound light microscope in the laboratory. On 6 November 2004, at 2150 h, an adult female *C. mitchellii* (total length [TL] ca. 700 mm) was collected along the road from La Paz to San Juan de la Costa, Baja California Sur, México (24.194733°N, 110.556789°W, WGS84). The female snake had two tick larvae (ZMB 48383, one larva was destroyed during identification), both swollen with blood meals, between the scales on the body. On 10 November 2004, at 2120 h, an adult female *C. ruber* (TL ca. 800 mm) was found on the road from Insurgentes to Puerto López Mateos, Baja California Sur, México (25.761458°N, 112.010964°W, WGS84). The snake had five larvae and nymph ticks (ZMB 48380), all filled with host blood, between the scales on the body. A juvenile *C. ruber* (TL ca. 300 mm) was collected on 25 November at around 2100 h on the highway Mex 1, Baja California Norte, México (29.983342°N, 115.206078°W, WGS84). The juvenile had six larvae and nymph ticks (ZMB 48381), filled with blood, on the body sides. On 28 November 2004 at 2020 h, an adult male *C. ruber* (TL ca. 700 mm) was found on the highway Mex 12 from Bahía de los Ángeles to the highway Mex 1, Baja California Norte, México (29.052358°N, 114.121942°W, WGS84). The snake had 10 larvae and nymph ticks (ZMB 48382), one was on the neck, and the others were on the snake's back and body side engorged with blood.

All ticks were identified as the soft tick *Ornithodoros turicata* (Acari: Ixodida: Argasidae) (*fide* Wenzel and Tipton 1966. Ectoparasites of Panama. Field Mus. Nat. Hist. Chicago, Illinois. 861 pp.). Voucher specimens of *O. turicata* were deposited in the arachnid collection of the Museum für Natukunde Berlin (ZMB), Germany. *Ornithodoros turicata* is a burrow-dweller known to inhabit burrows of the Gopher Tortoise, *Gopherus polyphemus* (e.g., Beck et al. 1986. J. Med. Entomol. 23:313–319). Additionally, *O. turicata* is reported as a vector of the relapsing or tick-born fever (TBRF), which is caused by several *Borrelia* species that are transmitted to humans by bites of this soft tick species (e.g., Dworkin et al. 2008. Infect. Dis. Clin. North Am. 22:449–68). The fact that *O. turicata* was found over a linear distance of about 780 km from north to south, on the Pacific as well as on the Gulf side, indicates that this tick species occurs throughout the Baja California peninsula.

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***CROTALUS MITCHELLII* (Speckled Rattlesnake). ARBOREAL BEHAVIOR.** At 1654 h on 14 May 2004, we observed an adult *Crotalus mitchellii* (sex undetermined) approximately 1 m above the ground in *Opuntia ramosissima* (Diamond or Pencil Cholla) in Granite Cove, Granite Mountains, San Bernardino Co., California, USA (34.7814°N, 115.6537°W, datum WGS 84; elev. 1276 m). Air temperature at the time of observation was 26.2°C. At first observation, the snake was in a coiled position in the cactus, rattling loudly. Upon being photographed, it uncoiled and began to move (Fig. 1). The snake was not collected, and within one hour, the snake had left the cactus.

To our knowledge, few records of arboreal behavior exist for this species, at heights of 0.46 m, 0.76 m, and 0.91 m (Klauber 1997. Rattlesnakes: their habits, life histories, and influence on mankind. Univ. California Press, Berkeley. 1580 pp.). Klauber (*op. cit.*) suggested that rattlesnakes climb more often in pursuit of prey than for refuge from predators or heat. Moore (1978. Copeia 1978:439–442.) showed that *C. m. pyrrhus* in the West Mojave Desert of California exhibit diurnal activity from April–May and October–November, feeding on the only diurnal mammalian prey available at the study site: *Ammospermophilus* (*Citellus*) *leucurus* (Antelope Ground Squirrel). *Ammospermophilus leucurus* are known to climb Pencil Cholla and other cacti and are found at the site of our *C. mitchellii* observation. Given the

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Fig. 1. *Crotalus mitchellii* in *Opuntia ramosissima* in the east Mojave Desert of California.

time of day and time of year, the subject of our observation likely climbed the cactus in pursuit of prey.

We thank Harry Greene for identifying the snake and encouraging publication of the observation.

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***CROTALUS OREGANUS HELLERI* (Southern Pacific Rattlesnake). DIET.** On 24 April 2010, at 1530 h, we collected an adult *Crotalus oreganus helleri* (total length = 127cm; 552.7 g), in Los Angeles Co., California, USA (34.478°N, 118.510°W; datum: NAD27). Upon capture, we noticed that the snake had consumed a large prey item. Once dissected, an adult California Thrasher (*Toxostoma redivivum*; 86.5 g) was removed from the snake. Positive identification of the prey item was made by L. Comrack. Because the prey item displayed no signs of digestion, we concluded that the bird had been recently consumed and was probably captured alive.

Snakes frequently prey upon eggs and nestlings of various bird species (Stake et al. 2005. J. Herpetol. 39:215–222; Tweit 1996. The Birds of North America. Cornell Lab of Ornithology, Ithaca. 20 pp.; Tyler 1986. Bull. Okla. Ornithol. Soc. 19:14–15); predation upon adult birds is less well-documented. Although snakes are listed as possible predators of juvenile *T. redivivum* (Cody 1998. *In* Poole [ed.], The Birds of North America Online. Cornell Lab of Ornithology, Ithaca), species-specific accounts have not been previously documented. To our knowledge, this is the first documentation of predation on *T. redivivum* by *C. o. helleri.* A digital photograph of the prey item and the specific account data is deposited in the Natural History Museum of Los Angeles County Ornithology Department.

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***DIADOPHIS PUNCTATUS PUNCTATUS* (Southern Ring-necked Snake). MAXIMUM SIZE.** On 19 May 2008, a female *Diadophis punctatus* was captured crossing the upper loop of the Carrick

Creek nature trail at Table Rock State Park, Pickens, Pickens Co., South Carolina, USA. The snake weighed 27 g and had an SVL of 47 cm. The total length (TL) was 52 cm but it should be noted the snake was missing part of its tail. Nevertheless, this TL exceeds the maximum recorded TL of 48.2 cm for *D. p. punctatus* (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 680 pp.). The specimen showed characteristics of *D. p. punctatus*, including uniform mid-ventral spots, but had an unbroken neck ring, suggesting some intergradation with *D. p. edwardsii*. The snake was photographed and released at site of capture.

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***DIPSADOBOA AULICA* (Marbled Tree Snake). DIET.** *Dipsadoboa aulica* is a small arboreal snake found in southeast Africa. It feeds nocturnally on anurans, geckos, and occasionally skinks and small rodents (Branch 1998. Field Guide to Snakes and Other Reptiles of Southern Africa. Struik, Cape Town. 400 pp.) but has not been documented to prey upon chameleons. At 1130 h on 10 January 2006, we collected a dead adult male *D. aulica* (SVL = 45.9 cm; total length = 58.4 cm) on a tar road (28.11889°S, 32.54667°E, datum: WGS84) near the village of St. Lucia in KwaZulu-Natal, South Africa. The snake had been run over at midbody and two undigested female *Bradypodion setaroi* (Setaro's Dwarf Chameleon) were partly visible extruding from the digestive tract (Fig. 1). Dissection revealed the head of the smaller chameleon (SVL = 5.1 cm; total length = 9.2 cm) in the hindgut of the snake. The larger *B. setaroi* (SVL = 6.6 cm; total length = 11.8 cm) was swallowed tail-first. *Bradypodion* is a South African endemic composed of at least 15 species generally restricted to small, allopatric distributions. *Bradypodion setaroi* is limited to subtropical coastal forests in the northeastern part of the country (Tolley and Burger 2007. Chameleons of Southern Africa. Struik, Cape Town. 400 pp.) and is currently listed as Endangered (EN B1+2c, 2006 IUCN Red List of Threatened Species); however, the species is to be down-listed to Least Concern in 2010 (W. Branch, pers. comm.).

FIG. 1. Road-killed *Dipsadoboa aulica* with two *Bradypodion setaroi* protruding from the digestive tract.

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FIG. 1. *Drymarchon melanurus erebennus* feeding on an Evening Bat (*Nycticeius humeralis*).

***DRYMARCHON MELANURUS EREBENNUS* (Texas Indigo Snake). DIET.** *Drymarchon melanurus erebennus* is a large, diurnal colubrid distributed across southern Texas in the United States southward throughout eastern Mexico to the state of Veracruz (McCranie 1981. Cat. Amer. Amphib. Rept. 267:1–4). While mostly terrestrial, it will occasionally climb into bushes and low branches of trees. An active forager, it preys on a wide variety of vertebrates including frogs, fishes, turtles, snakes (including venomous species), birds, and rodents (Wright and Wright 1957. Handbook of Snakes of the United States and Canada. Cornell Univ. Press, Ithaca, New York. 564 pp.; Werler and Dixon 2000. Texas Snakes: Identification, Distribution, and Natural History. Univ. Texas Press, Austin. 519 pp.). Herein we report the first record of predation by *D. m. erebennus* on a bat.

At 1708 h on 25 October 2008, at Southmost Preserve, Cameron Co., Texas, USA, we captured an adult *D. m. erebennus* (total length = 90.5 cm) in a ditch alongside a path adjacent to a large lagoon. The snake was in an area of abundant plant litter and in low light, so it was not immediately evident that the snake had a prey item in its mouth. However, upon closer examination we discovered the snake was attempting to ingest a bat. The bat's body was entirely within the snake's mouth with only the wings protruding (Fig. 1). Unfortunately, during the process of photographing the snake, it regurgitated the bat (which was still alive, albeit mortally injured). The bat was identified as an Evening Bat (*Nycticeius humeralis*; verified by Maxwell Pons, Jr.). *Nycticeius humeralis* roost in tree hollows and behind loose bark and forage in the early evening (Schmidly 2004. The Mammals of Texas. Univ. Texas Press, Austin. 501 pp.). It is likely the snake encountered the bat in a low level roosting area or emerging from it.

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***EPICRATES CENCHRIA* (Rainbow Boa). DIET.** *Epicrates cenchria* occurs in the Atlantic rainforest biome of Brazil from Rio de Janeiro to Pernanbuco. The diet of *E. cenchria* includes small mammals, lizards, bird and their eggs, amphibians, and bats (Freitas 2003. Serpentes Brasileiras. Editoria DALL, Bahia, Brazil. 78 pp.). On 19 January 2009, an adult *E. cenchria* (178 mm total length) was captured alive by a rural worker in Aparecidinha, Santa Teresa, Espirito Santo, Brazil, and brought to the Museu de Biologia Prof. "Mello Leitão," located in the same city. According to the worker, the snake was found in a hen house and had ingested seven domestic chicken (*Gallus gallus*) chicks. The snake was released several days later. This new diet record for *E. cenchria* represents an additional example of conflict between native and domestic wildlife. *Epicrates cenchria* is widely feared and frequently killed in rural areas of Brazil because of a misconception that it is venomous. In some cases the presence of domestic animals may attract native predators, putting them at risk from human persecution.

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***EPICRATES CHRYSOGASTER CHRYSOGASTER* (Turks Island Boa). DIET.** *Epicrates chryogaster chrysogaster* has been reported to feed on small introduced rodents such as rats and mice (*Rattus*, *Mus*), as well as the chicks and eggs of introduced birds such as chickens (*Gallus*; Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History, Univ. Florida Press, Gainesville. 720 pp.; Tolson and Henderson 1993. The Natural History of West Indian Boas, R&A Publishing, Taunton, Somerset, England. 68 pp.), though native lizards probably also factor heavily in the diet. The previous authors report that juvenile *E. c. chrysogaster* are probably saurophagous, but here we report that adults may be entirely saurophagous on small islands without *Rattus*, *Mus*, or *Gallus*. In addition, no previous studies have identified the species of lizards that are preyed upon by *E. chrysogaster*.

AT 0935 h on 8 August 2008, we found an adult male *E. c. chrysogaster* which had recently consumed a medium sized (SVL ca. 65 mm) *Leiocephalus psammodromus* (Turks and Caicos Curly-tailed Lizard). The snake was found on a small island on the Turks Bank, Turks and Caicos Islands. While the food item was not extracted entirely in order to prevent harm to the snake, we were able to determine the species of lizard that had been consumed. Additionally, herpetological surveys have determined that only three species of lizards inhabit the island: the *Anolis scriptus scriptus* (Southern Bahamas Anole), *Leiocephalus psammodromus* (Turks and Caicos Curly-tailed Lizard), and *Sphaerodactylus underwoodi* (Turks Dwarf Gecko). Of these, only *L. psammodromus* reaches sufficient size to have been the size of the food item. As no known record of *Mus*, *Rattus*, or *Gallus* exists for this island, it is expected that lizards are a major, if not the sole, component of the diet of this small population of *E. chrysogaster*.

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***EPICRATES CHRYSOGASTER CHRYSOGASTER* (Turks Island Boa). MAXIMUM SIZE.** To our knowledge, the previously reported maximum size for *Epicrates chrysogaster chrysogaster* is 1310 mm SVL (Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History, Univ. Florida Press, Gainesville. 720 pp.; Tolson and Henderson 1993. The Natural History of West Indian Boas, R&A Publishing, Taunton, Somerset, England. 68 pp.). At 1852 h on 12 August 2008, we found an adult female *E. chrysogaster* which we determined to be 1321 mm SVL by measuring the body with a length of string strung along the spine. The snake was found on North Caicos, Turks and Caicos Islands, about 2.25 km WNW of the town of Kew. The individual weighed 525 g and had a tail length of 228 mm.

In addition, an unusually large captive *E. chrysogaster*, maintained for educational purposes by the Turks and Caicos National Trust, was measured and is reported here to illustrate even larger size that may be reached by this species in captivity. The individual, a female, measured 1540 mm SVL, with a mass of 1100 g, and a tail length of 228 mm. The boa was excavated in the town of Kew, North Caicos, Turks and Caicos Islands during home remodeling and was brought to BNM by the property owner. It had been in captivity for approximately three years prior to our examination, which was performed on 12 August 2008.

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***EUNECTES NOTAEUS* (Yellow Anaconda). DIET / CANNIBALISM.** *Eunectes notaeus* is a marsh dwelling boid that preys upon a variety of vertebrates (Strüssmann 1997. Biociencias 5:35–52; Waller et al. 2001. Herpetol. Rev. 32:47). The implementation of a harvest program for this species in the Province of Formosa (Argentina), allowed us to evaluate the stomach contents of large numbers of specimens harvested each year from the highly productive floodplain that is seasonally inundated by the Pilcomayo River, Fortín Soledad, Bañado La Estrella, (24.1453°S, 60.6932°W, datum: WGS84). At this location *E. notaeus* is abundant and mainly feeds on waterfowl, bird eggs, aquatic rats, and the common and large *Hydrodynastes gigas* (False Water Cobra; Waller et al. 2007. *In* Henderson and Powell [eds.], Biology of the Boas and Pythons, pp. 340–362. Eagle Mountain Publishing, Utah).

On 3 June 2009, a hunter caught a female *E. notaeus* (SVL = 253 cm; 15 kg). The snake was in excellent body condition showing ovarian follicles in secondary vitellogenesis. In its stomach we found a freshly caught female conspecific (Fig. 1), as well as feathers of a Cormorant (*Phalacrocorax brasilianum*) and the digested remnants of a medium-sized but unidentified bird. This finding represents the first record of cannibalism in *E. notaeus*. The ingested anaconda was immature, 125 cm SVL and though it was not weighted, its size corresponds to an average 1.6 kg specimen (T. Waller, unpubl. data). Moreover, its subsequent dissection revealed a recently ingested juvenile aquatic rat (*Holochilus chacarius*; total length = 205 cm; ca. 35 g), showing that both snakes, predator and prey, were actively feeding.

Rivas and Owens (Herpetol. Rev. 31:45–46) found that large female *E. murinus* from the Venezuelan Llanos often prey upon smaller conspecifics, especially males, during the dry season. He suggested that this behavior could be a strategy to improve their survival during the long fasting periods of pregnancy. However, it is unlikely that such a behavior would be necessary at our highly productive study site, where prey availability does not seem to be a limiting factor for *E. notaeus* and reproductive females are generally in good condition year after year (Waller et al. 2007, *op. cit.*). Instead, this event may have been instigated by both snakes

Fig. 1. Dissection of an adult female *Eunectes notaeus* revealed ingestion of an immature conspecific female (shown here).

attempting to swallow the same prey. This also seems unlikely because the disparity in size between snakes would likely result in differences in prey size selection. Moreover, the absence of another fresh prey item in the stomach if the larger individual, as would be expected in such a situation, argues against accidental ingestion. Another explanation could be that the larger snake was attracted and confused by the scents left on the body of the smaller individual by the recently eaten rat; but again, it is hard to imagine that a large female anaconda would pursue the scent of such a small rodent (35 g) as prey. Regardless of the circumstances, this is the first time in nine years of work that we have received a reliable record of cannibalism by *E. notaeus*, suggesting that the phenomenon is unusual at this location.

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HELICOPS ANGULATUS **(South American Watersnake). DIET.** *Helicops angulatus* is a semi-aquatic and primarily nocturnal dipsadid snake that is widely distributed in northern South America. This species inhabits ponds, streams and rivers (Ford and Ford 2002. Carib. J. Sci. 38:129–132), where it is known to feed on amphibian eggs, adult frogs, and aquatic lizards, but primarily on fish and tadpoles of the genera "*Hyla*" and *Osteocephalus* (Martins and Oliveira 1998. Herpetol. Nat. Hist. 6:78–150).

On 16 May 2009, at ca. 1600 h, an adult female *H. angulatus* (SVL = 490 mm; tail length = 215 mm) was collected near the Unini river's south margin (01.7116°S, 62.8220°W; datum: WGS 84), Barcelos, Amazonas, Brazil. Upon capture, a Cane Toad (*Rhinella marina* = *Bufo marinus*) tadpole was removed from the mouth of the snake. The *H. angulatus* was deposited in the herpetological collection of Instituto Nacional de Pesquisas da Amazônia (INPA-H 25379). Upon dissection, we found another seven *R. marina* tadpoles inside the snake's stomach. All tadpoles collected were below the developmental stage 25 (Gosner 1960. Herpetologica 16:183–190).

Rhinella marina is known to be toxic and unpalatable to a wide range of predators, but a recent study showed a decrease of both toxin diversity and concentration during its tadpole stage (Hayes et al. 2009. J. Chem. Ecol. 35:391–399). Moreover, several other snake species within the subfamily Xenodontinae prey on adult toads and are able to tolerate bufonid toxins (Duellman and Trueb 1986. The Biology of Amphibians. McGraw-Hill Inc., New York. 670 pp.). Future research should investigate whether *H. angulatus* is also able to tolerate bufonid toxins found in adults, or if consumption of *R. marina* by this snake is restricted to the more palatable tadpole stage.

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HETERODON NASICUS **(Western Hog-nosed Snake). DIET AND ARBOREAL FORAGING BEHAVIOR.** *Heterodon nasicus* is a fossorial snake that primarily inhabits well drained, sandy grasslands of the Great Plains in the United States (Conant and Collins 1991. Reptiles and Amphibians Eastern/Central North America. Houghton Mifflin, Boston, Massachusetts. 450 pp.) *Heterodon nasicus* are known to burrow and forage along the ground for amphibians, reptiles, mammals, and birds, and their offspring, including eggs (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Press, Washington DC. 680 pp.). Herein, we describe arboreal foraging behavior of *H. nasicus*, including predation upon eggs of *Chondestes grammacus* (Lark Sparrow).

On 7 July 2008 at 2130 h, a pair of *C. grammacus* was discovered jumping and screeching around their nest. The nest was located 1.5 m high in a Chokecherry (*Prunus virginiana*) bush near Keystone Lake on Cedar Point Biological Station, Keith Co, Nebraska, USA (41.2110°N, 101.6574°W, datum: WGS84). Upon approaching the nest, an *H. nasicus* was discovered consuming eggs inside the nest, while being harassed by the sparrows. The birds appeared not to harm the snake, despite making physical contact with the snake's posterior end. After 3–5 min of harassment, the sparrows drove the snake away, but not before the snake grabbed another egg in its mouth. The snake awkwardly, but quickly (i.e., almost a controlled fall), undulated down the dense vegetation and moved 5 m away from the nest, underneath the bark of a fallen Eastern Cottonwood (*Populus deltoides*). The snake finished consuming the second egg under this cover. After 10 min, the snake (female; total length = 67 cm) was captured and when palpated, two eggs were found in her stomach. Upon discovery the snake performed a typical defensive display (Ernst and Ernst, *op. cit.*), but did not regurgitate the eggs. The snake was subsequently released under the same Eastern Cottonwood bark refugia. To our knowledge, this is the first record of arboreal foraging in *H. nasicus* and the first record of *C. grammacus* eggs in this species' diet.

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HETERODON PLATIRHINOS **(Eastern Hog-nosed Snake). MAXIMUM SIZE.** On 8 April 2010 a melanistic adult female *Heterodon* *platirhinos* was captured alive on Fort Stewart Rd. 70B, Fort Stewart, Bryan Co., Georgia, USA (32.0681°N, 81.5569°W, datum: WGS 1984). The snake was measured independently by two teams of experienced herpetologists, who differed in their total length measurements by ca. 2 cm; the mean of these measurements was SVL = 105.9 cm; tail length (tail was intact) = 20.9 cm; total length = 126.8 cm. Mass of the snake was 900 g (no apparent food boli).

The length of this snake exceeds the previously published maximum size (total length = 115.6 cm) for the species (Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.), based on a specimen from Beaver Co., Oklahoma reported by Platt (1969. Univ. Kansas Publ. Mus. Nat. Hist. 18:253–420). We deposited a voucher photograph of the specimen in the University of Florida Museum of Natural History Herpetology Collection (UF 157500).

We thank Kevin Stohlgren and Elizabeth Schlimm for their help measuring and photographing the specimen.

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HETERODON SIMUS **(Southern Hog-nosed Snake). DIET.** *Heterodon simus* is commonly reported to feed "almost exclusively" on anurans (Mount 1975. The Reptiles and Amphibians of Alabama. Agriculture Experiment Station, Auburn University. 345 pp.; Tuberville and Jensen 2008. *In* Jensen et al. [eds.], Amphibians and Reptiles of Georgia, Univ. Georgia Press, Athens. 575 pp.). Beane et al. (1998. Herpetol. Rev. 29:44–45) also reported two lizard species as prey. Here we report predation by *H. simus* on a large invertebrate.

An adult male *H. simus* (SVL = 330 mm; total length = 408 mm) was found road-killed ca. 9.7 km WNW of Wagram, Scotland Co., North Carolina, USA (34.904579°N, 79.470070°W, datum: WGS 84) on 4 October 2008. The stomach contained a third (final) instar Ox Beetle (*Strategus antaeus*) larva. The larva was too badly fragmented to measure accurately, but was estimated to be ca. 60 mm total length. Insect fragments are occasionally found in the digestive tracts and in the feces of *H. simus* (pers. obs.), but virtually all these almost certainly represent items secondarily ingested along with typical food items (e.g., *Scaphiopus*, *Bufo*). The large size of this grub, its only partially digested condition and lack of association with any recently ingested vertebrate prey, and its presence in the stomach rather than farther down the digestive tract indicate that it was almost certainly taken directly as prey and not secondarily ingested. A few tarsal bone fragments from an anuran of undetermined species were also present in the stomach, but they were obviously from a prey item that had been eaten much earlier. To our knowledge, this represents the first documentation of an invertebrate taken as primary prey by *H. simus*. The *H. simus* specimen is deposited in the herpetological research collections of the North Carolina State Museum of Natural Sciences (NCSM 74482). The *S. antaeus* remains are deposited in the entomological collections of North Carolina State University.

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LAMPROPELTIS GETULA HOLBROOKI **(Speckled Kingsnake). DIET.** *Lampropeltis getula* eat a variety of prey, including small mammals, birds, eggs, and other reptiles. Many species of snakes are eaten by *L. getula*, but the only species of watersnakes noted are *Nerodia erythrogaster*, *N. fasciata*, *N. floridana*, and *N. rhombifer* (Clark 1949. J. Tennessee Acad. Sci. 24:244–261; Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 668 pp.; Winne et al. 2007. Copeia 2007:507–519). No previous reports include *L. g. holbrooki* preying on *Nerodia cyclopion*.

On 23 March 2007, a *L. getula* (female; SVL = 89.1 cm; tail length = 12.8 cm; 288 g) was found constricting a *N. cyclopion* (male; SVL = 63.2 cm; tail length = 14.0 cm; 150 g) at Spanish Lake, Cade, Iberia Parish, Louisiana, USA. The *L. getula* had approximately 3½ loops wrapped around the anterior half of the prey, but released the watersnake when disturbed. The watersnake had been constricted tightly, but was still capable of slight movement. When the watersnake became responsive and alert, it was released at the site of capture. If ingestion had been allowed, this would have been a 52.1% prey mass/predator mass ratio.

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LEPTOPHIS DIPLOTROPIS **(Pacific Coast Parrot Snake). DIET.** *Leptophis diplotropis* is a colubrid endemic to México that feeds on a variety of frogs (Hardy and McDiarmid 1969. Univ. Kansas Publ. Mus. Nat. Hist. 18:182; Oliver 1948. Bull. Amer. Mus. Nat. Hist. 92:255). Although lizards are included in the diet of other species within the genus (Henderson 1982. Amphibia-Reptilia 3:71–80; Henderson et al. 1977. J. Herpetol. 11:231–232), to our knowledge no lizards have been reported in the diet of *L. diplotropis*. Here we present the first record of a lizard in the diet of this species.

On 13 November 2009, at 1344 h, an adult *L. diplotropis* was observed in the process of feeding on a *Phyllodactylus tuberculosus* at Campamento Aserradero, María Madre Island, Nayarit, México (21.6801°N, 106.6054°W, WGS84; elev. 41 m). The snake and prey were found on the ground near a wooden table used for remodeling buildings. At this site, geckos often seek shelter between the construction materials, where they are hunted by snakes. When encountered, the snake was holding its prey by the posterior body portion. It proceeded to swallow the lizard over the next 13 min. The event was photographed and a color slide (MFSI-REPT-859) was deposited in the amphibian and reptile collection of Museo de las Ciencias Biológicas "Enrique Beltrán," FES-Iztacala, Universidad Nacional Autónoma de México, México.

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***MASTICOPHIS* (= *COLUBER*) *MENTOVARIUS* (Neotropical Whipsnake). DIET.** Species in the genus *Masticophis* are known to prey on a diversity of vertebrates, including young birds, lizards, frogs, rodents, eggs, snakes, and small turtles (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 668 pp.; Werler and Dixon 2000. Texas Snakes: Identification, Distribution, and Natural History. Univ. Texas Press. Austin. 437 pp.). *Masticophis mentovarius*, like all members of the genus, is considered a generalist forager. On 1 December 2008, in tropical dry forest at Las Mojarras, Municipality of Oaxaca de Juárez, Oaxaca, México (17.11186°N, 96.72225°W; datum: WGS84; elev. 1683 m), we observed a male *M. mentovarius* feeding on a Grayish Mouse Opossum (*Tlacuatzin canescens*; Fig. 1). This is the first record of a marsupial in the diet of *M. mentovarius.*

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FIG. 1. Adult male *Masticophis mentovarius* feeding on an adult Grayish Mouse Opossum (*Tlacuatzin canescens*), Las Mojarras, Municipality of Oaxaca de Juárez, Oaxaca, México.

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***MASTIGODRYAS BRUESI* (Windward Tree Racer, White Snake). BEHAVIOR.** *Mastigodryas bruesi* is native to the Grenada and St. Vincent island banks and has been introduced on Barbados (Greene et al. 2003. Cat. Amer. Amphib. Rept. 777:1–3). Very little is known about the biology of the species (Henderson and Powell 2009. Natural History of West Indian Reptiles and Amphibians. Univ. Press Florida, Gainesville. xxiv + 495 pp.). From 3–22 June 2010, we had 32 encounters with *M. bruesi* on Union Island (St. Vincent and the Grenadines). These snakes were abundant at elevations ranging from sea level to nearly 300 m (just below the highest point on the island) and in a variety of habitats. The number of encounters and the broad distribution of *M. bruesi* on Union might be attributable to the absence of the Small Indian Mongoose (*Urva auropunctata*), which has been implicated in the extirpation or extinction of several species of ground-dwelling lizards and snakes in the West Indies (e.g., Powell and Henderson 2005. Iguana 12:62–77). Encounters with *M. bruesi* on St. Vincent and Grenada are comparatively rare and mongooses are common. On the larger mongoose-infested islands, arboreal, nocturnally active boids (*Corallus grenadensis* and *C. cookii*) have broad distributions at elevations under 500 m and can be encountered in a variety of habitats (Henderson 2002. Neotropical Treeboas: Natural History of the *Corallus hortulanus* Complex. Krieger Publ. Co., Malabar, Florida. xiv + 197 pp.; Powell et al. 2007. *In* Henderson and Powell [eds.], Biology of the Boas and Pythons, pp. 374–387. Eagle Mountain Publ., Eagle Mountain, Utah). In contrast, diurnally active and largely ground-dwelling *M. bruesi* is rarely encountered outside of disturbed areas where human activity is common and mongooses rare or absent. On mongoose-free Union, the frequencies of encounters with *C. grenadensis* and *M. bruesi* encounters were comparable.

Although 26 of 28 diurnal encounters were with individuals on the ground and two with snakes in rock crevices, *M. bruesi* is an excellent climber. Of 14 escapes we observed, 10 individuals fled downhill before ascending into shrubs or vines that they then used to gain access to the lower branches of larger trees. Arboreality might provide some protection from terrestrial predators (e.g., mongooses; Sajdak and Henderson 1991. Oryx 25:33–38). The other four snakes escaped by continuing downhill until out of sight or by entering rock crevices. When captured, snakes were not aggressive and seldom attempted to bite. In all instances, they released musk in an apparent effort to deter handling. Four snakes vibrated their tails when cornered or captured.

Three *M. bruesi* were encountered while actively foraging, probing and tongue-flicking in leaf litter and rock crevices where geckos (e.g., *Gonatodes daudini* and *Sphaerodactylus kirbyi*) occurred. They also responded actively to movements. Three individuals followed and struck at small rocks rolling downhill. We observed four snakes sleeping in trees at night while coiled on branches at heights of 2–8 m. Schwartz and Henderson (1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. xvi + 720 pp.) noted that *M. bruesi* sleeps at heights of at least 5 m.

Permits to conduct research on Union Island were issued by Brian Johnson, Director, Department of Forestry, St. Vincent and the Grenadines. Protocols were approved by the Avila University Animal Care and Use Committee. Fieldwork was funded by a grant from the National Science Foundation (USA) to Robert Powell (DBI-0851610).

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MICRURUS DISTANS **(Sinaloan Coralsnake). DIET.** *Micrurus distans* is an elapid snake distributed from southern Chihuahua and Sonora to central Guerrero, México (Lemos-Espinal and Smith 2007. Amphibians and Reptiles of the State of Chihuahua, México. Universidad Nacional Autónoma de México (UNAM) and Comisión Nacional para el conocimiento y uso de la Biodiversidad (CONABIO), México, D.F. 418 pp.). This species feeds on small snakes, lizards, and frogs (Ramirez-Bautista 1994. Manual y Clave Ilustrada de los Anfibios y Reptiles de la Región de Chamela, Jalisco, México. Instituto de Biología, UNAM, México D.F. 87 pp.), but few specific diet records are known. Here we report evidence of predator-prey interaction between *M. distans* and its presumptive Batesian mimic *Lampropeltis triangulum*.

On the morning of 25 March 2008, in tropical deciduous forest at Chamela UNAM Biological Station, Jalisco, México, we observed an *M. distans* preying on an *L. triangulum* in the leaf litter (Fig. 1). The snakes were of similar size (ca. 700 mm total length) and were observed wrestling, with the *L. triangulum* apparently using constriction as a defensive tactic against its predator. After about 10 min, the *M. distans* immobilized its prey by envenomation and later ingested it headfirst. After approximately 20 min, the *L. triangulum* had been fully ingested and the *M. distans* was hidden among leaf litter.

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Fig. 1. *Micrurus distans* preying on *Lampropeltis triangulum* in Jalisco, México.

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MICRURUS FULVIUS **(Harlequin Coralsnake). DIET.** The diet of *Micrurus fulvius* consists primarily of elongate reptiles including other snakes (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington D.C. 668 pp.). Previously, only one viperid has been documented as a prey item of *M. fulvius*. A *Sistrurus miliarius* (Pigmy Rattlesnake) was removed by dissection from a *M. fulvius* from the University of Texas at Tyler teaching collection. Locality data for the specimen was not available. The coral snake measured 551 mm SVL with a head width of 10.42 mm. The partially digested prey measured 138 mm in total length and 5.5 mm in diameter at its maximum point. After the prey was removed, the coral snake weighed 37.33 g and the prey weighed 1.88 g. From the remains, the prey generated the conservative estimates of the following prey-to-predator ratios: a weight ratio of 0.05, an ingestion ratio of 0.52, and a length ratio (= total length of prey/snout–vent length of predator) of 0.25. To my knowledge, this is the first report of a *S. miliarius* as a prey item of *M. fulvius*.

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MICRURUS NIGROCINCTUS NIGROCINCTUS **(Central American Coral Snake). DIET.** Caecilians are known from the diets of at least nine species of coral snake (Burger 1997. Bull. Chicago Herpetol. Soc. 32:145; Freile and Fletcher-Lazo 2009. Herpetol. Rev. 40:99; Roze 1996. Coral Snakes of the Americas: Biology, Identification and Venoms. Krieger Publ. Co., Malabar, Florida. 340 pp.), with the earliest record dating back to Boulenger (1913. Proc. Zool. Soc. London 1913:1019–1038). Although multiple early authorities recognized interactions between coral snakes and caecilians, the exact species relationships were not always reported; prey were often reported only as "caecilian." *Micrurus nigrocinctus nigrocinctus* is a common member of the genus within its range (Greene and Seib 1983. *In* D. H. Janzen [ed.], Costa Rican Natural History, pp. 406–408. Univ. Chicago Press, Illinois) and has been reported to consume caecilians but until now specific species of caecilians have not been reported. Here we present three independent accounts of *M. n. nigrocinctus* feeding on the caecilian *Oscaecilia ochrocephala*.

On 27 July 2003, at ca. ca. 1700 h, RVH observed a recently killed female coral snake (SVL = 419 mm; total length = 466 mm; 15.8 g after prey removal) in a private lawn in Gamboa, Colon Province, Panama. Closer inspection of the specimen revealed a blow to the upper body caused its death. The specimen appeared to contain a large food item and upon dissection was found to contain an *O. ochrocephala* that had been consumed headfirst (total length = 281 mm; 4.9 g). Both specimens were deposited at the Círculo Herpetológico de Panamá (Fig. 1; CH5730 and CH5732).

On 17 September 2009, at ca. 1130 h, AH collected a coral snake in the Río Agua Salud watershed, El Giral, Colon Province, Panama. After being placed in a bag, the snake regurgitated a partly digested *O. ochrocephala* that had been consumed headfirst. The snake was subsequently released and the caecilian left on site.

On 21 September 2009, at ca. 1330 h, RID observed a *M. n. nigrocinctus* biting an *O. ochrocephala* on a lawn in Parque Municipal Summit, Panama Province, Panama. Upon approach, the coral snake released the caecilian and fled to nearby cover. The caecilian appeared dead, and was moved 2–3 m away from the capture site. Some minutes later, the coral snake returned, appearing to be seeking the dead prey. The coral snake bit the caecilian and started eating it headfirst. At ca. 1400 h, the coral snake was observed swallowing its prey, from a concealed position (Fig. 2). The caecilian was somewhat longer than the snake

PHOTO BY R. V. HORAN III

Fig. 1. Preserved specimen of *Micrurus nigrocinctus nigrocinctus* and its prey *Oscaecilia ochrocephala*, collected in Gamboa, Colon Province, Panama, 27 July 2003.

PHOTO BY R. IBÁÑEZ-D

Fig. 2. *Micrurus n. nigrocinctus* feeding on an *O. ochrocephala* on a lawn in Parque Municipal Summit, Panama Province, Panama, 21 September 2009.

and consumption took approximately 50 min. No attempt was made to interrupt the feeding event or to collect the snake. Photos from all three observations are available on the Smithsonian Tropical Research Institute's Digital File Manager website at http://biogeodb.stri.si.edu/bioinformatics/dfm/.

Micrurus nigrocinctus nigrocinctus has previously been considered a generalist, consuming a wide range of small amphibian and reptile species. Based on the observations reported here, we think that caecilians might be a more important diet item for this species than previously considered.

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***NAJA MELANOLEUCA* (Forest Cobra). DIET AND FORAGING BEHAVIOR.** Primarily an arboreal snake restricted to tropical and subtropical African forests, *Naja melanoleuca* is a dietary generalist that preys on small mammals, anurans, birds, other squamates, and fish (Alexander and Marais 2007. A Guide to the Reptiles of Southern Africa. Struik, Cape Town. 408 pp.). The species is locally abundant in the coastal village of St. Lucia in northeastern South Africa, and is frequently encountered around human residences. The presence of *N. melanoleuca* in trees is often betrayed by the shrieking alarm calls of gregarious birds like the Dark-capped Bulbul (*Pycnonotus tricolor*), White-eared Barbet (*Stactolaema leucotis*), and Weavers (*Ploceus* spp.). Additionally, these birds sometimes engage in a series of mock attacks by making short, diving flights directly at the snake before quickly turning away to avoid contact. On three occasions, I have also observed *N. melanoleuca* coiled on or around small branches make reciprocal lunges with open mouths at birds as they fly past. On the morning of 10 February 2009, after observing part of one such encounter in a residential garden in St. Lucia (28.38293°S, 32.40816°E, datum: WGS84), I captured the snake (branch height = 2.5 m) and examined its stomach contents. The individual (SVL = 144 cm; mass = 984 g) regurgitated six adult *S. leucotis* (Fig. 1) that collectively weighed 361 g (36.7% of snake body mass). Although I did not witness the snake feeding, based on the presence of perturbed *S. leucotis* at the capture scene and the relatively undigested condition of the prey (all ingested head-first), the birds presumably had been eaten immediately before my arrival. *Stactolaema leucotis* sometimes roost communally in tree cavities (Hockey et al. 2005. Birds of Southern Africa, 7th ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town. 1296 pp.), so it is possible the snake trapped the six barbets in a nest prior to feeding. Alternately, *N. melanoleuca* might intentionally expose themselves to some avian prey because the resulting response behavior (mock attacks) by groups of birds puts the snakes in close proximity to multiple meals. *Stactolaema leucotis* has not been previously recorded in the diet of *N. melanoleuca.* Regurgitated stomach contents of other *N. melanoleuca* captured at St. Lucia during 2007–2009 also include an *Acontias plumbeus* (Giant Legless Skink), *Amietophrynus gutturalis* (Guttural Toad), and unidentified small mammals.

Fig. 1. *Naja melanoleuca* with regurgitated *Stactolaema leucotis.*

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***NATRIX MAURA* (Viperine Snake). NON-ACCIDENTAL SALT WATER ACTIVITY.** Snakes in the genus *Natrix* are occasionally found in marine environments but few records substantiate voluntary entry. The earliest record appears to be that of Böse (1897. Zoologischer Anzeiger 20[521]:255), a naval physician aboard the warship S.M.S. Blücher, who reported a *N. natrix* 1 km from the coast of the Second German Empire (1871–1918) in an unspecified (either the North Sea or Baltic Sea) location. *Natrix natrix* subsequently has been reported in the Atlantic Ocean 46.3 km off the coast of Norway (Hecht 1930. Mitt. Zool. Mus. Berlin 16:345–346), approximately 11 km from the coast of France between Île de Penfret in the Îles de Glénan and the coast (Guérin-Ganivet 1909. Bull. Inst. Oceanographie 132:1–2), and in the Bay of Biscay (p. 227 *in* Smith 1951. The British Amphibians and Reptiles. Collins, London. 318 pp.). Additional records include the North Sea (9.7 km from the coast of Bretagne, France; Hecht 1930. Mitt. Zool. Mus. Berlin 16:345–346) and the English Channel (p. 126 *in* Loveridge 1945. Reptiles of the Pacific World. Macmillan Co., New York. 259 pp.) but it is unclear whether these records reflect accidental or voluntary entry into saline waters.

Natrix tessellata, on the other hand, has been observed chasing small gobies in the Black Sea along the shore near Odessa (Ukraine; p. 164 *in* Boulenger 1913. The Snakes of Europe. Methuen and Company, London. 269 pp.) and a single specimen of *N. maura* was observed in a 0.2 m deep pool on the beach between Tarifa and Algeciras (Cádiz Province, Spain) that is inhabited by small fish and that, at high tide, is flooded with seawater (Cabot and Olea 1978. Doñana, Acta Vertebrata 5:107).

In August, when freshwater streams in southeastern Cádiz Province, Spain, are completely dry, *N. maura* is frequently seen fishing in small "pools" formed by sand and stones in the tidal zone by Piedra de las Morenas (36.07095°N, 5.7500889°W; datum WGS84). Many small fish remain trapped in these pools between low tide and high tide and, on one occasion, an individual that had captured a "cabozo" (*Gobius paganellus*) was seen. During August 1986–1987, while spear fishing in the area of Galerilla (Ensenada de Bolonia, Cádiz Province, Spain; 36.0737083°N, 5.7597778°W; datum WGS84) one of us (RC) observed a *N. maura* actively swimming on the surface of the Atlantic Ocean where water depth was 5 m. These observations confirm that *Natrix maura* engages in limited, non-accidental, activity in salt water.

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***NERODIA RHOMBIFER* (Diamond-backed Watersnake). INTERSEXUALITY.** Intersexuality is rare among adult snakes (Cole 1975. *In* Reinboth [ed.], Intersexuality in the Animal Kingdom, pp. 340–355. Springer-Verlag, New York). Adult female *Pseudoficimia frontalis* universally possess hemipenes, though they are smaller than those of males (Hardy 1970. Herpetologica 26:336–343). Adult female *Bothrops insularis* may be either normal or intersexual with most being intersexual. Normal females of this species appear to be sterile while intersexuals are fertile but are capable of carrying fewer embryos than sister taxa (Hoge et al. 1959. Mem. Inst. Butantan 29:17–88). Wilson and Robinson (1971. Bull. So. California Acad. Sci. 70:53–54) described an intersexual *Amastridium veliferum* that apparently functioned as a female though it possessed hemipenes. The hemipenes, however, were reduced in size and were not fully ornamented. An intersexual *Thamnophis sirtalis* was described by Krohmer (1989. Copeia 1989:1064–1068). Upon dissection, this individual possessed male sex characters on the left side and female sex characters on the right, though it was behaviorally only a male.

On 31 August 2007, 19 *Nerodia rhombifer* were collected from a private fish farm in Desha Co., Arkansas, USA (33.67992°N, 91.26831°W, datum: WGS 84). Of these, six were normal males, 12 were normal females, and 1 was an intersexual. The intersexual (SVL = 802 mm, tail length = 223 mm; ASUMZ 30809) lacked the papillae on the chin indicative of male *N. rhombifer*, but possessed hemipenes with full ornamentation (Fig. 1). Dissection showed oviducts and ovaries with pre-vitellogenic follicles and undeveloped Wolffian ducts, thus signifying a female. The right ovary (75 mm × 6 mm) was removed and follicles were measured (N = 6; mean length ± SD = 6.833 ± 1.722 mm; mean diameter ± SD = 3.833 ± 0.983 mm). Because the Wolffian ducts were not developed into ductus deferentia, it appears that this individual could only function as a female, and the abnormality was the possession of hemipenes. This individual is, therefore, considered a pseudohermaphrodite as opposed to a true hermaphrodite.

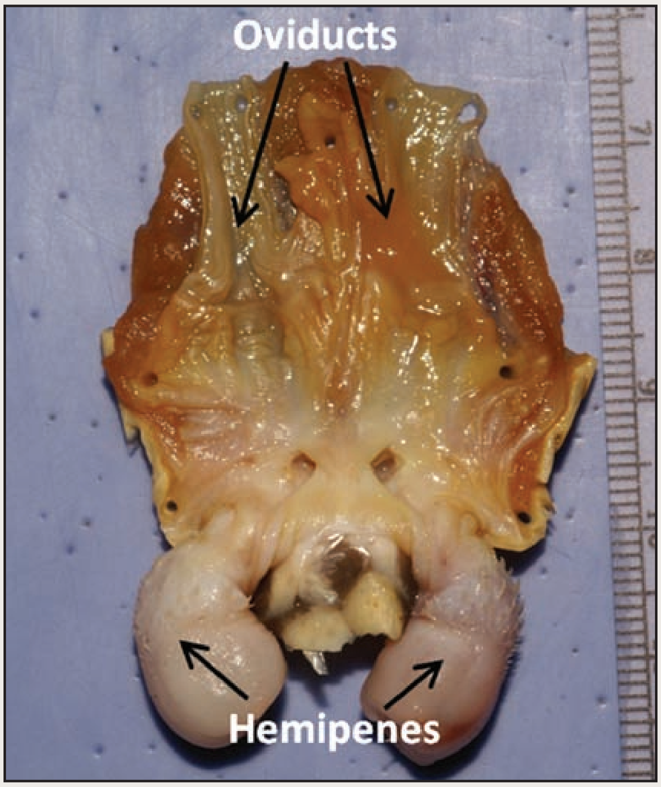

FIG. 1. Dissected cloaca of intersexual *Nerodia rhombifer* showing both male and female reproductive organs.

The cause of sexual abnormalities is not fully understood and both genetic and hormonal factors have been proposed (Hoge et al. 1959, *op. cit.*, Fox 1977. *In* Gans and Parsons [eds.], Biology of the Reptilia, Vol. 6, Morphology E, pp. 1–157. Academic Press, New York). Because our *N. rhombifer* represents a single instance of intersexuality in this species, aberrant hormonal or genetic factors are likely the cause.

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***NERODIA SIPEDON* (Northern Watersnake). DEFENSIVE BEHAVIOR.** Many reptiles have the ability to detach their tails when threatened or attacked. This antipredator behavior, called tail autotomy, has been reported for various species of lizards,

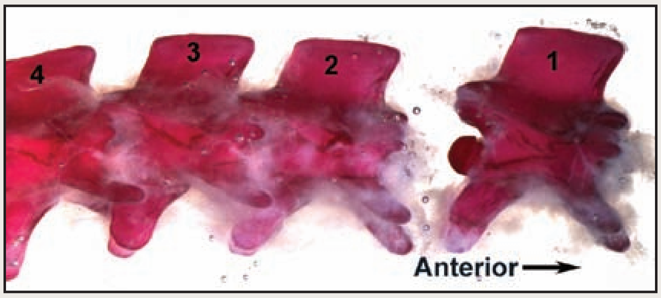

FIG. 1. *Nerodia sipedon* vertebrae caudal to the tail detachment site. Vertebra 1 has been isolated to show it is complete.

sphenodonts, amphisbaenids, and snakes. Among these taxa, an array of tail autotomy strategies exists (Arnold 1984. J. Nat. Hist. 18:127–169). True autotomy occurs when the tail is lost spontaneously and is later regenerated, as is the case with many lizards and *Sphenodon.* Often the tail breaks intravertebrally, along a pre-existing fissure. Pseudoautotomy occurs when a mechanical force is required to separate the tail from the body and the tail does not grow back; this is common in natricine snakes in North America (Cooper 1993. Amphibia-Reptilia 14:86–89; Fitch 1965. Univ. Kansas Publ. Mus. Nat. Hist. 15:493–564; Todd 2010. Amphibia-Reptilia 31:213–215). Pseudoautotomy is further divided into specialized pseudoautotomy where the tail anatomy facilitates breakage, and non-specialized pseudoautotomy where the tail is lost because it is long and fragile with no clear mechanisms to facilitate detachment (Slowinski and Savage 1995. Herpetologica 51:338–341).

At approximately 1130 h on 27 August 2009, we captured an adult *Nerodia sipedon* in Killarney Provincial Park, Ontario, Canada (46.08333°N, 81.33333°W, datum NAD 83). The snake was basking on a granite ledge, roughly 10 m from water's edge. The snake was caught by the tail and it immediately performed a lateral roll, causing its tail to detach. We dropped the tail and caught the snake before it could escape. Very little blood was lost through the wound, where the tail detached. The isolated tail continued to move in response to touch for almost 30 min. The tail was frozen and shipped to Dalhousie University, Nova Scotia, Canada for clearing and staining after fixation in neutral buffered formalin.

The wriggling of the tail immediately after detachment and prolonged response of the tail to touch suggests that these snakes may have anatomical features that facilitate tail detachment for predator evasion. This would fall into the category of specialized tail pseudoautotomy. To determine whether the tail had broken intra- or intervertebrally, the tail tissue was cleared using trypsin powder in sodium tetraborate and potassium hydroxide. The bone was stained with aliziran red. Fig. 1 shows the first four vertebrae after the break site. The first vertebra caudal to the break site is separated to show that it is complete, confirming that the tail broke intervertebrally and that *N. sipedon* displays tail pseudoautotomy in response to a sheer force sufficient to detach the tail. There are no distinctive osteological features before or after the break site, suggesting that anatomically, pseudoautotomy in *N. sipedon* is of a non-specialized nature.

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***OPHIOPHAGUS HANNAH* (King Cobra). DIET.** *Ophiophagus hannah* is a front-fanged elapid snake found throughout much of Southeast Asia. *Ophiophagus hannah* is known to primarily consume other snakes, but has also been documented to consume lizards, including varanids (Evans 1902. J. Bombay Nat. Hist. Soc. 14:409–418; Hesed 2006. Herpetol. Rev. 37:480; Smith 1943. Fauna of British India: Reptilia and Amphibia, Vol. III, Serpentes. Taylor & Francis, London). However, a review of published dietary observations in this species showed all records to be restricted to India, Malaysia, and Thailand (Hesed, *op. cit.*). To our knowledge, this is the first record of a varanid in the diet of *O. hannah* in the Philippines.

During fieldwork in the Philippines, we observed a male *Ophiophagus hannah* (total length = 327.5 cm; 3.75 kg) consuming, head-first, a 1.5 kg *Varanus cumingi* (Fig. 1.). The event occurred on 12 April 2009, in mixed primary and secondary growth forest, on a trail near a water intake system, in Pasonanca Natural Park, Barangay Pasonanca, Zamboanga City Province, Mindanao Island, Philippines (6.9922333°N, 122.0604333°E, datum: WGS-84; elev. 90 m). Both specimens were collected, preserved, and deposited at the Biodiversity Institute, University of Kansas (KU 321813*: Ophiophagus hannah*, KU 321814: *Varanus cumingi*).

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FIG. 1. An adult *Ophiophagus hannah* preying upon an subadult *Varanus cumingi* in Pasonanca Natural Park, Mindanao Island, Philippines.

OPISTHOTROPIS KUATUNENSIS **(Striped Stream Snake). DIET.** *Opisthotropis kuatunensis* is a small- to medium-sized aquatic snake which is widely distributed in southern China, including Fujian, Guangxi, Jiangxi, Zhejiang, Guangdong provinces and Hong Kong Special Administrative Region (Karsen et al. 1998. Hong Kong Amphibians and Reptiles. Provisional Urban Council. Hong Kong SAR. 186 pp.). This snake inhabits moderate- to high-gradient rocky streams on hillslopes with intact forest. It can be observed at night foraging in stream pools and riffles, probing crevices in the substrate for prey. Very limited information is available about its diet except that it consumes fish and tadpoles in captivity (Karsen et al., *op. cit.*). Here we report the first documented observation of *O. kuatunensis* consuming frog eggs and tadpoles in the wild, which also represents the first report of frog egg consumption by any snake in the genus *Opisthotropis*.

At 2105 h on 18 September 2009, at Kadoorie Farm and Botanic Garden (22.43386°N, 114.12736°E, datum: WGS84; elev. 415 m), New Territories, Hong Kong, we observed a female *O. kuatunensis* (SVL = 46 cm; total length = 55 cm) attempting to swallow an egg of *Paa exilispinosa* (Lesser Spiny Frog) in an artificial pond (length × width × depth = 50 × 30 × 18 cm) that was located in secondary forest and was connected to a 2 m wide stream nearby. When the egg was ingested halfway, the snake detected our presence, released the egg, and fled. We caught the snake for measurement and photographic record. A total of 19 eggs of *P. exilispinosa* at early tail-bud stage (Gosner 1960. Herpetologica 16:183–190) were found in the pond. Clutches of *P. exilispinosa* generally contain approximately 50–150 eggs and the entire clutch is typically deposited together in a small pool (N. Karraker, unpubl. data). The few eggs observed at this site suggest that the snake, or possibly some other predator, had consumed other eggs. Eggs of *P. exilispinosa* are approximately 12–23 mm in diameter, with embryos ranging from 9 to 11 mm, depending upon developmental stage (N. Karraker, unpubl. data). These are the second largest embryos of any stream-breeding frog in Hong Kong, aside from those of the Giant Spiny Frog (*P. spinosa*), and their size and oviposition as a group potentially represents a substantial food source for *O. kuatenensis*.

At 2040 h on 11 January 2010, at Tai Mo Shan (22.54278°N, 114.28917°E, datum: WGS84; elev. 878 m), New Territories, Hong Kong, a male *O. kuatunensis* (SVL = 32 cm; total length = 38.5 cm) was observed biting the head of a *Leptolalax liui* (Leaf Litter Toad) tadpole (total length ca. 3 cm) in a pool (length × width × depth = 62 × 30 × 8 cm) along a natural stream in secondary forest. The tadpole struggled and escaped after being held for 30 seconds, and we were unable to capture it. This sighting confirms that *O. kuatunensis* eats tadpoles in the wild. These two species are commonly sympatric in streams in Hong Kong, and it is likely that *L. liui* tadpoles are regular prey for *O. kuatunensis*. Although the natural diets of stream snakes in southern China are largely unknown, amphibians may be important prey here, as they are for stream-associated snakes in other regions of the world.

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OXYBELIS AENEUS **(Brown Vinesnake). MOVEMENTS AND FORAGING BEHAVIOR.** Monitoring movement patterns in vertebrates is a complex task, especially in secretive species such as snakes (Shine et al. 2006. Copeia 2006:103–115). Radiotelemetry has been used to better understand the ecology of snakes, but has seldom been applied to arboreal slender species or small terrestrial or fossorial species and many ecological aspects of these species are unknown (Madrid Sotelo and Balderas Valdivia 2008. Bol. Soc. Herpetol. Mex. 16:5–12). Here we use radiotelemetry to investigate movement patterns of seven female *O. aeneus* during the dry season in the tropical dry forest of Chamela, Jalisco, México. Additionally, we report observations of foraging behavior in the telemetered snakes.

Seven adult female *Oxybelis aeneus* were captured by hand in the first two weeks of April 2007 in the tropical dry forest around the Chamela Field Station. One radiotransmitter (< 5% of snake mass) model TXA-0061 (Telenax®, Mexico) was attached externally to the back of each individual (Madrid-Sotelo and García 2008. North-West J. Zool. 2:335–338) and the snakes were released at their capture location within 24 h. Between April and June snakes were relocated daily on an alternating morning (1000–1400 h) or afternoon (1600–1900 h) schedule and each snake's location was recorded using a handheld GPS (model Etrex, Garmin). Whenever possible, snake locations were verified visually and the habitat (tree, shrub, or soil) and approximate perch height was recorded. Activity area was estimated using the Movement Animal Extension in Arc View 3.2 (ESRI 1996). We also determined number of significant movements (those >10 m) and the mean movement distance travelled by each snake.

Activity areas were smaller than one hectare in most of the cases (Table 1) and movements were generally small; less than 20% were greater than 10 m. Similarly, the mean distance traveled was less than 30 m (Table 1). Most (88.2%) of all visualized snakes were in trees or shrubs 60 to 130 cm above the ground, whereas 5.9% were higher than 2 m and only 5.9% were located on the ground. On two occasions we observed snakes in their nocturnal perches in the typical rest, loose-coiled, head down

Table 1. Activity areas and movement characteristics of female *Oxybelis aeneus* in tropical dry forest of Chamela, Jalisco, México.

Individual identification	SVL (mm)	Number of relocations minimum convex polygon(ha)	Activity area — movements (>10 m)	Percentage of significant traveled (m)	Mean distance
Oa I	730	23	2.9	17.39	29.03
Oa II	900	26	1.47	12.5	7.22
Oa III	630	10	0.004	0	1.19
Oa IV	940	22	0.05	9.09	6.2
Oa V	790	21	0.49	14.28	9.69
Oa VI	800	26	0.2	11.53	9.32
Oa VII	860	22	0.05	9.09	6.94

position (Henderson 1974. Herpetologica 30:19–24). These snakes were located 85 and 178 cm above the ground within dense vegetation, which made observation difficult.

During this study there were several opportunities when it was possible to observe the foraging behavior of *O. aeneus*. A total of 20 foraging events was recorded, 17 (85%) towards *Aspidoscelis* spp., 2 (10%) towards *Anolis* spp. and 1 (5%) towards *Plestiodon parvulus*: only 3 (15%) all of these foraging events were successful, two for *Aspidoscelis* and one for *Plestiodon parvulus*. In all the observations the snakes used ambush foraging behaviors and active pursuit of prey was never observed.

Our results suggest that female *O. aeneus* have small, defined activity areas and move short distances; several times snakes were relocated in their previous relocation site. On the other hand, two individuals exhibited relatively larger activity areas (1.4 and 2.9 ha). This may be due to some unusual larger movements in which a snake moved outside of its habitual home range and soon returned. Such movements have been observed in female *Stegonotus cucullatus* which move outside of their habitual home range, apparently to oviposit in nesting sites, and then return to the areas usually occupied (Brown et al. 2005. J. Trop. Ecol. 21:605–612). In our case, however, we did not detect that any of the monitored females were gravid. Restricted movement by female *O. aeneus* during the dry season apparently minimizes wasted energy and may diminish risk of desiccation. In seasonal environments some snakes drastically increase movement patterns and home range during wet seasons, whereas others maintain similar patterns at both times of the year (Brown et al. 2002. J. Trop. Ecol. 18:549–568). It would be important to know if activity patterns of *O. aeneus* during the dry season are maintained during the rainy season.

The movement patterns and behavior that we observed suggest that *O. aeneus* is primarily a sit and wait predator. Similar patterns have been observed in other arboreal colubrids such as *Uromacer catesbyi* and *U. oxyrhynchus*, which spend about 95% of daylight hours relatively motionless, looking for active prey, and only descend to the ground to look for a new ambush site (Lillywhite and Henderson 1993. *In* Seigel and Collins [eds], Snakes: Ecology and Behavior, pp. 1–48. McGraw-Hill, Inc. New York). A similar pattern was also reported in vipers such as the Asian viper *Gloydius shedaoensis*, which is an extremely sedentary hunter. The home range in this species is 0.3 ha with daily movements of less than two meters (Shine et al. 2003. Oikos 2:342–352). Snakes using these foraging strategies have been defined by Greene (1997. Snakes: The Evolution of Mystery in Nature. University of California Press, Berkeley. 317 pp.) as mobile ambushers, that is to say, serpents that remain from days to months in the same site before moving to another place.

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OXYRHOPUS PETOLA DIGITALIS **(False Coral Snake). PREY.** Snakes of the genus *Oxyrhopus* feed on a wide variety of prey, but seem to be primarily predators of lizards and small mammals (e.g., Duellman 1978. Misc. Publ. Mus. Nat. Hist. Univ. Kansas 65:1–352; França et al. 2008. Copeia 2008:23–38; Vitt and Vangilder 1983. Amphibia-Reptilia 4:273–296). On 3 August 2007, at 1935 h, three of us (DV, MAG, CCS) found an adult female *Oxyrhopus petola digitalis* (SVL = 855 mm; tail length = 235 mm; 178 g) at the border of a forest fragment (22.445694°S, 42.764056°W, datum: SAD 69) near the Reserva Ecológica de Guapiaçu (REGUA) in the district of Guapiaçu, municipality of Cachoeiras de Macacu, state of Rio de Janeiro, Brazil. The snake was promptly captured and placed in a cloth bag. The next day, it had regurgitated a rodent (*Oligoryzomys nigripes*; 28.5 g) inside the bag (Fig. 1). The snake is currently housed at the reptile collection of the Museu Nacional, Rio de Janeiro (MNRJ 15370). The skin and skeleton of the rodent were deposited at the mammal collection of the same museum (MN 72716). Previous prey records for *O. p. digitalis* have included small mammals, lizards, and birds (Bernarde and Machado 2000. Herpetol. Rev. 31:247–248; Duellman, *op. cit.*; Palmuti et al. 2009. Biota Neotrop. 9:263–269; Rocha and Vrcibradic 1998. Cienc. Cult. 50:364–368). In most cases, mammalian prey have not been identified to species or genus, with the exception of Rocha and Vrcibradic (*op. cit.*) who provided the identity of the snake's prey as the rodent *Akodon cursor*. The present record adds another case of predation on mammals by *O. p. digitalis* and is the second in which the mammal prey was identified to species.

We thank Lena Geise for identifying the rodent species, IBAMA for issuing collection permit no. 13088-1, and Nicholas J. Locke of the Reserva Ecológica de Guapiaçu (REGUA) for making many facilities available during our fieldwork in that area. Fieldwork was funded by grants from Fundação Biodiversitas and RAN-ICMBio (0158A-012006), from the Conselho Nacional do Desenvolvimento Científico e Tecnológico - CNPq (Processes 307653/03-0 and 476684/2008-8) and from Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro – FAPERJ (Process E-26/102.404.2009) to CFDR. MAG and CCS received graduate fellowships from Conservation International do Brasil and CNPq, respectively.

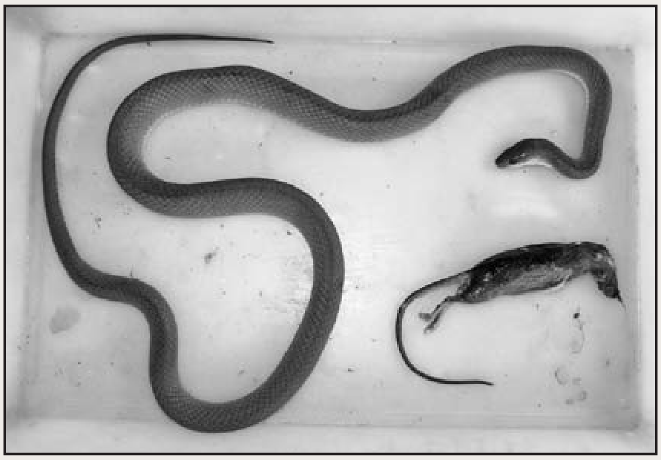

Fig. 1. Adult female *Oxyrhopus petola digitalis* and its recently regurgitated rodent prey (*Oligoryzomys nigripes*).

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PANTHEROPHIS BAIRDI **(Baird's Ratsnake). DIET AND FORAGING BEHAVIOR.** A *Pantherophis bairdi* was found inside a cave (La Sepultura) in the municipality of Cd. Victoria, Tamaulipas, México (23.7756667°N, 99.2288056°W, datum WGS84; elev. 597 m). The snake was found coiled 2 m above the ground along one of the walls of the cave attempting to catch bats of the species *Leptonycteris curasoae* (Fig. 1). Other species of bats found and identified in this cave included *Desmodus rotundus*, *Diphylla ecaudata*, and *Pteronotus parnelli*. Previous reports mention that *P. bairdi* preys on rats, mice, bats, birds, bird eggs, and lizards, without reference to specific species or families of each group (Schulz 1996. A Monograph of the Colubrid Snakes of the Genus *Elaphe* Fitzinger. Koeltz Scientific Books, Czech Republic. 439 pp.). Schulz (1996, *op. cit.*) mentions that caves are inhabited by several species of rat snakes at least temporarily. For example, *Pantherophis guttata*, *P. obsoleta*, and *Senticolis triaspis* were recorded from caves occupied by bats, which served as prey. Moreover, the only known *P. bairdi* record in this municipality was published in 2009, but referred to a specimen found by T. W. Walker in 1969 (Farr et al. 2009. Herpetol. Rev. 40:459–467). Thus, this record represents the second municipality record in a span of over 40 years. The snake and bats were not caught or collected and were identified photographically and with the help of Luis Canseco-Márquez and Arnulfo Moreno-Valdez, respectively. We also thank David Lazcano-Villarreal for revising the manuscript.

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PHOTO BY JOSÉ IVÁN CUMPIÁN-MEDELLÍN

FIG. 1. *Pantherophis bairdi* attempting to catch *Leptonycteris curasoae* in the cave La Sepultura, Tamaulipas, México.

PANTHEROPHIS SPILOIDES **(Gray Ratsnake). REPRODUCTIVE BEHAVIOR / ARBOREAL MALE COMBAT.** The goal of male combat in snakes is to establish dominance over an opponent through physical superiority (Gillingham 1987. *In* Seigel et al. [eds.], Snakes: Ecology and Evolutionary Biology, pp. 184–209. McGraw-Hill Publishing Co., New York). Male ratsnakes compete for mates by participating in dominance "combat dances" (Rigley 1971. J. Herpetol. 5:65–66; Stickel et al. 1980. Amer. Midl. Nat. 103:1–14); although the role of this behavior is not fully understood (Rigley, *op. cit.*). The arboreal habits of species in the *Pantherophis obsoleta* complex are also well documented (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press., Washington, D.C., 681 pp.), and arboreal mating has been noted in *P. o. obsoleta* (Padgett 1987. Catesbeiana 7:27–28), but to our knowledge, arboreal male combat has not been reported.

On 24 May 2006 at 1200 h, we observed a pair of free-ranging male *Pantherophis spiloides* engaged in arboreal combat on the Camp Shelby Joint Forces Training Center, Forrest Co., Mississippi, USA. The snakes were found entwined approximately 5 m above ground, hanging from a broken limb in a *Quercus marilandica* (Fig. 1). The smaller male (SVL = 141 cm, 612 g) continued to break contact and move up the tree, and was followed by

PHOTO BY T. M. DICKINSON

FIG. 1. Two adult male *Pantherophis spiloides* engaged in arboreal combat in Forrest Co., Mississippi, USA.

the larger male (SVL = 148.5 cm, 814 g). The larger male would continuously initiate contact and entwine with the smaller male along the tree branches attempting to press down the smaller male's head. At approximately 1235 h, the two snakes entered a decaying cavity of a limb and were unobservable. At 1239 h, the two snakes emerged from the cavity and began to move, entwined, towards the ground.

At approximately 1245 h, the two snakes reached the ground and continued in combat for 5 minutes until the smaller male retreated into nearby shrubbery without the larger male following. At this time, the snakes were collected for measurements and released at the point of capture the following day. A female *P. spiloides* was never observed to be present during this display or combat ritual. The behavior exhibited by both snakes was similar to the combat sequences described by Gillingham (1980. Herpetologica 36:120–127) for captive snakes.

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***PITUOPHIS MELANOLEUCUS LODINGI* (Black Pinesnake). REPRODUCTION and NEST LOCATION.** Our knowledge of *Pituophis melanoleucus* nesting ecology is primarily a result of intensive research conducted on a disjunct population of the nominate race, located at the northern limit of the species range (i.e., New Jersey Pine Barrens; Burger and Zappalorti 1986. Copeia 1986:116–121; Burger and Zappalorti 1991. J. Herpetol. 25:152–160). Although the first natural nest of *P. m. melanoleucus* outside of the Pine Barrens has recently been described (Beane and Pusser 2007. Herpetol. Rev. 38:469), information on nesting locations of the two more southerly distributed races remains anecdotal (i.e., *P. m. mugitus*: Franz 2005. *In* Meshaka, Jr. and Babbitt [eds.], Amphibians and Reptiles: Status and Conservation in Florida, pp. 120–131. Krieger Publ. Co., Malabar, Florida; Miller 2008. M.S. thesis, Univ. of Florida), or unknown (i.e., *P. m. lodingi*). In a note on *P. catenifer sayi* nesting, Iverson et al. (2007. Herpetol. Rev. 38:92) stated, "These data suggest that *P. melanoleucus* excavates its nest burrows, whereas *P. catenifer* uses natural cavities or burrows for oviposition; however, further data are needed for both species to determine the universality of this pattern." Herein we report a novel nesting location for *P. melanoleucus*, and provide, to our knowledge, the first published description of a natural nest of *P. m. lodingi*. The following observation took place in the southwestern portion of the Camp Shelby Joint Forces Training Center, Perry Co., Mississippi, USA.

On 3 September 2009, while searching the area around the last known location (i.e., burrow) of a telemetered *Gopherus polyphemus* (Gopher Tortoise), whose radio transmitter prematurely failed a month earlier, one of us (MGH) captured two hatchling *P. m. lodingi* which were basking on, or adjacent to, the apron of the tortoise burrow. On 4 September 2009, we revisited the site to excavate the burrow and immediately found a third hatchling *P. m. lodingi* tightly coiled and basking in the open, 6 m from the burrow's entrance. After taking some basic burrow measurements (i.e., width = 6.4 cm, height = 3.5 cm, angle of declination from the soil surface = 27°) following the methods of Doonan and Stout (1994. Am. Midl. Nat. 131:273–280), we excavated the burrow and located a clutch of six recently hatched eggs (cemented together in a single cluster) and two hatchling sheds at the burrows terminus (74 cm below the soil surface; measured to the bottom of the nest chamber). The straight line distance from the burrow's entrance to the terminus measured 161.9 cm; however, the total length of the burrow including turns (Doonan and Stout 1994, *op. cit.*) measured 188 cm. The chamber at the end of the burrow had a width of 14.5 cm and a height of 9 cm. The entire chamber and the last ~1/3 of the burrow were loosely packed with soil; however, a small tunnel (1.5 cm in diameter) extending from the chamber, presumably the route made by the exiting hatchling snakes, was observed. The tortoise was not found during the excavation, but was discovered 13 d later on the apron of a burrow that it had constructed previously.

The nest/burrow was located in a sandy area (McLaurin-Benndale soil series), with an open *Pinus palusrtis* (Longleaf Pine) canopy (canopy closure = 8%; estimated with a convex spherical crown densiometer), sparse mid-story (10%; visual estimate within 10 m^2), moderate *Andropogon* sp. (bluestem) dominated understory (60%; visual estimate within 10 m^2), and was in close proximity to a road (45 m); which are similar habitat characteristics reported for *P. m. melanoleucus* nests elsewhere (Burger and Zappalorti 1986, *op. cit.*; Burger and Zappalorti 1991, *op. cit.*; Beane and Pusser 2007, *op. cit.*). Interestingly, the depth of the nest reported here (74 cm), is nearly twice as deep as the nest found in North Carolina (41 cm; Beane and Pusser 2007, *op. cit.*), and three times deeper than those found in New Jersey (≤ 25 cm; N = 93; Burger and Zappalorti 1991, *op. cit.*). Although researchers have noted that *P. m. lodingi* infrequently utilize tortoise burrows as retreat sites (Baxley and Qualls 2009. J. Herpetol. 43:284–293; J. Lee, unpubl. data), this microhabitat likely plays an important role in the reproductive ecology of the Black Pinesnake, and may provide a suitable microclimate for the incubation of *Pituophis* eggs in warm climate areas (e.g., the southeastern portion of the species range).

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***PITUOPHIS MELANOLEUCUS MUGITIS* (Florida Pinesnake). PREDATION.** On 22 June 2007, at ca. 1130 h, one of us (TWT) observed a *Pituophis melanoleucus* (ca. 1.2 m total length) crossing a dirt road bisecting a tract of mature Longleaf Pine (*Pinus palustris*) forest on the Joseph W. Jones Ecological Research Center at Ichauway Plantation, Baker Co., Georgia, USA (31.210946°N, 84.445900°W; datum WGS84). The snake moved from the road into a briar thicket. Approximately 90 min later a bird-of-prey believed to be either a *Buteo jamaicensis* (Red-tailed Hawk) or *B. lineatus* (Red-shouldered Hawk) was startled from the brush and was seen carrying what appeared to be a dead *P. melanoleucus* (ca. 1.2 m total length) in its talons as it crossed the road approximately 50 m west of where the snake was sighted previously. Both

Red-shouldered and Red-tailed Hawks are present on Ichauway and are known to include snakes in their diet (Crocoll 1994. *In* A. Poole [ed.], The Birds of North America Online. Cornell Laboratory of Ornithology, New York; Preston and Beane 1993. *In* A. Poole and F. Gill [eds.], The Birds of North America.The American Ornithologists' Union, Washington, DC). Although Red-tailed Hawks prey heavily on *P. catenifer* (Gophersnake) in the western United States (Fitch et al. 1946. Condor 48:205–237; Grothe 1992. Red-tailed Hawk Predation on Snakes: The Effects of Weather and Snake Activity. M.S. thesis. Idaho State University. 103 pp.), birds of prey are not listed among predators of *P. melanoleucus* (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Books, Washington D.C. 668 pp.; Gibbons and Dorcas 2005. Snakes of the Southeast. Univ. Georgia Press, Athens. 253 pp.). To the best of our knowledge, this observation represents the first documentation of *P. melanoleucus* being depredated by a hawk.

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***PSOMOPHIS JOBERTI* (NCN). REPRODUCTION.** *Psomophis joberti* is a small species distributed in Brazil, Paraguay, and Bolivia. Despite its wide geographic distribution in South America, information on the ecology of this secretive species is limited to anecdotal reports on diet (Strüssman and Sazima 1993. Stud. Neotrop. Fauna Environ. 28:157–168) and behavior (Lima et al. 2010. Herpetol. Rev. 41:96–97). Herein, we present information on clutch size and reproductive investment for this species.

On 13 November 2009, we collected an adult female *P. joberti* (SVL = 388 mm; 11.0 g after egg removal) road-killed near Pentecoste Municipality, Ceará, Brazil (3.82145°S, 39.33824°W, datum: WGS84). Upon dissection, we found seven oviductal eggs (largest egg length = 14.2 mm; total eggs mass = 6.2 g). The relative clutch mass (total clutch mass / female mass without eggs) was high (approximately 0.56) representing an exceptionally high reproductive investment, especially considering that the eggs were not fully developed. To our knowledge, this is the first report on reproduction and clutch size for *P. joberti*. The snake is deposited in the herpetological collection of Universidade Federal do Ceará (CHUFC 3421).

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***PYTHON MOLURUS BIVITTATUS* (Burmese Python). REPRODUCING POPULATION.** The population of introduced *P. m. bivittatus* in Everglades National Park (ENP), Florida, USA is growing rapidly (Snow et al. 2007. *In* Henderson and Powell [eds.], Biology of the Boas and Pythons, pp. 416–438. Eagle Mountain Publishing, Utah). This growth has raised concerns about geographic expansion and the establishment of new populations. In areas of southern Florida outside of the core of the introduced range, large individuals are increasingly being noted in the popular news media. However, smaller individuals seem to be encountered much less frequently in the invasion periphery. Because the probability is arguably low that very young pythons found in wild areas are released/escaped from captivity, any such observations would suggest that reproduction was taking place at those locations.

At 0420 h local time on 26 July 2009, I discovered a male hatchling *P. m. bivittatus* (total length = 599 mm; tail length = 90 mm; 122 g, conspicuous umbilical scar, no gastric or cloacal contents externally palpable) dead on the road surface of Tamiami Trail (U.S. Highway 41) in Collier Co., Florida, USA. At this location (25.98723°N, 81.57438°W, datum: WGS84), the road is within the boundaries of Collier-Seminole State Park (CSSP). The snake had been hit once on the head while crossing from north to south. Based on the low level of traffic at that hour, I estimate it was killed no more than 1 h earlier. The roadside vegetation included palms, dense shrubs, and grasses. The habitat to the south was estuarine tidal marsh. A small brackish canal with mangroves runs along the north side of the road. Beyond the canal was freshwater marl prairie, with wet flatwoods 200 m further north. With regard to possible egg incubation sites, the nearest microhabitats not permanently or seasonally inundated were the road embankment itself, and a patch of scrubby flatwoods about 500 m to the NW. Night drives through this area over the following three nights yielded no additional specimens. The whole specimen, a tissue sample, and a photo voucher (image provided by R. W. Snow) are deposited in the Florida Museum of Natural History (UF 155674; species identity verified by K. E. Krysko).

This record represents the first direct evidence of *P. m. bivittatus* reproduction in Collier Co., Florida; previous Florida records of reproductive females, eggs, or hatchlings are from either Miami-Dade or Monroe counties (Snow et al. 2007. Herpetol Rev 38:93; Brien et al. 2007. Herpetol Rev 38:342–343; Krysko et al. 2008. Applied Herpetol. 5:93–95). If, as seems likely, this snake hatched in the wild, there are at least three possible interpretations of the population status of *P. m. bivittatus* in Collier Co.: 1) this record represents the first instance of successful reproduction; 2) reproduction is irregular (e.g., only in years with particular weather conditions), only in scattered locations, or occurs at very low frequency; or 3) reproduction is occurring frequently, but small pythons have an extremely low detectability. Interpretation 1 is unlikely, but cannot be discounted; if this is indeed the first instance, then land managers may start encountering juvenile pythons in Collier Co. As for interpretation 2, I independently queried two staff members at CSSP in 2008 about python sightings in that park; both agreed that between six and ten large (> 2.5 m total length) pythons had been seen in CSSP in the preceding 5–6 years, but no smaller pythons had been found. Even if the previous apparent absence of hatchlings was attributable to lack of road surveys, the lack of larger juveniles (1.0–2.4 m) suggests that pythons have not been regularly reproducing in CSSP heretofore. Regarding interpretation 3, *P. m. bivittatus* hatchlings are the same size as many native snakes. In 11 nights of driving the roads (1995 miles, 55.5 h) of Collier Co. from 02–09 August 2008 and 21–29 July 2009, I encountered the single hatchling python and at least 59 native snakes on the road. For comparison, I was systematically roadcruising in ENP during these same two time periods and observed five hatchling pythons and 102 native snakes in six nights of driving (1820 miles, 49.5 h). These comparative observations suggest that small pythons on roads are detectable, and further, indicate that the frequency of reproduction in Collier Co. is much lower than in ENP. Although future work is needed to determine factors that influence detectability of hatchling pythons, systematic road cruising on summer nights might be a useful method for assessing the reproductive status of *P. m. bivittatus* populations.

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***PYTHON SEBAE* (Northern African Python or African Rock Python). SIZE.** *Python sebae* is the largest snake in Africa, and one of the largest in the world. As with most giant snakes, *P. sebae* exhibits female-biased sexual size dimorphism. Although there are numerous claims about overall maximum size for this species (Murphy and Henderson 1997. Tales of Giant Snakes. Krieger Publ. Co., Malabar, Florida. 221 pp.), the largest individuals are likely females. Literature reviews suggest males attain maximum sizes of about 4 m total length and 30–40 kg (Reed and Rodda 2009. Giant Constrictors: Biological and Management Profiles and an Establishment Risk Assessment for Nine Large Species of Pythons, Anacondas, and the Boa Constrictor. U.S. Geological Survey Open-File Report 2009-1202, and references therein). Herein, we report on the largest known male *P. sebae* from an introduced population in Florida, possibly representing a new male size record for the entire species.

In response to a series of observations of *Python sebae* in the Bird Drive Basin area of western Miami (Miami-Dade Co., Florida, USA; Reed et al. 2010. IRCF Reptiles and Amphibians 17:52–54), an organized search for pythons was conducted during 12–14 January 2010; coincidentally, the search occurred just after a record prolonged cold snap in southern Florida during the first 11 days of January 2010. On 12 January 2010 at 1428 h (approx. 15°C ambient air temperature, with NNW winds at 15 kph), a male python was captured on a canal bank (25.7551°N, 80.4708°W, datum WGS84) by J. Dozier, D. Hazelton, and J. Prieto. The python was sluggish after a night during which temperatures in Miami dropped to 4.9°C, but later became active enough to partially escape from a bag that was not sufficient to fully contain it. The python exhibited no evidence of respiratory infection or other illness during initial examination, and was then euthanized. Body size was as follows: total length = 440 cm, SVL = 405 cm, maximal girth = 59 cm, 62.96 kg. The python was male, confirmed by voluntary eversion of hemipenes during capture, enlarged pelvic spurs, and observation of testes during necropsy. The skeleton, skin, and tissues from this specimen were accessioned into the Florida Museum of Natural History (UF 157217). Another large (total length = 376 cm, SVL = 336 cm, 32.9 kg) male was captured nearby during 12–14 January 2010, as were three adult females (total lengths 297–400 cm).

The larger male *Python sebae* is notable not only for its length, but also for its mass; despite being captured during winter when feeding is likely uncommon, the python was in excellent body condition (9.25 kg of fat bodies were recovered from the carcass), as were most of the four other pythons. Although larger individual *P. sebae* are known from the native range, most are confirmed or suspected to be female. Observations in Florida lend support to the proposal that sexual size dimorphism might be reduced in *P. sebae* as compared to *P. molurus* and other giant constrictors (Reed and Rodda 2009, *op. cit.*).

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***RINECHIS SCALARIS* (Ladder Snake). MAXIMUM SIZE.** *Rinechis scalaris* is a large colubrid that inhabits most of the Iberian Peninsula, southeastern France, and areas of northwestern Italy (Arnold and Ovenden 2002. Field Guide to the Reptiles and Amphibians of Britain and Europe. Collins, London. 288 pp.). The maximum size previously recorded for the species was a 1570 mm total length (TL) female (Cheylan and Guillaume 1993. *In* Böhme [ed.], Handbuch der Reptilien und Amphibien Europas. Band 3/I: Schlangen [Serpentes] I [Typhlopidae, Boidae, Colubridae 1: Colubrinae], pp. 397–429. Aula-Verlag, Wiesbaden). However, that record was from an insular population that is known to contain an unusually high proportion of large individuals, reflecting a lack of large predators. In southwestern Spain, maximum SVL recorded was 1385 mm, with a mean tail length of 15.5% (Pleguezuelos 2006. *In* Carrascal and Salvador [eds.], Enciclopedia Virtual de los Vertebrados Españoles. Museo Nacional de Ciencias Naturales. Madrid). Generally, specimens greater than 1200 mm TL are rare (Arnold and Ovenden, *op. cit.*) and sexual size dimorphism has not been reported (Pleguezuelos, *op. cit.*).

On 20 September 2007, a male *R. scalaris* was received at the Centro de Rescate de Anfibios y Reptiles (Alcalá la Real, Spain). Measurements were: TL = 1650 mm (tail slightly incomplete); SVL = 1410 mm (measured using ImageJ images analysis software). The specimen was found in a building site on the outskirts of a medium-size village (37.46°N, 3.93°W, datum: ED50; elev. 1000 m), surrounded both by forest and agricultural landscape. High densities of large prey favored by male *R. scalaris* (e.g., *Rattus* sp.) can be found in this habitat (Palomo and Gisbert 2002. Atlas de los Mamíferos Terrestres de España. Dirección General de Conservación de la Naturaleza-SECEM-SECEMU, Madrid. 564 pp.), even though this species seldom uses urban areas (Pleguezuelos, *op. cit.*).

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SALVADORA HEXALEPIS DESERTICOLA **(Big Bend Patch-nosed Snake). DIET AND PREDATION.** Witnessing tritrophic interactions among vertebrates is rare. One mechanism for such an event is that a predator is vulnerable while ingesting a prey item, presenting an opportunity for a second predator. Because snakes must swallow prey whole, they are especially vulnerable to predation while subduing and ingesting prey. For example, anacondas are vulnerable to predators during and after ingesting prey and often tighten their hold on prey when approached while feeding (Murphy and Henderson 1997. Tales of Giant Snakes: A Historical Natural History of Anacondas and Pythons. Krieger Publ. Co., Malabar, Florida. 221 pp.). Here we report a tritrophic interaction involving a *Geococcyx californianus* (Greater Roadrunner), a *Salvadora hexalepis deserticola*, and an *Aspidoscelis tesselata* (Common Checkered Whiptail).

Lizards are the primary prey of *Salvadora*, but few dietary data exist. Painter (1985. Herpetology of the Gila and San Francisco River Drainages of Southwestern New Mexico. Unpubl. report, New Mexico Game and Fish, Santa Fe. 333 pp.) and Degenhardt et al. (1996. Amphibians and Reptiles of New Mexico. Univ. New Mexico Press, Albuquerque, New Mexico, 431 pp.) reported that *S. h. deserticola* feeds on lizards, reptile eggs, small mammals, and grasshoppers. Greater Roadrunners are known to prey on snakes such as *Micruroides euryxanthus*, *Crotalus atrox*, and *Pituophis catenifer* (Sherbrooke and Westphal 2006. Southwest. Nat. 51:41–47). To our knowledge, this is the first report of *S. hexalepis* preying on *A. tesselata*, and the first report of a Greater Roadrunner preying on *S. hexalepis*.

On 3 May 2009 at ca. 0930 h, we were driving along Aguirre Springs Road in the Organ Mountains, Doña Ana Co., New Mexico, USA (32.411924°N, 106.547928°W, datum: WGS84; elev. 1524 m) when we observed a Greater Roadrunner that had captured a *S. h. deserticola*. The roadrunner was startled by our vehicles, dropped the snake on the road, and ran away before it could be photographed. The abandoned snake appeared uninjured and had an adult *A. tesselata* in its mouth. The snake was gripping the whiptail laterally by the torso and immediately dropped the lizard when we picked it up. Although neither predatory attack was observed, we presume that the roadrunner attacked the snake after the snake had captured the lizard. The released *A. tesselata* was sluggish, did not attempt to escape from our hands when picked up, and died within 5 min. Although its behavior suggested injury, there were no visible puncture wounds, but a small amount of blood was present on the torso; thus, we were unable to ascertain if the blood came from the lizard or the snake. Prey is seized and chewed by *S. h. deserticola* (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Institution Press, Washington, D.C. 680 pp.).

This event occurred during an educational field trip sponsored by the National Science Foundation GK-12 Ecohydrology of the Middle Rio Grande Environment (E-MRGE) fellowship program at the University of New Mexico. Eight 7th grade students from Belen Middle School witnessed this real-life example of complex foodweb interactions in a desert ecosystem. We thank GK-12 fellows J. Snider and T. Salem and PIs S. Collins and L. Crossey for encouraging the development of the Belen Outdoor Education Program. We thank M. Ryan for his valuable comments on the manuscript and I. Latella for providing relevant literature resources.

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SINONATRIX PERCARINATA SURIKI **(White-bellied Water-snake). DIET.** In Taiwan, *Sinonatrix percarinata suriki* primarily preys on frogs (e.g., *Fejervarya limnocharis* and *Rana longicrus*), and fishes (e.g., *Channa asiatic*, *Misgurnus anguillicaudatus*; Mao 2003. Population Ecology of Genus *Sinonatrix* in Taiwan. Doctoral dissertation, Trier University, Germany. 157 pp.). At 2245 h on 1 September 2007, during a routine survey of a *S. p. suriki* population in a hydrophytic pond of Fushan Botanical Garden, Ilan County, northern Taiwan (24.75975°N, 121.58367°E, datum: TWD97; elev. 665 m), a female *S. p. suriki* (total length = 489 mm; tail length = 115 mm) was observed moving among the leaves of a Taiwanese Yellow Pond Lily (*Nuphar shimadai*). The snake had an obviously enlarged mid-body and was forced to regurgitate a partially digested *Babina adenopleura* (Olive Frog; SVL = 47 mm; 6.6 g), which had been ingested vent-first. The snake was then released at its capture location.

Babina adenopleura is a fairly common anuran in mountainous wetlands (e.g., lakes, ponds, and pools) of northeast Taiwan from 300–2000 m elevation. Its tadpoles are the largest of the 31 native anuran species of Taiwan and have been observed to coexist with some *S. p. suriki* populations in Ilan County. Previously, a male *S. p. suriki* was observed preying on a tadpole of *B. adenopleura* in Mystries Lake, Ilan County, Tiawan (Mao, unpubl. data). However, to our knowledge, this is the first published report of *S. p. suriki* utilizing the adult frogs or tadpoles of *B. adenopleura* as food resources.

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TAENIOPHALLUS AFFINIS **(NCN). DEFENSIVE BEHAVIOR.** *Taeniophallus affinis* is a snake in the family Dipsadidae that is found in leaf litter in forested areas of southeastern and southern Brazil. Studies of the natural history of this species are lacking, and its defensive behavior is poorly documented. There are several defensive tactics used by snakes (Greene 1988. *In* Gans and Huey [eds.], Biology of the Reptilia, 16, pp. 1–152. Alan R. Liss, New York), and eversion of hemipenes has been observed in many species. Sazima and Abe (1991. Stud. Neotr. Fauna Environ. 26:159–164) observed this tactic in *Micrurus frontalis* from Minas Gerais, Brazil, and Martins (1996. *In* K. Del Claro [ed.], Anais XIV Encontro Anual de Etologia, pp. 185–199. Sociedade Brasileira de Etologia, Uberlândia, Brazil) reported it in *Erythrolamprus aesculapii* and *Imantodes cenchoa* from the Central Amazon. We observed an everted hemipenis in a specimen of *T. affinis* (SVL = 502 mm; tail length = 141 mm; 48.0 g) collected from a pitfall trap in the Parque Natural Municipal de Sertão (28.0456°S, 52.2141°W, datum: WGS84; elev. 670 m), Rio Grande do Sul, Brazil. The individual everted its hemipenis after being manipulated for photographs. This specimen was deposited in the Coleção de Répteis da Universidade de Passo Fundo (CRUPF 1698).

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***THAMNOPHIS CYRTOPSIS* (Black-necked Gartersnake). REPRODUCTION / AUTUMN COURTSHIP.** Male *Thamnophis cyrtopsis* are thought to follow a postnuptial pattern of reproduction, with males reaching maximum testicular weight and peak rate of spermiogenesis in autumn, prior to winter brumation (Goldberg 1998. Texas J. Sci. 50:229–234). However, females enter winter brumation with small, previtellogenic follicles and undergo secondary vitellogenesis and ovulation in spring, following emergence (Goldberg 1998, *op. cit.*). It is assumed that most breeding takes place in spring, but based on the male spermiogenic cycle in Arizona there is a possibility that some autumn breeding may occur (Goldberg 1998, *op. cit.*). The purpose of this note is to report an instance of courtship and suspected autumn copulation in *T. cyrtopsis*.

At Chimenea Canyon, Saguaro National Park (Pima Co., Arizona, USA; 32.15285°N, 110.60906°W; datum: NAD83; elev. 1033 m) on 19 November 2005, at 1124 h, one of us (EWS) encountered a pair of adult *T. cyrtopsis* engaged in courtship (Fig. 1). Both snakes were of similar size, estimated to be between 55–70 cm total length. The snakes were loosely intertwined in a circle on a substrate of coarse sand and leaf litter, ca. 2 m from a small (1 m^2), shallow (< 30 cm) pool in partial shade. One snake's tail was held to the side, with the other's wrapped alongside and around it in classic copulatory posture. The anterior 75% of each snake's body was still, while the posterior of one snake's tail made several quivering motions over 5–10 sec., leading us to suspect that copulation was occurring. However, no post-cloaca bulge was observed so we cannot conclude that intromission occurred. The snakes were aware of the observer's presence, who watched for 8–10 min. When an attempt was made to capture the snakes for measuring and to confirm sex, they quickly escaped under a large boulder < 0.5 m away. The shaded ambient temperature was 22.5°C, substrate temperature was 27.0°C, and overnight low temperature the previous night was ca. 10°C.

Our observation appears to be the first evidence that *T. cyrtopsis* in southeastern Arizona engages in courtship behaviors in the fall, which may place it among *T. atratus*, *T. ordinoides*, and *T. sirtalis* for which autumn breeding has been reported (Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. Oklahoma Press, Norman. 332 pp.).

FIG 1. Two *Thamnophis cyrtopsis* engaged in suspected copulation at Saguaro National Park, Arizona, USA, on 19 November 2005.

We thank Steven Goldberg for providing constructive comments on the manuscript.

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***THAMNOPHIS SIRTALIS PARIETALIS* (Red-sided Gartersnake). GIGANTIC SIZE.** *Thamnophis sirtalis parietalis* is a wide-ranging snake that provides a good model for understanding how growth rates and biological variables are expressed in reptiles across a range of geographic conditions (Aleksiuk and Stewart 1971. Ecology 52:485–490; O'Donnell et al. 2004. Behav. Ecol. Sociobiol. 56:413–419). Here we describe the presence of gigantic *T. s. parietalis* at the northern limit of their range in Manitoba, Canada. Of the 514 snakes captured between April 2005 and October 2006 near Jenpeg, Manitoba (54.3321°N, 98.3161°W; datum WGS 84), three individuals exceeded the previous length record of 1241 mm (Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America, 3rd ed. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.). The length of the longest individual was 1340 mm total length (SVL = 1060 mm, 435 g). To determine the approximate age of one large female (total length = 1275 mm, SVL = 1020 mm), a tail tip was analyzed using skeletochronology (Waye and Gregory 1998. Can J. Zool. 76:288–294). Although the analysis was not conclusive, it appeared that this individual was approximately 11 ± 1 years old.

Recent research on latitudinal body size variation in snakes has pointed to a number of factors that might influence growth rates and total length (Olalla-Tárragal et al. 2006. J. Biogeog. 33:781–793). Although latitudinal body size trends in snakes are still poorly understood, hibernation survival has been implicated as a strong selective pressure driving gigantism in northern snakes (Ashton 2001. Evolution 52:2523–2533). Snakes that can attain larger sizes have a higher likelihood of surviving the extended periods of hibernation required in northern Manitoba (Gregory 1982. *In* Gans and Pough [eds.], Biology of Reptilia, Vol. 13, pp. 53–154. Academic Press, New York).

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***XENODON HISTRICUS* (Rayed or Jan's Hog-nosed Snake). REPRODUCTION.** On 3 November 1962, R. Praderi collected a female *Xenodon histricus* (MNHN 1044; SVL = 310 mm; tail length = 40 mm) at Estancia de Patrón, near Salto Penitente, Dpto. Lavalleja, Uruguay (34.3333°S, 55.1166°W, datum Yacare). We found five eggs in the left oviduct. Mean egg length was 10.17 mm (range: 9.58–11.82 mm). These are the first reproductive data for *X. histricus*, which is seldom encountered throughout its range. The collection date suggests that this species has similar reproductive phenology as other reptile species in the region.

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BOOK REVIEWS

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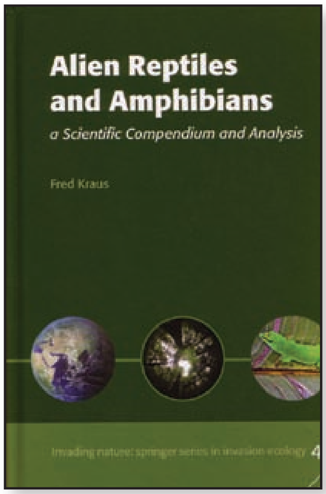
Alien Reptiles and Amphibians: A Scientific Compendium and Analysis

By Fred Kraus. 2009. Springer Verlag (www.springer.com). Hardcover. x + 563 pp. + CD-ROM. US $169. ISBN 978-1-4020-8945-9.



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Invasive species are increasingly recognized as one of the leading threats to global biodiversity. The field has grown complex enough to deserve its own journal (*Biological Invasions*) and encyclopedia (Simberloff and Rejmánek 2011), but the lion's share of attention has been paid to a few groups of organisms, such as rodents, plants, and ballast-water contaminants. While a few species of introduced reptiles and amphibians and certain geographic areas (Florida, Hawaii) have received research attention, most herp introductions have been largely ignored by the herpetological community. Instead, available knowledge of the great majority of herp introductions is scattered throughout a vast body of literature, often as short notes or as minor addenda to papers on tangentially related topics. In this volume, Fred Kraus offers the definitive literature-based treatment of the subject. Lever (2003) was the first to attempt a summary of herpetofaunal introductions, but Kraus goes far beyond Lever on both conceptual and taxonomic grounds, while correcting a number of errors in Lever's summary. For those desiring a general overview of his conclusions but not willing to suffer through this review, Kraus (2010) is brief and accessible.

A prodigious amount of data is shoehorned into the book, and is summarized with prose that is clear and readable. In fact, my overall impression is that this is a great book to read if one has a perverse desire to feel that, comparatively speaking, one's own scholarship is mediocre. I will present relevant statistics first, because an understanding of the volume of literature-based support behind the text will be an important factor for those deciding whether to purchase the book. The five written chapters sum to only 131 pages, but as noted below these five chapters are meaty and deserving of careful reading—they are also profusely illustrated with pertinent figures and graphs (Chapter 2, Introduction Patterns, alone includes 36 figures). These chapters are followed by two appendices of herpetofaunal introductions, with records dating back to 1850. If there's a bigger table than Kraus' Database of Introduction Records (Table A.1) in the herpetological literature, I'd like to see it—the table spans 220 pages. It is followed by a shorter table of erroneous and uncertain introduction claims. The Literature Cited is also massive, covering 167 pages despite a small font size. The sheer size of the tables would make data extraction by the reader a plodding exercise were not an accompanying CD included with the volume, containing a MS Excel file version of the database of 5,745 introductions. The file can be sorted, allowing readers to quickly extract data corresponding to their taxonomic or geographic interests.

Editorial oversight of the book was very good; I noticed only a few minor errors (e.g., p. 3, l. 22, 'than' should be 'that'; p. 60, l. 26, 'on' should be 'of', p. 87, l. 17, 'It's' should be 'Its', p. 32, Table 2.2, 'Teidae' should be 'Teiidae'). The binding has held up to repeated consultations of the text and tables over the last few months, although I did not subject it to the more rigorous Crombie Binding Test (Crombie 1992). I found an important indexing error on p. 557 of the Geographic Index—no entries past p. 217 of the text are indexed for the state of Florida, despite the fact that >80% of the entries for that state are found past this page. Spot-checks for other geographic areas did not reveal this error to be systemic, and the ability to sort the electronic database on the CD should obviate this issue.

Chapter 1 (*Background to invasive reptiles and amphibians*) is a concise introduction to invasive species concepts, including the gamut of processes from transportation and establishment through spread and impacts, as well as a concise history of research on invasive herps. This chapter would serve admirably as part of the introductory readings for a course on invasion biology, regardless of the conceptual or taxonomic interest of the reader. By page 5, Kraus has already considered and dispensed with the notions that invasive species are beneficial because they increase biodiversity, and that human-caused movement of animals is a 'natural' process. I found Kraus' argument that loss of beauty is an underappreciated but vital aspect of exotic species introductions to be the most riveting part of the chapter. Policy-makers often stress economic or ecological impacts; while Kraus discusses these in depth, he also offers the following: "I suggest that the distinctive co-evolved, unique beauty of (natural ecological) systems is besmirched by the introduction of alien species—much as a beautiful beach or coastline may be impaired by an oil spill. Or perhaps more aptly, the facile pollution of these self-generated biotas by human introductions is equivalent to splattering the canvases in the Louvre with day-glo paint; the structural integrity of the canvases may not be marred, the added colors may be beautiful, but the aesthetic integrity of the artworks is thoroughly violated. The difference, of course is that the impact of an oil spill lasts for mere years, vandalization of a painting may be rectified by careful restoration, but alien invasions are most usually irreversible and irreparable."

Chapter 2 presents introduction patterns for herps. Before 1950, introductions were largely intentional and associated with food and biocontrol pathways, but in later decades the primary pathway switched to the pet trade and the rate of introductions increased exponentially. Kraus calculated this exponential equation and concluded that the number of introductions via the pet trade pathway has been doubling every 15.3 years for the last 10 decades. In terms of established species, the pet trade again leads the way, but release pathways including cargo, intentional releases, the nursery trade, human food source, and biocontrol have been important contributors to the sum total. It is unsurprising that Europe and North America have been the recipients of the most introductions since these regions are the primary consumers of wildlife as pets, but some readers will be discomfited by the U.S. contribution to introductions elsewhere—for example, Kraus reports >1400 records of Red-eared Slider (*Trachemys scripta*) introductions worldwide. Kraus considers the pet trade pathway as intentional introductions, because, "…the importation was intentional and because the consequence of irresponsible ownership of animals will be the frequent and predictable escape of the deliberately imported pets." Researchers do not escape scot-free in this analysis; Kraus presents multiple examples of intentional introductions for scientific purposes, with varying levels of justification for conducting the release. This pathway is important for some taxa, as nearly 40% of all salamander releases were deliberate in nature and associated with research (and >80% of these releases were done by a single researcher!).

While Kraus does a good job of discussing regional (availability of knowledgeable reporters) and climatic (e.g., rates of establishment are lower in Europe than in the U.S.) contributions to reporting bias in herp introductions in Chapter 2, I would have preferred a more direct discussion of taxonomic and perceptual biases. Large (e.g., pythons, crocodilians) or otherwise distinctive (e.g., chameleons) species are much more likely to be noticed and reported than are small, drab, or highly secretive species. This undoubtedly leads to biased interpretations of establishment success—because introductions of small species are less frequently observed, their perceived rate of establishment (no. established populations/ no. introductions) is often high, but in reality the disparity in establishment success between obvious and less-obvious taxa may not be particularly striking. Failure to recognize the potential of taxonomic bias can have policy implications: representatives of the pet trade have used Kraus' calculation of low establishment success for the families Boidae and Pythonidae (they rank second to last and last, respectively, in his tabulation across herpetofaunal families) as 'proof' that large-bodied snakes represent low risk as invaders and therefore that regulatory efforts to reduce the odds of establishment are unnecessary.

Chapter 3 reviews impacts of introduced herps. Some authors have stated that herps tend to pose little threat as introduced species, which has tended to dampen researcher interest in documenting impacts that are assumed *a priori* to be minimal. Based on the few studies that have specifically examined deleterious impacts of introduced herps, Kraus reports that impacts have actually been recorded for a wide range of species. In Florida, for example, negative impacts of introduced herps have been demonstrated for virtually every species that has received research attention, although admittedly this conclusion is influenced by the fact that species that first receive research attention tend to be those that are most feared to have negative impacts. Looking farther abroad, most ecologists are familiar with the avifaunal devastation wrought by the Brown Treesnake (*Boiga irregularis*) on Guam, but may not be aware that, for example, Green Anoles (*Anolis carolinensis*) have caused the decline or extirpation of large numbers of insect species on Japanese islands or that Bullfrogs (*Lithobates catesbeiana*) have been implicated in the decline of a variety of vertebrate taxa at sites all over the globe. These are examples found under only one header (Removal of Native Prey Species) in the chapter; Kraus subsequently reviews ecological impacts including loss of native predators, changes in ecosystem dynamics, competition with natives, vectoring novel pathogens (e.g., chytridiomycosis), and community homogenization. He also examines evolutionary and social impacts, including scientific loss of knowledge based on confusion about native ranges, evolutionary status, or ecological relationships. Kraus ends by saying that 26 herp species can be credibly implicated in impacts on native wildlife or humans, but that such a relatively low number can likely be ascribed to inattention to impacts and the difficulty of demonstrating such impacts.

It is telling that Chapter 4 (*Management Responses*) is the shortest chapter in the book, as delays in recognizing the potential impacts and scale of herp introductions has curtailed interest in developing such responses among stakeholders, and availability of funding for such endeavors remains anemic as compared to better-known invaders such as mammals, plants, and ballast-water contaminants. Kraus reviews the three legs of the management tripod for exotic species—prevention, early detection, and rapid response, and management of well-established pests. In most countries, prevention of new introductions via regulatory or incentivized means is uncommon, and typically reactive rather than proactive; in other words, importation or ownership bans are enacted only after a species proves pestiferous, thus closing the barn door after the horses have fled. This tendency to consider only some members of taxonomic groups for regulatory action allows the live-animal industry to make compensatory switches after taxon-specific bans, such as was seen when turtle exporters in the United States switched from Red-eared Sliders to Painted Turtles (*Chrysemys picta*) after importation of sliders was prohibited by the European Union (ironically, the painted turtle has a climate match with larger portions of the E.U. than does the slider).

Kraus summarizes the few successes in eradicating invasive amphibians at a local scale (usually single ponds or drainages), but he could find no examples of a successful eradication of an established reptile population anywhere in the world. While Chapter 4 gives the specific details to back up this depressing statistic, the issue is most lyrically summarized in Chapter 1: "A second generality of extremely practical importance is that alien-species naturalizations are usually irreversible. In most instances, once introductions have been allowed to establish, no amount of money or effort can change the situation—much as is widely recognized for other lamentable and irreversible developments such as death, amputation, or the invention of disco music."

Because eradication of well-established populations has such a dismal record of success, Kraus next discusses long-term control. He largely focuses on the interdiction program for Brown Treesnakes (*Boiga irregularis*) on Guam, which aims to prevent the snake from reaching other areas, such as Hawaii, that are at risk of colonization by unintentional human transport of snakes. While this program has been successful in achieving its goals, it illustrates uncomfortable truths about the financial cost of long-term control and long timelines for research needed to develop effective control tools. The chapter ends with a discussion of limitations on our ability to manage introduced herps, focusing first on biology-related drivers (crypsis, high reproductive rates, and high population densities), then moving to social obstacles (disbelief in the magnitude of the problem, widespread intentional releases, etc.) and a general lack of commitment to developing adequate tools for the job. Taking the chapter as a whole, the take-home message is that reducing the rate of future invasions must be heavily reliant on prevention programs.

The final chapter (*Implications for Policy and Research*) offers a concise roadmap for those interested in developing solutions from a regulatory standpoint as well as researchers interested in fleshing out our limited scientific understanding of an increasing problem. Kraus presents a scathing indictment of regulatory structures and regulatory timidity in the United States and the European Union (the primary consumers of imported reptiles). Especially striking is the comparison of New Zealand with the U.S.; the former country has a single agency charged with preventing and managing exotic species, and this agency employs the precautionary principle when screening potential imports. Meanwhile, 36 to 40 federal agencies (and orders of magnitude more at the state level) have some role with invasive species in the U.S., and collectively they exhibit a history of regulating species only after they have become problematic invaders. The U.S. has a regulatory patchwork quilt with more holes than patches, and the result is sadly predictable—New Zealand has had zero exotic herpetofaunal establishments since the 1960s, while the U.S. has experienced at least 110 establishments during the same period.

Kraus also bemoans the 'dishonest market costing' in pet-trade-related herp introductions. He notes that in much of the world, animal importers and dealers are able to market herps at extremely low prices, allowing them to maintain high trade volumes including species that are poorly suited to captivity but which are abundant in source countries. Release or escape of animals by poorly informed, overwhelmed, or negligent owners is the near-inevitable consequence, and taxpayers end up picking up the tab for management of established populations. Kraus opines that costs of screening potential imports, educating purchasers, and controlling established populations should be internalized in the live animal trade, instead of being externalized by denying culpability and dumping the problem on others. Among other benefits, this raises the price of potential pets, promoting responsible care by owners and reducing the number of 'impulse buys' by those lacking the knowledge or resources to properly care for an animal.

The chapter concludes with a list of vital research questions that are needed to better understand the drivers of, and results of, herp introductions. This section could be a wellspring of ideas for new graduate students looking for thesis projects in applied herpetology. Kraus' recommendations on information that should be included in reports of new introductions or naturalizations should be of particular interest for readers of *Herpetological Review*, as this journal publishes many Geographic Distribution notes for introduced herps. He recommends including information on when the introduction occurred, how many introductions were involved (and numbers of individual organisms when these data are available), identification of relevant pathways and motivations for release, and the status of the current population. With the recent demise of the journal *Applied Herpetology*, the importance of *Herpetological Review* and *IRCF Reptiles and Amphibians Conservation and Natural History* (which has taken over the peer-reviewed section on exotic herps from *Applied Herpetology*) as outlets for such reports will likely increase.

In a recent conversation, Kraus indicated no desire to continue the Sisyphean task of compiling literature records on this subject. Where will be found the sucker who will take up the mantle of Assembler of Arcane Introduction Records? While there are myriad, and often competing, databases that attempt to track introduced organisms, most of these rely on volunteers posting new finds to the site or a few flustered agency employees attempting to compile records across all organismal taxa. This approach lends itself to fragmentary and taxonomically or regionally biased perceptions of introductions. It is also worth noting that while Kraus has assembled a monumental dataset, this is likely an *under*estimate of the numbers and taxonomic diversity of introduced herps. By including only those records reported in the peer-reviewed literature, Kraus ignored media accounts, unpublished observations, and unpublished museum records. Accurate and complete introduction databases will be vital to answering some of the most basic questions that are of interest to preventing and managing future herp invasions, but the task is large and the payoff often small (Kraus notes that, "To put it bluntly, applied herpetologists don't get tenure").

Kraus' opus will be of great interest to a wide range of scientists, land managers, and policy makers, and its distribution would help dispel many of the common myths and laissez-faire attitudes about introduced herps. Unfortunately, the book's price will reduce its penetration in the groups that would most benefit from reading it (in fact, certain cheapskate herpetologists might accept an invitation to write a book review in order to get a free copy). The book is currently available online for about 20% less than the suggested price. It is really a steal at this price when considering its scholarly treatment of the subject matter, lively prose, and a trove of easily mined data.

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The Amphibians and Reptiles of Ethiopia and Eritrea

By Malcolm Largen and Stephen Spawls. 2010. Edition Chimaira (www.chimaira.de). Hardcover. 693 pp. 98,00 Euros (approximately US $140.00). ISBN 978-3-89973-466-9.

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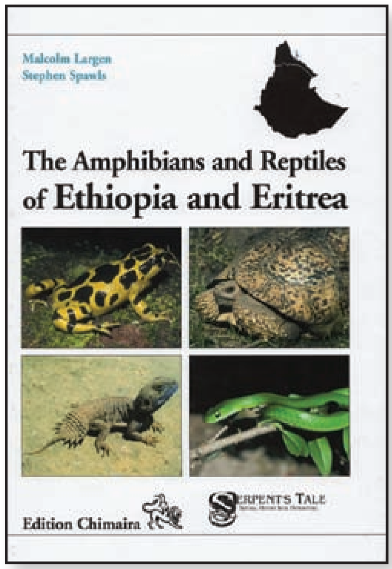

Ethiopia is a special place, not only because of its history but also because of its stunning geographical and biological diversity, and the amphibians and reptiles of the area are no exception. Ethiopia and Eritrea are home to some 285 species of amphibians and reptiles and especially among amphibians, the level of endemism is high, with over 40% of all anuran species being endemic to Ethiopia. At the same time, the highlands of Ethiopia are among the most densely settled areas in Africa and the human pressure on the environment is immense, which makes this area one of the most threatened global biodiversity hotspots. It is, therefore, all the more laudable that the two foremost experts on the amphibians and reptiles of Ethiopia and Eritrea have teamed up to produce a guide book that will serve as a concise introduction to the herpetofauna of the area. As the authors state in the introduction, the targeted audience is less the seasoned herpetologist but more the interested novice and especially young, local herpetologists who are sorely needed to help preserve this unique place.

The book is lavishly illustrated with over 380 color and 25 black and white photographs, in addition to some 23 black and white drawings and 282 distribution maps. The photographs are usually arranged two to a page but a fair number occupy a full page. With a few exceptions, the photographs are of very good quality although the colors seem a little off (a little faded or slightly too saturated) in quite a few images.

Following the table of contents, the preface, and acknowledgments, the book begins with a chapter on the zoogeography of North East Africa. This chapter introduces the various ecosystems of the area, their main characteristics and dominant plant species, and briefly describes the geological history as well as more recent changes. The chapter contains 23 color pictures illustrating a number of different habitats and a simple black and white map of the physical geography of Ethiopia and Eritrea. The color photographs are very instructive and give the reader a good idea of the various habitats but the map is too small and pretty dull and does not stand up to the quality of the rest of the illustrations in this book. It would have also been nice to include a map of the different vegetation zones and perhaps another map with rainfall data. The next, short chapter highlights conservation issues that pertain to the Ethiopian and Eritrean herpetofauna.

The following four chapters deal more specifically with amphibians and reptiles. The first of these provides a very general introduction to the two groups, their evolutionary history and some very brief information on their ecology, physiology, reproduction, etc., and the information provided here indeed only serves as a first introduction for someone who really does not know much about amphibians and reptiles. The second chapter gives advice on observing and collecting amphibians and reptiles. This chapter is more detailed than the previous and gives useful advice for collecting and handling amphibians and reptiles. This chapter appears to have been written with the beginner in mind and it would have been good to point out how important it is to preserve tissue samples in ethanol, particularly for specimens from some seldom visited places within Ethiopia and especially Eritrea. The third chapter briefly explains the rationale behind scientific nomenclature and the following short chapter provides some general advice on identifying amphibians and reptiles and how to use the identification keys provided in the book.

The more than 600 pages that follow are dedicated to the familial, generic and species accounts. The familial and generic accounts are quite short. The species accounts differ in length but comprise on average two thirds of a page to a full page. Species accounts are subdivided into a section describing the species and another section that provides information on its distribution and ecology. Almost all species accounts are accompanied by a small distribution map with point distributions mapped onto it and at least one color photograph. The species accounts are necessarily rather concise but contain enough information to help identify specimens and also provide a good summary of what is known about the distribution and some information on ecology. In the amphibian accounts, information on the conservation status is listed as a separate section whereas in the reptile accounts this information, where available, is integrated into the "distribution and ecology" section. Some recent taxonomic changes have not been implemented here and the taxonomy applied is best described as conservative. This is particularly apparent in gekkotan (Han et al. 2004) and amphibian (Frost et al. 2006) taxonomy, where recent changes have not been incorporated even though these are widely accepted now.

Following the species accounts are a gazetteer, a glossary, a bibliography with a "selection from the most relevant work published in or after 1970" as well as a taxonomic index and an alphabetic list of the amphibian and reptile species of Ethiopia and Eritrea with taxonomic authors.

In addition to the taxonomic accounts, the book contains keys to all genera of frogs, lizards, snakes, and turtles found in the area. Each key is accompanied by a schematic drawing illustrating the main diagnostic features used in the keys, which should help the novice navigate her or his way through the keys. Additional keys are provided for speciose genera although there seems to be no consistent pattern as for when a key is provided or not. The general rule seems to be to have keys for genera with seven or more species although for some, like *Agama* with seven species no key is provided whereas a key to the six species of *Platyceps* is included. I found that slightly puzzling, but I am sure that there are good reasons for this. Somewhat more puzzling is the pattern by which taxa are arranged in the book. Orders and families are arranged alphabetically (with one exception) whereas there is no consistent pattern for listing genera or the species within a genus. This might not seem to be much of an issue but it quickly becomes a nuisance if one has to go back and forth between species accounts within a species-rich genus, which either means frantically leafing through the book or constantly referring back to the table of contents. This is definitely something that should be rectified in any future edition.

Edition Chimaira publishes a number of different series, the most prominent of which are the "white" (also known as the Frankfurt Contributions to Natural History), and the "black" series. The present book is published in the white series, which is smaller in format than the black series. Given the substantial page count, it might have been better to publish this as part of the slightly larger black series, because the current size and especially weight of the book means it is actually not too dissimilar from a brick. I personally would not want to have to carry it into the field but it definitely seems to be sturdy enough to survive more than one field exposure, if you keep it dry of course.

The verdict? There are many small things to fret about but at the end of the day I found myself picking up this book far more often than I initially expected. This book is an excellent contribution to literature on African herpetology and every person with a remote interest in the herpetofauna of Ethiopia and Eritrea, and Africa more generally, would want to have this book in her or his library. It is admittedly not cheap but the print quality just about justifies the price. Sadly, I fear that the asking price will very likely prevent this book from reaching a circulation in Ethiopia or Eritrea that will exceed single digit figures. On the other hand, for people from overseas working in the area, it would make a great and surely much appreciated gift for a local collaborator.

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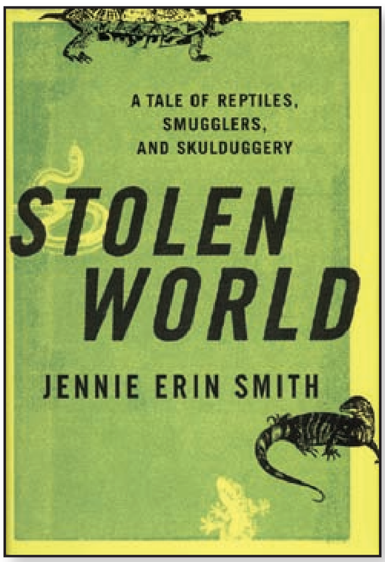
Stolen World: A Tale of Reptiles, Smugglers, and Skullduggery

By Jennie Erin Smith. 2011. Crown Publishers, New York (www.crownpublishing.com). Hardcover. 322 pp. U.S. $25.00. ISBN 978-0-307-38147-7



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By any measure, the last decade has been a challenging one for those involved with either the private reptile hobby (or, if one prefers the more grandiose term, industry), or the professional worlds of zoo and academic herpetology. For amateur enthusiasts and "herpetoculturists," flush with the optimism born of the explosion of these fields in the 1990s, the last decade has been a sobering wake-up call. With the rising popularity of keeping, breeding, and observing/photographing reptiles and amphibians in the wild has come pushback, in the form of legislative restrictions at the local, state, and national levels in the United States. Concurrently, zoological institutions have found that they are far from immune to these same regulations, and in many cases both the acquisition of new specimens and disposal of surplus animals have become equally problematic.

These regulations, justified or not, have been fueled, to a great extent, not only by lobbying from animal rights groups such as the Humane Society of the United States and People for the Ethical Treatment of Animals, but by sensationalized, unflattering, and (at times) dubiously factual depictions of reptile professionals and enthusiasts in the popular media. So it was with some trepidation that I approached Jennie Erin Smith's new book, an exhaustive account of the careers of three of the reptile world's most well known (and, truth be told, notorious) characters: Hank Molt, Tom Crutchfield, and Anson Wong. Although certainly of interest to herpetologists and reptile enthusiasts of all stripes, this book is aimed at a mass audience, and I worried that here I would find more of the same, the literary equivalent of those Animal Planet documentaries—heroes and villains portrayed in black and white terms, leaving the reader with little choice but to be led, cheering, to the author's inevitable and foregone conclusion.

I also expected the kind of ludicrous errors of scientific fact one commonly finds when a journalist writes on a herpetological subject. This passage on the very first page, in which Smith introduces (and attempts to define, in a lighthearted yet dismissive manner), the term "herpetoculture," did little to ease my discomfort:

> "…it [herpetoculture] sounded like "herpetology", but you needed a Ph.D. to be a herpetologist. If you woke up to find your pet snake had laid eggs, you were a 'herpetoculturist'."

Not exactly accurate on either count and guaranteed to annoy herpetologists and herpetoculturists alike.

However, as my reading progressed, I am pleased to report that I found quite the opposite of that which I feared. Over a decade's time, Smith immersed herself in the lives of her three protagonists, as well as those of a host of supporting characters from all sides of the law. What she found, unsurprisingly, were big plans, big egos, big mistakes, quite a lot of villainy, and a notable lack of heroes. In a disarmingly transparent style, she is content to lay out the facts and allow a truly fascinating story to speak for itself. I could detect very little personal bias in her prose, and, even better, factual errors were all but nonexistent. Smith is obviously either a bit of an enthusiast herself, ran her manuscript past some experts, or, more likely, both.

Despite the tawdry, unflattering, often illegal nature of many aspects of these stories, surprisingly few facts are seemingly in dispute. For those that are, Smith is careful to give the accounts of all protagonists equal weight, and generally refrains from editorializing, leaving the reader to reach his or her own conclusion. Given the information available, that conclusion is often pretty clear.

Most of the book is devoted to Molt and Crutchfield, and from the mid-1960s to the present, their careers evolve against a background of the great change that swept across the face of herpetology and reptile-keeping ("herpetoculture" had not yet been coined) in those decades—not incidentally including the ever-widening gap between academic herpetologists on the one hand, and those from the zoos and the private sector on the other. Two more fascinating personages could hardly be imagined.

The section on Anson Wong, the successful and wealthy Asian animal dealer, almost seems an afterthought, and almost pasted-on, leaving one curious to hear more about his exploits earlier in life. Interestingly, Wong is the only one of the three currently still imprisoned, in Malaysia, for his illegal activities.

Tom Crutchfield comes off as the most sympathetic character, a charming, brash, overbearing, somewhat volatile rogue, seemingly dismissive of authority yet, on another level, longing for acceptance and success in the mainstream of herpetology. In this respect, there are many like him out there, frustrated herpetologists who, in one way or another, lack the patience, focus, or other scholarly character traits that lead to success in the academic arena. Yet they certainly do not tend to channel that kind of frustration into illegal activities such as wildlife smuggling. Despite his illegal activities involving smuggled wildlife, one gets the impression that Crutchfield harbors a deep love and respect for reptiles, and would draw the line at doing anything that would have negative conservation consequences.

Hank Molt is more difficult to understand, as his passion for rare and unusual reptiles quickly combines with a seemingly congenital need for adventure and stimulation to push him far beyond the boundaries of the law, and even morality. Though obviously a man of considerable intelligence, he repeatedly makes fatal (and avoidable) errors that deliver him into the hands of the authorities. And yet soon he is back at it, seemingly addicted to the thrill of pulling scams, uncaringly ripping off friend and foe alike (and his treatment of his "friends" is profoundly base and deceitful—the term "sociopath" comes to mind here). As can be imagined, Molt's tale is a roller coaster ride, but certainly not boring!

The authorities, United States Fish and Wildlife Service agents most notably, but also federal prosecutors and the wildlife departments of various countries, are not exactly heroes here either. Personal vendettas, selective prosecutions, amateurish mistakes, sweetheart deals, bribery, and kickbacks are portrayed as commonplace. Reptile dealers are sent to prison while the famous zoos and museums, which actively encouraged "acquisition" (read smuggling) of protected species, are shielded by political connections. If personnel from these institutions were not fully aware of the illicit activities, they certainly turned a blind eye as long as they obtained their sought-after species.

And then there was the blatant hyperbole and self-promotion by U.S. officials, as Smith notes:

> "The Time Magazine story, which relied heavily on Agency sources, estimated the global illegal reptile trade as worth between $10 billion and $20 billion annually."

The above figures would have placed international reptile smuggling on a par with the global arms trade, at a time when TRAFFIC estimated the total LEGAL live animal trade (including ornamental fish, birds, reptiles and amphibians, and mammals at about US $826 million a year (with smuggling considered the barest fraction of that) (Roe et al. 2002). An agency official later concedes that their figures were made up out of whole cloth.

Caught in the middle were the zoos, increasingly desperate for rare specimens to attract visitors. At times they bankrolled and even explicitly supported the smugglers in private, with paperwork and "letters of introduction" on zoo letterhead. But in public they were very careful to appear spotless, and voiced nominal support for conservation organizations and NGOs bent on curtailing smugglers and even the wildlife trade itself. Of course this path was doomed to failure from the beginning, and good zookeepers and curators eventually lost their careers when the house of cards finally tumbled.

The big losers in this story are, of course, the thousands of individual reptiles and amphibians swept up in the illicit wildlife trade. With rare exceptions (the brazen theft of over 70 Ploughshare Tortoises from the Jersey Wildlife Preservation Trust compound in Madagascar, for example), the numbers involved apparently had scant effect on wild populations or species. But the carnage among the individual animals is difficult at times to comprehend. Entire shipments of Fiji Iguanas, Boelen's Pythons, Gray's Monitors, and countless other reptiles perished in a variety of nasty ways: in the country of origin due to brutal capture techniques, through being smuggled in horribly cramped and unsuitable containers, or from incompetent husbandry at the hands of government authorities and even zoos after confiscation.

Noteworthy is the fact that nearly all the fabulously valuable reptiles that were the object of smugglers in the 1970s and 1980s—Bismarck Ringed Pythons, Ridgetail Monitors, *Rhacodactylus* geckos, Green Tree Pythons, Blue-tongued Skinks—are now captive bred so frequently and in such quantity that their value no longer justifies the risks associated with smuggling, or, in many cases, even the cost and hassle of legal importation.

Stolen World is a sad, yet fascinating, look at all sides of illegal reptile trafficking. It is that rare book that will appeal to the masses as a good read, and yet simultaneously can be regarded as an important one as well. It should be read by anyone interested in truly effective conservation of reptiles and amphibians.

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Herpetological Review, 2011, 42(2), 313.

Secrets of the Snake Charmer: Snakes in the 21st Century

By John C. Murphy. 2010. iUniverse (www.iuniverse.com). xv + 400 pp. Softcover. US$ 36.95. ISBN 978-1-4502-2126-9.

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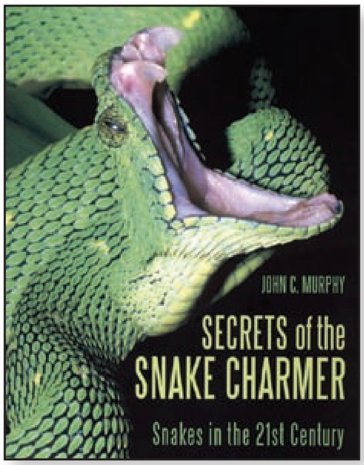

Catching up with all the new knowledge being accumulated on snakes, published in diverse journals all over the world and in many languages, is a time- and energy-consuming exercise. This is particularly true for the first decade of this century, which has already seen impressive progress on a number of aspects of snake biology and evolution. Fortunately for all naturalists and herpetologists, every few years one or more researchers seem to tackle this arduous task, for the benefit of the entire community. This is especially valuable when it is done by a skilled herpetologist such as John C. Murphy, who is an active field researcher and has an extensive experience in making scientific knowledge accessible to the public, as evidenced by his recent comprehensive volume on homalopsid snakes (Murphy 2007).

The new book is illustrated by 84 snake photos, plus two dozen others, mainly of other reptiles, as well as diverse drawings and figures. All are in black and white. It is thus definitely not a coffee table book, but rather a book to learn from. *Secrets of the Snake Charmer* focuses on snake research done during the first decade of the 21st century. Although released in April 2010, the book deals with literature through the beginning of the same year. Literature references are not indicated in the main text, but the commented bibliography (pp. 321–380) is organized by chapter and thus easily allows the identification of sources of the information presented.

As noted by the author (p. xii) "snakes can serve as a window to open the ideas of ecology and evolution to people otherwise distracted by religion, junk TV, technological gadgets, and sporting events." Although packed with information the book is written in an accessible style and makes a pleasant read for both professional herpetologists and amateurs. The selection of subjects dealt with in the main text (pp. 1–320) is wide: snake evolution, fangs and venom apparatus, predation, defense mechanisms, etc. The 14 chapters are themselves divided into numerous focal subtopics. Many topics are enlivened by the author's anecdotes based on personal experiences in the field.

A weak point of the book is the 'Index to Scientific Names and Authors' (pp. 389–400). The text uses snake common names (e.g., Burmese Python, European Cat Snake, King Cobra, Little File Snakes, Vine Snakes) extensively, and it would thus have been useful to include them in the index as well. In many cases the common name is not associated in the main text with the corresponding scientific name, and the exact identity of the snake is thus not always easy to determine. Further, many scientific names cited in the main text are not included in the index (e.g., *Coelognathus radiatus*, *Colubroelaps nguyenvansangi*, Crotalidae, *Enhydrina schistosa*, *Enhydris polylepis*, *E. subtaeniata*, *Oxyuranus microlepidotus*, *Pseudonaja textilis*, *Vipera aspis*), or only at the generic level, or not for all pages where they are cited in the main text. Among the non-reptilian scientific names mentioned in the main text, some are listed in the index (e.g., *Felis catus*), some not (e.g., *Rattus villosissimus*). As for the scientific names, authors listed in the main text are not all listed in the index either, and in any case the utility of an author index in such a work seems limited to us. There are some mistypings, mainly in scientific names and proper nouns, but not to the extent that they detract appreciably from the book.

Despite the few negative points noted, we generally had an excellent opinion of this new book. It makes a very good read for anybody seriously interested in snakes and who wants to know more about them and we recommend it to both interested novices as well as seasoned herpetologists.

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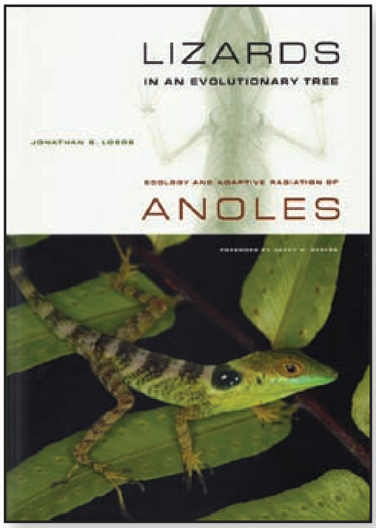
Lizards in an Evolutionary Tree: Ecology and Adaptive Radiation of Anoles

By Jonathan B. Losos. 2009. University of California Press (www.ucpress.edu). xx + 527 pp. Hardcover. US $95.00. ISBN 978-0-520-25591-3 (Paperback US $49.95. ISBN 978-0-520-26984-2).



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The history of evolutionary theory is tightly linked to vertebrates and islands. The year of evolution (2009) has reminded biologists and non-biologists that finches in the Galapagos Archipelago inspired some of the most provocative thoughts in Charles Darwin's mind. Since then, these ecologically diverse birds have gained a privileged place as promoters of one of the deepest revolutions in human thought. Far away from the Galapagos and from Darwin's itinerary, another group of vertebrates on another group of islands quietly awaited their own opportunity to gain a privileged place in the history of science. In *Lizards in an Evolutionary Tree*, Jonathan Losos tells the story of Caribbean anoles and their contributions to evolutionary biology. For over five decades anoles, particularly the genus *Anolis*, have been the subject of an extraordinary wealth of research dealing with most aspects of the fields of ecology and evolutionary biology. These lizards have not only been useful model systems, anoles are special because they have been instrumental in the development and refinement of theories that have shaped our view of ecological and evolutionary dynamics, contributing greatly to our understanding of major theories such as adaptive radiation and speciation. Anoles, therefore, deserve a great deal of attention from those interested in ecological and evolutionary processes as they occur in nature. However, to read and assimilate the monumental amount of literature on anole evolutionary ecology would require a large part of one's career. The good news is that Losos has done just this, achieving an extraordinary synthesis in a single, solid, entertaining, and comprehensive volume.

The book is impeccably well-organized and its 17 chapters cover the entire diversity of primary theoretical and technical fields relevant to understanding the evolution of adaptations and the origin of new species. While the many footnotes (477 on 409 pages)can be somewhat distracting , they typically contain important relevant information and are worth the pause from the main text. After a couple of pages these footnotes become pleasing distractions because they often also contain entertaining stories that tend to be absent from scientific books of this quality.

In the first three review chapters (2–4, Chapter 1 is a general introduction to the problem of evolution), Losos provides a fine account of the most important aspects of anole diversity. Information in these chapters covers themes as varied as species concepts, competition, key traits involved in sexual and ecological performance, biogeography, reproductive isolation, and arguably one the most comprehensive treatments about anole ecomorphs (and non-ecomorphs) available in the literature. In these chapters, the reasons why these lizards are excellent model organisms for evolutionary and ecological research become apparent. Losos also makes the case for how critical species-specific natural history information is for understanding evolutionary processes. Clear maps and astonishing color pictures contribute to making these chapters accessible and enjoyable to read.

In chapters 5–7, the book turns to phylogeny. Of particular interest for all comparative biologists are timely discussions of the application of phylogenetic approaches to evolutionary questions (Chapter 5), a field in which the author himself has made important contributions. From this chapter, it becomes clear that not all phylogenetically based analyses can be taken at face value. For example, Losos shows why ancestral reconstructions (widely used in the mainstream scientific literature) under several circumstances should be interpreted with caution. Chapter 6 discusses the phylogeny of anoles, and explains how this information has unravelled the biogeographic history of the group. In this phylogenetic framework, evolutionary changes that accompany the selective challenges encountered in newly colonized areas can be appropriately interpreted. This information is used to discuss the roles of divergent and convergent adaptation that have shaped anole morphologies, and remarkable historical scenarios emerge. For example, a well-established observation in biogeography is that colonization between mainland and islands is typically unidirectional, from the former to the later. Colonization in the other direction is thought to be less likely because island species are regarded as weak competitors if placed in continental ecological arenas. However, phylogenetic evidence suggests that anoles have not only recolonized the continent from the Caribbean islands several times, but also that these adventurous colonizers have been remarkably successful establishing an extraordinary lineage of almost 130 species. Patterns of dispersal and speciation emerge, and Chapter 7 covers the exciting topic of ecomorphological evolution in great detail. The predictability of body size and shape evolution are explored, with interesting accounts of phylogenetic patterns of ecomorphs and the debated, but intriguing, idea of evolution by character displacement. These chapters make a strong case for how autonomous the process of adaptation can be, and how crucial the effect of selection is to shaping the functional, causal, and dependent linkages between environmental pressures and phenotypes (see Hurst, 2009, for a discussion of the genetics of selection effects). As Williams (1966) vividly argued in his famous book, adaptation should be accepted as an explanation when other alternatives have failed. This imposes a difficult challenge as alternative hypotheses often offer appropriate mechanistic pathways to explain organismal features. However, as Losos shows in his book, the adaptive explanation for Caribbean *Anolis* evolution is strongly supported from a number of empirical angles, including replicated associations between ecological demands and morphological traits and functional capabilities. Losos also emphasizes that not all *Anolis* are the same, and that this idealized evolutionary story is much more complex on other islands and on the mainland. The field of ecomorphology is, in summary, richly presented in this section.

Losos broadly reviews the biology of anoles in the next section of the book (chapters 8–13), covering all aspects of anole interactions, from causes to consequences, and from ecology to sexuality. These broad discussions even touch on topics that lizard biologists rarely mention, including potential intelligence and sleeping habits. Chapter 8 includes a diversity of topics that are rarely known in such detail in any single genus, such as reproduction, growth, lifespan, parasites, predators, diet and other forms of ecological interactions. Chapter 9 focuses on one of the most exciting fields in evolutionary biology, the origin and impact of intraspecific interactions to determine social and sexual dynamics, with a clear review of the main principles of sexual selection theory. The discussion includes the unavoidable phenomenon of sexual dimorphism, a remarkable and debated outcome of evolutionary diversification within species. Losos presents a clear, unbiased and comprehensive review of the problem of phenotypic differences between the sexes. The chapter gives deserved weight to the two main explanations proposed by Darwin (1874), natural selection on ecological preferences or sex roles, and sexual selection. The focus of the analysis is primarily on the evolutionary forces that determine the direction of patterns of sexual dimorphism and the outcome. However, no particular detail is given to the complex genetic factors that allow or constrain divergence in alternative, sex-specific directions in the first place, once selection has provided the evolutionary impetus for the expression of this phenotypic divergence (Fairbairn et al. 2007). Chapter 10 presents a particularly informative review on how temperature, humidity, light and other factors govern the ways anoles exploit common areas by means of micro- and macro-environmental segregations. Once again, the pivotal role of anoles in the establishment of current theories and models is highlighted, as Losos reminds us how these lizards have been instrumental in the development of the field of thermal biology.

From Chapter 11, the book turns into a fascinating and dynamic synthesis of information from previous chapters and the focus shifts to the broad fields of adaptive radiation and speciation, which represent the real essence of evolution. In chapters 11–13, the theory of adaptive radiation is introduced from the multiple angles required to understand how evolutionary mechanisms (essentially, natural selection) ultimately drive evolution. A brief but clear theoretical background to adaptive radiation is presented, in which Losos emphasizes that this process is important because it results in the evolution of disparate ecological and phylogenetic diversity from single ancestors, whereas the timing of diversification (the well known “early burst”) is simply one of the features of the process, rather than a crucial concept involved in its definition. These three chapters offer a complete review of the anole adaptive radiation, where studies of community ecology (from predators to parasites), field manipulation of free-ranging lizards, and phylogenetics provide evidence of the effects of divergent natural selection on adaption and cladogenesis. Interesting syntheses of field evolutionary genetic experiments across generations and of geographic variation as an encouraging avenue to investigate adaptive radiations are presented.

The integration becomes still stronger in chapters 14–16, where the evolutionary diversification of anoles is reviewed in great detail. In these chapters, as in the rest of the book, no theoretical biases or biased speculations are found. All major theories of diversification are incorporated into the discussion, including the largely demonstrated fact that natural selection is a prominent driver of speciation. However, several controversial views, such as founder effect speciation (Coyne and Orr 2004), are also included in the discussion. As can be expected for an island adaptive radiation, due weight is also given to geographical models of speciation (allopatry, sympatry, parapatry). Some fascinating explanations of selection-based speciation are presented, such as the potential impact of head-bobbing and variation of dewlaps on the breakdown of gene exchange between diverging species. Phylogeny, rates of evolution, sexual dimorphism and niche expansion as agents of diversification, key innovations, island biogeography theory, ecomorphs, and the adaptive landscape approach, among others, are dynamically recalled in these final chapters. The book concludes with Chapter 17, in which an overview touching on other adaptive radiations elegantly summarizes the extensive information presented in the preceding chapters.

Throughout the book, Losos provides responsible and unbiased discussions and interpretations of the available evidence, and still better, maintains the tendency to complement certain ideas with novel speculations about the factors involved in anole lizard evolution. Although many scientists often feel reluctant to take intuitive speculations into account, it cannot be denied that scientific progress relies importantly on the freedom of imagination to suggest alternative explanations for phenomena. Some of these speculations may be proven incorrect, but they inspire the reader to think freely about possible explanations for evolutionary questions.

Finally, an important question that many potential readers of Losos's book may be asking is whether this is primarily about anole lizards or about evolutionary ecology. Many might immediately argue that this book is about evolutionary ecology. However, I believe one of the greatest achievements of Losos is the integration of fields he provides in this book. Losos, more than most evolutionary biologists, makes a strong case that species-level natural history is critically important to fully understand a complex multi-phenomena process like evolution. Hence, Losos has managed to write a book that will serve a broad audience. It represents one of the best and most comprehensive synthetic treatments of the theories of adaptive radiation and speciation based on the empirical context of a specific model system, but it also provides a thorough review of the diversity and natural history of anoles. It has to be said, however, that this is a decidedly scientific book, and clear understanding of theoretical concepts is paramount to the story it tells. For example, despite the enormous diversity of theories encompassed by Losos in this book, the introductory text for each of these ideas is generally brief. Hence, the author implicitly assumes that readers are familiar with the main concepts. However, in this book jargon and simple language are balanced, making it accessible to a broad audience, while maintaining a consistently high level of scholarship. This book is, therefore, a true representation of Einstein's quote "everything should be made as simple as possible, but not simpler."

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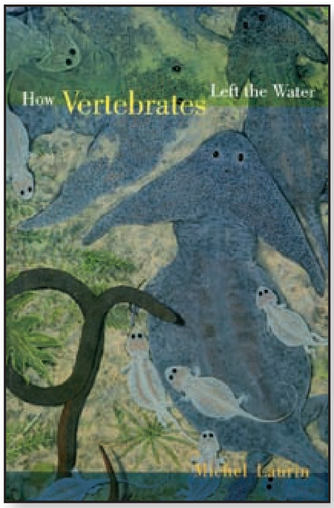
PUBLICATIONS RECEIVED

How Vertebrates Left the Water

By Michel Laurin. 2010. University of California Press (www.ucpress.edu). Hardcover. xv + 199 pp. US $34.95. ISBN 978-0-520-26647-6.



This is an English translation, with minor updates, of Laurin's original French book of 2008. It is concise, clear, and well written. The book serves both as a summary of the important changes that took place in this most important of vertebrate transitions and as an argument for parsimony and phylogenetic nomenclature. It begins with a critique of rank-based nomenclature and offers phylogenetic nomenclature as a solution to aspects of instability in the prevailing system. This is followed by an explanation of parsimony-based methods of phylogenetic reconstruction and a discussion of molecular and paleontological dating. The introductory chapter is rounded out by brief treatments of homology, the geological time scale, and paleogeography. Laurin then considers what living taxa can tell us about the conquest of the land before addressing such topics as the evolution of limbs, the diversity of Paleozoic stegocephalians, and the adaptation of the skeleton, respiratory system, skin, and sensory organs to life on land. The slender volume closes with a glossary of more than 50 terms, a bibliography of more than 150 entries, and a combined subject/taxon index. The book draws heavily on the author's works from the early 1990s onwards and unabashedly promotes his views on a number of topics. At the same time, it does a remarkable job of distilling down each of the subjects addressed to just a few clear, concise, information-packed pages. The book ably succeeds in the author's desire to make the material accessible to those with little prior knowledge in the field and, indeed, offers even novices a succinct view of how modern vertebrate paleontologists test hypotheses about the evolution and biology of extinct organisms. It may be especially useful for herpetologists, systematists, and anatomists whose work is chiefly or exclusively neontological and who would like an up-to-date primer of the events of the Paleozoic that set the stage for the modern world of terrestrial vertebrates.

L'Interprétation des Nomes Grecs er Latins d'Animaux Illustrée par le Cas du Zoonyme Sēps-Seps

By Liliane Bodson. 2009. Académie Royale de Belgique, Mémoire de la Classe des Lettres, Collection in-8°, 3° série, Tome XLIX, n°2062 (www.academieroyale.be). Softcover. 368 pp. 30,00 Euro (approximately US $42.00). ISBN 978-2-8031-02631.

This French language memoir explores the interface between classical studies and zoology and has a significant herpetological component. The ancient Greek word "sps," originally meaning "putrifying sore" (hence the word sepsis), was subsequently Latinized and applied to certain types of venomous animals known in the ancient world. The author examines both written and iconographic sources in order to determine the identity of the animals to which the term "seps" has been applied and the anthropological and toxicological criteria met by these disparate taxa that resulted in their inclusion under this term. This specific example is used to investigate the Greek and later the Roman approach to knowledge about the animal kingdom and is further used as an example that illustrates the way in which ancient sources can provide information about the ecology and zoogeography of animals in the ancient Mediterranean. Based on its usage by 31 authors over nearly two millennia, the term "seps" is shown to have been applicable to snakes, lizards, centipedes and caterpillars, with the majority of uses, and virtually all before the 6th century A.D., being herpetological. Additional iconographic sources, as well as modern interpretations of early uses of the term are also considered and the identities of the animals intended by ancient authors are carefully deduced through the comparison of the characteristics of the "seps" and modern knowledge about the distribution and biology of candidate species. Viperid snakes and scincid lizards are most consistent with the ancient data which, in many cases, are detailed enough to allow specific identification. All Greek and Latin sources have been translated into French and much of the data are summarized in convenient tables. The work is supported by a thorough bibliography of 40 pages and six indices (ancient sources, modern authors, Greek and Latin vocabulary, scientific names, French scientific and vernacular names of animals, and a general index) and is accompanied by four color plates and several black and white illustrations. Although highly specialized, this work will be of interest to herpetologists, and zoologists in general, who have an interest in history, as well as to ethnozoologists, anthropologists, and classicists.

Lista Anotada de los Anfibios y Reptiles del Estado de Hidalgo, México

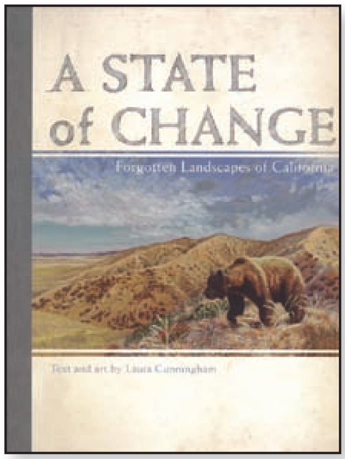
By Aurelio Ramírez-Bautista, Uriel Hernández-Salinas, Fernando Mendoza-Quijano, Raciel Cruz-Elizalde, Barry P. Stephenson, Victor D. Vite-Silva, and Adrian Leyte-Manrique. 2010. Universidad Autónoma del Estado de Hidalgo and CONABIO, Pachuca, Hidalgo. 104 pp. Softcover. US $25.00 (available from Bibliomania! www. Herplitsales.com). ISBN 978-607-7607-39-7. [In Spanish]

Here is another addition to the rapidly expanding list of state or other regional works concerning Mexican herpetofauna. This volume is the first treatment for the Mexican state of Hidalgo, which straddles the Sierra Madre Oriental of eastern-central Mexico, a region of substantial topographic and habitat diversity. This is an introductory work, offering an annotated list of species along with known localities, as well as preliminary analyses of the herpetofauna based on levels of endemism and association with specifc biotic communities. The authors include an overview and color photograph of each the 12 major vegetation types. There are four principal biogeographic regions within Hidalgo: Sierra Madre Oriental, Altiplano Mexicano (Central Plateau), La Faja Volcánica Transmexicana (Transvolcanic Belt), and Golfo de Mexico (Gulf of Mexico). Despite its small size (20,500 km^2, equivalent to the US state of New Jersey), Hidalgo boasts 173 species of amphibians and reptiles, emphasizing Mexico's status as a biodiversity hotspot. Taxonomically, the herpetofauna consists of 14 salamanders (all but 3 are plethodontids), 40 anurans (including the introduced *Lithobates catesbeianus*), 3 turtles (all *Kinosternon*), 37 lizards (including an undescribed species of *Xenosaurus*), and 78 snakes (including an undescribed species of *Rhadinaea*). Another five species (one anuran, four lizards) are listed as potentially occurring within the state. Of the 173 confirmed species, four are new state records: *Hyla euphorbiacea, Epicta goudotii, Thamnophis scaliger*, and *Rhamphotyphlops braminus* (introduced). Color photographs are provided for 90 species, in addition to 32 black-and-white images that depict an additional 12 species. A detailed map of Hidalgo with key reference points, as well as a vegetation map, would be helpful additions for readers not intimately familiar with the regional geography. The authors have produced an important foundational work that sets the stage for further research.

A State of Change: Forgotten Landscapes of California

By Laura Cunningham. 2010. Heyday Books, Berkeley, California (www.heydaybooks.com). 350 pp. Hardcover. US $50.00. ISBN 978-1-59714-136-9.

Biologist / illustrator Laura Cunningham has combined her artistic talent with a keen knowledge of contemporary and ancient communities to produce a masterpiece of historical ecology, accessible to a broad range of readers. Cunningham draws on the works of various researchers across diverse disciplines (archaeology, paleontology, geology, ecology) to describe what these same communities looked like prior to the arrival of European colonizers—before rivers were dammed for hydroelectricity, before vast swaths of land were converted for agriculture or cities, before wetlands were drained—and in some cases, much earlier (40,000 ybp). The illustrations range from beautiful oil paintings to pencil sketches. Particularly fascinating are the pairing of ancient and modern views of the same place. Thus, we are treated to a biologically informed rendering ("paleo art") of Santa Barbara 500 yrs ago alongside a contemporary photo of the same scene. Historical information is footnoted throughout the text, permitting readers to track down primary sources. Although this is not a herpetological work, per se, a few amphibians and reptiles receive featured treatment: Panamint Alligator Lizards (*Elgaria panamintina*), Amargosa Toads (*Bufo nelsoni*), and Foothill Yellow-legged Frogs (*Rana boylii*). Species are indexed by common name, although an appendix lists both common and scientific names.



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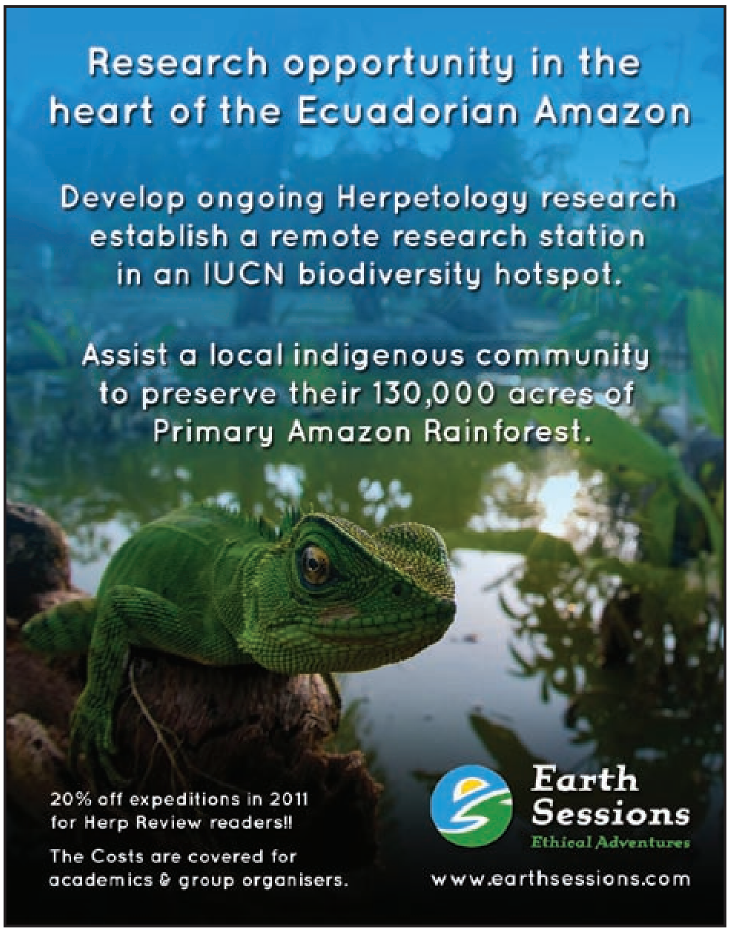

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